Eco-Industrial Parks of the Lviv Region as a Factor of the Inclusive Development of the Western Region of Ukraine

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Liubov G. Kvasnii (corresponding author)

Precarpathian Institute named of M. Hrushevsky of Interregional Academy of Personnel Management, 21 Ivasyuka St., 82200, Truskavets, Ukraine; Drohobych State Pedagogical University named after Ivan Franko, 24 Ivana Franka St. 82100, Drohobych, Ukraine; e-mail: lg_k@ukr.net; ORCID: 0000-0001-5248-544X (corresponding author)

Olena V. Moravska

Precarpathian Institute named of M. Hrushevsky of Interregional Academy of Personnel Management, 21 Ivasyuka St., 82200, Truskavets, Ukraine; e-mail: olena.v.moravska@gmail.com; ORCID: 0000-0002-0595-858X

Oksana Soltysik

Drohobych State Pedagogical University named after Ivan Franko, 24 Ivana Franka St. 82100, Drohobych, Ukraine; e-mail: soltysik73@gmail.com; ORCID: 0000-0003-3054-0158

Yurii O. Shulzhyk

Precarpathian Institute named of M. Hrushevsky of Interregional Academy of Personnel Management, 21 Ivasyuka St., 82200, Truskavets, Ukraine; e-mail: pimaup_doktorant@ukr.net; ORCID: 0000-0003-1699-054X

Oresta Ya. Shcherban

Lviv Polytechnic National University, 18 Gorbachevskii St., 79057, Lviv, Ukraine; e-mail: mppjavir@ukr.net; ORCID: 0000-0001-5422-4032

Stah O. Vovk

National Academy of Agrarian Sciences of Ukraine, Institute of Agriculture of Carpathian Region, 5 Mykhailo Hrushevskyi St., 81115, Obroshine, Ukraine: e-mail: vovkstah@gmail.com; ORCID: 0000-0002-1439-5483

Abstract

The article examines the key points of creating eco-industrial parks in the Lviv region and reforming existing industrial parks according to the principles of circular and green economy. The intensive increase in the number of industrial enterprises in the Lviv region is due to the active relocation of enterprises from the war zone of Ukraine. The purpose of the article is to justify the feasibility of creating eco-industrial parks in the Lviv region according to the principles of circular and green economy. The authors recommend the principles of selecting industrial enterprises in the territories of industrial parks, taking into account industrial symbiosis. As part of research cooperation, we conducted and researched the stages of the design, construction, and development of industrial parks in the Lviv region of Ukraine. Practical recommendations have been developed and proposed for the creation and implementation of the production of environmentally-friendly products with further processing and the secondary cycle of waste use in order to reduce the use of natural resources and environmental pollution, and increase the socioeconomic development of the western region of Ukraine.

Keywords

Lviv region, eco-industrial parks, environmental management, development, western region of Ukraine

Introduction

As a result of hostilities caused by the military aggression of the Russian Federation against Ukraine and full-scale war, in many areas, a number of production facilities were destroyed and the access of enterprises to resource and raw material and sales markets was complicated. Since the

beginning of the full-scale invasion, 225 enterprises have relocated to the Lviv region, out of which 164 are engaged in economic activity.

The Government of Ukraine approved the procedure for developing the State Strategy for Regional Development of Ukraine for 2021–2027 and the Action Plan for its implementation, which is especially important in the current conditions, when armed aggression and the temporary occupation of part of the territory has deepened the gap in the development of regions. There is ecocide, large-scale mining of territories, destroyed infrastructure, blocking of logistics routes, loss of human capital. This means that pre-war approaches to policies at the state and regional level are outdated. In such conditions, strategic planning using a territorially-oriented and security approach is key to the recovery and further development of Ukraine's regions and their territorial communities. The state regional development strategy covers 7 main areas: human capital, infrastructure, economy, institutions, environmental protection, security, and e-government.

The relevance of the topic regarding the creation and development of eco-industrial parks (EIPs) in the whole world lies in the need to find ways to solve environmental problems due to environmental pollution and excessive consumption of resources. An eco-industrial park is a more advanced version of an industrial park, which, in addition to economic benefits, improves environmental and social indicators, as well as contributes to the sustainable development of the region and territorial communities.

Eco-industrial parks are the result of growing awareness of environmental problems and the need for sustainable development. The general genesis of the creation of eco-industrial parks is due to the following reasons:

– the emergence of environmental problems;
– growing social and political awareness;
– search for innovative solutions.

The first eco-industrial parks appeared in the early 1990s and the most famous of them is the Calgary Eco-Industrial Park in Canada, founded in 1991. These parks allowed businesses to share resources and minimise waste and environmental impact.

