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Environmental Performance Index to Assess the Situation in Regions of Ukraine in Terms of their Competitiveness

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Abstract:

Purpose: *The objective of the study is the application of the environmental performance index (EPI) to the regional evaluation of the environmental situation of the Ukraine's territorial units, in the context of their competitiveness.*
Methodology: *The study based on indicators of environmental performance of economic growth, environmental sustainability and environmental health impact allowed to divide Ukraine into 9 sectors according to the index of ecological and economic efficiency, ecological price of economic growth, environmental friendliness, and environmental health index.*
Findings: *The Zaporizhzhia region is in a relatively better competitive position, considering all considered index indicators, whereas Dnipropetrovs'k and Donets'k regions are characterized by a significant lag due to air emissions and high-water consumption. The conducted research allowed to conclude that ecological safety determines the need for changing the current model of development towards sustainable development, which, apart from evident environmental benefits, improves the regional competitiveness level.*
Practical Implications: *It was concluded that environmental costs play a decisive role in ensuring the appropriate level of environmental sustainability. There is also a need for improvement in environmental legislation, especially in harmonization and integration of different regulations and ensuring funds for carrying out the planned measures.*
Originality/Value: *The regions of Ukraine vary considering the sustainable development level and therefore it is vital to consider them separately in terms of the EPI and competitiveness.*

Keywords: *Sustainable development, Gross Regional Product, economic growth, environmental safety, pollution level, competitiveness of regions.*

JEL code: *Q56, O13.*

Paper type: *Study research.*

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1. Introduction

Current societies face a challenge of environmental protection. Problems such as extensive use of non-renewable resources, risk of renewable resources depletion, overpopulation, increased energy use, biosphere pollution and resulting from it species diversity decrease, soil erosion, deforestation, natural landscapes deterioration, water scarcity and global warming, lead to significant life quality worsening (Zaremba-Warnke, 2013; Bucher, 2016; World Bank, 2008; Zanella *et al.*, 2012; Wojciechowska-Solis and Soroka, 2018; Prus, 2017; Goryńska-Goldmann, 2019; Śmiglak-Krajewska and Wojciechowska-Solis, 2020). Therefore, the matters of environmental pollution and climate change are the most significant obstacles to any economic and social development. These occurrences progress quickly and are less expensive than applying environmentally friendly solutions, but on the other hand the process of regeneration is slow, complicated, and requires significant financial resources.

Consequently, environmental economists recognize the environmental impacts of business as unpaid costs or externalities (Giddings *et al.*, 2002). Thus, there is a need for sustainable development associated with the opportunity to live and life preservation, not only for current generations but also for the future ones (World Commission, 1987). The awareness of the environment's role on an equal level with the economic and social element in ensuring sustainable development of the region is a vital step on the way to the reduction of the harmful human influence on the environment, challenging global crises and poverty (Sushchenko and Loseva, 2017). Therefore, sustainable development plays a crucial role in outlining national priorities, socio-economic development strategies, and the scenarios for further state reforms. It is still the main objective in international and national programs, and it is a crucial goal in the European Union policies comprising rules for the support schemes (Bucher, 2016). Thus, the governments should observe and control their environmental performance to define their position compared with other countries and to recognize the changes needed for improvement (Chess *et al.*, 2005).

Therefore, researchers at Yale and Columbia Universities, together with the World Economic Forum, have developed the international Environmental Performance Index (EPI), open to the public every 2 years since 2006 (Esty *et al.*, 2002; Hsu *et al.*, 2014; Sadovnikova, 2006). The EPI is a strongly performance-oriented and complex index, measuring progress directed to objectives of required environmental effects, considering country's present policies. The EPI is of particular meaning for decision-makers because of its strict input-output basis and short-term to medium-term time perspective, supporting accountability and performance assessment at the policy level (Buckland *et al.*, 2005; Samimi, 2010). It gives decision-makers access to appropriate environmental data organized to make it easy to understand, useful, and inviting to competing. The EPI allows for identifying best practices, leaders and laggards and attainable objectives, which are based on existing international agreements, researchers' studies on the harmful impacts of pollution on humans and ecosystems, and economically feasible environmental protection strategies.

Furthermore, comparing each country's performance in particular issue categories enable a more detailed evaluation between states (Samimi, 2010; Färe *et al.,* 2004; International…, 2005; Statistical…, 2007; Skillus and Wennberg, 1998; Stakeholder... 2018). The EPI uses an organized structure that groups indicators within the issue categories, then issue groups within policy objectives and policy objectives within the overall index. The EPI is based on two policy objectives, environmental health measuring threats to human health, and ecosystem vitality, which measures natural resources and ecosystem services. These goals reflect the dominant policy areas within which policymakers tackle environmental problems. In 2018, within the EPI, 24 indicators were collected and grouped into ten issue categories, such as: air quality, water and sanitation, heavy metals, biodiversity and habitat, forests, fisheries, climate and energy, air pollution, water resources and agriculture.

The 2018 EPI is based on data originating from international organizations, research institutions, academia, and government agencies. These sources use different techniques, including remote sensing data collected and analysed by research partners, observations from monitoring stations, surveys, and questionnaires, academic research, estimates obtained from on-the-ground measurements as well as statistical models, industry reports, and government statistics. It is worth to mention that the changes in methodology between versions of the EPI cause that former EPI scores cannot be compared, mainly due to adding and removing indicators and new weighting methods (Wendling *et al.*, 2018).

In Ukraine, the problems related to sustainable development are the essential ones. The lack of consistency in economic development and environmental safety requirements, the prevalence of outdated technologies that are resource and energy consuming, export consisting of mostly raw materials, low consumer environmental awareness created the technogenic type of economic development Consequently, the current human pressure on nature is nearing (and in particular regions of it has already approached) the boundaries of environmental sustainability that may cause irreparable changes (Kamensky and Boev, 2015; Figus, 2016; Gazzola *et al.*, 2019). Worth noting is also the fact that in Ukraine, environmental protection spending calculated as share of GDP fell from 3.3% of GDP in 1996 to 1.4% in 2014 (Report..., 2016). Therefore, Ukraine takes a distant place in the EPI ranking.

However, the natural and climatic conditions, the development of industry and agriculture cause that Ukraine’s regions are heterogeneous. Each region has its own specific features, economic potential, level of social development, natural resources, and level of environmental pollution. The greatly populated east part – with the center in Donetsk, specializes in industry, including energy, coal, metals (mainly Dnipropretrovsk), chemicals, construction materials, and heavy engineering. with well-developed transportation networks and relatively high industrial performance.

The north-eastern part, with major city of Kharkiv, is more differentiated, with a stronger service sector and a level of specialization in finances, real estate, and trade. The western part covers the Carpathian region (with the center in L'viv, also comprising Zakarpattya, Ivano-Frankivsk and Chernivtsi), the poorer northwest of the country (Volyn and Rivne), and the Podil area (covering Vinnitsa, Khmelnytskiy and Ternopil) in the central west. The Carpathian region, abundant water and forest, specializes in engineering, construction, metal processing, chemical products, and woodwork, and the region neighboring L'viv has high potential for tourism development. The Podil region, in the central west, is the lowest urbanized part and is deeply specialized in agriculture. In the northwest, Volyn and Rivne also focus agriculture, but they are converting into trade and services. The central regions – Cherkasy and Kirovohrad – concentrate on agriculture. In the north, Kyiv and the neighboring regions, Zhytomyr, and Chernihiv, demonstrate a high specialization in construction and high-level services (financial intermediation and real estate). In the south, the Black Sea coast is rather poor in natural and water resources, but because of the fertile soil agriculture dominates in economy of the region (OECD, 2014).

