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Measuring the Green Economy in Poland in Voivodeship Perspective

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Abstract:

Purpose: *The main objective of the study was to measure and evaluate the progress of the green economy implementation in Poland's voivodeships between 2005 and 2018. The primary focus of the conducted statistical analyses was the construction of original Regional Green Economy Measure (RGEM) and four synthetic measures related to the green economy areas: Natural asset base, Environmental and resource productivity of the economy, Environmental quality of life, and Economic opportunities and policy responses. Five measures allowed for multidimensional comparisons across voivodeships.*
Design/Methodology/Approach: *The study employed linear ranking methods based on synthetic variables, enabling the development of voivodeship rankings. Among the qualitative methods was an expert survey utilized during the process of substantive indicator selection, as well as a bibliometric analysis of the green economy concept.*
Findings: *Based on the conducted research, it was found that voivodships differ in the degree of the green economy implementation. The leader turned out to be the Śląskie Voivodship, while the weakest results in terms of the green economy principles implementation were usually achieved by the Świętokrzyskie Voivodship. The Śląskie Voivodship has achieved a leadership position in the implementation of the green economy through its focus on sustainable utilization of natural resources, improvements in energy efficiency, and the transformation of sectors towards greater ecological sustainability. The significant diversity in the development of the green economy across individual voivodeships highlights the need to establish more effective policy and strategic frameworks tailored to the unique conditions of each region.*
Practical Implications: *The study emphasizes the importance of region-specific strategies to address disparities in green economy development. Policymakers should focus on improving green economy indicators through targeted investments in sustainability, renewable energy, and efficient resource management. Strengthening data collection and monitoring systems can support informed decision-making and accelerate the transition to a sustainable economy, benefiting both the environment and regional development.*
Originality/Value: *The study introduces the original Regional Green Economy Measure (RGEM), a comprehensive tool for assessing green economy implementation across Poland's voivodeships. By combining quantitative methods with region-specific data, it provides a novel approach to measuring sustainability progress. The research's focus on regional*

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disparities and the use of multidimensional synthetic measures fills a gap in existing studies, offering valuable insights for tailoring policies to local conditions. This innovative framework can serve as a model for similar assessments in other countries.

Keywords: *Green economy, sustainable development, regional development, green economy measurement.*

JEL codes: *Q01, Q56, Q57, R11.*

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1. Introduction

The green economy based on the idea of sustainable development is the leading concept in transforming modern economic systems, as applied in scientific publications. The main objective of the study was to measure and evaluate the progress of the green economy implementation in Poland's voivodeships between 2005 and 2018.

The primary focus of the conducted statistical analyses was the construction of original Regional Green Economy Measure (RGEM) and four synthetic measures related to the green economy areas: Natural asset base, environmental and resource productivity of the economy, environmental quality of life, and economic opportunities and policy responses. Five measures allowed for multidimensional comparisons across voivodeships.

2. Literature Review

The aftermath of the global financial crisis between 2008 and 2010 sparked discussions regarding the need to transform modern economies (Barbier 2012; Barbier 2021). The effects of the global economic recession, environmental degradation, and deep social inequalities have obligated countries to alter their current development practices and transition towards the green economy (Davies 2013).

This alternative development paradigm based on sustainable development (Mensah 2019, European Environment Agency 2021, United Nations Division for Sustainable Development 2020, Green Economy Coalition 2020) offers the promise of growth while safeguarding the earth's ecosystems and reducing poverty levels (Division for

Sustainable Development, UN-DESA, UNEP, UN Conference on Trade and Development 2021; Huff 2021).

However, despite the growing interest in the green economy, there is no single, fully adequate, and exhaustive definition of the concept in the literature. Definitional analyses of the green economy conducted in many scientific publications (Green Economy Coalition 2017; OECD 2021a; OECD 2021b; OECD 2021c; Kasztelan 2017; UNEP 2020; Matthews 2013; Georgeson *et al.,* 2017; European Environment Agency 2022).

A notable study conducted by Merino-Saum and colleagues analyzed 140 different definitions of the green economy, resulting in the classification of definitions into four groups. The first group of definitions is based on four fundamental elements, such as social well-being, equality, ecological scarcity, and environmental hazards. The second group of definitions relates primarily to resource efficiency, i.e., reduction of fossil fuel consumption, pollution and greenhouse gas emissions, recycling of materials, energy efficiency, and development of renewable energy sources. The third group of definitions is closely related to the issue of sustainable development and recognizes the green economy as a path towards achieving sustainable development goals.

The last category consists of non-specific definitions, an example of which is E.A. Yakovleva's explanation that the green economy is an element of the natural environment and part of the global ecosystem (Merino-Saum *et al.,* 2020).

In another study based on bibliometric analysis, E. Loiseau (2016) and her colleagues aimed to identify the primary keywords associated with the concept of the green economy in the scientific literature. Researchers extracted 157 keywords from 877 documents which the term "green economy" appeared in the title, abstract, or keywords. In subsequent stages of analysis, these keywords were categorized into eleven semantic fields including environmental dimension, social dimension, economic dimension, practical implementations, management, geographical area, synonyms, tools, sustainable development, economic sectors, and economic theories.

The analysis revealed that over half of the keywords related to the green economy were associated with environmental and economic aspects. Less emphasis in the definitions of the green economy was placed on elements related to the social dimension. Nevertheless, in more than 35% of cases, the concept of the green economy was linked with words such as sustainable development or sustainability, demonstrating strong connections between the green economy and sustainable development (Loiseau *et al.,* 2016).

Death (2015) proposes an intriguing study on the concept of the green economy, identifying four distinct discourses of the green economy prevalent in the global South. The researcher argues that it is essential to understand these green economy

discourses as part of a broader "green state" political economy. The first of the four defined discourses is "Green Resilience" aimed at strengthening local and national economies to mitigate climate change-related threats while ensuring economic growth.

The second discourse is the more widely recognized and globally popular "Green Growth", which necessary transformations for greening economies are seen as a potential way to increase economic activity. The third discourse is "Green Transformation" primarily focused on investing in means to ecologically transform economies. The last discourse is "Green Revolution" advocating for the most radical changes, even a complete departure from the existing system (Death, 2015).

The author of this study also attempted a brief bibliometric analysis of the concept of the "green economy". The analysis utilized materials gathered from the Scopus scientific database, which comprises a list of over seventy million journals, articles, conference materials, and other publications.

During searching for the keyword "green economy", 1,411 scientific articles were found, with the "green economy" being one of the indexed keywords. The results were restricted to articles published between 2008 and 2019. The cutoff date of 2008 was chosen because it was only from that year onwards that the green economy was recognized as a key tool for the development of global economies, aimed at overcoming the economic crisis that had emerged.