The concept of eco-industrial parks began to gain popularity in other countries, such as Germany, Denmark, the USA, and others. This led to an increase in the number of EIPs and the expansion of their capabilities.

Nowadays, eco-industrial parks are becoming more and more popular and increasingly important in advancing the sustainability of industrial development as well as reducing its negative impact on the environment.

Therefore, the genesis of eco-industrial parks is the result of a combination of serious environmental problems, the search for innovative solutions, and an appropriate approach to sustainable development. These parks contribute to the reduction of waste, the use of secondary resources, and the reduction of pollution, which improves the quality of the environment and increases the sustainability of the industrial sector.

Taking into account the deterioration of the ecological situation in Ukraine and the whole world – within the framework of the state programme started in the pre-war period, and also destructive changes associated with the war – it is necessary to implement progressive rehabilitation mechanisms at the regional level. In particular, this involves stimulating the attraction of investments for reconstruction, the relocation of companies to the western regions, and the involvement of European companies in cooperation with the aim, after the end of the war, of the country's entry into the European Union as soon as possible. In this case, the construction and implementation of industrial parks in the western region, in particular in the Lviv region, is an important and correct decision.

Literature review

The issue of eco-industrial parks has been explored in the works of many Ukrainian and foreign scholars. Shvets, Rozdobudko, and Solomina (2013) note that a characteristic feature of the present is the low level of greening in the investment sphere in Ukraine and its regions. Galychyn and colleagues (2022) emphasise that the social and ecological consequences of urbanisation require comprehensive management of cities and their resource metabolism for long-term sustainability

and economic prosperity. Koval and co-authors (2021) underscore that the effectiveness of management depends on investments in the development of innovative and environmentally-friendly technologies. Latysheva and colleagues (2020) examine the position of enterprises in the competitive regional space in the context of sustainable development from the perspective of three dimensions of sustainability (social, economic, and environmental).

Gurochkina and Dukhno (2020), in their study on the transition process from a linear to a circular economy in Ukraine, note that circular economy is understood as a closed-loop system based on the recycling and utilisation of secondary raw materials. The key principles include minimising the consumption of primary raw materials, restoring resources, and preserving environmental cleanliness.

Chertow (2000), exploring the concept of industrial symbiosis (IS), closely linked to the concept of industrial ecology (IE), emphasises that the simplest IS model within the structure of IE involves the two-way integration of two enterprises: the waste from one enterprise becomes raw material for a neighbouring enterprise. Polovyan and Kazakova (2013) found out that depending on the symbiosis process, materials may require additional processing stages to be suitable for further use. However, in the best-case scenario, with optimal choices, waste can directly serve as raw material for another enterprise.

Researchers Shulzhik, Hrytsko, and Pekanets (2022) have demonstrated that in the conditions of modern digital transformation, changes are occurring not only in technologies, but also in the strategies of enterprises and organisations, reflecting a different way of thinking. Taking this into account, Maeen Md. Khairul and colleagues (2022) as well as Murillo Vetroni Barros and co-authors (2021) argue that the concept of circular economy in the IE model allows for not only environmental but also economic effects – forming new growth points and creating new jobs. In this context, Panchenko et al. (2013) investigated that the waste processing industry in the USA in 2010 provided 460,000 jobs with a total wage of 26 billion USD. The production and services of the industry exceeded 90 billion USD, comparable to the publishing business or coal mining. Specifically, in the USA, a 1% increase in the share of secondary waste use creates approximately 35,000 jobs, and in recent years, there has been an approximately 35% growth in this regard.

In their scientific research, Murillo Vetroni Barros et al. (2021) demonstrated that the principles of linear economy are based on the unlimited use of natural resources (production-waste), leading to both the depletion of natural resources and environmental pollution. The researchers substantiated the effectiveness of the existing eco-industrial parks worldwide, such as the Kalundborg Eco-Industrial Park (Denmark), the Marl Chemical Park (Germany), the Korea National Cleaner Production Centre (KNCPC), the Kawasaki Eco-Town (Japan), the Händelö Eco-Industrial Park, and others.

