“Towards sustainable development in a transition economy: The case of eco-industrial parks in Ukraine”

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TOWARDS SUSTAINABLE DEVELOPMENT IN A TRANSITION ECONOMY: THE CASE OF ECO-INDUSTRIAL PARKS IN UKRAINE

Abstract

Sustainable development for transition economies is an opportunity to accelerate and complete socio-economic transformations and at the same time an additional responsibility in situations of instability and uncertainty. The chances for strengthening sustainability are growing within the organized innovation space, which makes it possible to model scenarios of ecologically oriented development and, with the help of state and international support, to start their implementation. The paper aims to analyze the possibilities and directions of creating eco-industrial parks in a transition economy. It uses an innovative helix model in its triple, quadruple and quintuple variations for functioning and sustainable development of industrial parks in Ukraine.

The study adopts a descriptive comparative analysis of data on the planning and implementation of economic, primarily environmentally relevant, activities. Based on the analysis and description of exogenous factors, in particular within GEIPP, a SWOT table on the potential of eco-industrial parks was formed. The directions of development of industrial, technological, and scientific parks in Ukraine are determined using the quintuple helix model on the plane of "knowledge-innovation", in particular on quadruple helix transition to sustainability through the simultaneous development of socially oriented and environmental activities. Within the legislation, it is proposed to approve a sustainable form of artificially separated innovation parks, namely the "eco-industrial park". One of the conditions for advanced sustainable development in Ukraine is the creation of a national program to support the transformation of innovation parks into their environmental versions 2.0 and 3.0, as well as investing in greenfield eco-industrial parks.

Keywords eco-industrial park, helix innovation model, sustainability, transition economy, Ukraine

JEL Classification L16, Q56, Q57

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INTRODUCTION

The concept of sustainable development is global and focused on achieving its goals by each country, regardless of its economic development. For transition economies, sustainability means an additional opportunity to accelerate and at the same time complicate the transition not only to a state of economic development but also to environmental responsibility. The example of eco-industrial parks demonstrates the efforts of transition economies to accelerate sustainable development through the organization of space for innovations within a combination of economic, social, and environmental aspects taking into account the needs of future generations.

Industrial parks help to organize business connections between companies in different industries, as well as reduce their transport and other costs by using common infrastructure and promoting innova-

tion. The creation of these parks within the concept of sustainable development pursues primarily economic goals. Although such parks require monitoring of environmental pollution within their areas, in practice, this condition is more formal than motivational. This is usually the case in developing and transition economies, where industrial parks are mainly concerned with stimulating the development of entrepreneurship and industry by attracting additional investments (UNIDO, n.d.b). At the same time, industrial parks in economically developed countries have evolved into their environmentally relevant version, namely eco-industrial parks (EIP) (UNIDO, n.d.c), which is characterized by environmental friendliness and thrifty use of natural resources in addition to economic aspects involving organizational and technological innovations, as well as improved communications between businesses and local communities.

The prevention of limited greening of industrial parks in countries with economies in transition, including the Global Eco-Industrial Parks Program (UNIDO, n.d.a), given the complexity of EIPs as a multifaceted object of the study, requires the improvement of transdisciplinary knowledge of their functioning and development. It also includes issues such as interaction with the community or the creation of an "ecosystem" of parks through landscaping and the creation of recreational areas. Accordingly, an appropriate innovation modeling is appropriate in the context of reducing the gap between the planning of parks and the implementation of these plans.

The functioning of eco-industrial parks is assessed in terms of their management, as well as environmental, social, and economic indicators (The World Bank, 2018). They follow the Sustainable Development Goals (United Nations Ukraine, n.d.), namely Goal 7 "Affordable and clean energy", Goal 8 "Decent work and economic growth", Goal 9 "Industry, innovation and infrastructure", Goal 11 "Sustainable cities and communities", and Goal 12 "Responsible consumption and production". The actualization of environmental research within the implementation of innovative industrial projects, in particular, the quintuple helix model, is primarily related to Goal 13 "Climate action" (Carayannis et al., 2012).

Thus, the urgency of landscaping in industrial parks in transition economies, including Ukraine, is reinforced by their desire to accelerate sustainable development. Substantiation of such acceleration is in the field of "knowledge-innovation". The knowledge that reveals aspects of sustainable development taking into account situational factors, and innovations as a prerequisite and a basis for the specifics of industrial parks' functioning, are the basis for their modeling.

In other words, the necessary greening of industrial parks in Ukraine, not fragmentary, but systemic and expanded, requires research of interrelated scientific, educational, economic, state, social and environmental aspects, which in combination with the priority of innovation causes analysis and synthesis of relevant relationships. The functioning of industrial parks and the potential development of eco-industrial parks in Ukraine is based on use of the quintuple helix model within the concepts of a knowledge economy, social knowledge, and sustainable development.

1. LITERATURE REVIEW

Economically developed countries demonstrate the progressive evolution of environmental industrial activity within the framework of sustainable development. In particular, the US experience is related to the positive role of eco-industrial parks for social capital use and the extension of sustainable business possibilities (Veleva et al., 2015). Namely, it involves simplified access to infrastructure (railways, green buildings, and roads); reducing the value of a real estate and tax benefits; improving energy efficiency and efficiency of natural resources use; cooperation with local communities focusing on long-term partnerships; knowledge exchange and its coordination; formation of favorable programs for sustainable development and the growth of trust in local authorities supporting environmentally and socially oriented businesses.