Additionally, the Scopus database allows for the identification of related keywords. In the case of the "green economy", 159 related keywords were found. Most of them appeared in publications related to environmental sciences (25.2%), social sciences (19.4%), energy-related sciences (10.8%), and economics, econometrics, and finance (8.9%). On the other hand, the top ten associated keywords with the "green economy" are presented in Figure 1.

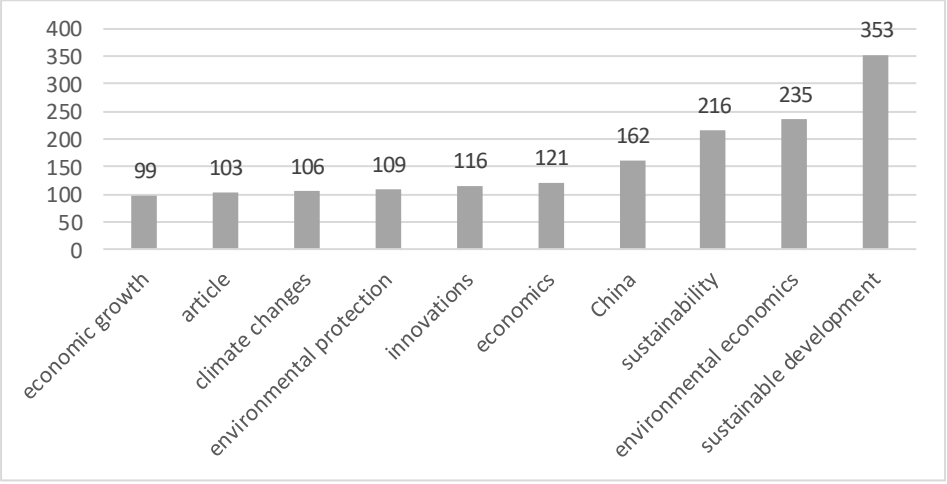
It is worth noting the definition of the green economy proposed by the Central Statistical Office in Poland. Here, the green economy is understood "as such that supports economic growth and development while maintaining access to natural capital and ecosystem services, which, in turn, affect human well-being" (Central Statistical Office 2021).

Additionally, the Central Statistical Office defines three goals of the green economy: increasing the efficiency of resource use in the economic sector, improving human well-being and social justice, and reducing pressure on the environment (Główny Urząd Statystyczny, 2020).

The definition of the green economy and the goals set by the Central Statistical Office in Poland form the basis for the concept analyzed in this study. They provide the framework for understanding how Poland is striving to achieve the green

economy. Simultaneously, the conducted research establishes concrete foundations and situates them within the Polish context, which is crucial for comprehending the issues under examination (Daniek 2020).

Figure 1. *The most frequently occurring keywords related to the green economy term.*



Source: *Own elaboration based on Scopus.*

The measurement framework established by the OECD identifies a total of 26 indicators to encapsulate the key attributes of green growth and to monitor advancements toward achieving green growth. The most recent, updated, and expanded set of green growth indicators, as proposed by the OECD, was published in 2017.

Similar to previous editions, the OECD categorizes these indicators into four interconnected groups (OECD, 2017): Environmental and resource productivity of the economy, Natural asset base, Environmental dimension of quality of life, and Economic opportunities and policy responses. It is emphasized by the authors of this classification that these indicators must be interpreted within the specific social context of each respective country. The fifth set of indicators supplements fundamental information related to the socio-economic condition of the state and provides a context for accurate interpretations (OECD 2017; OECD 2021d).

An attempt to create a set of indicators to measure the green economy was created by the Polish public statistics office, Central Statistical Office (CSO), which in 2017 published the document "Green economy indicators in Poland, 2017". The elements of the green economy (environment, economy, and society) are interrelated, and these relations have enabled CSO, similarly to OECD, to establish four areas to monitor the state of the green economy in Poland. Indicators of the green economy have been introduced and categorized in the following four groups (CSO, 2017). This study is based on a similar attempt to gather relevant indicators categorized into thematic

groups, similar to the approach used by the OECD and CSO. The United Nations Environment Programme (UNEP) has also put forth a series of indicators for assessing the green economy. The UNEP approach focuses on the utilization of the green economy indicators as part of an integrated approach to policymaking.

Additionally, UNEP underscores the necessity of incorporating changes into national economic policies, such as investments in clean technology, the enhancement of ecosystem services, and environmental preservation (UNEP 2012). The Global Green Economy Index (GGEI) was initially published in 2010 by a private consulting firm, Dual Citizen, based in the United States.

This index employs both quantitative and qualitative indicators to assess the performance of the green economy across four main domains: leadership and climate change, efficiency sectors, markets and investment, and the environment. GGEI predominantly relies on data that meet two criteria: quality and coverage (Dual Citizen LLC, 2021).

One of the other tools employed to gauge progress toward the green economy is the Green Economy Progress (GEP) composite indicator developed by the Partnership for Action on Green Economy (PAGE). It is aligned with the concept of the Inclusive Green Economy, which is associated with a "wealth of opportunities, both for people to improve their living environments and have decent jobs, and for businesses to increase benefits through more efficient production practices that generate savings" (The EU Switch to Green Flagship Initiative, 2019).

The GEP Measurement Framework comprises two components: the GEP Index and the companion Dashboard of Sustainability Indicators (PAGE, 2021). A Polish researcher, Bożena Ryszawska from Wroclaw University of Economics, also endeavored to create a composite indicator for the green economy. Her Green Economy Index is designed to assess countries' performance in alignment with the requisites and objectives of the green economy. This index tracks progress in the transition toward the green economy and monitors this progress over time (Ryszawska, 2013).

For over a decade, attempts have been made to develop a reliable tool for measuring the green economy, which is necessary to achieve the intended result (Hopkins 2020; Szyja 2015; Herrero *et al.*, 2018).

However, most of them are used for international comparisons, much less frequently, measures are created at the regional or the local level. A properly designed monitoring system enables an effective assessment of the phenomenon at a global, national, or regional level. What is important, it should be emphasized that there is no „one-size-fits-all" indicator (Bîrgovan *et al.*, 2022).

