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Pro-environmental spendings and the environment in the activities of local government. Case study of regions in Poland⁵

Abstract

Economic activities contribute to environmental degradation, which underscores the importance of sustainable development in supporting regional development from an environmental perspective. Pro-environmental spending constitutes a key instrument of public policy, as it enables the reduction of anthropogenic pressure, the improvement of residents' quality of life, and the strengthening of regional development resilience. The aim of this article is to assess the level of pro-environmental

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expenditures and the state of the environment in the regions of Poland based on data from the periods 2010–2012 and 2020–2022. The study employs the CRITIC–TOPSIS method for linear ordering, which revealed a growing, albeit still weak, relationship between pro-environmental spending and the state of the environment. The level of pro-environmental spending across Polish regions is clearly spatially differentiated, with highly industrialized regions, such as Śląskie, Dolnośląskie, and Małopolskie, demonstrating higher levels of expenditures, often of a compensatory nature in response to historical environmental burdens. Nevertheless, a high level of spending does not unambiguously translate into a better environmental condition, which highlights the importance of natural and economic factors in shaping ecological quality. Regions with favorable natural conditions, such as Warmińsko-Mazurskie, Pomorskie, and Podkarpackie, achieve high environmental indicators with relatively low levels of spending. Consequently, effective environmental protection requires a differentiated, regionally tailored approach that combines adequate financing with local strategies for transformation toward a green economy.

Keywords: sustainable development, ecology, pro-environmental spending, region, environment, regions, synthetic measure.

Wydatki proekologiczne a stan środowiska w działalności samorządu terytorialnego – studium przypadku regionów w Polsce

Abstrakt

Działalność gospodarcza przyczynia się do degradacji środowiska, co podkreśla znaczenie zrównoważonego rozwoju we wspieraniu rozwoju regionalnego w aspekcie ekologicznym. Wydatki proekologiczne stanowią kluczowy instrument polityki publicznej, umożliwiają bowiem redukcję presji antropogenicznej, poprawę jakości życia mieszkańców oraz wzmocnienie odporności rozwoju regionalnego. Celem niniejszego artykułu jest ocena poziomu nakładów proekologicznych oraz stanu środowiska w regionach Polski na podstawie danych z okresów 2010–2012 oraz 2020–2022. W badaniu wykorzystano metodę liniowego porządkowania CRITIC–TOPSIS, która wykazała rosnącą, choć wciąż słabą zależność między nakładami proekologicznymi a stanem środowiska. Poziom wydatków proekologicznych w polskich regionach jest wyraźnie zróżnicowany przestrzennie – regiony silnie uprzemysłowione, takie jak śląskie, dolnośląskie i małopolskie, wykazują wyższy poziom nakładów, często o charakterze kompensacyjnym, w odpowiedzi na historyczne obciążenia środowiskowe. Niemniej wysoki poziom nakładów nie przekłada się jednoznacznie na lepszy stan środowiska, co uwypukla istotną rolę czynników przyrodniczych i gospodarczych w kształtowaniu jakości ekologicznej. Regiony o korzystnych uwarunkowaniach przyrodniczych, takie jak warmińsko-mazurskie, pomorskie i podkarpackie, osiągają wysokie wskaźniki środowiskowe przy stosunkowo niskim poziomie wydatków. W konsekwencji efektywna ochrona środowiska wymaga zróżnicowanego, dostosowanego do specyfiki regionalnej podejścia, łączącego odpowiednie finansowanie z lokalnymi strategiami transformacji w kierunku zielonej gospodarki.

Słowa kluczowe: zrównoważony rozwój, ekologia, wydatki proekologiczne, region, środowisko, województwa, miara syntetyczna.

JEL: Q58, H76, R11, M11.

INTRODUCTION

All economic activities contribute to environmental degradation, including resource depletion. In the context of today's environmental challenges, sustainable

development, the green economy, green infrastructure, and the zero-waste concept are crucial for promoting regional development while maintaining ecological balance. Local governments play a pivotal role in leading sustainable development initiatives. In Poland, regional and local self-government bodies play a significant, albeit shared with the central administration, role in the implementation of adaptation policies as well as environmental protection and sustainable development measures. As indicated by Kalbarczyk and Kalbarczyk (2022) and Klóska, Ociepa-Kicińska, Czyżycki, and Szklarz (2020), territorial self-government units participate in the preparation and execution of climate change adaptation programs and development strategies, including the formulation of regional strategic programs, management of European Union funds, and coordination of activities aimed at enhancing environmental resilience. They focus on creating programs to protect ecosystems, combat environmental degradation, restore habitats, and address climate change impacts like floods and droughts, ensuring long-term sustainability and biodiversity protection.

Environmental degradation creates negative externalities that market forces cannot address alone. Governments mitigate these risks using tools like pro-environmental spending, energy efficiency, green energy, and environmental taxes. According to Bhowmik, Ahsan Anwar, Raza Syed, The Cong, and Ngan Ha (2024), efficient management of natural resource rents is key to preventing environmental harm. As global economic activity grows, demand for natural resources increases, prompting OECD countries, as Sohag, Husain, and Soytas (2024) point out, to implement policies that balance development with ecological sustainability. Gao, Zhang, and Gao (2024) emphasize eco-efficiency as essential for supporting economic sustainability by increasing production while reducing inputs.

Kuciński (2009) highlights the importance of ecological and spatial development in respecting the natural environment and creating spatial order. This is influenced by resources, production structure, environmental relations, development policies, social and economic potential, and infrastructure, including green infrastructure. Misuse of resources often results from a lack of information on the true social and environmental costs, with the environment shaped by both human and natural factors.

Graczyk (2015) notes that market solutions can minimize the social costs of environmental policy goals. Market instruments help address issues like climate protection, air pollution, water protection, and biodiversity conservation.