The Kalundborg Eco-Industrial Park (Denmark) is one of the first and main representatives of industrial symbiosis (Kalundborg symbiosis). The Marl Chemical Park (Germany) occupies an area of more than six square kilometres and provides about 10,000 jobs. The Korea National Centre for Clean Production (KNCPC) launched the National Eco-Industrial Park (EIP) in 2003 with the assistance of the Ministry of Trade, Industry and Economy (MOTIE). The result is the implementation of clean production and industry through industrial symbiosis. The Kawasaki Eco-Town (Japan) is located in the coastal zone and concentrates production and processing, metallurgical, chemical, petrochemical, cement, and other industries. An eco-city is a successful representative of the implementation of the system of industrial symbiosis, where industrial waste and by-products are used as raw materials. The Händelö Eco Industrial Park (located on a small island in eastern Sweden) is one of the best representatives of industrial symbiosis. In Norway, within the framework of the programme (the Norwegian Innovation Clusters programme), 38 clusters have been created that work according to the principle of the EIP. The main goal of the clusters is the development of the economy with the maximum saving of natural resources and the preservation of the environment.

Bakulina, Lehan, and Bakhov (2019) as well as Gurochkina and Dukhno (2018), taking into account the recommendations of the UNIDO and international experience in creating eco-industrial parks, note that the transition to a closed-loop economy based on the principles of “green economy” is an individual process for each country.

Gurochkina and Budzynska (2020) emphasise that moving away from the traditional “resource-consuming” development strategy requires a change in societal behaviour, the development of new

concepts of public governance, and entrepreneurial activities. Justifying this, Moravska, Levytskyy, and Schulzhyk (2020) consider that the implementation of industrial symbiosis in Ukraine is primarily associated with the realisation of the principles of circular and "green" economies. Circular economy can play a crucial role in sustainable business management (Murillo-Vélez et al., 2021). Boix et al. (2015) proposed optimisation works dedicated to the design of eco-industrial parks. Butturi and colleagues (2020) presented an optimisation methodology based on a multi-stakeholder perspective to evaluate energy symbiosis, including the integration of renewable energy sources within parks.

Based on the experience of developed Western countries (UNIDO), Gurochkina and Budzynska (2020) note that eco-industrial parks form the basis of circular economy, where waste from local enterprises is processed and recycled. In this connection, the issue of justifying the feasibility of creating eco-industrial parks in the Lviv region based on the implementation of the circular economy system and the principles of green policy as a factor in the inclusive development of the western region of Ukraine requires scientific research.

The aim of the study and research design

The article develops scientifically-grounded recommendations on the advisability of a gradual transition of the economy of the Lviv region to the circular economy model, taking into account the specific characteristics of this particular region in Ukraine. One of the goals of this article is to justify that the creation of eco-industrial parks in the Lviv region is a factor in the inclusive development of the western region of Ukraine.

The research methodology is based on the principles of integrity, logical consistency, completeness, and scientific pluralism.

The mixed-method approach was adopted for the study. An analysis of regulatory and legislative materials was carried out, including published domestic and foreign scientific and methodological developments, legislative projects, legal acts, as well as standards in the field of the creation and development of eco-industrial parks in Ukraine and abroad. In the process of analysing scientific sources on the subject under study, the experience of the transition to the circular economy model in economically-developed and developing countries was considered.

When conducting the research, the methods generally accepted in economic science were used: monographic; dialectical – in the process of conceptualising the implementation and development of EIPs in Ukraine after the end of military operations; analysis and synthesis; grouping – to determine the stages of EIP implementation in the Lviv region; generalisation and analysis; economic-statistical, abstract-logical, and systemic-structural – for the formation of the principles and methods of creating eco-industrial parks in the field of industrial activity, taking into account industrial symbiosis. The method of complex analysis was used to justify the possibility and expediency of creating eco-industrial parks in the Lviv region.

Results and discussion

The main points of the programme of the creation and implementation of EIP in the Lviv region

As of 1st January, 2023, there were 60 industrial parks in the Register of Industrial Parks of Ukraine. The necessary engineering and transport infrastructure has been created in only seven parks, while in most of them it is either absent or the improvement of the territory has just begun. However, the most telling fact is that by and large, only one enterprise in the refrigeration engineering cluster is active. Therefore, the global state of this industry can be studied only by describing the projects, and not by seeing them implemented in life.

In Ukraine, the current legislation on industrial parks provides extremely insignificant advantages to their participants, which are clearly insufficient for this mechanism to become a catalyst for economic development. Without an appropriate package of incentives, industrial parks in Ukraine will not be able to attract investments, including foreign ones. Even more so during the war, because international investors will necessarily need war risk insurance.

Considering the development of EIPs in the Lviv region, it is first of all worth focusing attention on the existing industrial parks. It should be noted that in 2019, the EIP implementation programme in Ukraine began.

As part of the Global Eco-Industrial Parks Programme (GEIPP), the existing industrial parks that showed the highest potential for transition into eco-industrial parks were selected. Parks were selected on the basis of economic, ecological, and social indicators of the participating enterprises. According to the results of the conformity assessment, three parks were chosen for cooperation: "Bilotserkiv Cargo Aviation Complex", or "BVAK" (Bila Tserkva) received the highest rating and showed the highest potential for transformation into an EIP. "Agromash" (Zaporizhia) and "Patriot" (Sumy) are small industrial parks that have been selected and will receive development assistance (GEIPP-Ukraine, 2024).