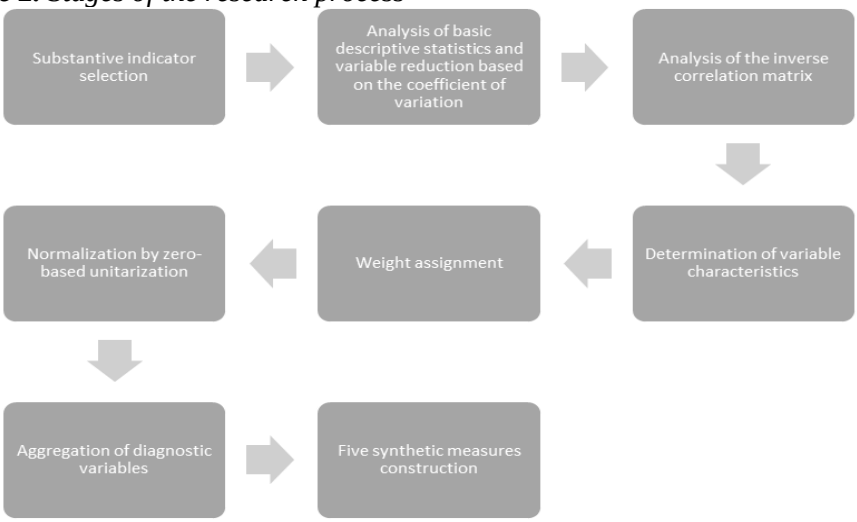
3. Research Methods

The aim of the study is to measure and evaluate the progress of the implementation of the green economy in Poland from a spatial and dynamic perspective using the original Regional Green Economy Measure (RGEM) and synthetic indicators of areas, enabling comparison of the level of the green economy development in all voivodships in Poland.

The key quantitative method used in this study was linear ordering. Linear ordering methods allow for establishing the order or classification of objects that are described by multiple variables. The idea of linear ordering of multidimensional objects is based on the concept of a binary ordering relation, which allows for determining which of the studied objects from the entire set is better, worse, or whether the given objects are identical (Kukuła and Luty 2015). Linear ordering can be used to study objects such as countries (e.g., based on the degree of development of a given phenomenon) or products (e.g., based on their utility value) (Bąk, 2017). In the case of this study, the objects of research were territorial units - sixteen voivodships of Poland.

The basis of linear ordering is a synthetic variable, and its values are estimated as a result of observing diagnostic variables that describe the studied objects (Grabiński 1992). The aim of this method is to rank objects from the best to the worst, according to a specified criterion. The procedure of linear ordering has certain stages of proceeding, such as: determining the nature of variables (their division into stimulants, de-stimulants, and nominates), determining variable weights and their normalization, and non-sample or sample aggregation (Bąk, 2017). The scientific research process consisted of several stages (Figure 2).

Figure 2. *Stages of the research process*



Source: *Own elaboration.*

The initial stage involved developing a set of indicators for the green economy, which were subsequently used to construct synthetic measures. During the substantive selection of indicators, three criteria were primarily considered:

- similarity of the selected indicators to green economy indicators proposed by the Central Statistical Office in publications entitled "Green Economy Indicators in Poland" (2017 and 2020 editions);
- availability and completeness of data covering the years 2005-2018;
- significance of the indicator for assessing the development of the green economy on a regional level.

An indicator was included in the set only if it met all three requirements. The main source of indicators was the Local Data Bank, as well as the Strateg and Regional Atlas. The Local Data Bank is the official statistical database maintained by the Central Statistical Office in Poland, which contains diverse information about regions, cities, and geographic areas within the country.

The Strateg and Regional Atlas is a source that provides geographic and strategic information and analyses for regions and local territorial units in Poland. Indicators were also aggregated from publications of the Central Statistical Office, such as yearbooks and seasonal and thematic publications. At this stage, an original questionnaire was also constructed to select indicators based on their usefulness and significance for building a synthetic measure to measure the advancement of the green economy in individual voivodships.

The questionnaire consisted of 41 indicators classified into four areas of the green economy, according to the division developed by the Central Statistical Office. The form was sent by email to 31 researchers involved in sustainable development, green economy, and statistical analysis. Eighteen respondents provided feedback, assessing each indicator on a six-point scale (where 0 indicated that the indicator was unnecessary, while the number 5 indicated that the indicator was very important). The results of the form showed that 38 indicators were rated as 3 or higher, indicating that most respondents considered the proposed indicators to be at least moderately significant for inclusion in the final set, which presented in Table 1.

Table 1. *The list of diagnostic variables selected for constructing synthetic measures*

NATURAL ASSET BASE	share of legally protected area in total country area (%)
	share of agricultural and forest land excluded from agricultural and forestry production in the total area (*own elaboration**)
	a) share of devastated, degraded, reclaimed, and developed land within a year in the total area (*own elaboration*) b) share of devastated and degraded land requiring reclamation in the total area
	forest cover (%)
	timber harvesting per 100 hectares of forest area (m^3)

	total exploitable groundwater resourcesm^3/h (*own elaboration*)
ENVIRONMENTAL AND RESOURCE PRODUCTIVITY OF THE ECONOMY	water consumption for national economy and population needs (m^3 per capita)
	water management in industry: share of industry in total water consumption (%)
	share of recovered waste in the total waste produced (%) (*own elaboration*)
	collected (mixed) municipal waste (kg per capita)
	share of selectively collected waste in relation to the total waste (%)
	household electricity consumption: electricity (kWh per capita)
	share of renewable energy in total electricity production
	energy savings (zł per capita)
ENVIRONMENTAL QUALITY OF LIFE	emission of gas pollutants from particularly troublesome plants (ton/km²)
	percentage of the population using sewage systems in relation to the total population (%)
	share of parks, green spaces, and neighborhood green areas in the total area (%)
	percentage of the population using gas installations in relation to the total population (%)
ECONOMIC OPPORTUNITIES AND POLICY RESPONSES	share of ecological agricultural land in the total agricultural land area (%)
	capital expenditures: protection of the atmosphere and climate (zł per capita) (*own elaboration*) capital expenditures: sewage management and water protection (zł per capita) (*own elaboration*) capital expenditures: waste management (zł per capita) (*own elaboration*) capital expenditures: protection and restoration of the utility value of soil, groundwater, and surface water protection (zł per capita) (*own elaboration*)
	share of capital expenditures for environmental protection in investment expenditures in the national economy (%) (*own elaboration*)
	fees and revenues for the environmental protection and water management fund (zł per capita)
	internal expenditures for RandD activities (zł per capita)
	innovative industrial enterprises in total enterprises (%)

Note: **own elaboration means own calculation caused by lack of the variable in databases.*
Source: *Own elaboration inspirated by OECD and CSO.*

After completing the process of substantive variable selection, the next step of the research was to conduct statistical analyses, which allowed for further elimination of indicators. Two variable selection methods were employed in the study. First, using the coefficient of variation defined by the formula:

$$v_j = \frac{s_j}{\bar{x}_j},$$

where: $\bar{x}_j$ – is the arithmetic mean of feature X_j; s_j – is the standard deviation of feature X_j

variables were excluded if they had a value below 10% in at least two analyzed cohorts. As a result, three indicators were eliminated. In the next phase of the research, a series of inverse correlation matrix analyses were conducted to eliminate variables carrying the same informational value. Based on the inverse correlation matrix, three additional indicators were eliminated.