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South Korea has had significant success in implementing the National Eco-Industrial Park Development Program since 2005 (Park et al., 2016). It includes interconnected direct and reverse hierarchical management approaches, and specially created regional centers, which coordinated joint meetings and actions of stakeholders, including scientists, businesses, and government representatives. Kim et al. (2018) reveal the Korean experience of the symbiosis of energy consumption of the industrial park and the city with the support of the government.

The Italian experience is characterized by the eco-industrial development, in particular in the form of parks (Daddi et al., 2015). Sweden's experience with the use of eco-industrial parks as inter-organizational innovation structures (Aid et al., 2017) is interesting as a more sustainable alternative to traditional approaches to waste management.

In addition, eco-industrial parks have not yet been widely developed in developing countries, such as South Africa (Greenberg & Rogerson, 2014).

Van Beers et al. (2020) summarize data on the experience of industrial parks in developing countries. In each of the studied countries, including Indonesia, Colombia, South Africa, Ukraine, etc., there are cost-effective parks; however, they have social and environmental problems. The biggest social problems are cooperation with local communities while environmental problems are related to waste management, climate change, and environmental monitoring. However, the availability of these parks already indicates the potential for the development of eco-industrial parks in the studied countries, with the support of governments and relevant international organizations, as well as public-private partnerships.

The experience of Vietnam shows that the impact of the industrial park can extend not only to local communities but also to the entire region near which the park is located (Cu & Nguyen, 2021).

China's experience in assisting the government in the environmental development of industrial parks is disclosed by Fu et al. (2019). A comparative assessment of the transformation of industrial parks in the direction of their greening was done. Of particular relevance are eco-industrial parks in China's chemical industry (Yune et al., 2016), which require the highest level of environmental safety in two areas: the totality of chemical companies as major polluters, and park infrastructure, especially its transport and logistics component.

Proper consideration of the above-mentioned experience can reduce the period of implementation of eco-industrial parks in countries that are at the initial stage of the landscaping of industrial parks, in particular in Ukraine. In China, for example, such a program was launched in 2001, and according to Hong and Gasparatos (2020), for almost two decades the interest in eco-industrial parks has been growing among various stakeholders, including local communities, especially in environmental protection and resource rationalization. However, in practice, Chinese parks do not have social and environmental efficiency, according to the initially established standards.

The role of industrial parks as special economic zones can also be combined with the role of a catalyst for sustainable development, even in an underdeveloped market environment, by borrowing global knowledge on environmentally friendly industrial parks combined with government support for real reforms (Zeng, 2019). Management of eco-industrial parks can address a shortage of natural resources, including water in arid regions (Litifu & Nagasaka, 2015), for example, by saving water for landscaping using treated wastewater.

Eco-industrial parks are an important attribute of Industry 4.0. Companies located in the park receive support for the development of innovation processes and projects primarily through the information component of the infrastructure, as well as modern methods of information management (Zhou et al., 2017).

Given the lack of consistent views on the ecological and economic nature and content of the components of the eco-industrial parks, as well as unified methods of managing it, it is advisable to take a comprehensive approach to its study. In particular, Farel et al. (2016) viewed social, as well as forms of ownership of eco-industrial parks, along with economic and environmental factors.

Within the synthesis of theoretical and applied knowledge about the circular economy, eco-industrial parks are considered as their most common organizational form at the territorial level (Goyal et al., 2021). Landscaping of industrial parks also means the development of closed production and logistics processes on their territory, as well as the promotion of a circular economy, which involves minimizing and recycling waste, as well as environmentally friendly optimization of their transportation, including vehicles (Al-Quradaghi et al., 2020).

Eco-industrial parks are a platform for the development and implementation of transdisciplinary knowledge within sustainable development, such as the biological economy (Lopes, 2015). Paula and Abreu (2019) explore the field of knowledge sharing in relation to industrial symbiosis and eco-innovation solutions as prerequisites for the development of eco-industrial parks. Wang et al. (2017) explore the institutional potential for the development of an eco-industrial park, as well as the related knowledge base for improving coordination processes while supporting them by local authorities. Eco-industrial parks as an object of knowledge management (Zhang et al., 2017) from both conceptual and practical points of view ensure the bridging of communication gaps between organizations. Gómez et al. (2018) also consider eco-industrial parks within the formation of knowledge models as an approach to organizational and information support for the development of a circular economy at the meso-level.

Zhou et al. (2018) offer conceptual modeling of eco-industrial parks, which includes the following operational levels: "unit operations, processes, plants, industrial resource networks, and eco-industrial parks." The conceptual model of the eco-industrial park, within which the sustainable innovation infrastructure operates, developed based on the institutional theoretical approach, is proposed by Zeng et al. (2017). The model demonstrates the reduction of institutional pressure on organizations and the expanded opportunities of the circular economy within the parks.

Bellantuono et al. (2017) develop a two-dimensional model of an eco-industrial park, where one dimension is related to the organizational characteristics of the park and the other reveals its sustainability. In addition to this model, a set of variables has been developed that strengthen its focus on the implementation of policies and strategies to increase the park's sustainability. Peng et al. (2020) model the landscaping of the logistics infrastructure of an eco-industrial park based on the integration of "green" relationships, structure, and knowledge. If the economic indicators of the model show a tendency to growth and subsequent stabilization, the trend of environmental indicators has a "U" shape. The Agent-Based Model for the coordination of knowledge and relationships within the eco-industrial park, developed by Zheng and Jia (2017), is also based on an institutional approach to study the possibilities of innovation.