Such a diversification of Ukraine's regions causes that it is advisable to assess the environmental situation on a territorial basis for each region. Thus, given the shortcomings in the practical use of the EPI, which are associated with difficulties that narrow the scope of its application, namely: the constant change in the calculation methodology during 2006-2018 and the number of countries covered as a basis for comparison do not allow the use of this index to analyse trends. Moreover, a certain set of indicators that are included in estimation of the index, cannot be calculated based on the open data of the State Statistics Service of Ukraine (SSSU), which enabled similar calculations to constantly monitor the situation. Finally, the international indicator is calculated for the country. However, it does not allow to effectively manage Ukraine's environmental security. Therefore, there occurs a need to develop an alternative method of estimating the index of ecological and economic efficiency of Ukraine's regions. Thus, the objective of the study is the application of the EPI to the evaluation of the environmental situation of Ukraine's territorial units, in the context of their competitiveness.

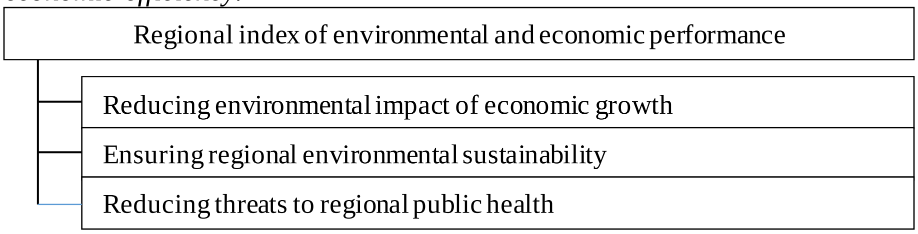
2. Materials and Methods

Environmental performance evaluations often use environmental indicators that quantify the pressure on the environment, assess the ecosystem condition of and impacts on human activity resulting from changes in the environment quality They measure the environment's characteristics and provide a starting point for performance assessments (Zanella, 2012). As mentioned above, the EPI is built on 2 strategic goals:

- environmental protection to reduce threats to people's lives.
- ensuring ecosystem vitality by moderate use of natural resources.

According to the previous studies' findings (Esty *et al.*, 2002; Hsu *et al.*, 2014; Samimi 2010; Liu *el al.*, 2017; Saisana and Saltelli 2008), the use of the EPI index as a benchmark that characterizes the level of environmental safety of Ukraine when providing place-to-place comparisons was proposed. In the study, the methodology to assess the index of the environmental and economic performance of Ukraine's regions in the framework of this academic study was applied (Brichuk, 2003; Serov, 1998). The index must accomplish three vital strategic goals (Figure 1).

Figure 1. *The functional purpose of the regional index of environmental and economic efficiency.*



Source: *Own elaboration.*

In the following steps, each strategic goal is considered in detail (Aleksandrov, 2012; Lagunova, 2003; Zebzeyeva, 2017):

1. Reducing the environmental impact of economic growth:

Any economic growth is associated with the increased negative human impact caused by higher environmental pollution. One can say that society pays a reasonable environmental price for each percent of economic growth. Regions of Ukraine are very heterogeneous according to the sectoral structure. For example, the major air pollutants in the Dnipropetrovs'k and Donets'k regions specialise in mining, processing, and electric power industries, in turn, in Vinnitsya and Chernihiv regions – in agriculture, forestry, and electric power industry, etc. Each industry is characterized by the average rate of value-added and pollution. Indicators of this group are the relative indices of performance that compare environmental damage and its impact on the economy. Air emissions, consumption and production of contaminated water, mineralization of agricultural areas and pesticide application, solid waste accumulation, and deforestation are used to assess the damage caused. Accordingly, the volume of gross regional product or the volume of agricultural and forestry products output assesses the economic impact:

$$I_{EE} = \frac{ED}{GRP} \tag{1}$$

where: I_{EE} – indicator of environmental performance of economic growth; *ED* – environmental damage; *GRP* – gross regional (industrial) product, c.u.

2. Ensuring regional environmental sustainability:

Regional environmental sustainability directly depends on the environmental damage rate. The calculation of the damage rate involves assessing the scale of the phenomenon attributed to the total area. Therefore, the basis for all the group's indicators is the following formula:

$$I_{ES} = \frac{ED}{RA}, \tag{2}$$

where I_{ES} – an indicator of the ecological footprint of a region; RA – total area of a region, ha.

3. *Reducing threats to regional health:*

Relative indicators that compare the ecological impact and population size are widely used in statistics, e.g., emissions to air per person. The indicators of this kind, which consider population as the basis of comparison, yield little information because:

- if emissions in a specific area remain unchanged, and the population size is growing, this indicator will decrease; however, the health of each person will be influenced by the same unchanged amount of emissions;
- if there is population growth in the area with a continually high ecological footprint, this means that the higher share of it begins to experience negative human impact.

Therefore, it was proposed to use the model of a multiplicative type to calculate indicators of environmental health impact:

$$I_h = EI_n \times Sp \tag{3}$$

To bring indicators values to the comparable expression, the procedure of their limitation (Kachinsky, 2001) is performed according to the formula: where I_h – an indicator of the environmental health impact; EI_n – standard environmental impact; S_p – standard population size. Every factor represented in model (3) changes in the range from 0 to 1. Thus, the resulting index I_h will vary [0; 1]. Lower environmental impact or population decline in a region will cause EI_n and S_p indicators minimization. This, in turn, will bring the indicator I_h to zero. Conversely, the growth of standard factors within the admissible parameters will automatically approximate the I_h indicator values to 1. To bring indicators values to the comparable expression, the procedure of their limitation (Kachinsky, 2001) is performed according to the formula:

$$I_{norm} = \frac{I - I_{worst}}{I_{best} - I_{worst}}, \tag{4}$$

where I_{norm} – a standard value of environmental and economic efficiency indicator; I – input indicator value; I_{best} – the best possible indicator value that should be reached; I_{worst} – the worst indicator value.

Values I_{best} and I_{worst} are chosen based on I values' assessment for all regions. Moreover, to monitor the resulting index value in dynamics, they were determined according to 2014-2016 data. If the indicator must be maximized, it equals the maximum value in all regions in the recent period and equals the minimum value. Conversely, if the indicator must be minimized, then it equals minimum value and equals maximum. Indicators convolution to the regional *PI* index of environmental and economic efficiency is carried out with the help of an additive model:

$$PI = \alpha_1 I_{EE} + \alpha_2 I_{ES} + \alpha_3 I_h \rightarrow \max \qquad (5)$$

where I_{EE}, I_{ES}, I_h – a group of indices for the 1st, 2nd, 3rd strategic target; α_1, α_2, α_3 – weighting coefficients which assess the importance of each strategic goal. Weighting coefficients, α_1, α_2, α_3 may vary from 0 to 1, and the sum must equal to 1. In the regional index, every strategic goal must equally affect the *PI*. It is possible if mean square deviations of each component are equal (Sadovnikova 2006), that is:

$$\sigma(\alpha_1 I_{EE}) = \sigma(\alpha_2 I_{ES}) = \sigma(\alpha_3 I_h) \qquad (6)$$

To ensure this identity, it is sufficient to use numerical methods for the following optimization problem solution as for unknown weighting coefficients, α_1, α_2 and α_3:

$$[\sigma(\alpha_1 I_{EE}) - \sigma(\alpha_2 I_{ES})]^2 + [\sigma(\alpha_2 I_{ES}) - \sigma(\alpha_3 I_h)]^2 \rightarrow \min$$

$$\alpha_1 + \alpha_2 + \alpha_3 = 1 \qquad (7)$$
$$\alpha_1 \le 1 \quad \alpha_2 \le 1 \quad \alpha_3 \le 1$$
$$\alpha_1 \ge 0 \quad \alpha_2 \ge 0 \quad \alpha_3 \ge 0$$

Group of indices for every strategic target were calculated using correlated standard index values according to formulas:

$$I_{EE} = \frac{\sum_{k=1}^{n_1} I_{EE,norm,k}}{n_1}; \quad I_{ES} = \frac{\sum_{k=1}^{n_2} I_{ES,norm,k}}{n_2}; \quad I_h = \frac{\sum_{k=1}^{n_3} I_{h,norm,k}}{n_3} \qquad (8)$$

where n_1, n_2, n_3 – respectively, is the number of indicators of the first, second and third strategic goals.