As a result of the recommended optimisation of production processes, a reduction in electricity consumption by 15%, natural gas – by 20%, solid fuel – by 17%, and water – by 12% is foreseen. The annual reduction of carbon dioxide associated with this innovative implementation of individual links of the production process amounts to 365.27 t CO^2 eq/year, and financial savings amount to 67,418 EUR/year (GEIPP-Ukraine, 2024).

The armed conflict, with the start of hostilities on 24th February, 2022, has led to a regressive economic state, with falling production and rising inflation. From April 2022, the Government of Ukraine created the National Council for the Recovery of Ukraine from the Consequences of the War and began planning for the post-conflict development of the country with a focus on economic reconstruction. In this context, the issue of the development and implementation of EIP remains a priority. Since April 2022, as part of the National Programme for Business Support and Development of EIP, the Ministry of Economy has promoted and aided the relocation of EIPs and individual enterprises from areas of intense hostilities to safer regions of western Ukraine. By the method of identification and mapping, with the development of an interactive map of the composition and specialisation of enterprises located in the respective territories, the gradual transfer of enterprises and EIPs is carried out. This technique makes it possible to maximally develop industrial symbiosis and implement the most convenient placement of transferred enterprises for the development of eco-industrial parks (Ministry of Economy of Ukraine).

Within the framework of this project, programmes of the creation and introduction of EIPs (Table 1) are inculcated and realised, and new instruments are controlled for a power effective and unpolluted production (Ministry of Environmental Protection and Natural Resources of Ukraine).

Table 1. Purpose, areas of activity, and performance indicators in the programme of the creation and implementation of EIPs in the Lviv region

Title	Content of the target indicators of the EIP implementation programme:
Purpose	– the creation of a production complex, which is united by interdependent energy and material flows, organisational-management, and financial-economic ties; a complex of movable and immovable property objects; – the complex should include: industrial-technological, transport, communal infrastructure used in the system of production, research, and educational activities to ensure the creation and market introduction of innovative safe technologies and industrial products.
Areas of activity	– the production of products according to innovative technologies; processing, recycling, and recycling of waste; – resource conservation, replacing the use of non-renewable natural resources in economic activity with secondary resources; – energy saving and energy efficiency; – monitoring, control, pollution reduction, and environmental protection; – the restoration of the components of the natural environment from human-made pollution.

Table 1. – cont.

Title	Content of the target indicators of the EIP implementation programme:
Indicators of the effectiveness of the EIP work	– economic effect (indicators of profit, profitability, payback periods, internal profitability, etc.); – ecological effect (reduction of ecological damage to the components of the natural environment, which is calculated, respectively, in money and in the quantitative indicators of pollution reduction: discharges, emissions, placed waste in tons); – resource-saving effect (reduction in the use of natural resources, energy, return to economic circulation of secondary resources); – socio-infrastructural (the development of industrial, scientific and technical, social infrastructure as well as the modernisation and technical rearmament of existing factories, the creation of new jobs, and the investment attractiveness of the region).

Source: Compiled by the authors based on Panchenko (2013).

The armed conflict, which began on 24th February, 2022, has resulted in a regressive economic state, characterised by declining production and rising inflation. Recognising the urgent need for recovery, the Government of Ukraine established the National Council for the Recovery of Ukraine from the Consequences of the War in April 2022. The primary focus of this council is to plan for the post-conflict development of the country, with a particular emphasis on economic reconstruction. In this challenging context, the development and implementation of Eco-Industrial Parks (EIPs) have emerged as a key priority.

Starting from April 2022, the Ministry of Economy has actively promoted and facilitated the relocation of EIPs and individual enterprises from areas of intense hostilities to safer regions in western Ukraine. As part of the broader National Programme for Business Support and Development of EIPs, a strategic approach is employed. The Ministry of Economy utilises identification and mapping methods, including the development of an interactive map detailing the composition and specialisation of enterprises in various territories. This approach enables the gradual transfer of enterprises and EIPs, fostering industrial symbiosis and facilitating the optimal placement of relocated enterprises for the development of eco-industrial parks (Ministry of Economy of Ukraine).

Within the framework of this project, the Ministry of Environmental Protection and Natural Resources of Ukraine is actively involved in implementing programmes for the creation and introduction of EIPs, as outlined in Table 1. The table specifies the purpose, areas of activity, and performance indicators associated with the programme of creating and implementing Eco-Industrial Parks in the Lviv region.