One of the most relevant issues regarding forms of innovative modeling in the landscaping of industrial parks is the helix model (Etzkowitz & Leydesdorff, 2000). In particular, the analysis of technology parks by Machado et al. (2018) is based on triple, quadruple, and quintuple helix models. Laguna and Durán-Romero (2017) explore the relationship between education, business, government, and environment within innovation parks, based on a theoretical quintuple helix model that should increase the capacity of parks to implement sustainable development strategies. Kitsios et al. (2021) use quadruple and quintuple helix innovation models to analyze the stimulation of innovative entrepreneurial development with the ultimate goal of improving the quality of life.

Given the above, the purpose of this study is to analyze the possibilities and directions of creating eco-industrial parks in a country with a transition economy. This analysis is carried out within the framework of an innovative quintuple helix model relevant to the symbiotic combination of five components, namely science, industry, government, society, and ecology, in their projection into the plane of functioning and sustainable development of industrial parks in Ukraine.

2. DATA AND METHODOLOGY

This study examines the processes of sustainable development in Ukraine based on descriptive comparative analysis of data related to the planning and implementation of activities within in-

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Source: Developed by the authors based on Carayannis and Campbell (2014).

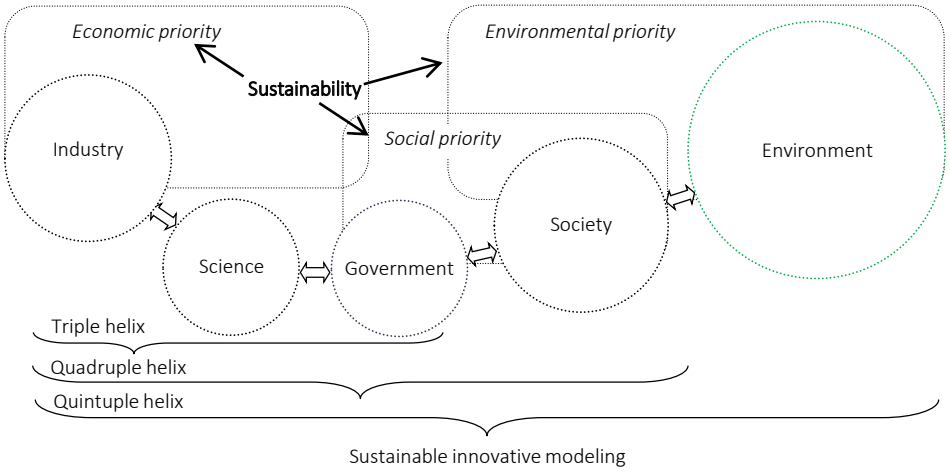

Figure 1. Relationship between the concept of sustainable development and helix modeling

dustrial parks by using Ministry of Economy of Ukraine (2021, n.d.), Ministry of Education and Science of Ukraine (2021a, 2021b). Table A1 (Appendix A) summarized environmentally relevant parts. This analysis in combination with the description of exogenous factors, in particular within GEIPP (UNIDO, n.d.a) is the basis for the formation of a SWOT table on the development potential of eco-industrial parks in Ukraine. The specifics of the analysis take into account two main characteristics of the object of study: the innovation of activities within eco-industrial parks, as well as its multifaceted nature. The conceptual basis for the formation of the relevant knowledge platform is helix modeling (Figure 1).

The specificity of the relationship between the concept of sustainable development and helix modeling is to transform aspects of sustainability into priorities, according to the elements of the helix model, namely:

- economic priority: triple helix "industry – science – government" ("science" and "government" are connecting elements, according to the innovative and supporting functions of the model);
- social priority: quadruple helix "society – industry – science – government";
- ecological priority: quintuple helix "environment – society – industry – science – government".

The uniformity of the helix approach makes it possible to compare the relationships between the components of the innovation park environment, regardless of the degree of development or transitivity of the economy, as well as the technology of parks' development (brownfield or greenfield).

According to the quintuple helix model, determining the stage of development of innovation (industrial, technological and scientific) parks in Ukraine is implemented in the plane of "knowledge – innovation" by analyzing and synthesizing factors of the internal and external environment of the park (actual activity and development potential in the short term), as well as their comparison with similar factors in other parks.

Along with determining the scope of environmentally relevant activities of parks to justify their landscaping in Ukraine, the study also analyzes the content of relevant legislation (Table A2, Appendix A) as a basis for institutional support for socially responsible and environmentally friendly industry and business.

3. RESULTS

Innovative spatial organization of ecological industrial activity has not yet been widely developed. As of 2016, there were about 30 officially registered eco-industrial parks in developing and transit countries (UNIDO, 2016, pp. 6-9). Parks have been established since 1960, namely in Morocco, where

Source: Developed by the authors based on Carayannis et al. (2012), Carayannis and Campbell (2014, p. 15), Etzkowitz and Leydesdorff (2000), Social Seeds (2018).

