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Measuring of Environmental Performance Index in Europe

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1. Introduction

Selecting the appropriate indicators and methodology for arriving at the acceptable environmental quality of life, which quantify the impacts of environmental degradation on well-being, including impacts on health, access to natural resources, and losses caused by natural disasters is a subject of much debate and research.

Sustainable development is now primary objective in European countries policies. It rules, which require consistently of three areas: economy, society, and environment are the basis of EU guidelines for the use of aid programs (Kasperska 2015).

The study mainly consists of a desk review, and proposes and approach designed and implemented by the authors. Per se, the paper does not provide new indicators, but it does emphasize the need to implement a more systemic approach to the policymaking process, namely one that considers policy impacts across sectors and actors.

Regional disparity and natural endowment of the European countries are also considered important when ranking the countries. The general paper allegation is that environmental health and ecosystem vitality is not homogenously distributed across the Europe, territorial disparities are very strong in the regions, and thus, environmental health and ecosystem vitality levels fluctuate widely, with significant differences between different countries.

Coelho et al. (2012) focus on the development and validation of the Cleaner Treatment Index (CTI), to assess the environmental performance of waste treatment technologies based on the Cleaner Treatment concept. Volpe et al. (2013) found strong linkage between various natural resources and the Global Aquaculture Performance Index (GAPI) which is the first tool to assess the environmental performance of global marine aquaculture production, permitting direct comparison of disparities species, production methods, and jurisdictions.

Because of the influence of natural resources depletion and unabated pollution on many sectors of the economy and well-being of the citizens, we considered necessary to evolve an Environmental Performance Index and recognize environmental performance by states and devolve central funds (Chandrasekharan et al. 2013). In recent decades, there has been a growing awareness in society about the potential effects of the continued and unmanaged economic growth for the public and health and welfare of current and future generations (Rogge 2012). The topic has been studied quite extensively, and there are existing journals and book series focusing on these issues, in general. Ecologists and social scientists have attempted to explain trends among countries for various indices of Environmental Performance based primarily on environmental health, ecosystem sustainability, with varying results (Urbanc et al. 2014, Costantini & Monni 2008, Dahl 2012, Hak et al. 2012, Moldan et al. 2012, Bujanowicz-Haraś et al. 2015, Makarewicz-Marcinkiewicz 2015).

Likewise, research conducted by Garcia-Sanchez et al. (2015), indicated that Environmental Performance Index allows for determining the negative impacts that the driving forces have on the environment and the supposed pressure effect on the natural state of the available resources, which cause harmful effects environment. Based on findings of a multidimensional scaling analysis, Hsu et al. (2013) introduces pared-down versions of the 2012 Environmental Performance Index and trend indices to evaluate performance and progress over the last decade on the five policy categories related to statements specified in: Water (Effect on Human Health), Biodiversity and Habitat, Forestry, Fisheries, and Climate Change and Energy.

One of the most crucial challenges in a modern civilization, is environmental protection, which constitutes natural life fundament, including all human activities. Problems such as depletion of non-renewable resources, an endangerment of renewable resources (e. g. intensive fishing leading to species extinction), overpopulation, environment pollution on a global scale and connected with this fact, an impact on human health, species diversity and natural landscapes, global warming, the change of consumption models from resource-efficient and concentrated on spiritual values, and long periods ones into wasteful ones, and the ones which are directed into material values and extemporary, an increasing risk of control of most world markets through international corporations, all these lead to life quality deterioration (Zaremba-Warnke 2013).

2. Material and Methods

Another central element of the literature analysis is the methodological evaluation that has examined the main techniques which can be applied to measure Environmental Performance from an ecological point of view.

The main aim of the research was to identify key determining factors of Environmental Performance in Europe. Research was provided by nine competitiveness categories of Environmental Performance: (A1) Health Impacts; (A2) Air Quality; (A3) Water and Sanitation; (B1) Water Resources; (B2) Agriculture; (B3) Forests; (B4) Fisheries; (B5) Biodiversity and Habitat and (B6) Climate & Energy. The Environmental Performance Index builds on measures relevant to two core arguments (Chandrasekharan et al. 2013) – (a) reducing environmental stress to human health (the environmental health statement) and (b) protecting ecosystems and natural resources (the ecosystem vitality statement). Development of systems for environmental protection and risk assessment in never ending – is doomed to evolution (Olkiewicz et al. 2015).

