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ENVIRONMENTAL SUSTAINABILITY AS A DETERMINANT OF THE ECONOMIC EFFICIENCY OF RATIONAL LAND USE

The purpose of the study is to examine and theoretically analyze the organization of the land-use system in the agricultural sector from an ecological-economic perspective, as well as to develop conceptual foundations for the transition to environmentally sustainable management. It is proven that modern land use is a multidimensional issue, and the causes of environmental conflicts stem from structural shortcomings in the economic management system, inefficient technologies, and the lack of effective institutional incentives. Two complementary models for ensuring environmental sustainability - the territorial model and the component-based model were identified, and their functional objectives were specified. The paper justifies the need to integrate environmental standards into the land resource management system, which involves the development of territorial and functional models for ensuring sustainability. A concept for adaptive measures was proposed that combines environmental regulations, institutional tools, and information and monitoring systems. It was shown that implementing such a model creates the conditions for maintaining soil productivity and increasing the efficiency of agricultural production in the long term.

Keywords: land resources, land-use economics, ecological-economic approach, rational land use, sustainable development.

Problem statement. The contradictions between the economic interests of agricultural production and the environmental requirements for the conservation of soils and land resources underscore the urgent need to develop new approaches to land-use management. The imperfections of the economic mechanism, the weakness of institutional tools, and the slow pace of environmental sustainability in the agricultural sector pose a threat to the long-term sustainability of agricultural systems and require scientific analysis.

Analysis of recent research and publications. Issues related to soil ecology and the rational and sustainable use of land resources have deep historical roots and likely arose at the same time as the emergence of agriculture. Therefore, a proper understanding of this subject requires a comprehensive analysis of the relationship between society and nature, which must be considered in the context of their dialectical unity.

Historically, the pursuit of maximum land exploitation for profit has yielded immediate economic benefits but has undermined the long-term sustainability of agricultural management and the preservation of soil fertility. At the same time, agricultural science has often neglected fundamental ecological principles such as the unity of organisms and the environment, adaptive mechanisms, the principle of moderation in transforming the natural environment, chain reactions resulting from intensive intervention, and the necessity of biodiversity. The large-scale conversion of land to agricultural use and the intensification of farming practices have led to the disruption of natural ecosystems, the weakening

of self-regulatory processes, and the loss of the balance that ensures the stability of landscape components [1-2].

The nature and causes of environmental conflicts in the field of land use are linked to the imperfections of the economic mechanism, the consequences of irrational land use, and extensive farming methods. Modern land management is a complex, multifaceted task involving numerous subsystems; therefore, in agricultural production, it is necessary to systematically assess the degree of anthropogenic impact on the environment and, in each specific case, strictly adhere to the principles of ecological balance to ensure the long-term sustainable development of farms [3].

In a broad sense, sustainable development is viewed as a new model for the functioning of civilization, one that entails a radical transformation of its historically established economic, social, and environmental parameters. The economic dimension of this process lies in orienting productive and economic activities not toward the maximum consumption of the biosphere's natural resource potential, but toward its rational and balanced use. The social aspect involves the implementation of democratic principles of governance, the integration of market mechanisms with the social functions of the state, and the assurance of social justice. The environmental dimension focuses on the impact of human activity on the natural environment, since human progress must be based on the responsible use of natural resources, rather than their uncontrolled exploitation [4].

Under market conditions, landowners often treat land as a commodity, which encourages a consumerist approach and an underestimation of environmental factors in its use; such practices are particularly dangerous during the formative stage of the land market. The existing regulatory framework does not fully ensure environmental safety in the use and protection of land; therefore, it is necessary to strengthen government regulation and focus on the issues of sustainable land use [5].

Annual national reports on the state of land in Ukraine consistently document instances where environmentally acceptable load limits on agricultural land are exceeded, leading to an intensification of degradation processes, a decline in the self-regulatory capacity of natural ecosystems, and a reduction in their productivity.

When analyzing the specifics of utilizing land resources in a market economy, one must proceed from the premise that the natural uniqueness of land as a resource necessitates systematic, multifaceted regulation by state institutions. This regulation must encompass the legal, economic, and organizational framework for relations related to the distribution, redistribution, exploitation, and regeneration of land, and must be implemented regardless of the specific model of the socioeconomic system [6].