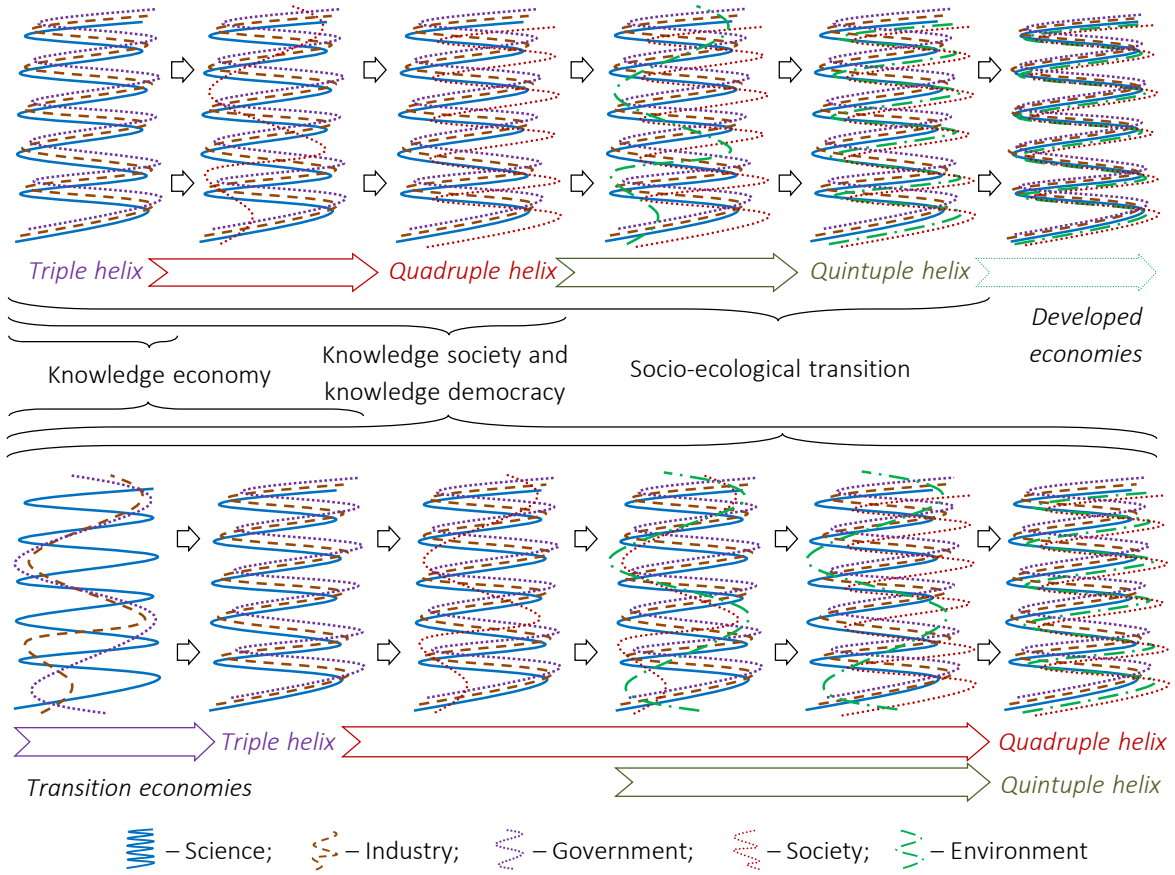

Figure 2. Quintuple helix model as a stable knowledge platform for innovative eco-industrial development

two parks have been established during 15 years. The same number of parks were created in Tunisia during 1981–1996. In terms of their area, a number of companies and employees, they are much inferior to the parks in Morocco. Other countries that joined GEIPP include India and China (with the largest number of parks and facilities), as well as Egypt, Costa Rica, Peru, El Salvador, South Africa, Vietnam, Colombia, and Cambodia. The parks created in these countries combine production and service activities and are focused on preserving the environment both inside and outside the parks.

From the point of view of the helix approach, the difference between transition economies and developed economies in their efforts to implement the concept of sustainable development is shown in Figure 2.

Transitional economies have not yet developed strong links between industry, research, and government support, so their innovation parks are not triple-helix yet. The participation in innovative economic activity with the possibility of civil society influence is the main feature of developed economies in comparison with transitional economies: accordingly, the operation of industrial parks on the principle of a quadruple helix in transition economies is not an intermediate stage between economic and environmental priorities (Figure 1), but a separate prospect. Environmental aspects of sustainable development are not only inferior but can also prevail over social aspects within innovation activities of transition economies: efforts to accelerate the transition to sustainability are associated with simultaneous and symbiotic development of socially oriented and environmentally friendly innovative activities.

Given the trends presented in Figure 2, as well as the results of analysis of concepts and activities of innovation parks in Ukraine, Figure 3 summariz-

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Source: Developed by the authors based on Carayannis and Campbell (2014, p. 4), Ministry of Economy of Ukraine (2021, n.d.), Ministry of Education and Science of Ukraine (2021a, 2021b), and UNIDO (n.d.a).