Subsequently, independent variable – Human Development Index was included in the model. Mukherjee & Chakraborty (2009) suggest that the EPI for the states is linearly dependent on a set of observable indicators and can be determined by adopting the Human Development Index (HDI) method, by putting the selected variable to start with under nine broad categories, namely A1) Health Impacts; (A2) Air Quality; (A3) Water and Sanitation; (B1) Water Resources; (B2) Agriculture; (B3) Forests; (B4) Fisheries; (B5) Biodiversity and Habitat and (B6) Climate & Energy.

Environmental indicators can be broadly classed into two types of measures: end-of-process measures, otherwise known as lagging indicators, or in-process measures, also known as leading indicators. The study presented lagging indicators that are the type of metrics most commonly reported. Lagging indicators can be easy to quantify and understand; preferred by the public and regulators. The principal advantages of using lagging indicators are that they are usually readily quantifiable and understandable, and the data are often collected for other business purposes. The main disadvantage is that, as the name implies, they lag or reflect situations where corrective action can only be taken after the fact, and often after incurring some cost, whether it be in fines or decreased credibility with regulators or the public.

A limitation of this analysis is heterogeneity of the countries within the categories of Environmental Performance Index, which was determined by the existence of statistically significant differences in the average score in each indicator. Consequently, we were limited to analyzed data and the available relevant sources thus this may be frustrating not to give a complete panorama of this interesting subject of research.

3. Results

According to the results based on hierarchical cluster analysis implying a three-cluster solution, the group average method analysis segmented the samples into to the three different clusters (Table 1).

The spatial distribution of the development of the Environmental Performance Index in Europe displays that there is a significant distinction between High-income countries located in Western Europe and Scandinavia on one side and middle-income countries in Eastern Europe. The extremely highest and the lowest values of competitiveness categories calculated from country-level data and statistics illustrate cluster 1 and cluster 3 (Table 1).

To further examination, the characteristics of each cluster, mean score of the clusters has been estimated. The priority to environmental issues in Europe for each section cluster presents Figure 1.

Table 1. Means standardized score used for calculation of the Environmental Performance Index in Europe (the year 2014)
Tabela 1. Średnie standaryzowane wyniki użyte do obliczenia wskaźnika efektywności środowiskowej w Europie (rok 2014)

Competitiveness categories	**Cluster 1**	**Cluster 2**	**Cluster 3**
ENVIRONMENTAL HEALTH (EH)	**93.9**	**84.5**	**73.4**
Health Impacts	98.8	92.5	85.7
Air Quality	87.6	80.3	75.9
Water and Sanitation	95.3	80.6	58.7
ECOSYSTEM VITALITY (EV)	**67.0**	**54.1**	**36.9**
Water Resources	82.5	43.5	14.8
Agriculture	62.5	67.1	63.4
Forests	33.7	56.1	59.2
Fisheries	19.0	8.7	8.6
Biodiversity and Habitat	78.3	72.2	37.3
Climate and Energy	66.6	55.4	52.6
ENVIRONMENTAL PERFORMANCE INDEX (EPI)	**77.8**	**66.2**	**51.5**