Table 2. Purpose, areas of activity, and performance indicators in the programme of the creation and implementation of EIP in the Lviv region

Purpose	Areas of Activity	Performance Indicators
Economic Reconstruction	relocation of EIP and individual enterprises	efficient transfer of enterprises from conflict zones
Power Effective Production	the identification and mapping of enterprises	the development of an interactive map
Unpolluted Production	strategic placement of relocated enterprises	the oromotion of industrial symbiosis and eco-industrial park growth

Source: Compiled by the authors.

This integrated approach aims to not only address the immediate challenges posed by the armed conflict, but also contribute to the long-term sustainable development of the Lviv region.

The stages of the implementation of the industrial parks of the Lviv region of Ukraine

Table 3. The stages of the implementation of the industrial parks of the Lviv region of Ukraine

Industrial Park Name	Inclusion Date	Managing Company	Ownership	Land Area (ha)	Location	Functional Purpose	Jobs Planned	Financing	Current Status
Lviv Industrial Park „Ryasne-2”	February 7, 2014	CityPark Lviv LLC (part of RYASNE-2 LLC, majority owned by Dragon Capital Investments Limited)	Private	23.9413	Microdistrict “Ryasne-2”, Lviv	V and IV hazard class enterprises	12,000	$100 million USD	Under Construction
Yavorivskyi Industrial Park	April 26, 2017	Not specified	Not specified	40	Yavoriv	Instrument building, mechanical engineering, metalworking, logistics, trade, and services	Not specified	State budget and investors	Preparatory Planning
Novorozdilsky Industrial Park	June 15, 2017	Not specified	Not specified	46.4	Former state mining and chemical enterprise territory	Environmentally-friendly products based on circular economy principles	1,150	State budget (for initial works), Investors needed	Under Construction
Sigma Park Yarychiv Industrial Park	September 4, 2017	Not specified	Not specified	15.7084	Stary Yarychiv, Lviv region	Environmentally-friendly products, industrial symbiosis	2,000-2,500	Seeking investors	Under Construction
Zahid Resurs Industrial Park	September 19, 2018	Not specified	Not specified	20.7662	Horodok, Lviv region	Food products, non-alcoholic beverages, textiles, wood processing, machinery, logistics	1,625	State budget, management company, investors	Design and Preparatory Work
Business Prime Industrial Park	August 19, 2019	Asset Management Company - Interest Group LLC	Not specified	17.5	Ternopillya, Lviv region	Food products, textiles, wood processing, machinery, logistics	1,750	Seeking investors	Design and Preparatory Work
Sparrow Park Lviv Industrial Park	May 14, 2021	Not specified	Not specified	18.8242	Signivka, Lviv	Mechanical engineering, logistics, light and food industry, processing industry	1,000	Company’s own funds and investors	Preparatory Work
Mostysky Dry Port Industrial Park	August 2, 2021	Not specified	Not specified	34.5116	Mostyskyi District, Lviv Region	Polymer building materials, furniture production, machinery, wood processing, logistics	1,150	State and local budget, non-state funds	Design and Preparatory Work
Eco-industrial park “InPark”	Not specified	Not specified	Not specified	20	Boryslav	Mixed industries	Not specified	Not specified	Planning Stage
Eco-smart industrial park “HALIT”	November 11, 2022	Not specified	Not specified	Not specified	Drohobych	Light industry, machine building, emphasis on green energy	Not specified	Not specified	Design and Preparatory Work

Source: Compiled by the authors.

The strategic development planning of the Lviv region for the period 2021–2027 provides for the development of industrial infrastructure, support for entrepreneurship, and the creation of clusters and industrial parks. Thus, there are ten industrial parks in the Lviv region (GEIPP-Ukraine, Achievement report), which are at the stage of design, planning, construction, and implementation (Table 3).

This is a good opportunity for business not only to transfer production from troubled regions, but also to have its representative offices in the western region.

Recommendations for the implementation of EIPs in accordance with environmental international standards