In formula (8), indicators with similar weighting coefficients for ranking are considered. If experts who make decisions obtain another ranking system, the appropriate formulas become of an additive and multiplicative form. The indicator system, which generates a group of indices for each strategic goal, was determined based on the following assumptions, indicators should fully reflect the state of human impact on all major contaminations, i.e., atmosphere, water consumption, fertilization and pesticides use, forest resources consumption, waste production, and recycling. In total, 20 indicators were used when generating the regional index of environmental and economic efficiency. When calculating the group index I_{EE} the following indicators were used:

- total emissions as well as CO_2 emissions in the air from stationary sources per 1 USD of regional product,
- total I-III hazard class of waste generation per 1 USD of regional product,
- deforestation area per 1 USD of the forestry sector,
- total pesticides use per 1 USD of agricultural products,
- total water consumption and production of contaminated water per 1 USD of regional product.

The calculation for the I_{EE} group index was based on the following indicators:

- total emissions and CO_2 emissions from stationary sources per m^2 of a region,
- total I-III hazard class of waste generation per m^2 in a region,
- total waste accumulation and I-III hazard class of waste per m^2 of a region,
- change of total canopy cover to the total forested area,
- pesticide application ratio to the total area of agricultural land,
- total water consumption and production of contaminated water per m^2 of a region.

The last group index I_h was calculated using the following indicators:

- the relative size of total emissions into the air per number of inhabitants by region,
- the relative size of pesticide application per number of inhabitants by region,
- the relative size of total water contamination per number of inhabitants by region.

When calculating the group index I_h, the indicators of the direct impact on human health, total waste generation in storage, and diminishing forest area were not considered. The solution to the optimization model allowed to obtain weighting coefficients for the equation:

$$PI = 0.2768 \times I_{EE} + 0.3163 \times I_{ES} + 0.4068 \times I_h \tag{9}$$

The values α_1, α_2 and α_3 form equal impact of each strategic goal on the regional index of environmental and economic efficiency: corresponding mean square deviations are:

$$\sigma(\alpha_1 I_{EE}) = \sigma(\alpha_2 I_{ES}) = \sigma(\alpha_3 I_h) = 0.0434 \quad (10)$$

Summary results of calculations are given in Table 1.

As it can be seen in Table 1, the worst situation according to 2016 data was observed in Donets'k, Dnipropetrovs'k, Zaporizhzhia and Luhans'k regions, and the best - in Zakarpattya, Volyns'k, Chernivets'k and Rivnens'k regions.

Table 1. *The results of calculations of the regional index of environmental and economic efficiency according to 2016 data*

Regions	I_{EE}	I_{EC}	I_h	PI	Rank
Vinnytsia	0.865	0.828	0.904	0.869	13
Volyn	0.941	0.907	0.971	0.943	2
Dnepropetrovs'k	0.511	0.439	0.577	0.515	23
Donets'k	0.356	0.347	0.548	0.431	24
Zhytomyr	0.908	0.854	0.958	0.911	5
Zakarpattya	0.973	0.946	0.968	0.962	1
Zaporizhzhia	0.574	0.646	0.866	0.715	22
Ivano-Frankivs'k	0.783	0.779	0.904	0.831	19
Kyiv	0.861	0.803	0.852	0.839	16
Kirovohrad	0.741	0.840	0.951	0.858	14
Luhans'k	0.493	0.791	0.887	0.748	21
Lviv	0.901	0.833	0.890	0.875	12
Mykolayiv	0.677	0.829	0.944	0.834	17
Odessa	0.743	0.836	0.908	0.839	15
Poltava	0.866	0.842	0.925	0.882	10
Rivne	0.915	0.880	0.964	0.924	4
Sumy	0.708	0.611	0.942	0.772	20
Ternopil	0.875	0.848	0.962	0.902	6
Kharkiv	0.814	0.789	0.882	0.834	18
Kherson	0.848	0.840	0.961	0.891	7
Khmelnytsky	0.881	0.823	0.948	0.890	8
Cherkassy	0.875	0.816	0.938	0.882	11
Chernivtsi	0.934	0.862	0.976	0.928	3
Chernihiv	0.843	0.855	0.945	0.888	9

Source: *Own study based on SSSU data.*

3. Results and Discussion

Thus, the scientific novelty of the study is the development of a model of regional index of environmental and economic efficiency, the functional purpose of which is to reduce the environmental cost of economic growth, ensure environmental sustainability of the region and reduce harm to public health. This index considers the shortcomings of the practical use of the international environmental performance index EPI, it is based entirely on the official open data of the SSSU and allows to study the trends of these phenomena in the dynamics and in terms of regions.

To obtain more informative results of the study, the index, and its components for the period from 2014 to 2016 was calculated. This made it possible to estimate the average annual growth rate of each of the considered indicators and compare them with current values (Table 2).

Table 2. *Classification of Ukraine's regions according to the index of ecological and economic efficiency based on the data for years n2014-2016.*

PI	Direction of change		
	Increase	Sustainable development	Decrease
Above average level	**(I)** Poltava, Kherson	**(II)** Zhytomyr, Zakarpattya, Rivne, Vinnytsia, Ternopil, Cherkassy, Chernihiv	**(III)** Volyn, Chernivtsi, Lviv, Khmelnytsky
Average level	**(IV)** Kirovohrad, Kharkiv	**(V)**	**(VI)** Ivano-Frankivs'k, Kyiv, Mykolayiv, Odessa
Below average level	**(VII)**	**(VIII)**	**(IX)** Sumy, Dnipropetrovs'k, Zaporizhzhia, Luhans'k, Donets'k

Source: *Own study based on SSSU data.*

Table 2 is a combinational grouping of two indicators:

- index of ecological and economic efficiency of regions, which for the purpose of grouping has been transformed into an attributive feature and takes values: above average level, average level, below average level, etc.
- the average annual growth rate of the index, which also in the form of an attributive feature takes the value: growth, which corresponds to a growth rate; sustainable development, where the growth rate is within 0; fall, with a negative growth rate.

The combination of possible values of these indicators forms 9 separate sectors that combine different regions of Ukraine with common indicators of ecological and economic development. Also in Table 2 arrows show the most likely transitions from one sector to another, taking into account the growth rate of the index:

- for the direction of change to "growth" the index of ecological and economic efficiency most likely improves the positions by transition to sector above. If there is a gradual slowdown, it leads to a transition from growth to sustainable development;

- for the direction of change to "fall", the index is most likely to worsen its position by moving to a lower sector. If the decline can be stopped, there is a transition to one of the sectors of sustainable development;
- sustainable development is characterized by a constant value, that is, vertical transitions across sectors do not occur.

The first sector is characterized by a value that exceeds the national average with a simultaneous tendency to improve. In terms of environmental and economic efficiency, these are the areas with the best current status and prospects for development. At the end of 2016, they included Poltava and Kherson regions. Although in the generalized rating of Table 1 these areas rank 7th and 10th, their ranks are calculated on the basis of static data and do not take into account the dynamics of change in recent years. When the growth rate of the environmental efficiency index slows down, the areas of this group continue to remain in the lead, but may move to the right to the second sector with sustainable development, which is the most numerous. Given the cyclical nature of any macroeconomic process, this transition is inevitable.

The second sector in Table 2 includes both leading regions in the index and areas with high competitive positions, but lower ratings. A feature of this sector is its sustainability over time due to sustainable development. Zakarpattya, Rivne, Zhytomyr and Ternopil regions have the best scores. At the beginning of 2017, they were leaders in environmental and economic efficiency. In the future, they have the opportunity to return to the first sector, or remain in the same position. At the same time, Vinnytsia, Cherkasy and Chernihiv regions of this sector have a much lower rating, so the main task for them is to reduce the risks of losing their position and preventing the transition to the third sector.

