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ECONOMIC DIMENSIONS OF ENVIRONMENTAL SUSTAINABILITY: INDICATORS, ASSESSMENT MODELS AND METHODOLOGICAL APPROACHES

The article examines the economic dimensions of ecological sustainability within Ukraine's national economic system, with particular focus on the period of simultaneous wartime reconstruction and European Union accession. It is established that environmental compliance under these conditions functions not merely as a regulatory obligation but as a structural driver of economic resilience and long-term competitiveness in the European market. The article analyzes Ukraine's quantified greenhouse gas reduction commitments under the 2024 Law on State Climate Policy and the second Nationally Determined Contribution, demonstrating that measurable progress in emissions reduction has been achieved even under active conflict conditions. The alignment of Ukraine's National Energy and Climate Plan with EU Acquis Chapter 27 requirements is examined as the institutional backbone connecting sustainability indicators to concrete investment and policy benchmarks. Market-based instruments – including the Emissions Trading System under preparation, carbon pricing mechanisms, and the Ukraine Facility financing architecture – are assessed as the primary economic levers for green transition financing. The article further evaluates the UN SDG monitoring framework as a tool for benchmarking economic-environmental integration across governance levels. Key implementation gaps are identified, including the delayed ETS rollout, biodiversity losses across war-affected nature reserves, and Carbon Border Adjustment Mechanism risks threatening electricity export revenues. Recommendations are advanced for developing conflict-resilient monitoring systems, streamlined environmental impact assessment procedures for reconstruction projects, and flexible policy timelines calibrated to post-conflict institutional realities.

Keywords: *ecological sustainability, economic dimensions, national economic system, sustainability indicators, emissions trading, Ukraine reconstruction, EU accession.*

Lit. 17.

DOI: 10.32752/1993-6788-2026-1-296-173-181

Peer-reviewed, approved and placed: *11.02.2026.*

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ЕКОНОМІЧНІ ВИМІРИ ЕКОЛОГІЧНОЇ СТІЙКОСТІ: ІНДИКАТОРИ, МОДЕЛІ ОЦІНКИ ТА МЕТОДИЧНІ ПІДХОДИ

У статті розглядаються економічні аспекти екологічної стійкості в рамках національної економічної системи України, при цьому особлива увага приділяється періоду одночасного відновлення в умовах війни та вступу до Європейського Союзу. Встановлено, що дотримання екологічних вимог за таких умов є не лише регуляторним зобов'язанням, а й структурним чинником економічної стійкості та довгострокової конкурентоспроможності на європейському ринку. У статті аналізуються кількісні зобов'язання України щодо скорочення викидів парникових газів відповідно до Закону «Про державну кліматичну політику» 2024 року та другого Національно визначеного внеску, що демонструє досягнення вимірюваного прогресу у скороченні викидів навіть в умовах активного конфлікту. Узгодження Національного енергетично-кліматичного плану України з вимогами розділу 27 acquis ЄС розглядається як інституційна основа, що

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пов'язує показники сталого розвитку з конкретними інвестиційними та політичними орієнтирами. Ринкові інструменти – зокрема система торгівлі викидами, що готується, механізми ціноутворення на вуглець та архітектура фінансування «Українського фонду» – оцінюються як основні економічні важелі для фінансування зеленого переходу. Далі у статті оцінюється система моніторингу ЦСР ООН як інструмент порівняльного аналізу інтеграції економіки та довкілля на різних рівнях управління. Визначено основні прогалини у впровадженні, зокрема затримку з впровадженням СТВ, втрати біорізноманіття у природних заповідниках, що постраждали від війни, та ризики, пов'язані з механізмом коригування вуглецевих кордонів, які загрожують доходам від експорту електроенергії. Надано рекомендації щодо розробки систем моніторингу, стійких до конфліктів, спрощення процедур оцінки впливу на довкілля для проектів відновлення та гнучких графіків реалізації політики, адаптованих до інституційних реалій післяконфліктного періоду.