Maintaining regional cooperation and holistic management of ecological systems is crucial for sustainable development. At the geographic scale, ecological synergy regions are necessary to maintain the integrity of regional ecosystems. At the administrative scale, as Hong *et al.* (2024) emphasize, governance entities must work together to manage these ecological spaces effectively.

The role of pro-environmental spending in local government activities, especially in Poland's regions, is essential in fostering sustainable regional development while balancing economic growth with environmental protection.

The aim of the article is to identify the level of pro-environmental spending and the state of environment, taking into account the context of spatial differentiation regions in Poland. The article presents the results of the study for the average value of the years 2010–2012 and 2020–2022, with the use of synthetic measure analysis, which allows to classify multi-objects. Based on the main objective, the following research hypothesis was formulated: pro-environmental spending does not significantly affect changes and the state of environment in Poland at the level of regions. Thus, the question is whether a higher level of pro-environmental spending is associated with a better state of environment at the regions?

The authors posed the following research questions: How do environmental and municipal expenditures affect the spatial variation of environment? What elements influence environmental activity? What is the relationship between spending on municipal management and environmental activities and environmental protection? To answer the above research questions and verify the research hypothesis, they used: analysis of the literature on the subject, descriptive statistics, and synthetic measures to achieve this aim.

LITERATURE REVIEW

Ensuring sustainable local economic development requires effectively utilizing both endogenous and exogenous resources. Jewtuchowicz (2005) highlights the importance of a holistic approach, integrating tangible and intangible aspects of human life and management. The environment provides energy, labour, and consumption means. Sustainable development involves recognizing that natural resources are limited, and their use should maximize recycling and reuse. The green economy connects elements like the environment, economy, infrastructure, and society, leading to monitoring areas such as natural capital and environmental efficiency (Global Green New Deal, 2020).

Skowroński (2003) emphasizes that eco-development integrates economic growth with environmental protection and quality of life. Climate action and green economies prioritize green policies and energy conservation. Environmental attractiveness can enhance the locational appeal for individuals, creating synergies that benefit local governments, society, and businesses while boosting competitiveness.

Huang, Gan, Liu, and Zhao (2024) highlight the growing importance of environmental issues in sustainable development discussions, focusing on balancing population growth, economic development, and ecological concerns. Achieving sustainability requires addressing environmental challenges through green infrastructure, pollution reduction, and eco-friendly supply chains. Ma *et al.* (2024) note that economies with limited green growth often neglect green policies to reduce pollution and energy waste.

Burchart (2001) emphasizes the importance of assessing environmental conditions for spatial planning. The closed-loop green economy (GE) offers benefits such as better resource management, reduced carbon footprint, and sustainable production. Leong *et al.* (2021) stress the importance of sustainable waste disposal for environmental protection. Khoshnava *et al.* (2019) define a green economy as one reliant on renewable energy sources, supporting sustainable development within environmental constraints. Ryszawska (2013) notes the multidimensional nature of the green economy, encompassing economic, social, and environmental aspects. Environmental expenditures are characterized by delayed effectiveness, partly due to the time required for industrial restructuring and the implementation of new technologies, which causes short-term evaluations to potentially distort the actual impact of such investments. Nevertheless, the literature emphasizes their crucial role in the green transformation: studies by Zhang, He, and Ma (2024) demonstrate that local fiscal expenditures on environmental protection contribute to CO₂ emission reductions through changes in industrial structure, whereas Krajewski (2016) indicates that these expenditures do not hinder economic growth and may even yield benefits during periods of crisis. Simultaneously, Yilmaz (2025) shows that increased public funding for environmental protection leads to reductions in certain gaseous pollutants, although the effects on CO₂ emissions may remain limited.

In Poland, there is a marked regional disparity in the level of public expenditures, including those environmentally focused, which directly influence the development of the green economy and the availability of green infrastructure. As noted by Jędrzejczak-Gas, Barska, Wyrwa, and Nowak (2024), these differences result from the varied availability of endogenous resources and the specific nature of regional and local administrative actions. Public expenditures by local governments constitute a key instrument shaping the regional conditions of the green transformation, and their analysis enables the identification of areas requiring support and optimization.

Telukdarie, Katsumbe, Mahure, and Murulane (2024) highlight the complexity of the green economy (GE), which requires a holistic approach to balancing environmental, economic, and social systems. GE aims to reduce environmental burdens, improve living conditions, and boost regional competitiveness (Hahnel, 2010). It ensures sustainable development through efficient natural resource use and focuses on reducing CO₂ emissions and promoting social inclusion (Dabyltayeva, Rakhymzhan, 2019). Fan and Wang (2024) emphasize GE as an effective means of implementing environmental sustainability through policies focused on clean technologies and renewable energy.

The green economy minimizes environmental risks, promotes social inclusion, and improves well-being (Yuyang, 2024). Efficient use of natural resources, as Ahakwa and Tackie (2024) note, can boost short-term ecological health but may harm it long-term if overused. Sustainable use reduces waste and environmental

impact, ensuring resources for future generations (Hassan, Shah, Yan, Yasmeen, Xu 2024). Ecological problems arise when human activities exceed the environment's natural capacity (Zhang, He, Ma, 2024).

Environmental investments in rural areas can create competitive advantages, improving economic performance (Rahko, 2023). Bozatli and Akca (2024) emphasize the importance of public spending in addressing environmental issues. Government spending influences business and household behaviour, promoting economic and technological processes that affect the environment (Borkowski, 2020). Environmental spending addresses waste management, biodiversity, pollution, and research, increasing as global demand for natural resources grows. Hossain (2024) notes that government spending is a crucial tool for solving environmental problems, accounting for a significant portion of GDP.