The third sector is represented by Volyn and Chernivtsi regions, which rank topmost in the environmental and economic efficiency, but have a moderate decrease between 2014 and 2016. Further research is needed to identify the factors that led to the negative growth rate and, through appropriate management, to transfer these areas to a sustainable development regime. Lviv and Khmelnytsky regions, which are also part of this sector, have lower levels and higher rates of decline. The main task for them is to identify a set of all the problems and prevent further deterioration of the situation by stabilizing it and moving to the fifth sector.

The fourth sector is characterized by the average values of the index in Ukraine and its gradual growth. It includes Kharkiv and Kirovohrad regions. Being in this sector for a long time, the region increases its competitive advantages, after which it moves to the first or second sector. In particular, Kharkiv region in 2014-2016 showed an annual increase of 1%. Although, in the overall ranking at the end of 2016 it ranked 18th, if this trend is maintained in the medium term, the region has the opportunity to improve its position in terms of environmental and economic efficiency. At the same time, Kirovohrad region has an annual increase of 0.27% and 14^{th} place in the ranking. Given this trend, this area is likely to move to the fifth sector over time. Therefore, special attention should be paid to environmental measures in the Kharkiv region to prevent a reduction in the positive dynamics.

The fifth sector, which does not currently include any region, is in equilibrium with the national average. It can be argued that this state is a bifurcation point, the presence of which does not guarantee an unconditional definition of future prospects. Even a slight deviation from this state will determine the further trajectory. The planned improvement of the ecological and economic situation in the region with the transition to the fourth sector will allow increasing competitive advantages over time.

Conversely, if we allow an increase in the environmental impact on the environment, over time the value of the index and the overall rating of the region will deteriorate. The inertia of ecological and economic processes, in this case, is very significant and it is connected, first of all, with the main pollutants of the environment, which are industry. The gross regional product of each region is formed by the corresponding branch structure; to change those considerable capital investments are necessary. For example, 46.0% of all air emissions in Ukraine are in the supply sector, and 31.7% - in the processing industry. If these industries are dominant in the structure of production, it is very difficult to change the ecological and economic situation in the region. In addition, over time, the gap between the areas will only widen. Examples of such regions are Donets'k, Dnipropetrovs'k, Zaporizhzhia, Ivano-Frankivs'k and Luhans'k regions. That is why the development strategy of the region in the fifth sector, can determine its environmental and economic prospects for the long term.

The regions of the sixth sector currently have average environmental and economic efficiency in Ukraine, but its growth rate is negative, ie, over time, the situation tends to deteriorate. These include Ivano-Frankivs'k, Kyiv, Mykolayiv and Odessa regions. The problems of these areas are the critical values of indicators of environmental efficiency of economic growth. In other words, the amount of damage caused to gross regional product significantly exceeds the national average. The seventh and eighth sectors provide for a level of environmental and economic efficiency index below the national average. The difference between them lies in the nature of the dynamics of the studied phenomenon: the seventh sector is in the zone of growth of the index, and the eighth - in the zone of sustainable development. At the end of 2016, no region of Ukraine was part of them. The ninth sector includes the most depressed regions in terms of environmental and economic efficiency. They are characterized by the greatest load on the environment, which over time tends to increase.

According to Table 2, it includes Sumy, Dnipropetrovs'k, Zaporizhzhia, Luhans'k and Donetsk regions. As noted earlier, the main problem in these areas is the focus of industry on primary processing of resources, which is characterized by high emissions of pollutants. In the short term, this problem can be partially solved through active financing, implementation and use of existing treatment facilities. However, in a strategic sense, improving the ecological and economic state of these regions is possible only through the reorientation of industry to modern, environmentally friendly production with a higher added value share.

The reluctance to solve the problems of ecological and economic efficiency of local authorities and the largest polluters in the areas of the sixth and ninth sectors is shown by comparative statistics of the gross regional product and the amount of damage to the environment. Table 3 shows the statistics on gross regional product for the regions with the lowest index for 2014-2016 and the corresponding growth rates.

Table 3. *Gross regional product according to the 2014-2016 data*

Regions	Gross regional product, UAH million				Gross regional product, million USD			
	2014	2015	2016	Growth rate	2014	2015	2016	Growth rate
1	2	3	4	5	6	7	8	9
Dnipropetrovs'k	176540	215206	240682	16,8%	14852	9852	9420	-20,4%
Donets'k	119983	115012	131600	4,7%	10094	5265	5150	-28,6%
Zaporizhzhia	65968	89061	98203	22,0%	5550	4077	3843	-16,8%
Ivano-Frankivs'k	37643	45854	52158	17,7%	3167	2099	2041	-19,7%
Kyiv	79561	104030	119034	22,3%	6693	4762	4659	-16,6%
Luhans'k	31393	23849	33615	3,5%	2641	1092	1316	-29,4%
Mykolayiv	35408	48195	56338	26,1%	2979	2206	2205	-14,0%
Odessa	74934	99761	119084	26,1%	6304	4567	4661	-14,0%
Sumy	30397	41567	45366	22,2%	2557	1903	1776	-16,7%

Source: *Own study based on SSSU data.*

Columns (2) - (4) of Table 3 present data from the SSSU on gross regional product in annual prices. The corresponding average annual growth rate, column (5), looks quite optimistic: we will have annual growth from 3.5% to 26.1%, depending on the region. However, if we take into account the inflation factor, then in comparable prices, instead of growth, in all regions without exception, we will get a significant decline. For this reason the volume of gross regional product in columns (6) - (8) was converted into dollars. at the average annual rate of the National Bank of Ukraine. The corresponding growth rates, column (9), indicate a significant economic downturn: annually, the economy of the regions in question lost from 14.0% to 29.4% of its gross domestic product. Thus, given that industry is one of the main sources of environmental pollution, it can be assumed that emissions of pollutants and CO_2 into the atmosphere should also have been reduced (Table 4).

Table 4. *Volumes of pollutant emissions into the atmosphere from stationary sources of pollution according to the data for 2014-2016*

Regions	Emissions of pollutants into the air, thousand tons				Emissions of CO_2 into the air, thousand tons			
	2014	2015	2016	Growth rate	2014	2015	2016	Growth rate
1	2	3	4	5	6	7	8	9

Dnipropetrovs'k	856	724	833	-1,3%	32919	25642	30993	-3,0%
Donets'k	1043	918	981	-3,0%	42376	36000	38180	-5,1%
Zaporizhzhia	207	194	167	-10,1%	12977	13901	13232	1,0%
Ivano-Frankivs'k	229	224	197	-7,3%	11274	11575	11267	0,0%
Kyiv	96	78	98	1,0%	5746	4632	5026	-6,5%
Luhans'k	198	115	156	-11,3%	15816	6550	9796	-21,3%
Mykolayiv	16	16	14	-6,5%	1872	1816	2067	5,1%
Odessa	23	26	26	6,7%	3030	3232	2097	-16,8%
Sumy	27	18	20	-14,4%	1509	1245	1602	3,0%

Source: *Own study based on SSSU data.*

The dynamics of emissions from stationary sources of pollution did not depend on production volumes. For example, in 2014-2016, Dnipropetrovs'k region annually reduced its gross regional product by 20.4%. At the same time, emissions of pollutants decreased by only 1.3% and CO_2 - by 3%. This means that firms are not interested in solving the environmental problems of the region and do not feel corporate social responsibility to the population. The reduction in production costs was due to the shutdown of treatment facilities. On the other hand, local authorities and regulatory authorities, assuming a similar situation, prove their inability to solve environmental and economic problems in the region. A similar disproportion between the dynamics of gross regional product and the volume of pollutant emissions into the atmosphere took place in all other regions. Some types of emissions even increased, e.g. in the Zaporizhzhia with a drop in production by 16.8%, CO_2 emissions increased by 1% annually. A similar situation occurred in Kyiv, Mykolaiv, Odessa, and Sumy regions. Thus, it may be concluded that the regions that are part of the ninth sector and currently have no prospects for solving environmental and economic problems, whicg sstrongly impacts their competitiveness level.