Source: Compiled by the author

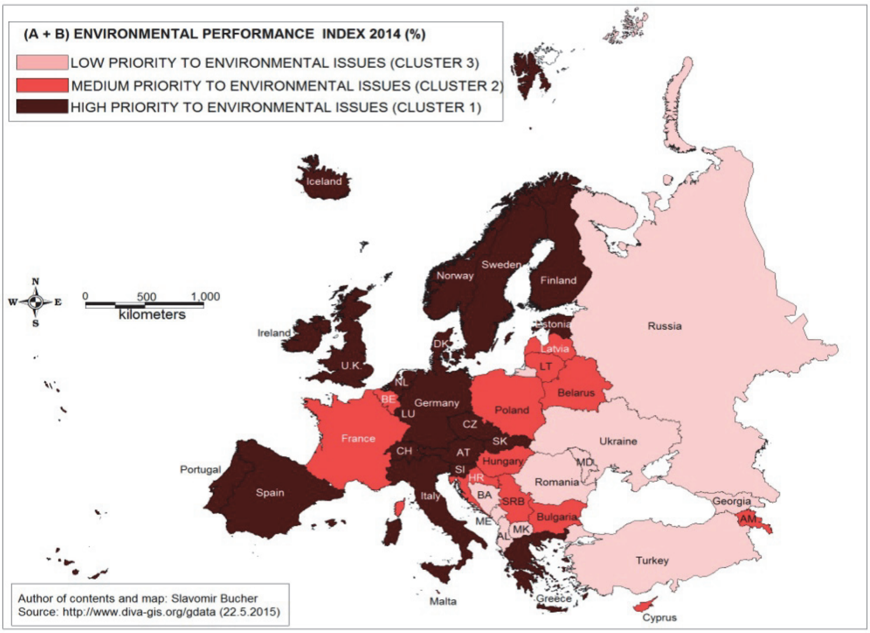

Fig. 1. Environmental Performance Index in Europe (the year 2014)
Rys. 1. Wskaźnik efektywności środowiskowej w Europie (rok 2014)

3.1 Environmental Health

To illustrate more specifically the basis for three categories related to environmental health, we evaluated of 43 selected countries individually (Table 2, Figure 2).

Table 2. Basic statistics of three categories related to EH for the Europe in the year 2014
Tabela 2. Podstawowe statystyki trzech kategorii związanych ze zdrowiem środowiskowym dla Europy w roku 2014

	N	Average	Std. Deviation	Coefficient of variation	Min. value	Max. value
ENVIRONMENTAL HEALTH (%)	**43**	**86.3**	**10.2**	**11.8**	**61.9**	**99.4**
Health Impacts (%)	43	93.8	8.2	8.7	66.1	100
Air Quality (%)	43	82.7	10.9	13.2	64.3	98.3
Water and Sanitation (%)	43	82.4	20.2	24.5	31.3	100

Source: Compiled by the author

Health Impacts measures child mortality. In the policy area, child mortality is narrowly defined as the death rate of children between the ages of one and five. Countries such as Turkey (66.1), Moldova (76.0) or Georgia (79.4) with the lowest values in this category face with higher child mortality as average in Europe due to environmental factors, including air pollution, airborne particulates, and lack of access to clean and drinkable water. Malnutrition, poverty, diseases, inadequate health care, and environmental factors all contribute to high child mortality. Contrary, on the other side of scale should be found countries such as Switzerland (100), Czech Republic (100), and Germany (100) among others, mostly located in Western part of Europe with the lowest child mortality rates and high standards of sanitation and health care. Disentangling the precise contributions is difficult, yet research conducted by Hsu et al. (2014) shows that diarrheal disease, lower respiratory tract infections, and other preventable diseases are highly linked to water and air pollution.