The next step of the study was the stimulation of diagnostic variables, which is based on identifying the direction of the variables' interaction with the status of objects from the perspective of the studied complex phenomenon (Młodak et al. 2016). Taking into account this direction, variables are divided into stimulants (whose higher value indicates a better position of the object in the studied phenomenon) and destimulants (whose higher value indicates a worse position of the object in the considered context). The differential formula was used for the analysis, according to the formula:

$$x_{ij}^{s} = c - bx_{ij}^{D}, (i = 1, \dots, n),$$

where: constant $b > 0$. It was assumed that the value of the diagnostic feature would be reduced to a stimulant as the inverse of the value of the diagnostic feature: $c \geq max_{ij}$ and $b = 1$.

Various weights of variables are used in scientific publications (for example, weights can be determined through expert assessment or factor analysis) - in this paper, weights were determined based on the coefficient of variation, according to the following formula:

$$\alpha_j = \frac{v_j}{\sum_{j=1}^{m} v_j}, (j = 1, \dots, m)$$

where v_j – is the coefficient of variation of feature *j* before normalization.

Higher weights were assigned to features with a relatively high degree of discrimination, where the weighting calculation is based on the original values of diagnostic features, and the weighting procedure itself is performed after the normalization stage.

The next stage was the normalization of diagnostic variables. The method of zero-unitarization with parameters $a_j = \min_i x_{ij}$ i $b_j = \max_i x_{ij} - \min_i x_{ij}$ was chosen as the method of variable normalization for stimulants, and $a_j = \min_i x_{ij}$ i $b_j = \max_i x_{ij} - \min_i x_{ij}$ for destimulants. The method of zero-unitarization satisfies all seven postulates set for methods of normalizing diagnostic features by K. Kukuła, thus claiming to be a universal method (Kukuła, 1999).

The next step was to choose a formula for aggregating the diagnostic variables. As emphasized by Strojny, a large number of analyzed objects requires the construction of a synthetic measure that enables a comprehensive ordering of objects (Strojny 2009). Therefore, due to the nature of the data, non-pattern methods were used in the analysis, which involve constructing a synthetic measure. The synthetic measure was based on the mean value, as all variables (stimulants and destimulants) were originally measured on an interval or ratio scale, and differential transformation and zero-unitarization were applied during stimulation. The value of the synthetic measure with values of μ_i can be expressed using the formula:

$$\mu_i = \frac{1}{m}\sum_{j=1}^{m}\left(z_{ij}\alpha_j\right),$$

where: z_{ij} – normalized data values; α_j (j = 1,…,m) – weights for variables

In the next stage, synthetic measures were calculated for each area separately, as well as for the Regional Green Economy Measure, which is an average of four analyzed areas: Natural asset base, Environmental and resource productivity of the economy, Environmental quality of life, and Economic opportunities and policy responses.

The following section focused on analyzing the dynamics of changes in voivodships in terms of the analyzed synthetic measures - the Regional Green Economy Measure and the four area measures. The percentage difference in the value of a given measure between the initial year (2005) and the final year (2018) was taken into account, as well as the average rate of change over the period, according to the formula:

$$i_g = \sqrt[n-1]{\frac{y_n}{y_0}}$$

where: y_n – the value from the last period; y_0 – the value from the first period; n – the number of periods.

Based on this formula, the rate of change was calculated:

$r = i_g - 1.$

4. Results

The results of the study are as follows. The synthetics indicators have been developed for each of the four areas proposed by OECD, as well as inspired by their development, the Central Statistical Office. Table 2 in the Appendix presents the results of the indicator related to natural capital obtained by individual voivodships in the years 2005-2018. The environment is a source of natural resources that are essential for the proper functioning of the economy and social well-being.

The Natural asset base indicators include issues related to renewable and non-renewable resources, which are of crucial importance for the development of the green economy. Excessive exploitation of the natural environment makes it necessary to monitor the use of its resources in order to take appropriate steps to maintain the proper balance of natural capital. The task of the green economy is to ensure the supply of natural resources and ecosystem services that will be sufficient to maintain appropriate economic growth.

The Natural asset base indicator consisted of seven indicators related to land protection, forestation, wood harvesting, and exploitable water resources. Analysis of the Natural asset base indicator showed that in the years 2005-2018, the top three most frequently appearing voivodships were: Mazowieckie (14 times), Podkarpackie (13 times), and Małopolskie (8 times), while the bottom three were: Dolnośląskie (13 times), Śląskie (12 times), and Opolskie (12 times).

The high-ranking positions of the Mazowieckie may be the result of the benefits derived from the proximity of the National Park, nature reserves, and protected areas in this region. Furthermore, the presence of rural areas may contribute to a larger share of agricultural and forest land excluded from agricultural and forestry production, thereby increasing the value of the indicator. Podkarpackie also holds favorable positions, which is associated with a large number of forests and protected areas, similar to Małopolskie, where significant protected areas include the Tatra region.

On the other hand, regions such as Dolnośląskie and Śląskie seem to have lower KAB indicator scores. This could be due to higher levels of urbanization and industrial activity in these regions, potentially leading to greater utilization of natural resources. Particularly problematic is the high air pollution, and although pollution levels have gradually decreased, frequent breaches of air quality standards are still observed in Dolnośląskie.

The second analyzed measure is the measure related to the environmental efficiency of production, whose results are presented in Table 3 in the Appendix. The starting point for the Environmental and resource productivity of the economy is the

production sphere and its relationships with the natural environment. Environmental resources are used during production processes, which lead to the production of goods and services. The consequence of production processes is their negative impact on the environment, including the generation of large amounts of pollution and waste.

Tracking the progress of the green economy enables the production generated to be related to the use of environmental services and allows for an assessment of decoupling trends, which means breaking the link between production and the environment.

The measure of the area related to environmental production efficiency consists of eight indicators related to water and waste management, as well as energy consumption and savings. The highest results in this measure were achieved by the Podlaskie Voivodship (13 times), Kujawsko-Pomorskie Voivodship (10 times), and Śląskie Voivodship (9 times), while the lowest results were most often achieved by Wielkopolskie Voivodship (14 times), Zachodniopomorskie Voivodship (10 times), Świętokrzyskie Voivodship (8 times), and Mazowieckie Voivodship (8 times).

The analysis of the results reveals interesting variations between different voivodeships in Poland. Podlaskie stands out as a leader, achieving high scores throughout the examined period. This suggests that the region effectively manages resources, reduces energy and water consumption, and minimizes waste generation. Similarly, Kujawsko-Pomorskie and Śląskie voivodeships demonstrate high environmental efficiency, which may be surprising given the differences in their economic profiles. Kujawsko-Pomorskie is often perceived as an agricultural area, while Śląskie is an industrial hub. However, both of these voivodeships exhibit positive trends in resource management and energy efficiency, which may result from environmental protection efforts.

The Environmental quality of life of the population is related to the regulatory, cultural, and spatial services provided by the natural environment. The quality of the environment is of paramount importance for the overall well-being of the population due to its impact on the health of humans and all other living organisms. Indicators of the Environmental quality of life inform, among other things, about the population's exposure to environmental pollution and its consequences, or present data related to access to basic services in the field of water and sewage management that also promote environmental protection. The set also includes subjective measures determining the population's perceptions of the environment in which they operate (Table 4 in the Appendix).