In accordance with the international requirements of "Environmental protection" related to the ISPR component (Inclusive and sustainable industrial development) proposed by UNIDO: International framework regulations on eco-industrial parks and International Guidelines for Industrial Parks (GEIPP-Ukraine, 2017), Strategies for the Development of Industrial Parks to In 2030, we have proposed recommendations regarding the need to comply with environmental measures during the construction, planning, and implementation of eco-industrial parks. These recommendations are not merely indicative but imperative for fostering a harmonious coexistence between industrial progress and environmental conservation. In the light of the specified international guidelines, our proposed measures emphasise the incorporation of ecologically-sound practices during the construction phase, ensuring that the parks' infrastructure is developed with minimal ecological impact. This entails the use of environmentally-friendly construction materials, energy-efficient technologies, and waste reduction strategies. Moreover, in the planning stage, we advocate for a comprehensive environmental impact assessment to identify potential ecological risks and devise proactive mitigation strategies. Our recommendations further stress the importance of integrating green spaces, biodiversity conservation, and sustainable water management practices into the parks' layout, contributing to the creation of a balanced and ecologically-resilient industrial ecosystem. During implementation, our guidelines call for the establishment of robust monitoring and enforcement mechanisms to guarantee ongoing compliance with environmental standards. This includes regular audits, performance assessments, and the implementation of corrective measures as needed. Additionally, fostering awareness and collaboration among stakeholders is highlighted as essential for promoting a culture of environmental responsibility within the eco-industrial park community.

Note (Fehrer & Wieland, 2020) that the model of the circular economy, which is the basis of the EIP, is based on the "principle of three Rs" – reduce, reuse, and recycle. This are the main principles that must be taken into account when planning and building an EIP. In addition, when planning and building an EIP, it is necessary to use business models, taking into account the possibility of implementation in this territory.

The processing and involvement of waste in the secondary cycle of production

Note that the storage of natural resources, waste processing, and their reuse is one of the important elements of the circular economy. The key to the realisation of the "principle of three Rs" is undoubtedly innovative technologies.

The model of the closed cycle economy in relation to waste processing is defined as follows: the use of waste for the production of goods (products); performance of works; the provision of services, including reuse of waste for its intended purpose (recycling); the return of waste to the production cycle after appropriate preparation (regeneration); the extraction of useful components from waste for its reuse (recovery).

Taking into account the deterioration of the ecological situation in Ukraine due to the accumulation of various types of waste as well as the impossibility – due to certain economic and financial reasons – to implement individual waste processing lines, we suggest using the services of specialised companies.

The implementation of green economy

Scientists emphasise that there is a slowdown in the implementation of rational nature management in Ukraine, creating additional risk factors for the populating and worsening the quality of life in conditions of low implementation of Greentech (Koval et al., 2021). Taking into account the environmental situation in the world in general, and specifically on the territory of Ukraine, within the framework of global and state policy in the field of environmental protection (Downey et al., 2021; Dankevych et al., 2021; Belmonte-Ureña et al., 2021), environmental safety as well as land protection and management, we have proposed practical recommendations for the implementation of the green economy:

1) Policy Frameworks:
   – developing and enforcing comprehensive environmental policies that promote sustainable practices;
   – establishing clear regulations and standards for industries to reduce pollution, waste, and resource consumption;
   – providing incentives for businesses to adopt environmentally-friendly practices.
2) Investment in Renewable Energy:
   – allocating funds for research and development of renewable energy sources;
   – offering financial incentives and subsidies to businesses and individuals investing in renewable energy projects;
   – encouraging the adoption of clean energy technologies in both public and private sectors.
3) Green Infrastructure:
   – investing in eco-friendly infrastructure projects such as public transportation, cycling lanes, and green buildings;
   – developing and maintaining green spaces to enhance biodiversity and provide recreational areas for communities;
   – implementing sustainable water management practices, including water recycling and rainwater harvesting.
4) Circular Economy Practices:
   – promoting a circular economy by encouraging recycling, reusing, and reducing waste;
   – implementing extended producer responsibility (EPR) programmes, making manufacturers responsible for the entire life cycle of their products;
   – encouraging the use of sustainable materials and design products for easy disassembly and recycling.
5) Education and Awareness:
   – implementing educational programmes to raise awareness about environmental issues and the benefits of a green economy;
   – promoting sustainable practices at schools, universities, and within communities;
   – fostering a culture of environmental responsibility and stewardship.
6) Green Jobs and Training:
   – investing in training programmes to develop skills for green jobs in renewable energy, energy efficiency, and environmental conservation;
   – providing incentives for businesses to create green jobs and transition existing jobs towards sustainability;
   – supporting workforce development initiatives focused on environmental sustainability.
7) Public-Private Partnerships:
   – encouraging collaboration between governments, businesses, and non-profit organisations to address environmental challenges;
   – facilitating partnerships that promote sustainable practices and innovations;
   – establishing platforms for sharing best practices and knowledge transfer.
8) Carbon Pricing and Incentives:
   – implementing carbon pricing mechanisms such as carbon taxes or cap-and-trade systems to internalise the environmental costs of carbon emissions;
   – providing financial incentives for businesses that reduce their carbon footprint and adopt sustainable practices.