Environmental pollution affects lifestyles and ecosystems, leading to increased demand for environmental protection, which puts pressure on governments. According to Yang, Feng, Chang, and Wang (2021), environmental spending can improve efficiency, but rapid economic development often reveals a conflict between growth and environmental degradation. Local governments continue to spend on environmental protection, despite fiscal decentralization (Pan, Li, Guo, Pu, 2020). Fan, Yan, Chen, Ding, and Wang note that while environmental spending is key to social welfare, few studies explore its spatial interactions.

Sustainable local economic development requires proper use of endogenous resources and attraction of exogenous resources. Independent regional development highlights environmental factors, addressing challenges in peripheral areas by integrating ecological, economic, and social aspects (Wróblewski, 2012). Green areas are increasingly incorporated into development plans due to their ecological and social benefits, varying based on infrastructure design. Green infrastructure (GI) integrates natural processes into planning, enhancing environmental protection.

Pirowski (2014) equates GI with biodiversity and green spaces. Zhou *et al.* (2024) stress its role in reducing carbon emissions and supporting a circular economy. A. Zabel and Häusler (2024) note that GI generates local benefits, though its distribution and quality depend on financial resources and urban conditions. Economic barriers, like entrance fees and transportation costs, can limit access to GI, highlighting the need to address community and urban inequities (Wu, Wei, Liu, García, 2023).

Ecological risk, resulting from natural changes or human activities, threatens ecosystem health. Urbanization and industrialization make riverine ecosystems particularly vulnerable, especially in developing countries with rapid economic growth and high population density. Lu, Li, Fang, Deng, and Sun (2023) emphasize ecological risk assessment as crucial for understanding and preventing these threats, with risks varying by spatial scale.

RESEARCH METHODOLOGY

The study employed the CRITIC–TOPSIS method (Velasquez, Hester, 2013; Kozera, Dworakowska-Raj, Standar, 2021) for linear ordering of objects. Diagnostic variables were selected based on their substantive relevance, the authors' research experience, and the availability of comparable data from the Local Data Bank of the Statistics Poland (GUS). The dataset includes indicators of local government pro-environmental expenditures as well as measures of environmental conditions and ecological activity, enabling a comprehensive assessment of sustainable development efforts. The selection of variables reflects key areas of environmental policy, such as waste management, air protection, water and sewage management, energy efficiency, and anthropogenic pressure. The analysis covers the years 2010–2012 and 2020–2022, treated as representative periods corresponding to successive European Union funding programming cycles, due to the full availability of consistent data and the ability to capture changes in development and environmental policies. In this study, the term “region” refers to a voivodeship (province) as an administrative unit in Poland.

In creating a synthetic measure using the TOPSIS method, the following stages were applied (Wysocki, 2010):

Stage 1: Selection of study subjects (regions in Poland) and diagnostic variables (Table 1). This was done using the inverse correlation matrix method (diagonal value = 10) (Łuczak, 2015) and the coefficient of variation (cut-off value = 0.10) (Malina, 2004). The resulting observation matrix was formed accordingly.

$$X_{ij} = \begin{bmatrix} x_{11} & \cdots & x_{1n} \\ \vdots & \ddots & \vdots \\ x_{m1} & \cdots & x_{mn} \end{bmatrix} \quad (1),$$

where, X_{ij} – denotes the values of the j -th variable for the i -th object, a matrix of diagnostic variables describing the objects in terms of pro-environmental spending and ecology and environment, i – object number ($i = 1, 2, \dots, n$), j – variable number ($j = 1, 2, \dots, m$).

Table 1. Diagnostic variables describing pro-environmental spending (X1–X7) and environment and ecology activity (X8–X19)

No.	Diagnostic variables	Measure	s/d
1	2	3	4
Pro-environmental spending			
X1	Expenses for utilities	PLN/inhabitant	s
X2	Expenses for urban and rural cleaning	PLN/inhabitant	s
X3	Expenses on maintenance of greenery in cities and municipalities	PLN/inhabitant	s
X4	Expenditures on lighting of streets, squares and roads	PLN/inhabitant	s

1	2	3	4
X5	Expenditures on protection of atmospheric air and climate	PLN/inhabitant	s
X6	Expenditures on sewage management and water protection	PLN/inhabitant	s
X7	Expenditures on municipal waste management	PLN/inhabitant	s
Environmental			
X8	Forests	%	s
X9	Total dust emissions	t/r / km2 of area	d
X10	Total waste generated during the year	tys t / inhabitant	d
X11	Total legally protected areas	%	s
X12	ecological grounds	ha per 100 ha	s
X13	water consumption	m3 / inhabitant	d
X14	Industrial and municipal wastewater treated as % of wastewater requiring treatment	%	s
X15	Total mixed waste collected during the year	kg / inhabitant	d
X16	wild dumps existing – as of December 31	units per 100 km2	d
X17	wild landfills – liquidated – during the year	units per 100 km2	s
X18	Share of renewable energy in total electricity generation	%	s
X19	Population using wastewater treatment plants as % of total population	%	s

s/d – stimulant/destimulant

Source: own study based on data from the Statistics Poland (GUS) available in the Local Data Bank for the years 2010–2022 (<https://bdl.stat.gov.pl/bdl/dane/podgrup/temat>).