Ключові слова: *екологічна стійкість, економічні аспекти, національна економічна система, показники стійкості, торгівля викидами, відновлення України, вступ до ЄС.*

Statement of the problem. The economic dimensions of ecological sustainability have emerged as a defining challenge for national economies navigating structural transformation under conditions of geopolitical instability. For Ukraine, this challenge is compounded by the unprecedented simultaneity of active armed conflict, post-war reconstruction imperatives, and accelerating EU accession requirements – a combination that renders standard sustainability transition pathways analytically insufficient. The destruction of energy infrastructure, the contamination of agricultural land, and the conversion of protected natural areas into conflict zones have fundamentally altered the parameters within which environmental policy must operate, creating conditions where conventional assessment frameworks and incremental reform models fail to capture the full economic cost of ecological degradation.

Against this backdrop, the question of how to measure, model, and operationalize ecological sustainability within a conflict-affected national economy acquires urgent practical significance. Existing indicator systems and assessment models were largely developed for stable institutional environments, and their application to Ukraine's current reality requires critical adaptation rather than mechanical transposition. The alignment of domestic environmental performance metrics with EU Acquis requirements, SDG monitoring frameworks, and international carbon market standards introduces additional methodological complexity that existing analytical tools are not fully equipped to address.

Analysis of recent studies and publications. The economic dimensions of ecological sustainability have attracted increasing scholarly attention, reflecting the growing recognition that environmental performance and economic competitiveness are structurally interdependent. Contemporary scholarship increasingly treats ecological sustainability not as a constraint on economic growth but as a precondition for it, situating environmental governance within broader frameworks of national economic resilience.

D. Khakhaliev and O. Haharinov examine enterprise-level economic resilience as the foundation of sustainable development under global change, proposing assessment models based on quantitative and qualitative indicators and emphasizing flexible adaptive management under uncertainty [1]. L. Klevchik, O. Harnyk, and S.

Pavliuk analyze the assessment of economic stability of national economies within global entrepreneurial structures, identifying key factors influencing stability at both domestic and international levels [2]. L. Shovkun-Zabloska and S. Zolotarova argue that outdated growth models disregarding environmental impact are losing relevance and that new managerial approaches must integrate economic and ecological factors into coherent development strategies [3]. N. Bukalo investigates the economic nature and accounting treatment of ecological costs, analyzing capital investments in environmental protection and the evolving regulatory framework for environmental expenditure reporting [4]. S. Matveiev examines economic stimulation within the financial support system for greening production, substantiating the need for a motivational mechanism for economic actors in environmental protection [5]. L. Liubokhinets and S. Moroz assess key aspects of environmental responsibility in the context of Ukraine's sustainable development, analyzing intensity indicators in dynamics and recommending integration of sustainable development principles with harmonization toward the European Green Deal [6]. V. Nitsenko et al., in turn, investigated the conceptual foundations of the formation of sustainable development of agriculture, renewable energy sources and the space industry [7-10].

Despite the breadth of existing contributions, the reviewed literature has not sufficiently addressed the methodological challenges specific to conflict-affected economies, where standard indicator systems and assessment models require fundamental adaptation to remain analytically operational – a gap that the present study directly seeks to address.

Identification of previously unresolved aspects of the problem. Despite the growing body of literature on ecological sustainability indicators and assessment models, existing research has been predominantly oriented toward stable economic environments and has not adequately addressed the methodological challenges arising from conflict-induced infrastructure collapse, forced population displacement, and the simultaneous destruction of industrial capacity and natural ecosystems. The specific configuration of Ukraine's sustainability challenge – where carbon market development, biodiversity loss, energy transition, and post-war reconstruction must be pursued concurrently under martial law conditions– remains insufficiently theorized in both domestic and international scholarship, necessitating the development of adapted indicator frameworks and assessment methodologies capable of generating actionable policy guidance in non-standard economic environments.

Formulation of the objectives of the article (statement of the research task). The purpose of this study is to systematize and critically assess the economic dimensions of ecological sustainability through the analysis of indicator frameworks, assessment models, and methodological approaches applicable to national economic systems operating under conditions of armed conflict, post-war reconstruction, and accelerated European integration, with particular reference to Ukraine's experience during the 2024–2026 period.