The above classification of regions enabled obtaining a general comparative description of regions according to the index of ecological and economic efficiency and to assess their future prospects. However, such an analysis does not fully elucidate the causes of the lag and the most vulnerable pollution factors. For a more detailed analysis, the index should be broken down into components. It is known to be formed by the index of the ecological price of economic growth I_{EE}, index of ecological sustainability of regions I_{EC} index of damage to public health. Table 5 shows the results of the classification of regions of Ukraine according to the I_{EE} index and the dynamics of its growth.

Table 5. *Classification of Ukraine's regions according to the index of ecological price of economic growth according to the 2014-2016 data.*

I_{EE}	Growth rate		
	Growth	Sustainable development	Fall
Above average level	**(I)** Poltava, Kherson	**(II)** Zhytomyr, Rivne, Vinnytsia	**(III)** Volyn, Zakarpattya, Lviv, Khmelnytsky, Chernivtsi, Kyiv, Ternopil, Cherkasy, Chernihiv

Average level	**(IV)**	**(V)** Kharkiv	**(VI)** Ivano-Frankivs'k
Below average level	**(VII)** Kirovohrad	**(VIII)**	**(IX)** Odessa, Mykolayiv, Sumy, Dnipropetrovs'k, Donets'k Zaporizhzhia, Luhans'k

Source: *Own study based on SSSU data.*

In order to interpret the obtained results, it should be mentioned that indicators of the environmental price of economic growth measure environmental damage as a share of economic performance, i.e., gross regional product. If indicators of the I_{EE} index increase, this means that environmental pollution is more rapid than corresponding regional growth in volume terms. Corresponding standard values of indicators will decrease, nearing zero. Conversely, a decrease in this group's indicators' values means that each USD of the gross regional product causes less environmental damage. Corresponding standard values of the indicators will rise nearing 1. Considering this, the drop in the I_{EE} index for the vast majority of regions is of concern. The worst situation is observed in Zaporizhzhia and controlled territories of Donets'k and Luhans'k. Even though the gross regional product in comparable prices in years 2014-2016 fell rapidly, environmental damage per 1 currency unit rose.

Hence, facing growing effects of economic crisis, income reduction amid lower demand, business owners almost all over Ukraine optimize spending, first of all, at the cost of environmental protection measures. The situation requires tight state regulation and the introduction of a penalty system. The penalty system should establish environmental protection measures in terms of expenditures feasible for a domestic producer. Porter and van der Linde (1995) believe that proper environmental regulatory policies will encourage enterprises to apply innovative products or technologies. The environmental-friendly investment behavior of enterprises not only supports the innovation and use of clean technologies but also decreases the cost of environmental pollution. Simultaneously, it may influence productivity growth and create a competitive advantage (Ansutegi and Marsiglio, 2017; Zhang 2019). Expenses on investment in environmental protection, both public and private sector, are very low in Ukraine. Programs in this field include far more than might be financed, and the share of realised application is low (usually less than 10%).

Furthermore, sometimes the programs that were realised, not necessrily were of highest importance. (World Bank, 2016). Currently, the most attention should be paid to the technologies ensuring increase of resource efficiency (effective management of resources through their entire life cycle), that strictly relates to eco-innovations, modifications in the production and consumption structure), growth of awareness (management awareness is believed to be a crucial element in the area environemental protection). Pprogress in green technologies, with the increasing acceptance of renewable energy sources, rising popularity of ecological management and new systems of recording, monitoring and reporting on pollutants and wastes are also crucial (Sushchenko and Loseva, 2017).

In order to determine the reasons for the I_{EE} index fall in the years 2014-2016, the factor analysis of this indicator applying the method of absolute differences was conducted (Table 6) (Khvesyk, 2014; Natsionalna… 2007; Tatatynov, 2010).

The last column in Table 6 contains the total change of I_{EE} caused by all factors simultaneously, the previous columns – by individual factors. The following symbols are used in Table 6:

$\Delta I_{EE,1}$ – change of the I_{EE} index caused by air emissions from stationary sources per 1 USD of regional product, kg;

$\Delta I_{EE,2}$ – change of the I_{EE} index caused by CO_2 emissions in the air from stationary sources per 1 USD of the regional product;

$\Delta I_{EE,3}$ – change of the I_{EE} index caused by waste generation per 1 USD of regional product, kg;

$\Delta I_{EE,4}$ – change of the I_{EE} index caused by I-III hazard class of waste generation per 1 USD of regional product, kg;

$\Delta I_{EE,5}$ – change of the I_{EE} index caused by the area of pesticides use per 1 USD of agricultural product, m^2;

$\Delta I_{EE,6}$ – change of the I_{EE} index caused by water consumption from natural water body per square kilometer of a regional product, m^3;

$\Delta I_{EE,7}$ – change of the I_{EE} index caused by the production of contaminated water per 1 USD of regional product, m^3;

ΔI_{EE} – a total change of the I_{EE} index relative to the 2014 baseline.

***Table 6**. The results of factor analysis illustrating indicators impact on* I_{EE}.

Regions	$\Delta I_{EE,1}$	$\Delta I_{EE,2}$	$\Delta I_{EE,3}$	$\Delta I_{EE,4}$	$\Delta I_{EE,5}$	$\Delta I_{EE,6}$	$\Delta I_{EE,7}$	ΔI_{EE}
Donets'k	-9.56%	-9.05%	-1.93%	-4.98%	-5.71%	-7.74%	-1.77%	-40.75%
Dnipropetrovs'k	-3.42%	-3.06%	-4.02%	-0.47%	0.57%	-1.98%	-1.56%	-13.94%
Luhans'k	-5.03%	-4.35%	-0.51%	-0.52%	-0.43%	-1.34%	-1.03%	-13.20%
Sumy	-0.05%	-0.66%	-0.01%	-7.86%	-0.83%	-0.58%	-1.35%	-11.34%
Zaporizhzhia	-0.64%	-2.94%	-0.33%	-0.34%	-0.06%	-4.60%	-1.04%	-9.94%
Ivano-Frankivs'k	-1.89%	-3.95%	-0.24%	-0.16%	-0.15%	-0.35%	-0.04%	-6.79%
Odessa	-0.17%	0.07%	-0.01%	-0.22%	-1.38%	-2.71%	0.42%	-4.01%
Khmelnytsky	-0.40%	-0.93%	-0.14%	-0.20%	-1.44%	-0.67%	0.08%	-3.70%
Ternopil	-0.25%	-0.13%	-0.17%	-0.59%	-1.51%	0.09%	-0.14%	-2.71%
Lviv	-0.61%	-0.54%	-0.08%	-0.09%	-0.14%	-0.21%	-0.78%	-2.44%
Chernihiv	-0.34%	-0.60%	-0.05%	-0.06%	-1.97%	-0.31%	0.98%	-2.33%
Kyiv	-0.50%	-0.42%	-0.09%	-0.70%	0.02%	-0.42%	-0.17%	-2.29%
Cherkasy	-0.15%	-0.81%	-0.12%	-0.02%	-0.01%	-0.30%	-0.31%	-1.72%
Zakarpattya	-0.14%	-0.09%	-0.04%	-0.04%	-0.25%	-0.47%	-0.44%	-1.47%
Chernivtsi	-0.12%	-0.14%	-0.10%	-0.01%	-0.62%	-0.39%	-0.02%	-1.38%