In turn, to calculate the indicator of the area's environmental quality of population' life, four indicators were used, such as pollutant emissions, the population using sewage and gas installations, and green areas. In the top three best results, Śląskie

Voivodship appeared most frequently, and one of the weakest results was again obtained by Świętokrzyskie Voivodship.

Śląskie Voivodship distinguishes itself as a leader, achieving the highest scores in that measure. This may be surprising considering that Śląskie is one of the most industrialized areas in Poland. However, this result suggests that the voivodship has focused on implementing effective measures to control emissions of gaseous pollutants, contributing to improved air quality and the quality of life for residents.

In contrast, Świętokrzyskie Voivodship has obtained one of the weakest scores in the indicator. This may be due to a lower level of advancement in sewage infrastructure and the use of gas installations compared to other regions. It is worth noting that the quality of life for residents is directly related to access to sewage services, which influences environmental protection.

Water shortages are mainly associated with droughts and climate changes, as well as high water consumption by industries. Besides droughts, floods are also a significant threat to Świętokrzyskie Voivodship. Świętokrzyskie is an area with diverse natural and landscape values, which possesses significant deposits of rock raw materials, making it one of the main areas for their economic extraction.

Pomorskie Voivodship has also achieved good results, which may be the result of effective control of emissions of air pollutants and access to green areas and parks. This underscores the importance of maintaining a balance between industrial development and preserving natural green areas for improving the quality of life for local society.

The transformation of the traditional economic model towards the green economy implies the necessity of applying a range of instruments within the economic policies pursued by the government and local authorities. Political decision-makers can effectively shape specific behaviors through such tools as legal regulations and taxes, as well as support actions aimed at increasing efficiency by providing incentives for the development of pro-environmental consumption patterns and production models.

The indicator of the area related to the Economic opportunities and policy responses comprises nine indicators related to ecological use, investments in fixed assets including various aspects of environmental protection, as well as indicators related to research and development activities and innovative enterprises.

In the years 2005-2018, the highest indicators were mostly occupied by Zachodniopomorskie Voivodship (12 times), Łódzkie Voivodship (8 times) and Mazowieckie Voivodship (8 times). On the other hand, the bottom three weakest voivodships were quite diverse, with ten different voivodships appearing, including once again Świętokrzyskie Voivodship (Table 5 in the Appendix).

The indicator consists of several components related to expenditures on various aspects of environmental protection, which explains the high position of, for example, the Mazowieckie Voivodship, where these expenditures are the highest. Voivodships with lower expenditures achieved correspondingly weaker results. Furthermore, the indicator was also influenced by investments in research and development activities and innovative enterprises, which are characteristic of the Zachodniopomorskie, Łódzkie, and Mazowieckie Voivodships.

The results show that some regions, such as Mazowieckie Voivodship, Podkarpackie Voivodship, and Małopolskie Voivodship, have better scores in Natural asset base, suggesting better protection of natural resources. In terms of Environmental and resource productivity of the economy, Podlaskie Voivodship, Kujawsko-Pomorskie Voivodship, and Śląskie Voivodship are the most efficient regions in waste management, water consumption, and the use of environmentally friendly energy.

Dolnośląskie Voivodship, Śląskie Voivodship, and Pomorskie Voivodship have the highest scores in environmental quality of life, implying effective measures in reducing gas pollution and better access to green areas. On the other hand, Dolnośląskie Voivodship, Śląskie Voivodship, and Opolskie Voivodship have the lowest scores in Natural asset base, and Świętokrzyskie Voivodship, Łódź Voivodship, Podlaskie Voivodship, and Lubelskie Voivodship have the lowest scores in Environmental quality of life.

Lubelskie Voivodship also has the lowest scores in Economic opportunities and policy responses, suggesting significant challenges in budgetary planning for the green economy development. Used in scientific publications, the original Regional Green Economy Measure (RGEM) analysis and the rankings based on it are presented in Table 6 in the Appendix.

Used in scientific publications, the original Regional Green Economy Measure (RGEM) analysis and the rankings based on it are presented in Table 6. Compared to other voivodships, Dolnośląskie Voivodship achieved the highest RGEM in the early years of the study, and the best position it was able to take was third place in 2006.

Dolnośląskie Voivodship maintained a position in the top half of the ranking for most of the study period, suggesting active development of the green economy in the region. In the regional strategy, it is emphasized that there is an increasing degradation of biodiversity in the region due to the rising urbanization rate and a low percentage of protected areas (Dolnośląskie Voivodship Regional Strategy).

In the most cases, Kujawsko-Pomorskie Voivodship achieved high results - in eleven cases, RGEM scored above 0.400. From 2005 to 2014, Kujawsko-Pomorskie Voivodship held high rankings and was in the top five, but since 2015, there has been a noticeable deterioration in RGEM results. Kujawsko-Pomorskie faces a series

of challenges related to improving the state of the natural environment. One of these challenges is climate change, which is causing numerous consequences in the region, both in the economy and society (Kujawsko-Pomorskie Voivodship Regional Strategy). Kujawsko-Pomorskie stands out as one of the leaders in the green economy, often occupying the first place in the ranking. On the other hand, its weakening position in recent years indicates the need for more radical actions towards transitioning to a green economy.

The situation in Lubelskie Voivodship is stable, and RGEM achieves results in the range of 0.275-0.367. Throughout the study period, Lubelskie Voivodship held final rankings. Lubelskie is one of the least developed regions, and its socio-economic situation has shown little significant change compared to other voivodships for the past several years. The economy of Lubelskie Voivodship is still classified as traditional, with a relatively high proportion of the agricultural sector and a low proportion of the service sector.

Despite being one of the least forested regions, Lubelskie Voivodship places significant emphasis on legally protected areas, which make up almost one-fourth of the entire voivodship (Lubelskie Voivodship Regional Strategy). There is a gradual improvement in air quality in Lubelskie due to reduced emissions, and a decrease in the consumption of natural resources.

There is also significant variability in ranking positions for Łódzkie Voivodship. The best ranking achieved by Łódzkie Voivodship was fifth place (0.376 in 2005), seventh place (0.374), and eighth place twice (0.387 in 2006 and 0.374 in 2012). The regional strategy of Łódzkie Voivodship highlights the importance of a closed-loop economy, which can facilitate the transition to the green economy (Łódzkie Voivodship Regional Strategy).

Łódzkie Voivodship has a relatively small surface area of legally protected areas, mainly due to issues such as legal status complexities, the absence of protection plans, and a shortage of comprehensive environmental monitoring. The lack of consistency in the protected area system presents risks to the preservation of biodiversity.