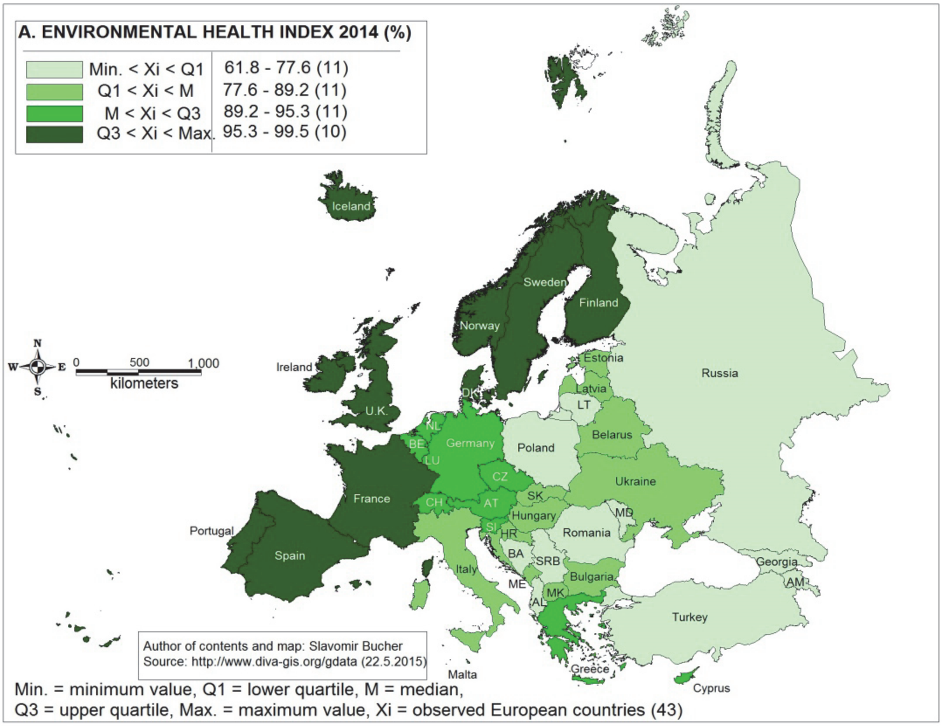

Fig. 2. Environmental Health in Europe (the year 2014)
Rys. 2. Zdrowie Środowiskowe w Europie (rok 2014)

Category profile of *air quality* includes three indicators: air pollution – average exposure to PM_{25} (fine particulate matter); PM_{25} Exceedance; and household air quality – indoor solid fuel usage. The lowest score of air quality gained Macedonia (64.3), Serbia (67.2), and Albania (68.2), which means, that the high percentage of the population still burning solid fuel (biomass such as wood, crop, residues, dung, charcoal, and coal) for cooking compared to countries located in Western part of Europe. Countries such as Malta (98.3), Finland (98.3), and Iceland (98.3) obtained the highest rating in air quality. It demonstrates that mentioned countries using a lower percentage of the solid fuel for cooking, which contributes to acute minor respiratory infections and another disease such as lung cancer. For prevention, it is necessary to monitor and report coarse particulate pollution or PM_{10} (particles between 2.5 and 10 microns in diameter).

Water and sanitation represent the last category among the environmental health framework. It is formed by a set of variables related to the percentage of households with access to drinking water; percentage of households with access to sanitation equipment. The highest score could be observed in Malta (100), Finland (100), and Iceland (100); which represent the countries with a high standard of well-being and good access to clean drinking water and sanitation. Unfortunately, in Europe, we may also detect broad regional disparities related to the quality of water and sanitation infrastructure. Poor quality of water and inadequate sanitation in the Eastern part of Europe; countries such as Romania (31.3), Lithuania (43.8), and Moldova (53.7) has further impacts on quality of life for millions of people, extending beyond public health by exacerbating gender inequality and stunning economic development.

3.2 Ecosystem Vitality

The second one statement provided the overarching structure of the 2014 EPI is Ecosystem Vitality, whose base consists of the selected categories: water resources, agriculture, forests, fisheries, biodiversity and habitat, and climate and energy (Table 3, Figure 3).

Table 3. Basic statistics of six categories related to EV Ecosystem Vitality for the Europe in the year 2014
Tabela 3. Podstawowe statystyki sześciu kategorii związanych z żywotnością ekosystemów dla Europy w roku 2014

	N	Average	Std. Deviation	Coefficient of variation	Min. value	Max. value
ECOSYSTEM VITALITY (%)	**43**	**56.1**	**13.6**	**24.2**	**24.6**	**84.7**
Water Resources (%)	43	54.9	33.7	61.3	0	98.8
Agriculture (%)	43	64.1	14.5	22.7	16.9	96.0
Forests (%)	43	46.5	29.7	63.8	3.3	100
Fisheries (%)	43	13.5	12.4	91.6	0	32.9
Biodiversity and Habitat (%)	43	66.9	26.6	39.7	2.5	100
Climate and Energy (%)	43	59.9	12.8	21.2	27.8	85.7