In the agricultural sector, efforts to make land use more environmentally friendly are progressing slowly, and the increasing degradation of land poses a real threat of economic bankruptcy to agricultural producers. In the context of the transition to private land ownership and the persistence of a consumerist attitude toward land use, this justifies the need for greater government intervention: improving legal regulation, stricter enforcement of environmental standards, introducing economic incentives for sustainable practices, and developing institutions capable of ensuring the restoration and rational use of land resources [7].

In the practical implementation of sustainable ecological and economic development principles across various regions, there is a tendency toward a superficial approach - authors often provide only a list of conservation measures without methodological justification for their prioritization, integration into land policy, or an assessment of long-term consequences [8-10]. However, radical transformations in land relations require scientific support for both the strategy and tactics of greening land use, therefore, the development of conceptual approaches and practical directions for solving the problem is a priority. The mismatch between current methodological developments and the real needs of practice hinders the process of transforming land relations, complicates the implementation of sustainable approaches to land resource use, and negatively affects the quality of the relevant legislative framework.

The purpose of the article is to provide a scientific justification for the conceptual foundations of rational land use that combine economic efficiency with environmental sustainability and ensure conditions for the sustainable development of the agricultural sector.

Results and discussion. In today's context, the greening of land relations requires, first and foremost, the greening of the organizational and economic restructuring of the existing land-use system.

Environmental laws - that is, ecosystem theory, which is based on integrity and a systems approach, can serve as the unifying principle in this regard [11]. In this case, the sustainable development of any economic entity pursues a threefold goal: ecological well-being, economic profitability, and equitable socioeconomic conditions. At the same time, sustainability is based on the principle that it is necessary to meet the needs of the present without compromising the ability of future generations to meet their own needs.

When formulating sustainable development goals for economic entities, one should proceed from the need to balance environmental requirements with economic interests. In other words, the goal is to increase agricultural production while simultaneously preserving and improving the environment. Therefore, before moving on to the principles that underpin the sustainable use of land resources, it is necessary to define this term, which, in our view, is already quite widespread.

A more appropriate definition can be formulated as follows: sustainable use of land resources is the implementation of a set of measures within the “human – land – land use” system aimed at maintaining used ecosystems in a state of balanced stability among their components while maximizing the harvest of biological products [12]. This definition allows us to conceptually outline the paths toward a transition to sustainable land use in Ukraine. The essence of this transition must lie in the realization by all parties involved in land relations including the state, landowners, and land users that the decline in agricultural production was primarily caused by the ecological limits of land resources. Consequently, every person who works the land faces the psychological challenge of changing their economic strategy with the aim of restoring and preserving the ecological sustainability of each specific plot of land with its unique characteristics.

When developing approaches to the transition to sustainable land use, it is important to maintain an optimal balance between areas affected by human activities and those that have not been affected. Undisturbed areas should be viewed as a stabilizing factor that counteracts anthropogenic impacts on the landscape. M. Song et al. propose banning any use of undisturbed areas, with the exception of traditional land management practices by indigenous peoples living in these areas to enhance this stabilizing effect [13].

To establish a mechanism for the sustainable use of land resources, it is crucial to expand the category of land designated for nature conservation by creating new nature reserves, wildlife sanctuaries, and national parks. In this regard, the concept of an ecological framework defined as “the establishment of a specific system of lands with special status” is relevant to the issue at hand [14]. According to this concept, such lands must be subject to regulated and low-impact uses, and a separate usage regime must be defined for each plot based on its role in maintaining ecological stability both in the surrounding area and throughout the entire region or oblast.

Ensuring the ecological sustainability of land ownership and land use can be achieved through two main approaches (Table 1).