The RGEM results were significantly better in Małopolskie Voivodship. Since 2016, Małopolskie Voivodship has maintained its leading position and has been at the top of the ranking. Małopolskie Voivodship is well-known for elevated levels of air pollution, with smog posing a significant issue, especially for residents of Krakow and its surrounding areas. Although there have been gradual improvements in reducing pollution levels, a substantial challenge remains in consistently exceeding acceptable standards.

Despite the substantial challenges facing Małopolskie Voivodship, particularly in terms of environmental preservation and combatting pollution, it is among the

voivodships that have achieved the highest scores in the Regional Green Economy Measure.

Mazowieckie Voivodship is characterized by a large variability in the range of achieved ranking positions, and RGEM results range between 0.349 and 0.489. Mazowieckie Voivodship is a highly unique region characterized by notable disparities, economic predominance, and substantial financial allocations, especially for environmental purposes.

An important issue in this voivodship is unregulated suburbanization, which results in significant social expenses and environmental deterioration. While the voivodship's growing economic strength portrays Mazowieckie as a robust region with high living standards and resident incomes, the rapid economic development may also lead to environmental neglect and reduced efforts to address social disparities that contribute to social exclusion.

Throughout the study period, Opolskie Voivodship remained in the lower part of the ranking for most of the study period. However, there were no significant declines. Increased investments in renewable energy sources and actions to improve air quality may be necessary.

Air and surface water pollution, as well as the tangible impacts of climate change, pose significant risks to Opolskie Voivodship. Furthermore, Opolskie lags behind other voivodships in terms of generating energy from renewable sources. The voivodship consistently demonstrates poor performance in the Regional Green Economy Measure, especially receiving low ratings in the Natural Asset Base category.

In the case of Podkarpackie Vivodship, significant fluctuations in rakings positions were observed, but it stayed in the middle of the ranking for most of the study period. However, there was a slight decline after 2013. Podkarpackie Voivodship has notable environmental advantages, including its significant biodiversity, conducive environment for organic farming and sustainable production, and a healthy groundwater supply.

Positive environmental trends also include a growing emphasis on waste segregation, the adoption of renewable energy sources, energy efficiency measures, and reduced water resource consumption. Moreover, there is a discernible decrease in atmospheric pollutant emissions in Podkarpackie. However, the region may make efforts to increase investments in renewable energy sources and promote sustainable economic activities.

The Podlaskie Voivodship is characterized by significant progress in its RGEM. The Podlaskie Voivodship is distinguished by having the highest indicator related to protected areas, particularly those known for their rich biodiversity. Its

environmental attributes and relatively low levels of air pollution position Podlaskie as one of the cleanest regions in Poland. The limited pollution is mainly attributed to the scarcity of nuisance industrial facilities.

However, the region faces a growing waste problem, marked by a yearly increase in waste volumes. Wild dumping sites pose a significant threat to preserving a healthy environment, compounded by low ecological awareness among residents, discouraging waste disposal fees, and an unstable system for handling large waste items.

Additionally, the insufficient infrastructure for water and wastewater management presents an environmental challenge. Conversely, there is significant potential for renewable energy production and the promotion of a closed-loop economy, offering substantial opportunities for development (Podlaskie Voivodship Regional Strategy).

The ranking position configuration in the case of Pomorskie Voivodship is also not unequivocal. The ongoing climate changes have a particularly severe impact on the environmental security of Pomorskie Voivodship. Increased occurrences of weather anomalies lead to numerous negative consequences (Pomorskie Voivodship Regional Strategy). Pomorskie Voivodship faces challenges related to its inadequate management of water resources, further complicated by urbanization, which results in poor water quality.

Although one-third of the voivodship consists of protected areas, there is growing concern about the progressive degradation of nature, especially in conjunction with the expanding tourism sector, increased waste production, and an insufficient level of environmental awareness.

Śląskie Voivodship is a leader in terms of RGEM and achieved an RGEM level of 0.425-0.505 throughout all the years of the study. Śląskie Voivodship topped the ranking ten times, earning first place. In addition to its robust industrial sector and substantial economic potential, the Śląskie Voivodship boasts several advantages for green economy development.

These include its abundant natural resources, well-established research and development capabilities, and vast areas of natural forests that cover a significant portion of the region. These strengths translate into favorable outcomes in both the Regional Green Economy Measure and the rest indicators. Śląskie Voivodship stands out as a prominent leader in the adoption of the green economy practices, as demonstrated by its consistently high rankings in various assessments.

In contrast to the results achieved by Śląskie Voivodship, Świętokrzyskie Voivodship is always ranked outside the top ten, with the best position recorded for Świętokrzyskie Voivodship being only thirteenth place in 2013 of 0.336. Świętokrzyskie Voivodship is characterized by its small geographical area, low

population, and relatively low population density and urbanization rate. Water scarcity mainly arises from droughts, climate change, and substantial industrial water consumption. In addition to droughts, the region faces the significant risk of flooding.

One of the environmental strengths is the high proportion of protected areas, crucial for conserving the region's valuable biodiversity. An environmental challenge for Świętokrzyskie is mitigating air pollution, with particular concern surrounding smog (Świętokrzyskie Voivodship Regional Strategy).

Warmińsko-Mazurskie Voivodship achieved much higher RGEM, placing twelfth in the rankings in the first three surveyed years. From 2008 to the end of the research period, it placed at various positions but never outside the top ten. Warmińsko-Mazurskie Voivodship records some of the lowest indicators related to air pollution and boasts a substantial number of projects dedicated to nature preservation.

Nevertheless, the regional strategy highlights that the region's environmental status is far from meeting its objectives (Warmińsko-Mazurskie Voivodship Regional Strategy). However, incremental advancements offer optimistic prospects for a more dynamic adoption of the green economy.

The rising levels of consumption and affluence among the residents of Wielkopolskie Voivodship are exerting pressure on environmental resources, which should be subject to special attention in regional policy. The increasing climate-related threats and insufficient utilization of renewable energy sources are affecting disruptions in the energy sector.