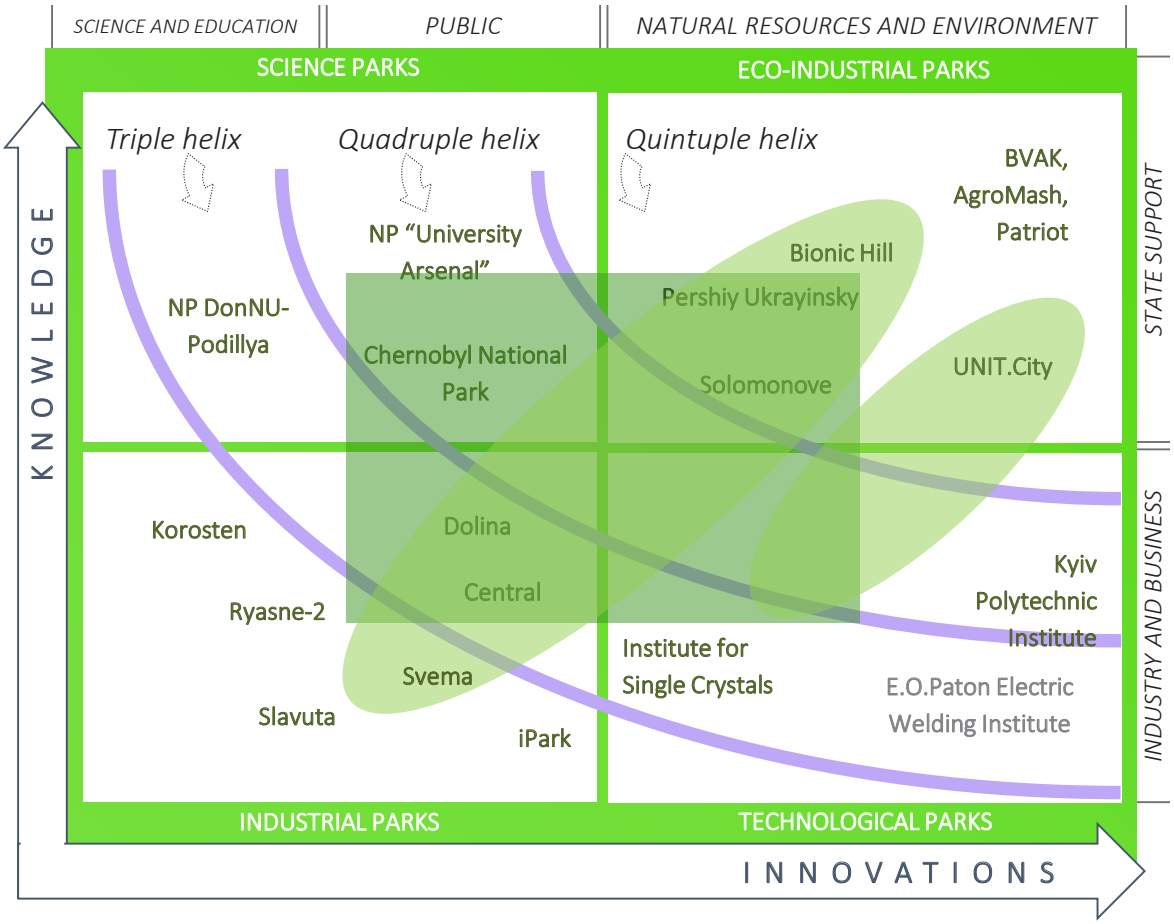

Figure 3. Quadrants of landscaping in innovation parks of Ukraine on the plane "knowledge – innovation" according to the stages of helix modeling

es the state of ecological and innovative development of industrial, scientific, and technological parks in Ukraine.

According to the criterion of ecological relevance, in particular, within the development of scientific and educational spheres, Ukrainian innovation parks belong to one of the quadrants defined on the plane and have an intermediate character. The central quadrant in Figure 3 is the plane of potential development of parks according to three priorities: economic, social, and environmental (Figure 1). For example, following the logic of helix modeling, environmental education involves the accumulation of relevant knowledge in a symbiotic combination with sustainable innovation. This is possible at different levels of development of innovation parks: from additive (greening of knowledge with insufficient development of innovations – triple helix) to integrated (symbiosis of knowledge potential and sustainable innovation – quintuple helix).

According to the World Bank Group, United Nations Industrial Development Organization (UNIDO), and German Development Cooperation (GIZ) GmbH, which created the first joint international structure for eco-industrial parks (EIP), "around 250 self-classified EIPs exist globally; about a third of them in non-OECD countries, and those numbers are growing". The impact of countries and regions on sustainable development is also growing (The World Bank, 2018).

In 2019, Ukraine as a country with a transitional economy joined GEIPP (UNIDO, 2018) subject to the following conditions:

- the roadmap is not uniform for all countries within the GEIPP, but corresponds to the motivation and readiness of the country to develop EIPs;
- budget allocations for Ukraine, as well as for Colombia, Peru, and Vietnam, amount to 2 million CHF;
- government support should be consistent with potential EIPs, including the possibility of parks' merging;
- a coordination center is established, which contacts the companies and the government.

Figure 3 presents the first Ukrainian project within the GEIPP, which includes three eco-industrial parks: BVAK, AgroMash, and Patriot.

EIP aims to improve the economic performance of participating companies while minimizing their impact on the environment. The components of this approach are a green design of park infrastructure, cleaner production, pollution prevention, energy efficiency. EIPs also seek to benefit neighboring communities (Lowe, 2001, pp. 1-2).

According to the study conducted by the United Nations Specialized Agency for Industrial Development (UNIDO, 2017, p. 12):

- EIPs are perceived differently by different stakeholders;
- EIPs practice does not always correspond to the stated ambitions;
- the most useful approaches are based on processes and continuous improvement;
- the lack of experience, awareness, support for regulations slows down the development and implementation of eco-industrial parks.

The benefits of EIPs are as follows (UNIDO, 2017, p. 13):

- not just commercial, but strategic nature of the activity, which leads to risk reduction, competitiveness, and business development;
- companies are allowed to make and implement collective business decisions to solve environmental problems through the efficient use of resources and cooperation through common infrastructure;
- the main socio-economic benefits include direct and indirect job creation;
- the environmental benefits of eco-industrial parks are very diverse and include the reduction of pollution, more efficient use of natural resources, conservation and protection of biodiversity as well as the reduction, reuse, and recycling of waste;
- competitive business: industries operating in well-designed and managed eco-industrial parks can benefit from resource efficiency, risk reduction, reduction in operational costs and productivity growth, climate change mitigation, addressing environmental and social issues related to the local community and government.