Table 1 - Approaches to ensure environmental sustainability

Type of approach	Purpose	Examples of measures
Territorial	Preserving natural ecosystems in designated areas to maintain ecological balance	Establishment of protected areas; a network of forest plots; conservation areas
Component-based	Regulating the size of individual land parcels to restore and maintain landscape balance	Expansion of forest buffer zones; restoration of pastures; optimization of agricultural land use

Source: compiled by the authors based on [15]

Tactical approaches to addressing the challenges of making land use more environmentally sustainable also exist in global practice. One need only cite examples of strict regulation of land relations in the agricultural sectors of the United States, the Netherlands, the United Kingdom, and Western Europe. In these countries, legally enshrined economic mechanisms for the environmental sustainability of land use have been in place for a long time [16]:

- 1) a mechanism of “mutual agreements” and mutual concessions on the part of farmers and the state;
- 2) providing economic incentives for land users to voluntarily adopt certain land-use practices that serve the public interest;
- 3) planning the use of land resources with the designation of “economically sensitive areas”;
- 4) the development and implementation of comprehensive programs that fully take into account the agricultural and environmental aspects of land use;
- 5) restrictions on the timing of agricultural work and the use of certain agricultural techniques, which are set forth in relevant documents and agreed upon with the landowner at the time the landowner acquires ownership rights.

Thus, an important prerequisite for ensuring truly environmentally friendly production must be the formation of a new society that clearly understands economic goals while taking environmental constraints into account. Two types of initial measures aimed at bringing about these changes should be highlighted:

- 1) bans on actions that are driven by economic necessity but are incompatible with environmental goals;
- 2) reducing the impact on the environment either directly or indirectly by lowering the per-unit consumption of products (in order of importance, these measures include those involving the structural reorganization of the economy, the modernization of enterprises, and the integration of new components into core technologies that enable the recycling or capture of waste).

The implementation of these measures is impossible without the introduction of economic mechanisms that support environmental development (environmental insurance, licensing, certification, taxation) and operate on the basis of automated environmental information systems [17].

A strategy for transforming the current sustainable use of land resources must take into account:

- 1) the limited nature of land resources;
- 2) the ongoing trend toward the degradation of agricultural land and the assessment of these processes as a future threat to the country’s food security;
- 3) regulation of land resource use through regulatory acts and recommendations based on the level of degradation;
- 4) the need to develop regulatory documents for executive bodies at various levels.

The main objectives of sustainable development as a factor in enhancing the economic efficiency of land resource use are those presented in Table 2.

Table 2 - Sustainable development goals for improving the economic efficiency of land use

Objectives	Brief description	Expected effect
Reorienting the activities of agricultural entities toward environmentally sound forms of farming	Transition to practices with minimal negative impact on the environment	Reduction in soil degradation; long-term preservation of soil fertility
Establishing an environmentally balanced production structure for agricultural enterprises	Developing a production structure that takes environmental constraints into account	Optimization of resource use; increased system resilience
A scientifically sound balance between the variety and volume of crops	Rotating crops over time and space to replenish nutrients	Replenishment of lost nutrients; reduced need for fertilizers
Adapting production volumes to available resources	Aligning production plans with environmental, technical, and financial resources	Prevention of ecosystem overload; economic stability
Implementing economic incentives and financial support for environmentally sound practices	Establishing financial incentives, subsidies, and support mechanisms for environmental practices	Encouraging the transition to a sustainable agricultural production model; increasing investment in environmental protection

Source: compiled by the authors based on [18]

Issues related to the preservation of natural resource and environmental potential are also linked to improving land use efficiency, which is reflected in increased returns (revenue for the state and local communities) from the use of land attractive to investors, as well as the preservation of the potential of valuable natural areas that constitute cultural and natural heritage.

Currently, there are quite a few environmentally degraded areas in Ukraine. In this regard, a differentiated approach to the use of land resources as the most limited and vulnerable and the implementation of state land policy and regional programs in the field of land use are of paramount importance for bringing Ukraine's economy and individual regions out of the crisis and transitioning them to a model of sustainable development that ensures a balanced solution to the socio-economic challenges of conserving land resources for present and future generations [19]. Having assessed the key role of land resources in the existence of the biosphere, it is necessary to integrate their use into an ecological framework that will prevent the destruction of the natural mechanism for regulating the environment.