Presentation of the main research material. Environmental sustainability in Ukraine represents a critical intersection of ecological protection and economic development, particularly within the context of post-conflict recovery and European Union integration. The economic dimensions of environmental sustainability encompass the strategic alignment of green transition initiatives with broader eco-

nomic recovery objectives, creating synergies that support both environmental goals and financial stability. This integration becomes especially significant as Ukraine navigates the dual challenges of wartime reconstruction and EU accession requirements, where environmental compliance serves as both a regulatory necessity and an economic opportunity. The framework establishes environmental sustainability as a driver of economic resilience, innovation, and long-term competitiveness in the European market [11].

Understanding the full scope of these economic dimensions requires a systematic methodological framework capable of capturing the complexity of Ukraine's sustainability transition under conflict conditions. This report examines the comprehensive framework of environmental sustainability indicators within Ukraine's economic context for the period 2024-2026, utilizing multiple methodological approaches to assess progress and challenges. The scope encompasses key performance metrics including greenhouse gas emission reduction targets, air quality monitoring systems, waste management protocols, and biodiversity conservation measures, all evaluated through their economic implications and EU compliance requirements. Assessment models integrate UNDP-supported Environmental Impact Assessment registries, Strategic Environmental Assessment processes, and economic modeling through TIMES-Ukraine energy system simulations that demonstrate potential GDP growth alongside environmental improvements, providing a holistic view of sustainability's economic dimensions [12].

At the core of this methodological framework lies a set of quantified sustainability indicators that translate environmental commitments into measurable economic and policy benchmarks. Ukraine's environmental sustainability framework for 2024-2026 centers on ambitious greenhouse gas emission reduction targets established through the 2024 Law on State Climate Policy, which mandates climate neutrality by 2050 and an intermediate reduction of at least 65% by 2030 compared to 1990 levels. The country's second Nationally Determined Contribution (NDC2), approved in November 2025, extends this commitment with a net GHG emissions reduction target of more than 65% by 2035 versus 1990 baseline levels of 916.5 MtCO eq, limiting future emissions to under 321 MtCO eq. This ambitious framework builds upon documented progress, including a 5.6% GHG emissions drop from 2016–2020 including LULUCF sectors, demonstrating Ukraine's capacity for emissions reductions even amid conflict conditions [13].

These quantified reduction commitments do not exist in isolation but connect directly to Ukraine's broader institutional architecture for EU accession and energy transition planning. The environmental indicators align comprehensively with EU Acquis Chapter 27 requirements through Ukraine's National Energy and Climate Plan (NECP) 2030, which emphasizes decarbonization, renewable energy expansion to 27% of final consumption by 2030, and coal phase-out by 2035. The Covenant of Mayors initiative further supports local-level implementation, with 363 Ukrainian signatories covering 51% of the population committing to 33% GHG reduction targets by 2030. Industrial pollution control measures and biodiversity indicators integrate into this framework through enhanced monitoring systems, waste management protocols, and ecosystem restoration strategies that support both environmental protection and economic recovery objectives under the broader Ukraine Plan implementation [14].

Translating these institutional commitments into economic outcomes requires market-based instruments that create direct financial incentives for compliance and innovation. Ukraine employs sophisticated market-based mechanisms to evaluate environmental sustainability, with carbon pricing and emissions trading system preparation serving as cornerstone economic instruments. The country's Emissions Trading System, established through the October 2024 Law on State Climate Policy, is preparing for a pilot phase in 2026 with mandatory monitoring, reporting, and verification (MRV) requirements reintroduced in January 2025. Carbon pricing mechanisms include quarterly-calculated minimum prices for carbon credits to prevent fraud and stabilize markets, complemented by existing carbon taxes projected to generate Ъ102 billion over 88 years for decarbonization efforts. These market mechanisms create direct economic incentives for emissions reductions while generating revenue streams for green transition financing.