Source: Compiled by the author

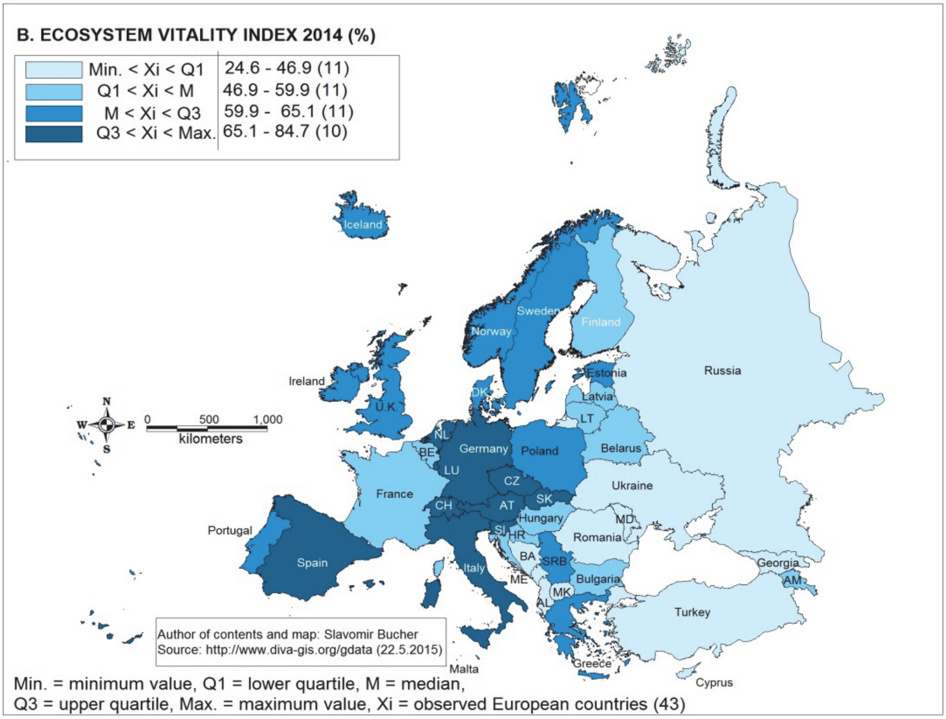

Fig. 3. Ecosystem Vitality in Europe (the year 2014)
Rys. 3. Żywotność ekosystemów w Europie (rok 2014)

Water resources tracks how well countries treat wastewater from households and industrial sources before releasing it back into to the environment. Among the leaders in recycled water, when water is given more advanced treatments and is used indirectly for drinking are followed countries: Netherlands (98.8), United Kingdom (97.9), Switzerland (96.0), and Germany (95.1). Untreated sewage typical for less development part of Eastern Europe (Georgia, Bosnia and Hercegovina, Albania, etc.) may disrupt the functioning of downstream ecosystems. Wastewater is comprised of domestic greywater (water from baths, sinks, washing machines, and kitchen appliances) and blackwater (water from toilets), as well as the industrial wastewater that may have additional chemical contaminants.

The second category of ecosystem vitality – *agriculture*, focuses predominantly on agricultural subsidies as a proxy measure for the degree of environmental pressure exerted by subsidizing agricultural inputs. Serbia reached the most favorable score (96) among 43 European countries. That country follows the *Convention on Persistent Organic Pollutants* using a low amount of pesticides, which are a significant source of pollution in the environment and public subsidies for agricultural protection and agrochemical inputs, which cause the expansion of farmland into sensitive areas, and the overexploitation of resources like water and soil nutrients. Authors Czechowska-Kosacka et al. (2015) emphasized that sewage sludge is a sustainable source of phosphorus and potassium compounds for the growth of biomass. Their application on cultivated land could be beneficial on condition that the level of pollution does not exceed the acceptable level, in particular with regard to heavy metals.

Further category *forestry* deals with the percent change in forest cover between 2000 and 2012 in areas with greater than 50 percent tree cover. The most encouraging score was observed in Serbia (100), Montenegro (100) and Moldova (100), there was limited reduction in the extent of forest cover, which has significant negative implications for ecosystem services and habitat protection.

Next category is *fisheries,* describe overall fishery health by showing whether countries are harvesting fish and invertebrates at unsustainable rates or through practices that significantly harm the coastal shelf ecosystem. Unfortunately, we faced with a lack of relevant data for 43 European countries; therefore, our research basis offers limited outputs.