Stage 2: The diagnostic variables were normalized using the zero unitization method (Sompolska-Rzechuła, 2021). The normalization was done according to the formula:

$$X_j \in S; Z_{ij} = \frac{x_{ij} - \min_i x_{ij}}{\max_i x_{ij} - \min_i x_{ij}} \quad (2),$$

$$X_j \in D; Z_{ij} = \frac{\max_i x_{ij} - x_{ij}}{\max_i x_{ij} - \min_i x_{ij}} \quad (3),$$

where, S – stimulant, D – destimulant, $\max_{x_{ij}}$ – maximum value of the j -th variable ($i = 1, 2, \dots, n; j = 1, 2, \dots, m$), $\min_{x_{ij}}$ – minimum value of the j -th variable, x_{ij} – denotes the value of the j -th variable for it object. The matrix Z_{ij} of the normalized value of the j -th variable for the i -th object belongs to the interval $[0;1]$, has the formula:

$$Z_{ij} = \begin{bmatrix} z_{11} & \cdots & z_{1n} \\ \vdots & \ddots & \vdots \\ z_{m1} & \cdots & z_{mn} \end{bmatrix} \quad (4).$$

Step 3: A system of weights for variables was established using statistical procedures based on the CRITIC method (Yin *et al.*, 2023). A higher value of C_j indicates greater information derived from the criterion (Hassan, Alhamrouni, Azhan, 2023):

$$w_j = \frac{C_j}{\sum_{k=1}^K C_k}, j = 1, 2, \dots, K \quad (5),$$

$$C_j = S_{j(Z)} \sum_{k=1}^K (1 - r_{jk}), j = 1, 2, \dots, K \quad (6),$$

where, C_j denotes the information capacity measure of the i -th variable, $S_{j(Z)}$ is the standard deviation calculated from the normalized values of the i -th variable, r_{jk} correlation coefficient between the j -th and k -th traits. Z_{ij} the normalized value of the j -th variable for the i -th object, taking into account the level of weights, was determined according to the formula:

$$Z_{ij}^* = Z_{ij} * w_j \quad (7).$$

Step 4: The distance of each site from the pattern and anti-pattern of development was calculated (Jahanshahloo, Hosseinzadeh, Davoodi, 2009), and the value of the synthetic measure of pro-environmental spending and its impact on the environment and ecology was determined. The TOPSIS method, a benchmark approach (Glowicka-Woloszyn, Wysocki, 2018), was used to calculate this synthetic measure according to the formula (Velasquez, Hester, 2013; Kozera, Dworakowska-Raj, Standar, 2021):

$$q_i = \frac{d_i^-}{d_i^- + d_i^+}, \text{ gdzie } 0 \leq q_i \leq 1, i = 1, 2, \dots, n \quad (8),$$

$q_i \in [0; 1]$; d_i^- – means the distance of the object from the anti-pattern (from 0), d_i^+ denotes the distance of the object from the pattern (from 1).

Step 5: Inference, linear ordering, assessment of spatial relationships, and typological classification of objects based on the value of the synthetic measure were conducted. The results were presented through maps illustrating the spatial differentiation of regions, tables, and descriptive statistics created using Statistica software.

The calculated synthetic measure values allowed for the division of the studied regions into typological groups. Four typological classes of s were established using the mean ($\bar{x}$) and standard deviation (S_d) Provinces assigned to the first group exhibited the best performance, while those in subsequent groups showed progressively weaker results. The grouping was done according to the following formula:

$$\begin{array}{ll}
\text{Grupa 1} & \bar{x} + S_d \leq q_i \\
\text{Grupa 2} & \bar{x} \leq q_i < \bar{x} + S_d \\
\text{Grupa 3} & \bar{x} - S_d \leq q_i < \bar{x} \\
\text{Grupa 4} & q_i < \bar{x} - S_d
\end{array} \quad (9).$$

To assess the diversity (inequality of distribution) of the study population, the Gini coefficient was calculated:

$$G(y) = \frac{\sum_{i=1}^n (2i-n-1)y_i}{n^2 \bar{y}} \quad (10),$$

where: y_i is the value of the i -th observation, $\bar{y}$ is the average value of all observations y_i ; $G(y) \in [0,1]$. It should be interpreted that the higher the level of the coefficient, the greater the inequality of a given variable (Makarewicz-Marcinkiewicz, 2015).

RESULTS

The synthetic measure of pro-environmental spending in Poland ranged from 0.27 (Świętokrzyskie) to 0.64 (Śląskie) in 2010–2012, and from 0.15 (Warmińsko-mazurskie) to 0.65 (Dolnośląskie) in 2020–2022. The variation across regions was indicated by a coefficient of variation of 24.44 (2010–2012) and 32.72 (2020–2022), with the Gini coefficient showing a slight increase in concentration from 0.255 to 0.304. In terms of ecological status, the mean ranged from 0.52 to 0.54 across both periods. There was a slight decrease in provincial differentiation, with the coefficient of variation falling from 15.99 to 15.62, and the Gini index indicating a slight reduction in concentration (from 0.213 in 2010–2012 to 0.211 in 2020–2022).

Some regions, like Kujawsko-pomorskie and Wielkopolskie, maintained their rankings regarding pro-environmental spending, while Warmińsko-mazurskie was a consistent leader in ecological status. However, several regions, including Dolnośląskie, Małopolskie, and Świętokrzyskie, showed a decline in their positions concerning both pro-environmental spending and the environmental.

In group (I) of regions with a high level of pro-environmental spending were 2 regions (Śląskie i Dolnośląskie) in 2010–2012 and 3 regions (Dolnośląskie, Śląskie, Małopolskie) in 2020–2022. In the last group with the lowest synthetic measure were 2 regions (Podlaskie, Opolskie, Kujawsko-pomorskie, Warmińsko-mazurskie) (group IV). The regions in group I were characterized by a significantly higher level in the context of the variables studied in terms of stimulants and a lower level in terms of destimulants. The weakest group (IV) was described by relatively lower measures of diagnostic variables (Table 3). It is possible that expenditures on utilities and environmental protection have not kept pace with developments in the sphere of ecology (e.g. changes in green infrastructure, ecological infrastructures) in individual regions.