It should be emphasized that the main causes of the crisis are the disregard for scientific recommendations on the effective use of land, a sharp reduction in the application of organic fertilizers, irrational irrigation, insufficient measures aimed at eliminating the causes of land degradation, and inconsistency in adhering to environmental principles of land use. In many agricultural enterprises, the organization and management of land resources are not geared toward sustainable land use. The transition to sustainable development for any agricultural enterprise requires the establishment of a land-use mechanism at the national and regional levels, with a socio-ecological-economic orientation in public administration.

In the transition to sustainable land use, it is necessary to take into account the principle of mandating the use, in economic activities, of developed but, to one degree or another, degraded areas that have sufficiently developed infrastructure, housing stock, and labor resources. Adherence to this principle will ensure that modern technologies are applied with an environmental focus.

The issue of achieving an optimal balance between the condition of land resources and the manner in which they are used is particularly relevant to agricultural land. The surplus of land used in the agricultural sector, along with its irrational and inefficient use, which entails enormous energy costs are obvious factors hindering the agricultural sector's transition to sustainable development.

One of the key principles underlying the mechanism of sustainable land use is to obtain the maximum possible yield of agricultural products per unit of farmland while maintaining its productivity. Adherence to this principle is possible with the foundation of the "Green Revolution": new breeds of livestock, species, and varieties of high-yielding crops that are optimally adapted to specific agro-climatic conditions, as well as scientifically sound farming and agricultural management systems.

It is particularly important to note that most of the existing problems in the functioning of the "human-land-land use" system stem from the inadequacy of the ecological-economic mechanism in land use and the land monitoring system as an informational and regulatory factor, the disregard for ecosystem-based approaches in the use of land resources, the lack of a methodology for making the land cadastre more environmentally friendly, as well as an insufficient level of knowledge in this field, ranging from administrative bodies to specific economic entities [20].

Among the challenges to be addressed in the process of transitioning the agricultural sector to sustainable land use are the following: the need to restore soil fertility and rehabilitate degraded ecosystems; the introduction of incentives for land users who operate in a sustainable manner; increasing the economic significance of land resources in addressing social and economic problems in the agro-industrial complex of specific regions; taking into account historically traditional forms of land use; imposing environmental restrictions on land users; and training highly qualified personnel [3].

Improving the quality of land resources depends on the development of a comprehensive theory of their use as a component of systematic natural resource management. The development of this theory requires an interdisciplinary, comprehensive, and targeted approach. This implies the need for a comprehensive integration of biosphere theory and rent theory, as well as the interconnection of the laws of ecological development with a range of economic laws.

Consequently, ensuring the ecological sustainability of land resource use is based on a set of principles that define organizational, technological, and environmental protection measures for preserving fertility and ecological balance (Table 3).

Table 3 - Principles for ensuring environmental sustainability in land use

Principle	Brief description
The mandatory nature of environmental sustainability in natural resource use	Integration of environmental requirements into all forms of economic activity
A system of relatively homogeneous territories	Formation of land parcels taking into account natural, economic, environmental, and social conditions
Compliance with environmental, socioeconomic, and technological conditions	Ensuring comprehensive requirements in the planning and formation of land use and land tenure
Criteria for the rationality of land-use planning	Focus on high economic, environmental, and recreational efficiency and the preservation of public health
Environmental justification and standardization	Supporting sustainable land use through environmental justifications and standards

Source: compiled by the authors

Thus, the main measures implemented during the transition to environmentally sustainable development as a factor in improving the economic efficiency of land use can be presented in the form of a diagram (Figure 1).