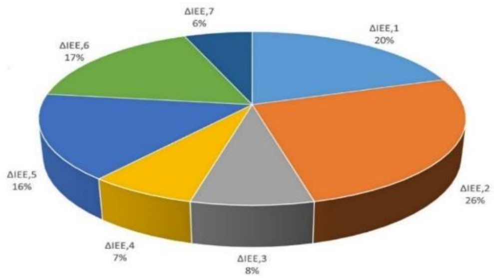
Mykolayiv	-0.09%	-0.76%	-0.23%	1.92%	-1.22%	-0.46%	-0.53%	-1.37%
Volyn	-0.07%	-0.15%	-0.09%	0.02%	-0.63%	-0.05%	0.10%	-0.88%

Source: *Own study based on SSSU data.*

Thus, for the controlled territory of the Donets'k, the index of the environmental price of economic growth dropped by 40.75%. The most influential factors were: emissions into the air per 1 USD of the regional product (-9.56%); CO_2 emissions per 1 USD of the regional product (-9.05%); water consumption from natural water body per 1 USD of the product (-7.74%); area of pesticides use per 1 USD of agricultural product (-5.71%); I-III hazard class of waste generation per 1 USD of the product (-4.98%) etc. In the Zaporizhzhia region, the index of the environmental price of economic growth dropped by 9.94%. The most influential factors were: water consumption from natural water bodies per 1 USD of the regional product (-4.60%), CO_2 emissions per 1 USD of the regional product (-2.94%); emissions into the air per 1 USD of the regional product (-0.64%). Therefore, using the results of factor analysis (Table 6), an opportunity to develop a program of environmental and economic recovery for each region focused on reducing ecological footprint in the most significant areas occurs.

The generic indicators ranking by their impact on I_{EE} in the area of Ukraine was built based on the arithmetic mean and ranking method, according to Table 6. Hence, emissions of CO_2 and other air pollutants per 1 USD of the regional product were the biggest problem of Ukraine's economic growthi n 2014-2016. The effect of indicators on change of the I_{EE} for entire Ukraine as a whole is shown in Fig. 2. It shows the correlation between indicators of the environmental price of economic growth and its drop for Ukraine as a whole. This ratio represents the system of benefits that should be taken into account for maximizing I_{EE} in the future.

Figure. 2*. The effect of indicators on I_{EE} change for the entire Ukraine in the years 2014-2016.*



Note: *For indications see table 6.*
Source: *Own study based on SSSU data.*

The next component of the environmental and economic performance index is the index of environmentally sustainable regions I_{ES}. Table 7 shows the results of the classification of Ukraine regions by their ranking and dynamics of growth. The calculation of the index of environmentally sustainable regions I_{ES} is based on a system of indicators for measuring the environmental damage correlated with the region. When environmental damage decreases, the standard value of the index I_{ES} upturns nearing 1. In contrast, the growth of human impact on the environment in a specific area will near the standard value of the index I_{ES} to zero.

Table 7. *Classification of regions of Ukraine applying the index of environmentally sustainable regions in the years 2014-2016.*

I_{ES}	**Growth rates**		
	Growth	**Sustainable development**	**Recession**
Above average	**(I)** Zakarpattya region, Rivne region, Mykolayiv region, Poltava region, Ternopil region, Kherson region	**(II)** Chernivtsi region,Vinnytsya region,Zhytomyr region,Lviv region	**(III)** Volyn region, Kirovohrad region, Odessa region, Khmelnytsky region, Cherkasy region, Chernihiv region
Average	**(IV)** Luhans'k, Ivano-Frankivs'k, Kharkiv regions	**(V)** Kyiv region	**(VI)**
Below average	**(VII)** Donets'k region, Dnipropetrovs'k region	**(VIII)**	**(IX)** Zaporizhzhia region, Sumy region

Source: *Own study based on SSSU data.*

The most struggling regions are located in sectors where the index of environmentally sustainable regions' value is below average and where its growth rate is negative. The combination of these two factors is typical for Zaporizhzhia and Sumy regions, located in the ninth sector. According to factor analysis, the following main factors of the I_{ES} change in these regions were identified:

a. in the Zaporizhzhia region, the overall change was -9.94%, i.e., mainly due to the following factors: total canopy cover to the total forested area decreased, which reflected in -3.31% indicator change; pesticide application size rose (-0.91% indicator change); CO_2 emissions per km^2 increased (-0.09% indicator change); pollutant emissions per 1 km^2 decreased (0.58% indicator change); water consumption from natural water body declined (0.5%); production of contaminated water fell (0.45%).
b. in Sumy region: total I-III hazard class of waste generation per 1 km^2 increased (-3.99%); total canopy cover to total forested area declined (-0.98%); total I-III hazard class of waste accumulation per 1 km^2 increased (-0.71%); the volume of pesticide application rose (-0.39%); production of contaminated water increased (-0.23%); water consumption from natural water body decreased (0.13%); pollutant emissions per 1 km^2 fell (0.12%).

Thus, in Zaporizhzhia and Sumy regions, the origins of the index of environmentally sustainable regions' dynamics were unclear: specific indicators set testifies growth of human impact in absolute terms, the other proves upward trends. However, it should

be taken into consideration that according to the assessment for the end of 2016 in the Zaporizhzhia and Sumy regions, these standard values are the lowest in Ukraine, except for Donets'k and Dnipropetrovs'k regions. Thus, public regulatory bodies in these regions should provide strong fiscal measures against enterprises breaking environmental laws to prevent further negative impacts on the environment in the face of the persistent recession and production scaling down.
Seventh sector regions are characterized by the upward trend of the I_{EE} between 2014 and 2016; however, its value by the end of 2016 significantly worsened than in other regions. Thus, the growth of I_{EE}, in the investigated period in Donets'k region from 0.3406 to 0.3468 was equal to 1.82% and in Dnipropetrovs'k region from 0.3943 to 0.4385, which was 11.20%. Hence, the ecological footprint in these regions significantly exceeds similar indicators in other regions. Moreover, current growth rates of I_{EE}, especially in the Donets'k region, cannot improve the mid-term environmental situation. The most relevant indicators of environmental sustainability, which level is significantly below average around Ukraine, are as follows:

- Dnipropetrovs'k region: waste generation (8124 Kt in 2014 and 6448 Kt in 2016 per km^2) and the overall total of accumulated waste (313146 Kt in 2014 and 320717 Kt in 2016 per 1 km^2) is the highest among all Ukrainian regions; water consumption (49024 m^3 in 2014 and 10284 m^3 in 2016 per 1 km^2); production of contaminated water (9773 m^3 in 2014 and 7643 m^3 in 2016 per 1 km^2); the next largest after Donets'k air polluting region (emissions of 26.8 tons in 2014 and 26.1 tons in 2016 per 1 km^2) and CO_2 emitter (emissions of 1031 tons in 2014 and 970 tons in 2016 per 1 km^2).
- Donets'k region: the largest air polluting area in Ukraine (emissions of 39.3 tons in 2014 and 37.0 tons in 2016 per 1 km2) and carbon CO_2 (1598 tons in 2014 and 1440 tons in 2016 in 1 km^2); I-III hazard class of waste production (4.6 Kt in 2014 and 5.5 Kt in 2016 per 1 km^2) and the overall total of accumulated waste (37151 Kt in 2014 and 32611 Kt in 2016 per 1 km^2); water consumption (63996 m^3 in 2014 and 40284 m^3 in 2016 per 1 km^2); production of contaminated water (11162 m^3 in 2014 and 7643 m^3 in 2016 per 1 km^2).

Evidently, the set of ecological issues for these regions stems from their industry structure and the need for significant capital investment. All third sector regions in Table 8 experienced a decrease in the environmental sustainability index between 2014 and 2016 by less than 1%. Therefore, the main task is to stop further deterioration of its value. These regions' typical problems are reducing total canopy cover (except Kirovohrad region) and extensive pesticide application in agriculture. The outlined challenges can be effectively resolved using regulatory instruments.