Table 2. Ranking of regions by synthetic measure of pro-environmental expenditures and environment in regions in Poland in 2010–2012 and 2020–2022 (according to the average value for the period)

Regions (voivodeship)	Synthetic measure of pro-environmental spending 2020–2022	Position	Regions (voivodeship)	Synthetic measure of pro-environmental spending 2010–2012	Position	Change in value	Change in position
Dolnośląskie	0.65	1	Śląskie	0.64	1	0.05	↑
Śląskie	0.61	2	Dolnośląskie	0.58	2	–0.1	↓
Małopolskie	0.59	3	Zachodniopomorskie	0.49	3	–0.01	↑
Pomorskie	0.5	4	Lubuskie	0.48	4	0.01	↑
Zachodniopomorskie	0.5	5	Małopolskie	0.45	5	–0.24	↓
Lubuskie	0.47	6	Łódzkie	0.45	6	0.02	↑
Podkarpackie	0.45	7	Podlaskie	0.41	7	0.48	↑
Łódzkie	0.44	8	Lubelskie	0.41	8	0.09	↑
Mazowieckie	0.42	9	Pomorskie	0.38	9	–0.24	↓
Świętokrzyskie	0.41	10	Podkarpackie	0.37	10	–0.17	↓
Lubelskie	0.37	11	Opolskie	0.35	11	0.28	↑
Wielkopolskie	0.33	12	Wielkopolskie	0.35	12	0.06	–
Podlaskie	0.28	13	Warmińsko-mazurskie	0.34	13	1.25	↑
Opolskie	0.28	14	Mazowieckie	0.33	14	–0.2	↓
Kujawsko-pomorskie	0.26	15	Kujawsko-pomorskie	0.28	15	0.08	–
Warmińsko-mazurskie	0.15	16	Świętokrzyskie	0.27	16	–0.35	↓

Regions (voivodeship)	Synthetic measure environment 2020–2022	Position	Regions (voivodeship)	Synthetic measure- re environment 2010–2012	Position	Change in value	Change in position
Warmińsko-mazurskie	0.68	1	Warmińsko-mazurskie	0.66	1	-0.03	–
Pomorskie	0.65	2	Kujawsko-pomorskie	0.64	2	0.06	↑
Podkarpackie	0.61	3	Pomorskie	0.63	3	-0.03	↓
Lubuskie	0.61	4	Podkarpackie	0.61	4	0	↓
Kujawsko-pomorskie	0.6	5	Lubuskie	0.59	5	-0.03	↓
Podlaskie	0.59	6	Podlaskie	0.58	6	-0.02	–
Zachodniopomorskie	0.57	7	Małopolskie	0.55	7	-0.01	↑
Lubelskie	0.56	8	Lubelskie	0.53	8	-0.05	–
Małopolskie	0.55	9	Zachodniopomorskie	0.51	9	-0.12	↓
Wielkopolskie	0.53	10	Łódzkie	0.49	10	0.22	↑
Opolskie	0.49	11	Dolnośląskie	0.46	11	-0.03	↑
Dolnośląskie	0.47	12	Mazowieckie	0.45	12	0	↑
Świętokrzyskie	0.47	13	Wielkopolskie	0.45	13	-0.15	↓
Mazowieckie	0.45	14	Opolskie	0.44	14	-0.1	↓
Śląskie	0.42	15	Świętokrzyskie	0.43	15	-0.08	↓
Łódzkie	0.4	16	Śląskie	0.41	16	-0.03	↓

Source: own study based on data from the Statistics Poland (GUS) available in the Local Data Bank for the years 2010–2022 (<https://bdl.stat.gov.pl/bdl/dane/podgrup/temat>).

Table 3. Selected characteristics of region due to the synthetic measure of pro-environmental spending in regions in Poland in 2010–2012 and 2020–2022 (according to the average value for the period)

Description	2020–2022				2010–2012			
Group	I	II	III	IV	I	II	III	IV
Synthetic measure of pro-environmental spending	0.62	0.47	0.38	0.24	0.61	0.46	0.36	0.28
Number of units in the group	3	5	4	4	2	5	7	2
Expenditures for utilities	27.8	13.32	5.43	7.31	16.06	9.5	8.91	2.42
Expenditures on urban and rural cleaning	44.52	36.35	22.98	25.11	34.41	28.98	20.03	18.94
Expenditures on maintenance of greenery in cities and municipalities	45.27	33.13	25.48	25.38	23.99	15.99	13.82	13.43
Expenditures on lighting of streets, squares and roads	66.93	70.15	76.01	59.91	48.44	45.07	42.72	43
Expenditures on protection of atmospheric air and climate	48.58	22.51	33.43	21.64	2.97	1.64	1.19	0.81
Expenses on sewage management and water protection	83.65	81.91	54.47	50.71	96.61	73.6	74.45	61.58
Expenditures on municipal waste management	290.07	260.31	232.15	218.06	12.21	14.8	10.65	7.58
Synthetic measure environment	0.48	0.57	0.5	0.59	0.43	0.54	0.54	0.53
Forests	30.88	37.05	25.56	28.86	31.47	33.65	29.39	26.09
Total dust emissions per 1 km ² of area	0.16	0.06	0.07	0.07	0.61	0.15	0.14	0.23
Total waste generated per year	6.61	1.7	2.22	1.16	9.78	2.06	1.24	1.36
Total legally protected areas (%)	0.31	0.31	0.37	0.35	0.21	0.33	0.34	0.49
Ecological lands	0.15	0.2	0.14	0.2	0.17	0.16	0.16	0.18
Water consumption per capita	106.68	184.83	495.84	98.52	115.12	273.88	225.37	577.07
Share of treated wastewater in wastewater requiring treatment	81.41	89.52	91.22	99.07	81.67	98.39	94.4	70.47
Total mixed waste collected during the year per capita	230.04	220.34	191.17	210.79	281.75	231.48	213.01	180.93
Existing wild landfills – as of December 31 per 100 km ²	1.89	0.77	0.33	0.56	2.04	1	0.84	0.72
Wild landfills – liquidated – during the year per 100 km ²	9.86	2.81	2.42	1.55	6.88	5.08	2.39	2.82
Share of renewable energy in total electricity generation	11.41	36.79	26.3	55.63	5.62	18.07	17.49	35.54
Population using wastewater treatment plants as % of total population	77.45	78.88	68.38	74.92	75.15	67.17	65.81	60.77

Sorted by measure of pro-environmental spending

Source: own study based on data from the Statistics Poland (GUS) available in the Local Data Bank for the years 2010–2022 (<https://bdl.stat.gov.pl/bdl/dane/podgrup/temat>).