The last two categories of EV have characterized *biodiversity and habitat*, and *climate and energy*. According to a partial score of *biodiversity and habitat indicator* the highest values reached Switzerland (100), Slovenia (100), Luxemburg (100), and Germany (100); they apply strict habitat protection law as well as conservation of biodiversity and support ecosystem services that are critical to sustaining human life and well-being. The lowest score of biodiversity and habitat presented Bosnia and Hercegovina (2.5), and Moldova (7.5). Given values point out on the negative impact on land use and microclimate change, increase the probability of invasive species and uncover overexploitation of remain biodiversity and habitat environment.

Climate and energy category divide countries into two main groups: first one represent by high-income European countries followed by Switzerland, Sweden, Norway, which reduce their outputs in carbon intensity. The second one includes middle-income European countries such as Ukraine, Bosnia, and Hercegovina or Armenia that reduce their change in the outputs of carbon intensity.

The correlation of the individual categories of environmental health and ecosystem vitality with the overall index of Environmental Performance (Table 4) has a high informative value, especially regarding the outcomes for the environmental sustainability and protection. A significant correlation is shown between Environmental Performance Index and environmental health, water, and sanitation, ecosystem vitality and water resources; on the other hand, the low correlation has been shown between the indicators agriculture and biodiversity and habitat.

Table 4 and Fig. 4 presents the results of the linear regression of the environmental health, ecosystem vitality, Human Development Index and Environmental Performance Index in 43 countries of Europe. In presenting model, the variables were entered consecutively to explore the effects separately. The independent variables are the environmental health, ecosystem vitality, and Human Development Index. Environmental Performance Index was significantly associated with the three independent factors. Complementary factors strongly influence the model.

According to this model, R-square, the percent of Environmental Performance Index, explained by three factors is 1.000. It means that three independent model explains 100 % of the variance. An important information presented in Table 4 refers to the adjusted R-square, which value is 1.000, meaning that the penalty for the possibility that some of the variances may be due to chance is zero. On the other side, the calculated standard error is Sig. (F) = 0.0, which means that the statistic has no random error. Analyzed results also show that Environmental Performance Index has a positive association with ecosystem vitality and environmental health according to standardized coefficient Beta. Partial correlations also show that the environmental health and ecosystem vitality have positive associations with Environmental Performance Index in the countries of Europe.