The last component of the index of environmental and economic performance is the index environmental health impact I_h. The most influential indicators directly affecting public health are air pollutant emissions, excessive pesticide application in agriculture, and waterbody contamination. Table 8 shows the classification of regions of Ukraine by the index value and its growth rates. Evidently, the set of ecological issues for these regions stems from their industry structure and the need for significant capital investment. In this case, the declining index of environmental health impact was observed only in the Kyiv region $\Delta I_h = -7.21\%$ due to the increasing volume of produced contaminated water (-2.56%); the higher number of pesticides applied (-2.34%), and larger emissions of air pollutants (-2.31%). Particular attention should also be paid to the regions in the seventh sector. It is characterized by a positive growth rate of I_h. However, the current environmental health impact values index is lower than the Ukrainian average (these include the Zaporizhzhia, Dnipropetrovs'k, and Donets'k regions).

Table 8. *Classification of regions of Ukraine applying the index of environmental health impact in the years 2014-2016.*

I_h	**Growth rates**		
	Growth	**Sustainable development**	**Recession**
Above average	**(I)**	**(II)** Chernivtsi region, Volyn region, Zhytomyr region, Zakarpattya region, Kirovohrad region, Mykolayiv region, Poltava region, Rivne region, Sumy region, Ternopil region, Kherson region, Khmelnytsky region, Cherkasy region, Chernihiv region	**(III)**
Average	**(IV)** Ivano-Frankivs'k, Luhans'k, Kharkiv regions	**(V)** Vinnytsya region, Lviv region, Odessa region	**(VI)**
Below average	**(VII)** Zaporizhzhia region, Dnipropetrovs'k region Donets'k region	**(VIII)**	**(IX)** Kyiv region

Source: *Own study based on SSU data.*

The determined indices allowed to indicate the better-positioned regions, which, to some extent, also reflects in higher regional competitiveness. Meyer-Stamer (2008) defined territory competitiveness as "the ability of a locality or region to generate high and rising incomes and improve the livelihoods of the people living there." This definition bases on the benefits to the population of a region. It characterizes competitive regions not only by using output-related terms such as productivity but also by determining the sustained or raised level of comparative prosperity (Bristow 2010). Dijkstra *et al.* (2011) highlighted that regional competitiveness combines both companies and inhabitants' view. It is the "ability to offer an attractive and sustainable environment for firms and residents to live and work." They also underline that sustainability is not understood in the environmental sense only.

However, it means a region's capacity to provide an attractive environment in short- and long-term. Therefore, the conducted research proves that the Zaporizhzhia region is in a significantly better competitive position, considering all considered index indicators. It is at the average national level due to the amount of pesticide used and water pollution affecting public health. The lag refers to the total emissions of pollutants. However, the region has an excellent opportunity to improve its position and move to the fourth sector considering the present trend to their reduction, which will reflect in the region's competitiveness. Meanwhile, Dnipropetrovs'k and Donets'k regions are characterized by a significant lag due to air emissions and high-water consumption.

5. Conclusions

The scientific novelty of the research is developing the model of the regional ecological and economic performance index. Its functional purpose is to reduce the environmental cost of economic growth, ensure the environmental sustainability of a region, and reduce public health impact. This index considers the disadvantages of the international environmental performance index (EPI) application: it is based on the State Statistics Service of Ukraine's official open data. It allows for studying the dynamics of trends and the regional context as well. The research results revealed the following advantages and disadvantages of the proposed model. Besides, some regions of Ukraine illustrate practical calculations of the EPI model efficiency. Advantages of the EPI index of environmental efficiency include:

1. The EPI index allows to perform interstate comparisons of Ukraine as well as other countries situation (Pimonenko *et al.*, 2018);
2. Disaggregation of the EPI index enables finding out the strengths and weaknesses of Ukraine in terms of environmental protection and sustainability;
3. The methodology of the EPI scoring is available to the public, which allows, to a certain extent, to assess the impact of policymaking on its quantitative value;

On the other hand, practical application of the EPI as an indicator of the national economy development is based on specific objective difficulties, which significantly reduce the scope of its application, namely:

1. The EPI assessment methodology was adjusted between 2006 and 2018 (Esty *et al.*, 2002, Hsu *et al.*, 2016). Each report was different from the previous one because of the set of assessment indicators and the number of countries covered by this study. Recent changes to the EPI calculation methodology were made in the 2018 report: by now, as it was mentioned before, it covers 24 indicators calculated for 180 countries around the world (Wendling, 2018). Thus, continuous assessment methodology adjustments and the number of countries scored as the comparison's bases do not allow to analyze the dynamics of trends;
2. A certain set of indicators included within the EPI, e.g., Biodiversity and Habitat indicators group cannot be calculated using SSSU open data. On the other hand, researchers from Yale and Columbia Universities receive data directly from international organizations, research institutes, and public institutions. The collection process is based on a variety of methods. Indicators that cannot be obtained by continuous or selective observation are calculated within the statistical

models. Therefore, it is possible to apply the indicators already calculated for the analysis for period of 2 years. However, it is hardly possible to perform similar calculations to monitor the situation on an ongoing basis;
3. The Environmental Performance Index is calculated for every country. However, Ukraine's environmental conditions, industry, and agriculture development are heterogeneous, each region has its peculiarities, economic potential, social development, natural resources, and environmental pollution. Therefore, aggregate EPI assessment provided at a national level is insufficient for effective environment safety management in Ukraine.
4. Expert judgment, input data reliability, and lack of subjectivity contribute to its lower credibility.

The developed model of regional ecological and economic performance index allowed to conduct a comparative analysis of Ukraine's regions defining the most problematic ones (Donets'k and Dnipropetrovs'k regions, due to their industrial character and lack of investment). Further indicators' factor analysis provided a quantitative assessment of anthropogenic impact and specify the priority environmental improvements (first implementing appropriate regulations and growth of capital investment) aiming towards lowering the ecological footprint, ensuring regional environmental sustainability and reducing public health impact, which translates in the level of competitiveness of regions.

Based on the study, it was concluded that the financial factor, especially environmental costs, has a significant meaning in providing a suitable level of environmental sustainability. One of the most important conclusions of the EPI is that reaching sustainability aims needs investment in the infrastructure essential to preserve ecosystems and humans. Building facilities for providing better sources of drinking water, managing wastewater, and reducing pollution is essential in this area. (Krysovatyy *et al.*, 2018).

Such activities improving the infrastructure of business and society would increase the competitiveness of the Ukraine’s regions. These results evidently showed that Ukraine needs a consistent regional policy, comprising properly created strategies and current goals with suitable instruments to achieve these targets in the most efficient manner. This policy should be aimed in strategic perspective and designed in a way to ensure environmental protection, competitiveness, and economic growth in regions.

The range of environmental legislation in Ukraine is somewhat broad and comprehensive, nevertheless, it is mostly declaratory and not harmonised, moreover, the necessary implementation mechanisms are insufficient (World, 2016) Some improvement may be reached by the signing in 2014 of the Ukraine-EU Association Agreement and the implementation of the 2014-2017 action plan for its execution and the adoption of plans for introducing EU directives and regulations linked to energy, environment and technical guidelines.

Moreover, the Ukraine-2020 Sustainable Development Strategy approved in 2015 outlines goals to guarantee sustainable economic development without exhausting the natural environment. The Action Plan for the introduction of the Strategy recommends integrated measures for improving environmental management as well as monitoring methods (Report…, 2016), which will make the regions of Ukraine more competitive on domestic and international market.

References:

Aleksandrov, I.O. 2012. Metodolohiya otsinky yakosti navkolyshnoho seredovyshcha Ukrayiny. Marketynh i menedzhment innovatsii, 3, 221-228.

Ansuategi, A., Marsiglio, S. 2017. Is Environmental Protection Beneficial for the Environment? Rev. of Dev. Econ., 21(3), 786-802.

Brinchuk, M.M. 2003. Environmental Law. Yurist, Moscow.

Bristow, G. 2010. Critical Reflections on Regional Competitiveness. Routledge.