Analyzing the characteristics due to the level of the synthetic measure of the environment, 4 regions (Warmińsko-mazurskie, Kujawsko-pomorskie, Pomorskie, Podkarpackie) in 2010–2012 and 2 regions (Warmińsko-mazurskie, Pomorskie) in 2020–2022 were in Group I. The weakest group 4 was composed, respectively in the studied years, of three regions: Opolskie, Świętokrzyskie, and Śląskie, as well as Mazowieckie, Śląskie, and Łódzkie. The relationship between spending on municipal management and environmental protection and the state of ecology is not as obvious as it might seem. Group I regions were characterized by higher values of diagnostic variables (stimnat) than those of Group IV (Table 4).

Table 4. Selected characteristics of provincial groups due to the synthetic measure environment of regions in Poland in 2010–2012 and 2020–2022 (according to the average value for the period)

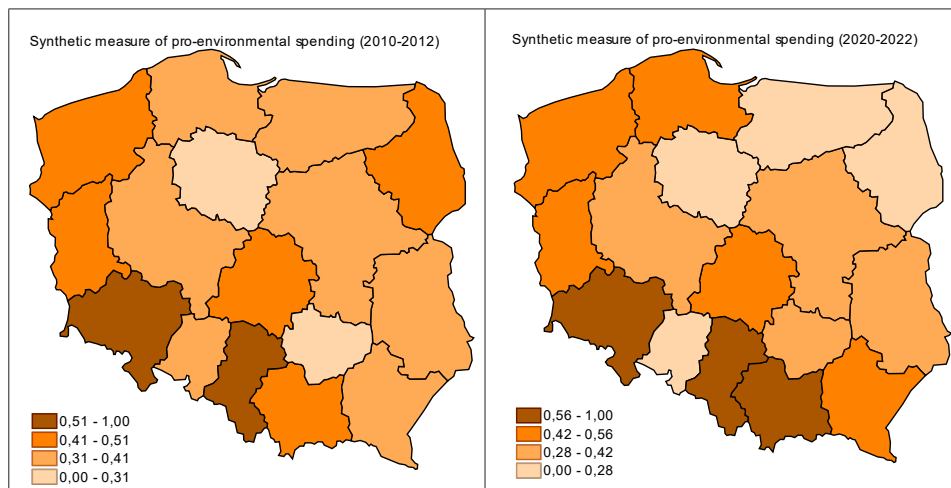
Description	2020–2022				2010–2012			
Group	I	II	III	IV	I	II	III	IV
<i>I</i>	2	3	4	5	6	7	8	9
Synthetic measure environment	0.67	0.58	0.49	0.42	0.63	0.56	0.47	0.42
Number of units in the group	2	7	4	3	4	4	5	3
Forests	34.94	33.46	28.37	25.99	32.54	33.39	27.42	29.43
Total dust pollution emissions per 1 km ² of area	0.03	0.06	0.09	0.16	0.14	0.13	0.17	0.49
Total waste generated per year per capita	1.06	1.47	4.59	3.68	0.88	1.56	4.24	3.43
Total legally protected areas (%)	0.4	0.35	0.36	0.24	0.39	0.37	0.24	0.38
Ecological lands per 100 ha	0.25	0.21	0.14	0.08	0.24	0.18	0.15	0.07
Water consumption per 1 inhabitant	77.38	167.69	402.29	227.96	102.11	115.99	443.17	414.38
Share of treated wastewater in wastewater requiring treatment	99.82	95.83	92.95	70.25	94.3	98.81	96.6	67.18
Total mixed waste collected during the year per 1 inhabitant	208.7	201.91	227.4	219.76	213.46	199.3	257.44	211.86
Existing wild landfills – as of December 31 per 100 km ²	0.75	0.46	0.8	1.75	0.37	0.86	1.16	1.88
Wild landfills – liquidated – during the year per 100 km ²	2.94	3.18	2.42	7.22	2.26	3.62	4.36	5.39
Share of renewable energy in total electricity generation	75.65	42.28	19.55	6.81	40.77	17.95	7.89	6.92
Population using wastewater treatment plants as % of total population	81.12	72.67	75.48	75.72	72.29	60.75	68.74	64.17
Synthetic measure of pro-environmental spending	0.32	0.42	0.42	0.49	0.34	0.44	0.44	0.42
Expenditures on utilities	15.69	12.53	9.58	14.51	8.13	11.16	8.77	8.61
Expenditures on urban and rural cleansing	35.68	30.45	30.06	34.32	20.31	23.78	28.79	23.84

1	2	3	4	5	6	7	8	9
Expenditures on maintenance of greenery in cities and municipalities	27.25	31.36	33.33	32.51	16.19	13.22	18.97	13.03
Expenditures on lighting of streets, squares and roads	62.85	65.67	78	65.94	39.72	41.78	49.65	44.34
Expenditures on protection of atmospheric air and climate	6.82	35.5	24.3	39.74	0.42	2.45	1.04	2.48
Expenses on sewage management and water protection	65.21	70.5	64.99	65.78	77.94	69.59	70.08	88.33
Expenses on municipal waste management	226.53	236.54	220.05	327.85	11.24	15.6	10.51	9.41

Sorted by measure environment and ecology

Source: own study based on data from the Statistics Poland (GUS) available in the Local Data Bank for the years 2010–2022 (<https://bd1.stat.gov.pl/bd1/dane/podgrup/temat>).