9) Green Finance:
   – developing financial mechanisms and investment funds that prioritise environmentally-sustainable projects;
   – encouraging banks and financial institutions to integrate environmental criteria into their lending and investment decisions.

The implementation of green economy requires a holistic approach, involving multiple stakeholders and addressing social, economic, and environmental aspects. It is essential to balance economic development with environmental preservation to ensure long-term sustainability.

The main tools and strategies for the implementation of EIP in the Lviv region

A special feature of eco-industrial parks is resource-efficient and clean production, which combines comparative practices in the areas of clean production, environmental efficiency, waste management, and pollution prevention. By resource-efficient and clean production we mean an approach to the effective use of natural resources (materials, water, and energy) and the reduction of waste and emissions into the atmosphere (Kristensen & Mosgaard, 2020; Habib et al., 2021). The Eco-Industrial Parks Toolkit contains nine different tools (Table 5).

Table 4. Tools for creating eco-industrial parks in the Lviv region

EIP tool	Purpose of the tool:
Assessment Tool	is to assess an industrial park against the International Eco-Industrial Park Framework (UNIDO, World Bank and GIZ, 2017)
Capability Monitoring Tool	is to monitor and report on resource savings and impacts from EIP capabilities identified and implemented in industrial parks supported by (international) national development projects.
Capability Monitoring Tool	is to monitor and report on resource savings and impacts from EIP capabilities identified and implemented in industrial parks supported by (international) national development projects.
Policy Support Tool	is to assist international development agencies (eg UNIDO) and their national partners in providing technical support to policy makers in the planning and development of EIP policies.
Selection tool	is to support the selection of industrial parks with high potential for EIP development and the creation of successful, visible and replicable EIP projects.
Industrial symbiosis identification tool	is to support the identification of industrial symbiosis opportunities (exchange of by-products and waste) between companies. This tool can be used in existing industrial parks (brownfields) to provide stakeholders with information on symbiosis opportunities associated with companies operating in the park.

Source: GEIPP, 2017; GEIPP-Ukraine, 2018; Kristensen & Mosgaard, 2020; Habib et al., 2021.

Resource-efficient and clean production covers three main areas of sustainable development:
– production efficiency: the optimisation of the productive use of natural resources (materials, energy and water);
– environmental management: the minimisation of the impact on the environment and nature by reducing waste and emissions;
– human development: the minimisation of risks for people and communities; supporting their development.

Being a project at the intersection of infrastructure and real estate, which involves a significant amount of construction, the industrial park will inevitably face risks in the field of construction, with significant financial risks associated with fluctuations in the exchange rate and interest rates on loans taken to finance the project, the impact of crisis situations on capital markets on the ability to raise funds for the project through the sale of securities and other instruments, the possibility of cash gaps, etc. (Fainmesser & Galeotti, 2020; Bondarenko et al., 2021).

Creating eco-industrial parks in the Lviv region, as in any other region, requires careful planning and management to minimise negative environmental impacts and ensure sustainable development. Here are several measures that can help reduce risks when establishing eco-industrial parks:
– environmental assessment before commencing work;
– strategic planning;

– the utilisation of modern technologies;
– monitoring and control system;
– collaboration with local communities;
– economic sustainability;
– waste management planning;
– developing an effective waste management system and exploring options for recycling or reusing waste;
– education and public engagement.

Figure 1. presents the results of the evaluation of incentives for the development of EIPs in Ukraine.

	2020 done	The start of the GEIPP project in Ukraine Analysis of stakeholders in the field of EIP Analysis of gaps in EIP policy
	2021 done	EIPs are included in the Government's National Economic Strategy until 2023 1st and 2nd Seminars on EIP policy for decision-makers The official Interagency Working Group on EIP Policy is established EIP policy implementation road map 1st and 2nd meeting of the Interdepartmental Working Group on EIP Policy
	2022 done	Analysis of stakeholders in the field of EIP (updated) International proposals for the EIP policy vision and roadmap Report on EIP support mechanisms in Ukraine EIP is included in the project of the 2030 PE Strategy Strategic environmental assessment of the IP 2030 Strategy with an EIP perspective EIP policy development scenarios (Analysis of Regulatory Impact) The draft Law on EIP has been developed (amendments to the Law on IP and others) 3rd meeting of the Interdepartmental Working Group on EIP Policy
	2022 done	National sociological study of market readiness for EIPs Training course (online) for decision-makers and business in the field of EIP Report on supply chains in the field of EIPs in Ukraine
	2023 plan	The adoption of the EIP Law has been developed Adoption of EIP by-laws (criteria, verification, monitoring) Bringing national policies into line with the International EIP framework Development of an access to finance tool (Access to Finance tool) for EIPs in Ukraine

Figure 1. The results of the evaluation of the development of EIPs of Ukraine in 2020–2023

In Figure 2, proposals are presented for new incentives for the EIP, which include support for infrastructure development through the State Fund for Regional Development, partial compensation of the loan rate and non-refundable financing for the arrangement of the engineering, as well as transport infrastructure of the parks through the expenditure of state and regional funds, state subsidisation for construction, reconstruction, repair engineering, and transport infrastructure.