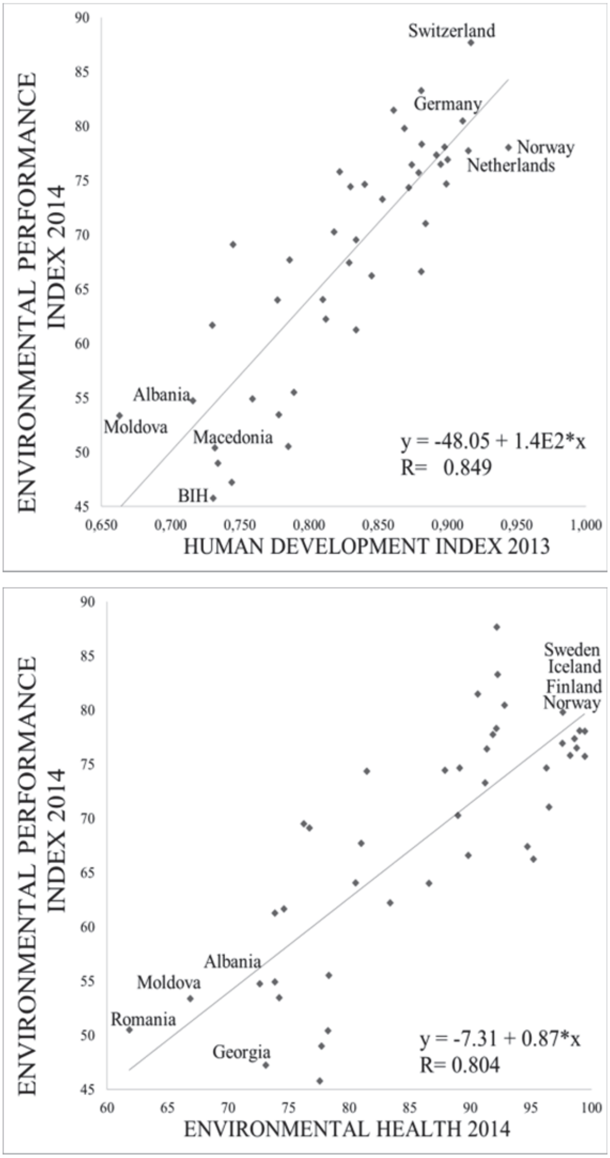

Fig. 4. Scatter charts of Environmental Performance Index 2014 and Human Development Index, Environmental Health in Europe
Rys. 4. Wykresy rozrzutu wskaźnika efektywności środowiskowej w 2014 oraz wskaźnika rozwoju społecznego, zdrowia środowiskowego w Europie

Table 4. Environmental Performance Index in relation to Environmental Health, Ecosystem Vitality and Human Development Index

Tabela 4. Wskaźnika efektywności środowiskowej w odniesieniu do zdrowia środowiskowego, żywotności ekosystemów i wskaźnika rozwoju społecznego

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations		
	B	Std. Error	Beta			Zero order	Partial	Part
(Constant)	0.002	0.008		0.272	0.787			
Environmental Health	0.400	0.000	0.368	4513.7	0.000	0.804	1.000	0.213
Ecosystem Vitality	0.600	0.000	0.738	10432.6	0.000	0.955	1.000	0.492
Human Development Index	-0.013	0.016	0.000	-0.827	0.413	0.849	-0.131	0.000

a. Dependent Variable: Environmental Performance Index, R^2= 1.000, Adjusted R^2= 1.000, DW= 1.689
F= 149740357.1 Sig. (F) = .000
** Correlation is significant at the 0.05 level (2-tailed)*
Source: Compiled by the author

4. Discussion

In the past decades researchers, attention was focused mainly on human consumption of natural resources and mounting evidence that elevated degradation and loss of habitats and species (Fish 2011). Our study showed that geographic variations and typologies of Environmental Performance at national level exist and may be identified.

Our research results regarding the influence of Human Development Index on Environmental Performance are by previous research results and confirm a positive relationship, as mentioned above.

On that note, there is ample of empirical research dedicated to determining what influences Environmental Performance. For instance, O'Brien (2013) investigated the influence of environmental health that is one key determinant of health, air, water and sanitation quality, and its positive effects on Environmental Performance outcomes as well known.

Brown (2014) has also studied the factors that determine Environmental Performance. The author concluded, that geographic dimension of environmental performance rate implies various distribution, territorial disparities and different types of evolution. Identification and understanding of geographic inequalities of Environmental Performance rate become an important mechanism needed in any study that aims a thorough analysis and causalities. The spatial analysis that was conducted in our research is an important tool for every study that aims to detect possible sources of heterogeneity or spatial patterns.

Previous ecological studies (Ekins 2011, Bell & Morse 1999, Jackson 2009, Prescott 2001), tested and measured the influence of other indexes, such as Well-Being Index, Living Planet Index, Ecological Footprint, City Development Index and its impact on environmental health and ecosystem vitality. A potential explanation of low correlation of indexes mentioned above on ecosystem vitality and environmental health can be found in the different methodological approaches and indicator measurement.

Authors Klonowska-Matynia & Sasin (2015) attempted to determinate the level of sustainable development EU countries based on estimated indicators in the context of the Europe 2020 strategy (a strategy for smart, sustainable and inclusive growth).

Ekkins (2011) suggests that there is a relationship between Environmental Performance and actions improving environmental sustainability. Ideally, these actions would involve: (1) the development of better measurement and monitoring systems to improve environmental data collection; (2) the creation of policies to address particularly weak areas; (3) the communication and reporting of national-level data and statistics to international agencies such as the United Nations; and (4) the delineation of sub-national metrics and targets for improved environmental performance.