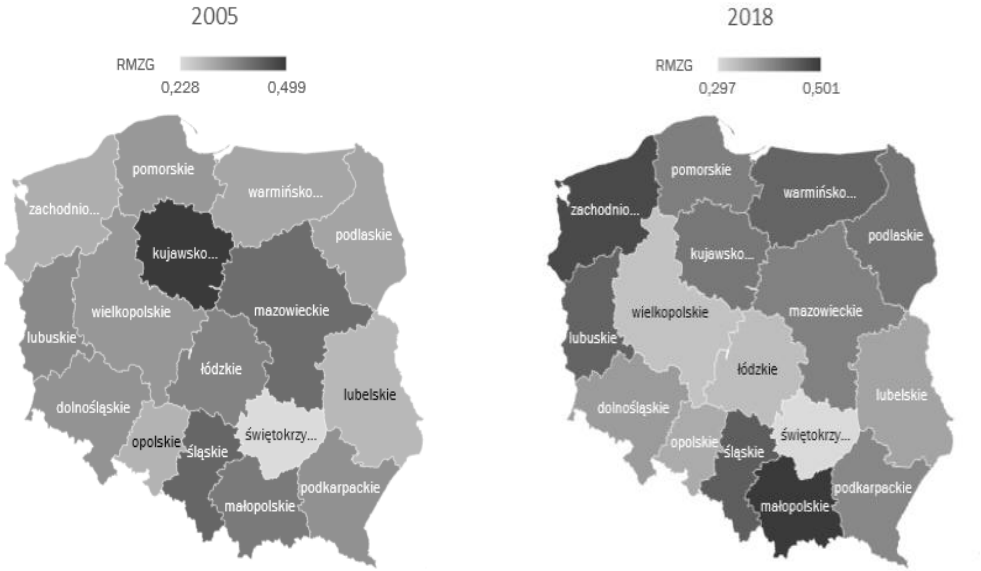
Wielkopolskie Voivodship has particularly low scores in Environmental and resource productivity and has ranked in the bottom three in this category on fourteen occasions. This has ultimately led to unsatisfactory results in the Regional Green Economy Measure, where Wielkopolskie Voivodship ranked second to last in the regional context.

A significant variation in results was observed in the case of Zachodniopomorskie Voivodship, whose RGEM ranged from 0.304 to 0.481. Similar to Pomorskie Voivodship, which shares similar socio-economic conditions due to its coastal location, Zachodniopomorskie Voivodship is particularly exposed to climate change and the associated weather anomalies, such as floods and droughts.

The challenge for Zachodniopomorskie Voivodship includes not only protecting itself from environmental threats but also adopting more rational waste management practices and utilizing water resources more efficiently (Zachodniopomorskie Voivodship Regional Strategy). One of Zachodniopomorskie Voivodship's environmental advantages is undoubtedly its relatively better air quality.

In turn, the results of the RGEM, which included all four synthetics indicators, are as follows. In the initial examined date, the lowest results were achieved by Opolskie, Lubelskie, and Świętokrzyskie Voivodships, while thirteen years later, it was Łódzkie, Wielkopolskie, and Świętokrzyskie Voivodships. In 2018, only one Voivodship repeated its position from the bottom three: Świętokrzyskie, which once again took last place. The best results in the RGEM were achieved in 2005 by Kujawsko-Pomorskie, Śląskie, and Mazowieckie voivodships, while in 2018 it was Małopolskie, Zachodniopomorskie, and Śląskie voivodships. An analysis of the results of the Regional Green Economy Indicator showed an increase between 2005 and 2018, with improvement in this indicator for twelve of the voivodships (Figure 3).

Figure 3. *Regional Green Economy Measure at the regional level for 2005 and 2018*



Source: *Own elaboration.*

5. Discussion

The results of the analysis indicate several main conclusions. Undoubtedly, the leader in implementing the green economy is Śląskie Voivodship, which has been in the top three fourteen times, with ten first place finishes. The results of the Małopolska Voivodship should also be emphasized, which, although not appearing in the top three even half as often as Śląskie Voivodship, has made significant progress in the last few years. Kujawsko-Pomorskie Voivodship in third place in terms of frequency of occupying top positions.

However, its positions have significantly decreased in recent years. The weakest voivodships in terms of achieving results in the Regional Green Economy Measure are Świętokrzyskie and Lubelskie, which should take decisive actions towards the green economy.

The Śląskie Voivodship, renowned for its industrial prowess in Poland, particularly in areas like the Upper Silesian Industrial District and the Rybnik Coal District, boasts a thriving economy with coal mines, power plants, and steelworks as its prominent industrial assets.

Moreover, the region enjoys a wealth of natural resources, a well-established research and development sector, and extensive forested areas, forming a significant portion of its landscape. These factors collectively underpin its exceptional performance in various environmental indicators, including the Regional Green Economy Measure.

Despite its industrial might and economic accomplishments, the Śląskie Voivodship faces certain environmental challenges that warrant attention and action. Notably, its natural capital indicators, despite the abundance of resources, exhibit room for improvement, with concerns about potential overexploitation and inadequate land management. Additionally, the region's heavy reliance on conventional energy sources underscores the need for substantial investments in renewable energy to align with sustainable development goals. Balancing industrial strength with environmental conservation remains a complex task.

Demographically, the region grapples with high population density and a declining natural population growth rate, necessitating strategies for revitalized growth and sustainable development. To ensure long-term prosperity, the Śląskie Voivodship must prioritize industrial modernization and innovation while addressing potential environmental degradation concerns.

In response to these challenges, the Śląskie Voivodship has already demonstrated its commitment to environmental protection by increasing its budget allocation for climate and environmental initiatives, resulting in reduced atmospheric emissions. The "Green Silesia" strategy, marked by its emphasis on environmental preservation, sustainable development, and innovation, provides a clear roadmap for the region to maintain its leadership in green economy development throughout Poland.

Discussing the results of our study, it is worthwhile to consider the work of G. Drozdowski and P. Dziekański, who evaluated the spatial differentiation of the life quality using a synthetic measure and linked the results to the green economy. They argue that improving the quality of life is a fundamental goal of sustainable development. According to their research, elements that shape the quality of life can be found within the scope of green economy analysis.

They emphasize that regional development should be closely tied to environmental concerns, the preservation of ecosystem capabilities to provide specific services, and ensuring good quality environmental components. All of these factors should positively impact the quality of resident's life. In their study, they compared the synthetic measure obtained for data from 2010 and 2020.

In 2010, the voivodships with the best results were Pomorskie, Mazowieckie, Dolnośląskie, and Zachodniopomorskie. Ten years later, Pomorskie, Mazowieckie, Wielkopolskie, Dolnośląskie, and Małopolskie voivodships ranked among the best. In our own study conducted in 2018, we observe that Małopolskie Voivodship continues to maintain a high quality of life, suggesting that this could be the result of long-term investments in regional development and environmental protection.

However, it is worth noting that in our 2018 results, we observe differences, particularly in the ranking of voivodships such as Zachodniopomorskie, which consistently achieved high scores in both studies. This raises questions about the factors contributing to the consistent high quality of life in this voivodship and how these factors may differ from others.

Another noteworthy study to consider is the work of A. Kasztelan, who assessed the green competitiveness of Polish voivodships in 2004 and 2018. Kasztelan used 25 indicators of environmental state and protection, as well as environmental pressures. His results revealed that in 2018, the top-ranking voivodships were Podkarpackie, Warmińsko-Mazurskie, and Zachodniopomorskie, while the lowest-ranking voivodships were Mazowieckie, Podlaskie, and Świętokrzyskie.