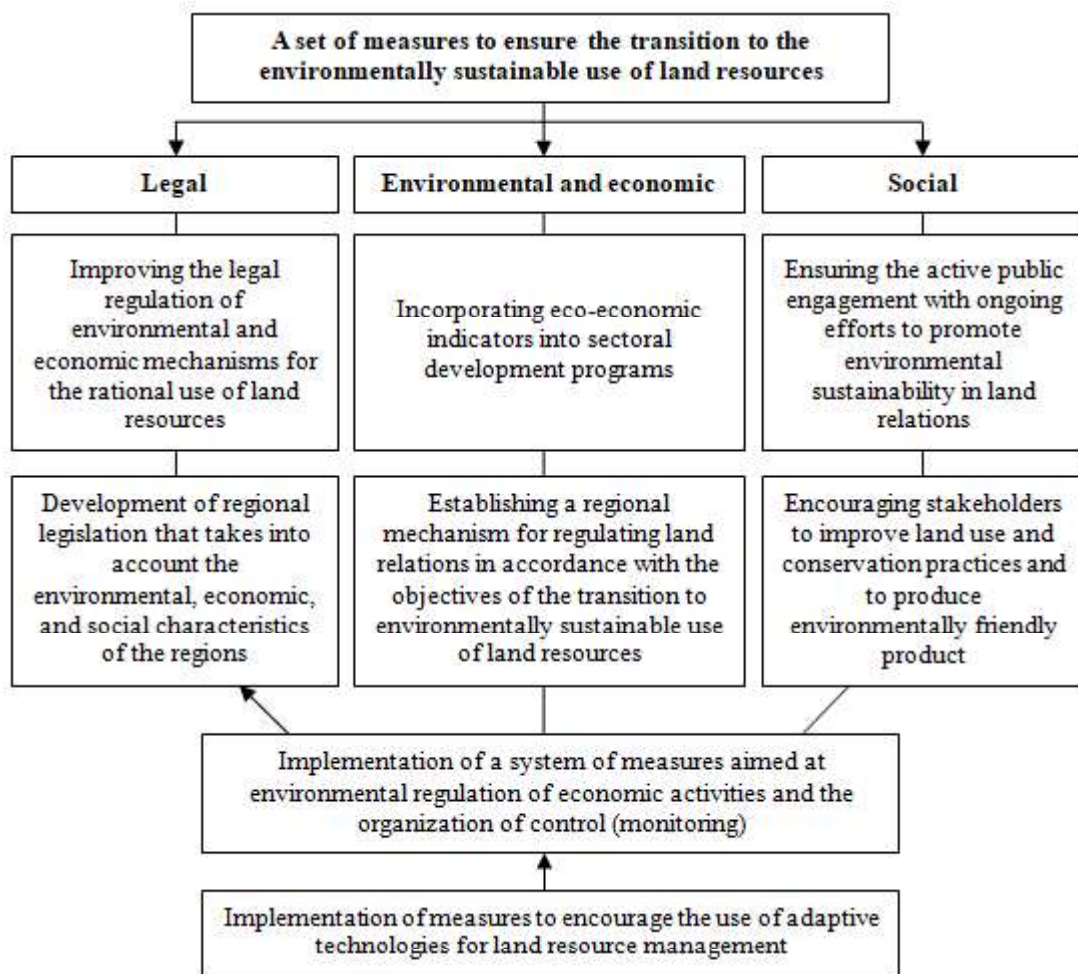


Fig. 1 - A system of adaptive measures for the transition to environmentally sustainable land use

Source: compiled by the authors

Thus, the mechanism for regulating and ensuring the sustainable use of land resources, taking into account their environmental component, constitutes a comprehensive set of methods and tools through which the processes of land use and conservation are organized, regulate, and coordinate the processes of land use and protection, and ensure the restoration of soil fertility as a natural resource constituting part of society's wealth and a specific environmental benefit. Currently, the use of land resources must be carried out on an ecological basis, that is, by ensuring ecological balance in adjacent territories through the interaction between humans and nature, and by reconciling ecological and economic interests.

Conclusions. The results of the study showed that current land-use practices in the agricultural sector are in a state of profound environmental and institutional crisis. It was found that the imperfections of the economic mechanism, the weakness of institutional instruments, and the lack of effective integration of environmental standards into production and economic activities lead to the intensification of degradation processes, loss of soil fertility, and a decline in the resilience of agricultural landscapes. A systemic and institutional-economic analysis has made it possible to identify key contradictions between economic interests and environmental requirements, as well as to demonstrate that the existing model of land resource management does not meet the objectives of sustainable development.

The study confirmed the relevance of the issue of rational land use and the need to develop new conceptual approaches that would ensure a balance between economic efficiency and environmental sustainability. The practical significance of the findings lies in their potential application to improve government policy on land use, develop programs for the greening of agricultural production, and establish institutional mechanisms capable of ensuring the restoration and conservation of land resources.