On the basis of the synthetic measure of pro-environmental spending and the synthetic measure of environmental, the spatial differentiation of regions in 2010–2012 and 2020–2022 is indicated, as shown in Figure 1. Pro-environmental activity in recent times has been directed at popularizing the concept of a green economy. It is related to the numerous crises in recent years, i.e., the climate, environmental, food, financial, and economic crises. Developing a green economy means solving environmental problems while ensuring economic security and social stability and creating additional conditions for sustainable development. The transition to a green economy is an inevitable direction of change in the local economy, which will take greater account of the relationship of ecology, environment, and infrastructure of the local economy.



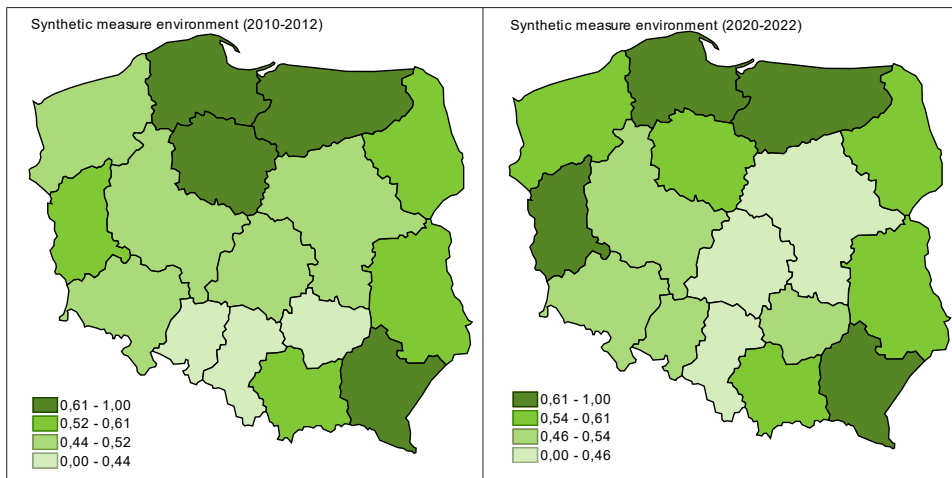


Figure 1. Spatial variation of measures of pro-environmental spending and environment in regions in Poland in 2010–2012 and 2020–2022 (by average value for the period)

Source: own study based on data from the Statistics Poland (GUS) available in the Local Data Bank for the years 2010–2022 (<https://bdl.stat.gov.pl/bdl/dane/podgrup/temat>).

DISCUSSION

Based on the conducted analyses, persistent and deepening disparities among regions were observed both in terms of the synthetic indicator of pro-environmental spending and environmental quality during the periods 2010–2012 and 2020–2022. Regions with the highest expenditures – particularly Dolnośląskie and Śląskie – did not always rank highly in environmental quality, whereas units such as Warmińsko-mazurskie maintained good results despite relatively low spending levels. This points to the complexity of the relationship between expenditures and ecological outcomes, as well as the need to consider these effects over a longer time horizon. Notably, despite high expenditures, some regions experienced a decline in their standing in both pro-environmental funding and environmental quality, indicating the multifaceted and multidimensional nature of factors influencing the effectiveness of pro-environmental efforts. The analysis shows that expenditures do not always directly translate into short-term improvements in environmental conditions, which requires accounting for local specificities and longer-term assessment horizons for the impacts of investments and activities.

These results are consistent with findings from previous studies on the spatial differentiation of environmental policy effects in Poland. Senetra, Pawlewicz, and Pawlewicz (2019) demonstrated significant disparities in synthetic environmental condition indices across voivodeships, while Dziekański, Popławski,

Wyszkowski, and Wrońska (2023) confirmed strong regional polarization of the green economy, indicating that the scale of pro-environmental expenditures does not uniformly translate into improvements in environmental conditions. Similar conclusions were drawn by Bąk (2023), who emphasized that environmental quality of life is shaped by local factors such as waste management, pollution levels, and access to ecological infrastructure. These findings confirm the complexity and multidimensionality of factors determining the effectiveness of pro-environmental actions, highlighting the key role of regional specificity. Furthermore, the heterogeneity of natural resources and socio-economic conditions – highlighted in comparative European-level research (Kowalczyk, Nowak, Rutkowski, 2022) – justifies the need for an individualized approach to evaluating the effectiveness of environmental policies. These authors point out that differences in social capital, economic structure, and institutional capacity of regions directly influence the diversity of local development strategies, which is also reflected in the results of this analysis. Natural resources can both support and hinder ecological sustainability. While energy production and mineral rents contribute to economic growth, they also cause environmental harm. Kang, Li, and Feng (2023) stress the importance of reducing the environmental impact of resource extraction and consumption to ensure sustainability.

The lack of an immediate response of ecological indicators to increased pro-environmental expenditures is an expected phenomenon, resulting from the delayed effects of environmental investments that require time for implementation and tangible impact on the environment. Moreover, the outcomes of pro-environmental actions are modulated by external factors such as climate change and urbanization pressure, complicating the short-term assessment of their effectiveness. Consequently, short-term analyses may not fully capture the influence of expenditures on environmental conditions, which should be considered when interpreting results and planning further research (Hocherman, Trop, Ghermandi, 2025). In the regional context, sustainable management of natural resources is also crucial, as these resources can both support economic development and constitute a source of environmental pressure (Kang, Li, Feng, 2023).

Regional differentiation is also confirmed by observed trends and changes in the rankings of individual voivodeships. Units such as Dolnośląskie and Warmińsko-mazurskie differ not only in the levels of synthetic indicators but also in the dynamics of changes and the structure of implemented pro-environmental measures, reflecting differences in their socio-economic conditions and environmental pressures.