5. Conclusion

Environmental Performance is the result of many intertwining factors. Ecological inequalities in the Environmental Performance Index are presented in all the countries of the world, even in the most developed ones. In order to create sustainable and efficient green environment essential for human health that would result in desired ecosystem vitality and environmental health outcomes, there has to be cooperation between the environmental sector and others sectors in a country.

The results of the research conducted in this paper indicate the competitive rank of European countries positioned on nine categories of Environmental Performance Index. To be precise, the results indicate that Human Development Index significantly influences Environmental Performance Index.

Lack of a competent environmental bureaucracy and legislation affect on environmental protection and sustainability. Moreover, the absence of functioning institutions and the government has had significant consequences for local ecosystems, along with disturbed biodiversity and habitat protection. Therefore, European countries such as Ukraine struggling with problems extend beyond their inability to sustain environmental and human health.

Outcomes of this research strongly highlight (Figure 4) that Iceland, Sweden, Denmark display admirable achievement regarding most effective indicators of Environmental Performance as a result of share smart policies that target improvements to their natural and built environments, along with a strong commitment to renewable energy.

Environmental Performance Index allows countries to compare their social and environmental inequalities. The Environmental Performance Index clearly demonstrate that the key to winning the competitive race in the sustainable environment is improvement and investment in the future: infrastructure (sanitation, water, and electricity facilities), healthcare, and education. In other words, improvement in the partial competitiveness of a country empowers growth in it long-term competitiveness.

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Miara wskaźnika efektywności środowiskowej w Europie

Streszczenie

W artykule przedstawiono jak indeksy wskaźnika efektywności środowiskowej (EPI) są skonstruowane, poprzez zebranie i obliczenie w dziewięciu kategoriach odzwierciedlających dane środowiskowe na poziomie krajów. W badaniu tym wykorzystano najnowsze trendy i działania w celu rozważenia oceny wpływu wskaźników na konkurencyjność efektywności środowiskowej w Europie.

W badaniach wykkorzystano wybrane metody wieloczynnikowej hierarchii obiektów i klasyfikacji. Przedstawiono również szeroki zakres najważniejszych i najczęściej używanych wskaźników oceny efektywności środowiskowej w oparciu o podstawową klasyfikację systemową potencjału środowiska.

Wysoka korelacja pomiędzy wskaźnikiem efektywności środowiskowej i wskaźnikiem rozwoju społecznego sugeruje, że analizowane kraje powinny poprawić stan zdrowia środowiskowego i witalności ekosystemów w celu poprawy długoterminowego zrównoważonego rozwoju. Innymi słowy, poprawa w części konkurencyjności danego kraju daje wzrost jego długoterminowej konkurencyjności środowiska.

Niniejszy artykuł to próba uszczegółowienia metodologii konstruowania EPI (wskaźnika efektywnoiści środowiskowej) dla danego kraju oraz, w oparciu o wyniki EPI, oceny krajów i pokazania osiągnięć dotyczących najważniejszych wskaźników zrównoważonego środowiska i rozwoju.

Abstract

The paper demonstrates how indices of Environmental Performance Index (EPI) is constructed through the calculation and aggregation of nine categories reflecting national-level environmental data. This study uses the most recent performance and trend data in order to consider the evaluation of indicators affected on Environmental Performance competitiveness in Europe.

Selected methods of multivariable objects hierarchy and classification have been used in the study. A wide range of the most important and most often used Environmental Performance assessment indicators based on a basic systemic classification of environmental potential will also be presented.

High correlation between Environmental Performance and Human Development Index suggested that the analyzed countries should improve environmental health and ecosystem vitality to improve the overall long-term sustainable development. In other words, improvement in the partial competitiveness of a country empowers growth in its long-term environmental competitiveness.

This article attempts to detail a methodology for constructing an EPI for the country and based on the EPI scores, rank the states and demonstrate commendable achievement regarding the most effective indicators of environmental sustainability and development.

Słowa kluczowe:
wskaźnik efektywności środowiskowej, zdrowie środowiskowe,
żywotność ekosystemu, Europa, zrównoważony rozwój, jakość środowiska

Keywords:
Environmental Performance Index, environmental health, ecosystem vitality,
Europe, sustainable development, environmental quality.