Buckland, S.T., Marrugan, A.E, Green, R.E., Fewster, R.M. 2005. Monitoring Change in Biodiversity Through Composite Indices. Philos. Trans. of the R. Soc. B., 360, 243-254.

Bucher, S. 2016. Measuring of Environmental Performance Index in Europe. Rocz. Ochr. Śr., 18, 46-64.

Dijkstra, L., Annoni, P., Kozovska, K. 2009. A New Regional Competitiveness Index. Theory, Methods and Findings. European Union Regional Policy. Working Papers, 2.

Esty, D.C., Levy, M.A., Granoff, I.M.E., de Sherbinin, A. 2002. Environmental Sustainability Index. Yale Center for Environmental Law & Policy, New Haven.

Färe, R., Grosskopf, S., Hernandez-Sancho, F. 2004. Environmental Performance: an Index Number Approach. Resour. and Energy Econ., 26, 343-352.

Figus, A. 2016. Sistema Ucraina. Eurolink University Press.

Gazzola, P., Dymchenko, O., Sribnyi, V., Panova, O. 2019. Towards Sustainable Urban Development: the Ukrainian situation. Geopolitical, Soc. Sec. and Freedom Jour., 2(2), 92-100.

Gorynska-Goldmann, E. 2019. Barriers to the development of consumption sustainability: The consumers' perspective on the food markets. In: Double-blind peer reviewed proceedings part I. of the International Scientific Conference Hradec Economic Days 2019 Hradec Králové, February 5-6, 2019, Hradec Králové, Czech Republic, Jedlička, P., Marešová, P., Soukal, I. (Eds.), University of Hradec Kralove, Hradec Kralove, 243-251.

Hediger, W. 2000. Sustainable development and social welfare. Ecol. Econ., 32(3), 481-92.

Hsu, A., Emerson, J.W., Levy, M.A., de Sherbinin, A., Johnson, L., Malik, O.A., Jaiteh, M. 2014. The 2014 Environmental Performance Index. Yale Center for Environmental Law & Policy. New Haven, USA.

Chess, C., Johnson, B.B., Gibson, G. 2005. Communicating About Environmental Indicators. J. of Risk Res., 8(1), 63-75.

International Atomic Energy Agency. 2005. Indicators for Sustainable Development. International Monetary Fund.

Kachinsky, A.B. 2001. Environmental safety of Ukraine: systematic analysis of prospects for improvement. NISD, Kyiv.

Kamensky, E.G., Boev, E.I. 2015. An innovation civilization in the context of the anthroposphere crisis of the technogenic society. Asian Social Science, 11(4), 328.
Khvesyk, M.A. 2014. Ecological and natural-technogenic safety of Ukraine in the regional dimension. DU Instytut ekonomiky pryrodokorystuvannya ta staloho rozvytku NAN Ukrayiny. Kyiv, Ukraine.
Krysovatyy, A.I., Zvarych, I.Y., Zvarych, R.Y., Zhyvko, M.A. 2018. Preconditions for the Tax Environment of a Alterglobal Development. Comparative Economic Research. Central and Eastern Europe, 21(4), 139-154.
Lagunova, A.I. 2003. The structure of ecological safety of Russia. SibGTU, Krasnoyarsk.
Liu, G., Brown, M.T., Casazza, M. 2017. Enhancing the Sustainability Narrative through a Deeper Understanding of Sustainable Development Indicators. Sustainability, 9.
Meyer-Stamer, J. 2008. Systematic Competitiveness and Local Economic Development. In: Large Scale Systemic Change: Theories, Modelling and Practices Bodhanya, S. Ed. Nova Science Pub Inc.
Natsionalna ekolohichna polityka Ukrayiny: otsinka i stratehiya rozvytku: (Pidhotovleno v ramkakh proektu PROON/HEF «Otsinka natsionalnoho potentsialu v sferi hlobalnoho ekolohichnoho upravlinnya v Ukrayini»), Kyiv, Ukraine, 2007.
OECD. 2014. OECD Territorial Reviews: Ukraine 2013. OECD Publishing.
Pimonenko, T., Lyulyov, O., Chygryn, O., Palienko, M. 2018. Environmental Performance Index: relation between social and economic welfare of the countries. Environ. Econ., 29(3), 7-16.
Porter, M.E., van der Linde, C. 1995. Toward a New Conception of the Environment Competitiveness Relationship. J. of Econ. Perspect., 9, 97-118.
Prus, P. 2017. Sustainable Farming Production and its Impact on the Natural Environment - Case Study Based on a Selected Group of Farmers. Proceedings of the 8th International Scientific Conference Rural Development, 1280-1285.
Punyatoya, P. 2014. Linking environmental awareness and perceived brand eco-friendliness to brand trust and purchase intention. Glob. Bus. Rev., 15(2), 279-289.
Report on Green Transformation in Ukraine. 2016. Eap Green. Ministry of Economic Development and Trade of Ukraine.
Sadovnikova, L.K. 2006. Ecology and environmental protection by during chemical pollution. Vysshaya Shkola, Moscow.
Saisana, M., Saltelli, A. 2008. Sensitivity Analysis of the 2008 Environmental Performance Index. European Commission, Joint Research Centre, Luxembourg.
Samimi, A.J. 2010. Environmental Performance Index and Economic Growth: evidence from some Developing Countries. Aust. J. of Basic and Appl Sci., 4(8), 3098-3102.
Serov, G.P. 1998. Legal regulation of environmental safety in the implementation of industrial and other activities. Os-89, Moscow.
Skillius, A., Wennberg, U. 1998. Continuity, Credibility and Comparability. Key Challenges for Corporate Environmental Performance Measurement and Communication. The International Institute for Industrial Environmental Economics at Lund University, Lund.
Śmiglak-Krajewska, M., Wojciechowska-Solis, J., Viti, D. 2020. Consumers' Purchasing Intentions on the Legume Market as Evidence of Sustainable Behaviour. Agric., 10(10), 424.
Stakeholder Forum for Our Common Future. International Environmental Governance: A Briefing Paper. 2002.
Statistical Economic and Social Research and Training Center for Islamic Countries. 2007. Environmental Performance of OIC Member Countries, Ankara.

Sushchenko, O., Loseva, O. 2017. Management technologies of ensuring environmental protection as the territory development strategic priority. Innovative Economic Symposium 2018 - Milestones and Trends of World Economy. SHS Web of Conferences, 61, 1-11.
Tatarynov, A.V. 2010. Ekolohichna bezpeka ta stalyy rozvytok u suchasnomu sviti. Stratehichni priorytety, 3(16), 83-88.
Wendling, Z.A., Emerson, J.W., Esty, D.C., Levy, M.A., de Sherbinin, A. 2018. 2018 Environmental Performance Index. Yale Center for Environmental Law & Policy, New Haven.
Wojciechowska-Solis, J., Soroka, A. 2018. Polish society in the light of the use of renewable energy sources. Appl. Ecol. and Environ. Res., 16(1), 893-901.
World Bank. 2016. Ukraine Country Environmental Analysis. Washington.
World Bank. 2008. Environmental sustainability: An evaluation of World Bank group support. Technical report. World Bank, Washington.
World Commission on Environment and Development. 1987. Our Common Future. Oxford University Press, Oxford.
Zanella, A., Camanho, A.S., Dias, T.G. 2018. Benchmarking countries' environmental performance. J of the. Oper. Res. Soc., 64(3), 426-438.
Zaremba-Warnke, S. 2013. Marketing as a tool in the accomplishment of strategic paths of the economics of sustainable development. Rocz. Ochr. Śr., 15, 2850-2862.
Zebzeyeva, V.A 2017. Ekologo-gumanisticheskoye obrazovaniye: na puti k cheloveku kultury Available at: http://infoculture.rsl.ru/donArch/home/news/dek/2007/10/2007 10_r_dek s3.htm.
Zhang, J. 2019. Environmental Protection Investment and Market Value. Mod. Econ., 10, 399-411.