Given these generalizations and the above stages of helix modeling and relevant approaches to the organization of innovative economic activity (Figure 2), reflected in the functioning of innovation parks (Figure 3), strategic directions of eco-industrial parks in Ukraine, are presented in Table 1.

An important component of the presented areas (Table 1) is the institutional support for the development of environmentally relevant research and educational activities within the industrial parks of Ukraine (Figure 4).

Institutional support should meet:

- the Program of the Government of Ukraine to stimulate the economy to overcome the effects of COVID-19 for 2020–2022; given that there are no environmental or climatic measures in the program; "Sustainability" in the document is understood as stability, not environmental friendliness" (EU-Ukraine civil society platform, 2021, p. 13);
- renewed nationally defined contribution of Ukraine to the Paris Agreement (WB2) (The Government Portal, 2021).

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Table 1. SWOT-analysis of EIP development in Ukraine

Source: Developed by the authors based on Park et al. (2016, p. 36), Kechichian and Jeong (2016, pp. 11-14), World Bank Group (2019, p. 50), Ministry of Economy of Ukraine (n.d.).

External environment / Internal environment	Possibilities (SO)	Threats (ST)
	• Support of international organizations, in particular, UNIDO • Experience in implementing international environmental standards, including ISO • Government reforms aimed at industrial restructuring and revitalization of industrial zones • Ongoing educational and research activities of pro-environmental NGOs • Great "heritage" for the development of Brownfield areas	• Lack of an effective system for implementing national standards • Lack of initiative and effective activities in the environmental sphere • Insufficiently favorable investment environment • Insignificant support for environmental NGOs • Shortcomings of the legislation, in particular, regarding the creation of Greenfield zones by big business
Strengths (S) • Industrial traditions, including those supported within technological parks • Existing policy of sustainable industrial development • Existing cases of spontaneous industrial symbiosis • Existing scientific parks at universities	**Strategies (WO) → Eco-IP 3.0** • Pilot experimentation and phased implementation of the EIP program • Dissemination of successful experience • Participation of local governments • Intensifying the development of services, including ecosystems	**Strategies (WT) → Eco-IP 2.0** • Mobilization of business through state financial support (usually through research funds) • Capacity building through training and development of knowledge-management • Institutional support and implementation assistance
Weaknesses (W) • Insignificant experience in the development and dissemination of cleaner production technologies • Lack of experience in creating agro-industrial parks • Worn out infrastructure • Lack of awareness and motivation of business • Insufficient information support	**Strategies (WO) → Eco-IP 2.0** • Creation of centers of eco-industrial development • Consultations with international experts, in particular UNIDO, UNEP, EBRD • Institutional support and implementation assistance • Comprehensive information support	**Strategies (WT) → Eco-IP 1.0** • Evaluation of the feasibility and content of project proposals • Conducting eco-forums and round tables • Ideologizing and teaching • Wide involvement of public-private partnership • Propaganda and systematic public discussion

Source: Developed by the authors based on the Verkhovna Rada of Ukraine (1999, 2009, 2013), EU-Ukraine civil society platform (2021, pp. 21-23).

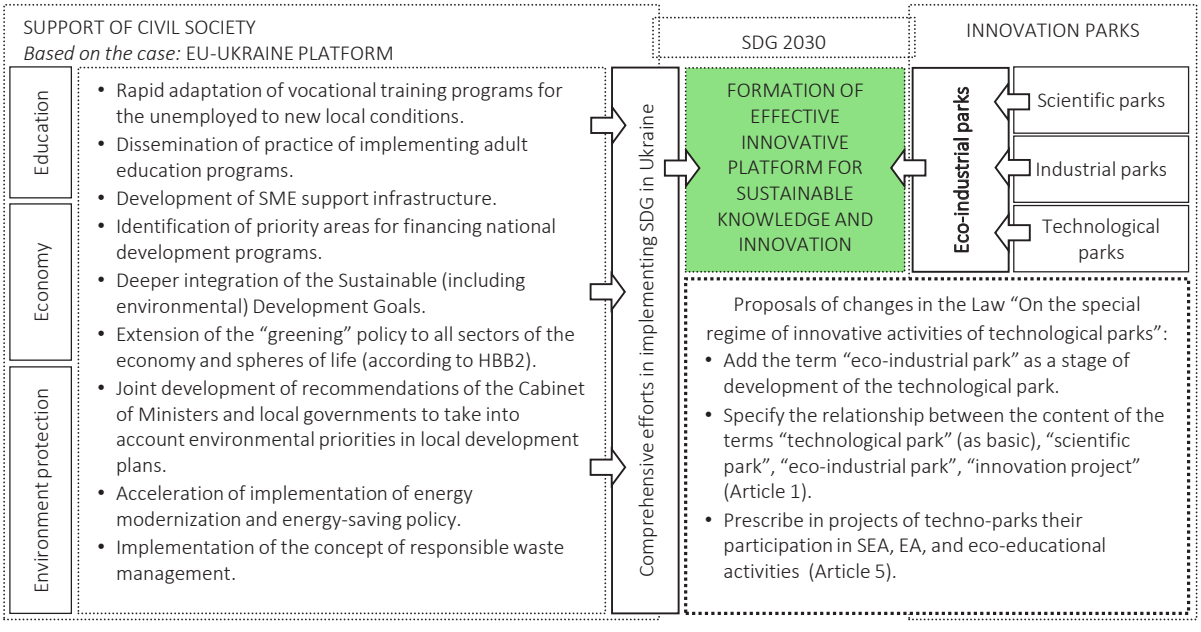

Figure 4. Institutional support for the development of ecologically relevant knowledge within the framework of the landscaping of innovation parks in Ukraine