The Government has developed the Procedure for providing funds on a non-refundable basis for the arrangement of industrial parks and/or ensuring the construction of adjacent infrastructure facilities necessary for the creation and operation of industrial parks. Upon application to the Ministry of Economy, the applicant will be granted no more than 60 million UAH from the state or local budget, provided that it does not exceed 80% of the project cost.

Park management efficiency	• national framework conditions: EIP terminology and criteria; • financing infrastructure development of EIPs within the framework of the State Fund for Regional Development; • expanding national tools for arranging EIP infrastructure; • partial compensation of the loan rate; • irrevocable help; • budgetary support for infrastructure development.
Environmental indicators	• national framework conditions: the deregulation of relations for production, supplies (distribution), use of resources (raw materials, energy, water); • platforms for sharing resources, reuse of materials and waste; • state technological cooperation programme; • market instruments for projects in the EIP: specialised loans, loan guarantee fund; • green bonds for EIP projects (pilot issues/budget support).
Social indicators	• national framework conditions: a mandatory social component in the EIP Concept; • financing the creation of social infrastructure within the framework of the State Fund for Regional Development; • supporting the creation of social infrastructure of EIPs at the expense of local budgets.
Economic indicators	• the state programme to support the transformation of private enterprises to the level of EIPs; • exemption from payment of VAT when importing equipment; • exemption from payment of customs payments when importing equipment.

Figure 2. Proposals for new incentives for EIPs

Conclusions

As a result of hostilities caused by the military aggression of the Russian Federation against Ukraine and full-scale war, in many areas a number of production facilities were destroyed and the access of enterprises to resource and raw material and sales markets was complicated. Since the beginning of the full-scale invasion, 225 enterprises have relocated to the Lviv region, out of which 164 are engaged in economic activity. Most of the others have already returned to their previous places of work or have opened branches in the region. According to the analysis, the largest number of enterprises were relocated to the Lviv, Stryi, and Drohobytsky districts. The authors emphasised the fact that owing to the social component, eco-industrial parks would be able not only to help companies moving from the war zone to the Lviv region to resume their activities quickly and efficiently, but also to provide their employees and their families with high-quality social infrastructure in western regions of Ukraine.

Considering the deterioration of the ecological situation in Ukraine and worldwide, within the framework of the state programme initiated even before the pre-war period, as well as the destructive changes associated with the war, it is necessary to implement progressive rehabilitation mechanisms at the regional level. This includes stimulating investment attraction for reconstruction, relocating enterprises to western regions, and engaging European companies in cooperation with the aim of expediting the country's accession to the European Union after the war.

The article argues that the creation of eco-industrial parks in the Lviv region is the most optimal method for inclusive development of the western region of Ukraine, based on the principles of transitioning from linear economy to circular economy.

Scientifically-grounded recommendations for a gradual transition to the circular economy model (taking into account the specificity of the western region) are developed in the article. This transition aims to facilitate the realisation of a future where industrial progress harmoniously coexists with environmental management, fostering the creation of a sustainable and inclusive industrial landscape for future generations.

The implementation of the circular economy system in the Lviv region is expected to achieve the following results: optimise the activities of economic entities, find rational methods for resource utilisation, ensure a closed production cycle for efficient use of existing capacities, support economic growth rates, develop other economic sectors to replenish natural resources, increase GDP, and expand the labour market.

Therefore, within the framework of the UNIDO project, the article proposes specific methods and mechanisms, and provides concrete recommendations for the planning, construction, implementation, and realisation of industrial parks in the Lviv region based on the principles of circular economy.

The article examines the results of the work carried out in the direction of the introduction and development of industrial parks in the Lviv region. The methods and possibilities of the transition of already existing enterprises that work on the principles of linear economy to innovative production on the principles of circular economy are considered. Recommendations on the selection of enterprises based on the principles of industrial symbiosis are provided. Following these guidelines, we hope to contribute to the realisation of a future where industrial progress coexists harmoniously with environmental management, fostering the creation of a sustainable and inclusive industrial landscape for future generations.

In Ukraine, these issues are extremely important, because not only local communities of the Lviv region will be interested in employment, but also internally displaced people and those who will return from abroad after previous evacuation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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