The revenue potential of these market mechanisms is further amplified by the substantial external financing architecture that has been constructed around Ukraine's reconstruction agenda. The Ukraine Facility's Ъ50 billion program strategically funds reconstruction toward a low-carbon, zero-pollution economy through three integrated pillars, with Ъ36.8 billion already mobilized by February 2026. Sectoral priorities emphasize energy infrastructure with the largest Ukraine Investment Framework share targeting 1.5 GW renewable capacity and Ъ2 billion mobilization, metallurgy and strategic industries through dual-use technologies, and heat supply via municipal energy enterprises and infrastructure restoration. Economic incentives for green agriculture favor small and medium enterprises through carbon credit programs, where farmers adopting sustainable practices like reduced tillage and cover cropping can generate income from soil carbon sequestration, though high certification costs under standards like Verra and Gold Standard currently limit SME participation [15].

Monitoring the effectiveness of these financing mechanisms demands robust benchmarking systems capable of operating across multiple governance levels and under the disruptions of active conflict. Progress benchmarking utilizes UN Sustainable Development Goals dashboards tracking 17 SDGs through 86 nationalized targets and 183 indicators, with 110 indicators measured using UNESCAP methodology via Current Status and Anticipated Progress Indices. The World Bank contributes significantly to infrastructure restoration in war-affected areas, focusing on critical systems aligned with SDG 9 for Industry, Innovation, and Infrastructure, while UN agencies support environmental monitoring capabilities despite conflict-related disruptions. This comprehensive framework integrates economic assessment with environmental outcomes, enabling systematic evaluation of green transition progress while maintaining alignment with international standards and reconstruction priorities through coordinated multilateral support mechanisms [16].

Yet the very conflict conditions that have accelerated certain dimensions of Ukraine's green transition simultaneously undermine the institutional and ecological foundations upon which long-term environmental sustainability depends. Ukraine's environmental sustainability framework faces significant implementation challenges, particularly in biodiversity conservation and emissions trading system development. The ongoing war has severely impacted biodiversity progress, with over 12,000 square kilometers of nature

reserves transformed into war zones and landscape fires burning 1.39 million hectares in 2025 alone, far exceeding pre-war levels. The Emissions Trading System rollout has experienced substantial delays, with the preparatory stage now spanning 2025–2027 for legislative development, pushing the pilot stage to 2028 and full operations only after martial law ends. These delays are compounded by EU integration challenges, including the Carbon Border Adjustment Mechanism threatening to reduce Ukraine's electricity exports by over 60% without market coupling until at least 2028 [17].

Addressing these structural gaps demands a recalibration of policy instruments to reflect the specific operational realities of an economy simultaneously rebuilding and integrating into EU regulatory frameworks. To strengthen economic-environmental integration and improve assessment methodologies, Ukraine should prioritize developing integrated monitoring systems that can function effectively under conflict conditions while maintaining EU compliance standards. Recommendations include establishing streamlined environmental impact assessment procedures for reconstruction projects that balance speed with environmental protection, creating dedicated funding mechanisms within the Ukraine Facility for biodiversity restoration in war-affected areas, and developing flexible ETS implementation timelines that account for post-conflict economic realities. Additionally, Ukraine should enhance coordination between renewable energy expansion and protected area management through comprehensive spatial planning frameworks, while establishing robust data collection systems that can support both immediate reconstruction needs and long-term environmental sustainability goals aligned with EU accession requirements.

Conclusions. The analysis of the economic dimensions of ecological sustainability within Ukraine's national economic system demonstrates that environmental governance has undergone fundamental structural transformation driven by the intersection of armed conflict, reconstruction imperatives, and EU accession requirements. The formation of a coherent sustainability indicator system has proven essential not only for environmental monitoring but for anchoring investment decisions, mobilizing external financing, and demonstrating compliance with European regulatory standards.

Market-based instruments – including the Emissions Trading System under preparation, carbon pricing mechanisms, and the Ukraine Facility financing architecture – represent the primary economic levers through which environmental commitments are translated into financial incentives for green transition, yet their effectiveness remains contingent upon institutional continuity and data integrity severely compromised under conflict conditions.

The implementation gaps identified – delayed ETS operationalization, accelerating biodiversity losses, and Carbon Border Adjustment Mechanism risks to electricity export revenues – confirm that existing assessment models require critical recalibration for non-standard economic environments. The integration of economic, ecological, and social sustainability dimensions within a single coherent framework remains the necessary condition for durable resilience and Ukraine's competitive positioning in the European single market.

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