- During the formation of proposals (Figure 4) it is taken into account that:

- "strategic environmental assessment is a procedure for determining, describing and assessing the impact of state planning documents on the environment, including public health, justified alternatives, developing measures to prevent, reduce and mitigate possible negative consequences" (The Verkhovna Rada of Ukraine, 2018, Art. 1);

- "environmental impact assessment is a procedure that involves: preparation of an environmental impact assessment report by the business entity; holding a public discussion; analysis by the authorized body of the information provided in the environmental impact assessment report; providing the authorized body with a reasoned opinion on the environmental impact assessment, taking into account the results of the analysis; taking into account the conclusion on the environmental impact assessment in the decision to carry out the planned activities" (The Verkhovna Rada of Ukraine, 2017, Art. 2).

4. DISCUSSION

For an eco-industrial park to have a positive impact on the external environment, especially the natural and social environment, the internal environment of a park must have a high level of sustainability. In particular, the creation of a recreational environment on its territory within the framework of improving the quality of working and leisure conditions for employees of enterprises located in the park may be a catalyst for changes in the socio-economic situation in the regional (Petrushenko et al., 2019) or intersectoral (Shevchenko et al., 2016) levels. The analysis of EIP locations in the world shows that some of them are specially created near national nature parks (UNIDO, 2016, p. 10), wetlands, in forests, in environmentally sensitive areas with high biodiversity, on environmentally sensitive peninsulas, etc. The expediency of the new planning of the industrial zone near a natural reserve is explained only by the lack of alternative location options, which is exacerbated by compliance with strict environmental requirements. In addition, the infrastructure of the industrial park (Silva et al., 2017) should be integrated into the natural landscape, under the project solution for local tree species and coordination with land use and recreational infrastructure, such as bicycle paths, within the surrounding area. The eco-industrial park is considered as a "living laboratory" for adapting the implementation of spatial innovative economic and technological projects to the conditions of functioning and preservation of local ecosystems.

Therefore, the "greening" of industrial parks in the literal sense, i.e. in the context of creating a favorable natural, in particular, recreational, environment in eco-industrial parks is, on the one hand, an indicator of its ecological sustainability, and on the other – evidence of non-interference or an element of positive influence on the transformation of the external environment.

CONCLUSION

On the example of the ecologically-oriented activity of industrial parks and the formation of eco-industrial parks in Ukraine, the paper analyzes the features of sustainable development of the transitive economy. Innovative helix modeling has demonstrated the need to intensify knowledge about the social component, in particular in relation to environmentally relevant research and educational activities, within the complex solution of the development of eco-industrial parks. The initial condition for such development is institutional support, which includes improvements in the relevant legislation: it is proposed to move from artificially separated (in Ukraine) scientific, technological, and industrial parks – to a generalized definition of an innovative industrial park and its strategic direction – eco-industrial park. This approach pursues the specific goal of creating a realistic model of development for eco-industrial parks that would meet the best world standards and at the same time preserve the positive Ukrainian experience or rather formalized intentions, including the status of free economic zones, wide involvement of academic science and traditions aimed at sustainable development. For these features to serve

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the development of the national economy and motivate entrepreneurs to carry out eco-industrial activities, real support from the state and international organizations is needed. Proactive development of EIPs in Ukraine is possible under the condition of creating a national program to ensure their development and orientation of the best projects of eco-industrial parks towards 2.0 and 3.0. At the same time, it is possible to reduce the number of formally existing parks by consolidating and clustering them, in particular, following the example of Ukraine's participation in GEIPP, and at the same time creating conditions for attracting investments in greenfield eco-industrial parks.

AUTHOR CONTRIBUTIONS

Conceptualization: Mykola Petrushenko.
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Formal analysis: Mykola Petrushenko, Hanna Shevchenko.
Funding acquisition: Borys Burkynskyi, Hanna Shevchenko.
Investigation: Hanna Shevchenko, Mykola Petrushenko.
Methodology: Mykola Petrushenko, Hanna Shevchenko, Borys Burkynskyi.
Project administration: Hanna Shevchenko.
Resources: Borys Burkynskyi, Mykola Petrushenko, Yevhen Baranchenko.
Software: Mykola Petrushenko, Yevhen Baranchenko.
Supervision: Hanna Shevchenko, Borys Burkynskyi.
Validation: Hanna Shevchenko, Yevhen Baranchenko.
Visualization: Hanna Shevchenko, Borys Burkynskyi, Yevhen Baranchenko.
Writing – original draft: Mykola Petrushenko, Hanna Shevchenko.
Writing – review & editing: Mykola Petrushenko, Hanna Shevchenko.

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APPENDIX A

Table A1. Ecologically relevant and scientific-educational activities of industrial parks by regions of Ukraine, 2021

Source: Analyzed by the authors based on Ministry of Economy of Ukraine. (n.d.).