Prospects for further research include developing a methodology for integrating environmental indicators into the economic planning system of agricultural enterprises, creating models to assess the long-term effects of adaptive measures, as well as in exploring opportunities to combine traditional land-use practices with innovative technologies that promote biodiversity conservation and increase the productivity of agricultural systems without harming the environment. Of particular importance is research into institutional mechanisms capable of ensuring effective monitoring of compliance with environmental standards and incentivizing the adoption of sustainable land-use practices.

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ЕКОЛОГІЧНА СТІЙКІСТЬ ЯК ДЕТЕРМІНАНТА ЕКОНОМІЧНОЇ ЕФЕКТИВНОСТІ РАЦІОНАЛЬНОГО ЗЕМЛЕКОРИСТУВАННЯ

Проблема. Сільськогосподарське використання земельних ресурсів у сучасних умовах виявляється багатовимірною проблемою, що поєднує економічні та екологічні суперечності. Недосконалість господарського механізму та екстенсивні практики призводять до деградації ґрунтів і знижують потенціал аграрних систем до сталого розвитку.

Мета. Метою дослідження є дослідження та теоретичне осмислення організації системи землекористування в аграрному секторі крізь призму еколого-економічного підходу, а також розроблення концептуальних засад переходу до екологічно стійкого господарювання.

Результати. Дослідження спирається на системний аналіз, інституційно-економічний підхід, порівняльний аналіз практик регулювання землекористування, класифікацію підходів та експертні оцінки; методологія поєднує теоретичну інтерпретацію з аналізом управлінських інструментів. Доведено, що сучасне використання земель є багатовимірною задачею, причини екологічних протиріч зумовлені структурними недоліками економічного господарського механізму, нераціональними технологіями та відсутністю ефективних інституційних стимулів. Визначено дві взаємодоповнювані моделі забезпечення екологічної стійкості - територіальну та по компонентну, конкретизовано їхні функціональні завдання. Обґрунтовано необхідність інтеграції екологічних норм у систему управління земельними ресурсами, що передбачає формування територіальних та функціональних моделей забезпечення стійкості.

Наукова новизна. Запропоновано концепцію адаптивних заходів, яка поєднує екологічне нормування, інституційні інструменти та інформаційно-моніторингові системи. Показано, що реалізація такої моделі створює умови для збереження продуктивності ґрунтів і підвищення ефективності аграрного виробництва в довгостроковій перспективі.

Висновки. Результати проведеного дослідження засвідчили, що сучасна практика землекористування в аграрному секторі перебуває у стані глибокої екологічної та інституційної кризи. Виявлено, що недосконалість господарського механізму, слабкість інституційних інструментів та відсутність дієвої інтеграції екологічних норм у виробничо-господарську діяльність призводять до посилення деградаційних процесів, втрати родючості ґрунтів і зниження стійкості агроландшафтів. Системний та інституційно-економічний аналіз дозволив окреслити ключові суперечності між економічними інтересами та екологічними вимогами, а також показати, що існуюча модель управління земельними ресурсами не відповідає завданням сталого розвитку.

Дослідження підтвердило актуальність проблеми раціонального землекористування та необхідність розроблення нових концептуальних підходів, які б забезпечували баланс між економічною результативністю та екологічною стійкістю. Перспективи подальших досліджень полягають у розробленні методології інтеграції екологічних показників у систему економічного планування аграрних підприємств, створенні моделей оцінки довгострокових ефектів адаптивних заходів, а також у вивченні можливостей поєднання традиційних практик землекористування з інноваційними технологіями, що сприяють збереженню біорізноманіття та підвищенню продуктивності агросистем без шкоди для довкілля. Особливо важливим є дослідження інституційних механізмів, здатних забезпечити ефективний контроль за дотриманням екологічних норм та стимулювати впровадження сталих практик у землекористуванні.

Ключові слова: земельна політика, земельні ресурси, сталий розвиток, раціональне землекористування, екологічна безпека, стратегічне планування, інститути управління.

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