Statistical results revealed an increase in disparities in expenditure levels (coefficient of variation: 24.44 → 32.72; Gini index: 0.255 → 0.304), alongside a slight decrease in the variability of ecological outcomes (15.99 → 15.62).

The combination of these trends suggests that growing investment disparities do not directly translate into increased differentiation of environmental conditions. The analysis of membership in groups I–IV further confirmed high dynamics of changes – numerous regions shifted classes in terms of both expenditures and effects, and a high level of investment did not guarantee classification into groups with the best environmental status. These findings clearly indicate the absence of a straightforward relationship between expenditures and immediate improvements in environmental quality, highlighting the significance of local conditions.

The results demonstrate clearly that higher expenditures do not automatically lead to better environmental conditions; however, the discussion does not provide explanations of this phenomenon based on specific regional data. Cases such as substantial investments in industrial regions (Śląskie, Dolnośląskie) combined with low or deteriorating ecological outcomes require interpretation considering factors such as persistent environmental pressure, economic structure, historical pollution, or the type of funded investments. Similarly, the high environmental quality in voivodeships with low expenditures should be explained by natural factors, lower urbanization intensity, or previous investments.

Regions in Poland are responsible for developing and implementing regional environmental protection programs, integrating national ecological goals with local needs. Key tasks include creating and updating environmental protection plans, sustainable development strategies, and actions to improve air and water quality, as well as biodiversity. Pro-environmental expenditures cover investments in renewable energy, waste management, and green infrastructure, such as wastewater treatment plants, air quality monitoring systems, and parks. Voivodeships also promote the green economy by supporting businesses in renewable energy, ecological technologies, and recycling, and by fostering pro-environmental sectors like organic farming.

Żylicz (1990) emphasizes that environmental policy must balance conflicting needs from economic agents, society, and local authorities, aiming to preserve the environment to enable socio-economic development. In the regions pro-environmental spending is directly linked to environmental protection, a significant issue in Poland. Given the global and transboundary nature of environmental problems, coordinated and effective policies are essential to counter industrial expansion's environmental impact.

Xuan, Jiang, and Fang (2023) argue that integrating sustainable economic and environmental growth is vital, with the green economy improving quality of life and protecting the environment. Green infrastructure can address environmental problems, support ecosystem stability, and promote sustainable development, making it a key component in regional planning (Nygaard, 2024).

CONCLUSIONS

The conducted analyses confirm significant spatial differentiation in the level of pro-environmental expenditures and environmental conditions across the regions in Poland. In the period 2010–2012, the highest values of the synthetic measure of pro-environmental spending were recorded in the Śląskie and Dolnośląskie regions, while in the period 2020–2022, Małopolskie also joined this group. The lowest spending levels were observed in the Warmińsko-mazurskie, Kujawsko-pomorskie, Podlaskie, and Opolskie regions, indicating persistent disparities in the intensity of pro-environmental activities between regions.

The results obtained do not confirm the existence of a strong and unequivocal relationship between the level of pro-environmental spending and the state of the environment. Regions characterized by the highest financial outlays, i.e., Śląskie, Dolnośląskie, and Małopolskie, did not occupy leading positions in environmental quality rankings, and in the case of the Śląskie region, one of the lowest values of the synthetic environmental measure was recorded in both analyzed periods. This suggests that in heavily industrialized regions, a significant portion of expenditures has a compensatory nature and is aimed at mitigating the effects of prolonged industrial pressure and historical environmental burdens.

At the same time, the regions with relatively favourable natural conditions, particularly Warmińsko-mazurskie, Pomorskie, Podkarpackie, and Lubuskie, achieved high values of the synthetic environmental measure with moderate or low levels of pro-environmental spending. The Warmińsko-mazurskie region remained a leader in terms of environmental quality in both 2010–2012 and 2020–2022, highlighting the significant role of natural factors and the lower scale of anthropogenic pressure in shaping this measure's level.

The analysis of expenditure structure revealed clear differentiation in public intervention priorities between regions. In regions such as Dolnośląskie and Śląskie, spending on waste management, air protection, and technical infrastructure predominated, whereas in the Pomorskie and Zachodniopomorskie regions, investments related to water and sewage management and urban greenery maintenance were relatively more significant. This differentiation influences the pace and scope of observed ecological effects, which primarily manifest over a longer time horizon.

The research findings indicate the necessity of conducting territorially differentiated environmental policies that take into account the specific characteristics of individual regions. The effectiveness of pro-environmental actions requires not only increasing financial allocations but, above all, better targeting, coordination at the regional level, and integration with a long-term strategy of transformation toward a green economy and a circular economy, adapted to the conditions of regions such as Śląskie, Dolnośląskie, Małopolskie, Warmińsko-mazurskie, and Pomorskie.

This study is based on data aggregated at the regional (voivodeship) level, which may obscure local variations present at lower administrative levels, such as counties and municipalities. The results may also be limited by time lags in the manifestation of the effects of pro-environmental actions, as well as by the influence of external factors, such as climate change and urbanization pressure – that were not directly accounted for in the model.

Future research should include more detailed spatial analyses and apply cause-and-effect modelling at the local level to better capture the complex relationships and effects of environmental policy. The results also suggest a need for further research using structural models, which would allow for a more accurate determination of the complex relationships and mechanisms that affect the environment. In addition, this research could be expanded to include analyses of links with the circular economy and demographic and financial factors.

The value of the present work lies in its comprehensive approach, encompassing a broad spectrum of variables and comparing the periods 2010–2012 and 2020–2022, which constitutes a significant contribution to the discussion on improving the effectiveness of sustainable development implementation at the regional level. Particularly important is the continued coordination of actions aimed at the transformation toward a green economy and circular economy model, tailored to the specific conditions of individual territorial units.

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