Region / IP	Environmentally relevant activities	
	Production and services	Science and education
Vinnytsia		
Winter sport	Environmental Impact Assessment (EIA) and Strategic Environmental Assessment (SEA) scheduled for 2021	No information available
Volyn		
Ecotechnopark "Volyn" (project)	Biotechnology: scientific laboratories for the development of ecological agricultural production; energy park: 15 hectares for solar panels with a capacity of 1 Megawatt	No information available
Dnipropetrovsk		
IP Pavlograd	Development of technologies in the field of environmental protection, technologies in the field of energy-saving	No information available
Donetsk		
IP Technocity	Environmental impact assessment and strategic environmental assessment are scheduled in 2021	No information available
IP AzovAquaInvest	Production of ecological fertilizers	No information available
IP Chemical and metallurgical plant (project)	A site with a complex of buildings has been prepared for the possible placement of a waste processing line. Slag processing for road construction has been organized	Research and development work of "NIOCHIM"
Zhytomyr		
IP Korosten	As of 01.02.2021, no environmental impact assessment and strategic environmental assessment have been carried out	No information available
Kyiv region		
IP Paton	It is planned to plant greenery	It is planned to install multi-purpose conference halls
Luhansk		
IP Eastern region	Ecological processing of solid household waste	No information available
IP Rubindastri	Ecological processing of solid household waste	No information available
Lviv		
IP Novorozdilsky	Production to reduce the consumption of natural resources; production from raw materials of secondary origin; production from raw materials of natural origin	No information available
Poltava		
Lannivsky	It is planned to build a biogas plant	No information available
Rivne		
IP Rivne	Processing of secondary resources	No information available
IP Liberty	The SEA is planned for 2021	No information available
Sumy		
IP Svema	The project includes the construction of an industrial solar power plant with a capacity of 1.0 MW with ground-based panels	Reconstruction of the research and exhibition center
Kharkiv		
IP Earth and Water (project)	Construction of plants for the production of biogas, biodiesel, and waste sorting line	No information available
Kherson		
IP Slavuta	It is planned to produce alternative fuels	No information available
Chernihiv		
IP Mensky (project)	SEA was conducted (approved by the order of the head of the Mensk district state administration No. 120 of 10.07.2020). In 2021, it is planned to approve the concept of IP and include it in the Register	No information available
The City of Kyiv		
IP Bionic Hill (not implemented)	Energy-saving and energy efficiency projects	No information available

Table A2. Main aspects of IP included in the Register of industrial parks as of November 12, 2020, under the Ukrainian legislation

Source: Compiled by the authors based on the Verkhovna Rada of Ukraine (1999, 2009, 2013), and Ministry of Education and Science of Ukraine (2021b).

Dimension	Type of innovation park		
	Industrial park (IP)	**Scientific park (SP)**	**Technological park (TP)**
Definition of the concept	An area with infrastructure defined by the initiator, following the needs of participants and urban planning documentation, within which the IP participants can carry out economic activities in the field of processing industry, information, and telecommunications, as well as research activities under the conditions of the Law of Ukraine "On industrial parks" (The Verkhovna Rada of Ukraine, 2013) and the agreement on IP activities	A legal entity created on the initiative of a higher education institution and/or research institution by combining the contributions of the founders for the organization, coordination, control of the process of development and implementation of SP projects	A legal entity or group of legal entities – TP participants, operating under the agreement on joint activities without the creation of a legal entity and pooling of contributions to create organizational foundations for TP projects for the production of science-intensive products, high technologies, and industrial production of competitive products
Goal	The goal, tasks of creation, and functional purpose of IP are determined by its concept according to the Law of Ukraine "On industrial parks" (The Verkhovna Rada of Ukraine, 2013, Art. 17)	Development of scientific-technical and innovative activity in higher education/scientific institution, for commercialization of research results	Complex organization of science-intensive production and ensuring the reproduction of the full life cycle of innovations: from research to mass industrial production of high-tech products
Participants	Initiator of the creation of IP (public authority/local self-government body, legal entity, or physical person). Management company of IP (legal entity) with which the initiator has agreed about IP. Authorized state executive body within the framework of state investment policy. Participant of IP is an economic entity registered on the territory of the administrative-territorial unit of Ukraine where IP is located	Founders of SP are a higher education institution/scientific institution and other legal entities that have agreed on the establishment of SP. SP partners are business entities that have concluded a partnership agreement with the SP	TP participants – legal entities – subjects of scientific, research and technical, business activities that have entered into an agreement with each other under technical
Funding and state support	Funds from state and local budgets, funds from private investors, including those raised on the model of public-private partnership, loans from banks and other financial institutions, etc. State support may be provided from the state and local budgets and other sources not prohibited by law	SP statutory fund and other funds, financial revenues from the activities of SP, investments, charitable contributions for the development of SP, funds of the state and local budgets, funds of customers SP's request regarding the state order of products/services is considered in priority order. In the case of SP project implementation, scientific, laboratory, and research equipment imported by the SP is exempt from import duties	A special legal regime for innovation, which provides for state support to stimulate the activities of TP for a period of 15 years and is valid in the implementation of TP projects State support for TP innovation activities is provided through state financial support and targeted subsidies (in the form of import duties) for TP projects. A budget program is introduced within the annual State Budget for financial support (interest-free lending to projects)
Priority areas of activity	Not specified	Economically and socially determined research, scientific-technical and innovative activities that meet the goals of SP, industry profile and/or specialization of the university and/or research institution (which are the basic elements of SP), take into account the needs of the region	Economically and socially determined areas of scientific, technical, and innovative activities of TP, which meet the statutory scientific, technical, and innovative priorities and aimed at industrial production of competitive high-tech and innovative products

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