Comparing these results to our research, we observe a repetition of the high-ranking position of Zachodniopomorskie (2nd place in 2018) and low-ranking position of Świętokrzyskie (last place in 2018). This suggests that certain regions consistently perform well or poorly in terms of green competitiveness, and this pattern merits further investigation.

Additionally, P. Janulewicz and B. Bujanowicz-Haraś constructed their own measure to assess the level of Polish voivodships sustainable development. They categorized the voivodships into four groups based on their level of sustainable development. The top three in their study were Podlasie, Podkarpackie, and Warmińsko-Mazurskie voivodships, while the weakest level was found in Dolnośląskie, Łódzkie, and Świętokrzyskie voivodships. In our study, conducted in 2017, we also observed Łódzkie Voivodship (12th place) and Świętokrzyskie Voivodship (16th place) occupying lower positions.

The parallel trends observed in these comprehensive studies underscore the persistent challenges and opportunities faced by various Polish voivodships on their path towards sustainable development. The recurring high rankings of certain regions, as well as the enduring struggles of others, serve as a poignant reminder of

the intricate interplay between quality of life, environmental considerations, and the overarching goal of sustainable development. This convergence of findings underscores the importance of concerted efforts at both, regional and national levels, to address the identified disparities, harness the strengths, and pave the way for a more sustainable and prosperous future.

However, it is essential to emphasize that the issue of the green economy is not only highly multidimensional but also constantly evolving. This evolution necessitates the construction of more flexible sets of indicators that can accommodate new variables while discarding outdated ones.

Nevertheless, it is worth noting, there has been no universally accepted set of green economy indicators at the regional level. Hence, it can be concluded that this is a challenging and complex task, and proposals for such indicators will always raise questions. Moreover, conducting research in this area appears both, justified and necessary, as each attempt brings us closer to optimal solutions for this issue.

6. Conclusions

Several main conclusions can be drawn from the analysis conducted. Undoubtedly, the leader in implementing the green economy is Śląskie voivodship, which has been ranked in the top three fourteen times, with ten first-place finishes. The results of Małopolska Voivodship should also be emphasized, as it has made significant progress in recent years and even outperformed Silesia in the last three years.

Kujawsko-Pomorskie Voivodship ranks third in terms of the frequency of top rankings, although its position has declined in recent years. The weakest voivodships in terms of RGEM achievements are Świętokrzyskie and Lubelskie, which should intensify their efforts to promote the green economy.

Studies similar to presented work suggest that some results are similar within a certain range. However, in selected scientific publications, the high position of Śląskie Voivodship in research is not replicated, which can be explained by different sets of indicators being selected.

Despite being perceived as one of the most polluted regions in Poland due to industrial activity, Śląskie Voivodship is conducting intensified actions to combat pollution and protect the environment. This includes various programs and initiatives aimed at improving air quality and support for renewable energy sources. The region also carries out activities related to the protection of natural resources and ecological education as “Silesian Eco-energy” (aimed at the development of renewable energy sources and the improvement of energy efficiency in the region), the “Green Counties” program (promoting ecological solutions), or the “Silesian Air Protection Package” (limiting emissions of pollutants through support for projects related to air protection and pollution control).

Although Śląskie Voivodship has unfavorable indicators related to pollution, other indicators that make up the Regional Green Economy Indicator had such high scores (or other voivodships had such weak ones) that in the final rankings, Śląskie Voivodship turned out to be a leader in implementing the concept of the green economy. This will allow breaking away from the long-standing image of Silesia as a polluted and therefore unattractive region.

The strategy developed by Śląskie Voivodship is strongly linked to the green economy, and the additional name "Green Silesia" clearly indicates the priorities of regional policy. The flagship strategic objectives include actions to protect the environment, transition to sustainable development, implementation of innovative projects, and development of renewable sources. More ecological solutions are also to be introduced in mining and energy sectors.

In the face of increasing interest in the concept of the green economy, the research contributes valuable insights to this emerging area. The study provides an in-depth analysis of the utilization of green economy indicators at the regional level, but it also charts a course for further research into sustainable development in Poland.

Addressing this research gap is pivotal for gaining a better understanding of how regions are engaging with the objectives of the green economy and the challenges they encounter. The findings can serve as a reference point for future studies and support decision-makers and policymakers in making more informed choices regarding regional development and environmental conservation. In this way, the research aligns with the global efforts to create more ecologically sustainable societies, benefiting both the realm of academia and society.

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Appendix:

Table 2. *The values of the Natural asset base and rankings for all voivodships between 2005 and 2018*

Voivodship	2005		2006		2007		2008		2009		2010		2011		2012		2013		2014		2015		2016		2017		2018	
	KAB	R	KAB	R	KAB	R	KAB	R	KAB	R	KAB	R	KAB	R	KAB	R	KAB	R	KAB	R	KAB	R	KAB	R	KAB	R	KAB	R
Dolnośląskie	0,141	**16**	0,212	**16**	0,193	15	0,264	15	0,155	**16**	0,192	**16**	0,181	**16**	0,181	**16**	0,157	**16**	0,21	**16**	0,15	**16**	0,137	**16**	0,224	**16**	0,336	13
Kujawsko-pomorskie	0,341	11	0,459	8	0,408	8	0,529	7	0,403	9	0,453	10	0,431	8	0,314	13	0,408	8	0,41	9	0,42	9	0,526	6	0,465	10	0,464	9
Lubelskie	0,451	6	0,582	**1**	0,43	5	0,512	8	0,484	4	0,621	3	0,453	6	0,467	6	0,461	6	0,535	6	0,506	5	0,549	4	0,489	9	0,493	6
Lubuskie	0,458	5	0,473	6	0,443	4	0,553	5	0,44	8	0,533	5	0,476	5	0,388	9	0,44	7	0,555	5	0,425	6	0,371	13	0,541	4	0,537	4
Łódzkie	0,366	8	0,409	11	0,311	13	0,444	11	0,293	13	0,447	11	0,384	12	0,409	7	0,362	13	0,393	12	0,341	13	0,47	9	0,437	12	0,391	12
Małopolskie	0,501	4	0,561	4	0,419	7	0,673	**1**	0,479	5	0,644	2	0,523	3	0,537	4	0,486	4	0,62	3	0,572	3	0,608	3	0,674	2	0,646	2
Mazowieckie	0,541	3	0,57	3	0,509	2	0,598	2	0,54	2	0,657	**1**	0,553	2	0,591	2	0,584	**1**	0,648	2	0,632	2	0,685	**1**	0,742	**1**	0,693	**1**
Opolskie	0,235	14	0,222	15	0,253	14	0,326	14	0,234	14	0,22	15	0,445	7	0,293	15	0,499	2	0,331	14	0,218	15	0,272	14	0,352	14	0,322	14
Podkarpackie	0,557	2	0,571	2	0,775	**1**	0,588	3	0,497	3	0,584	4	0,659	**1**	0,63	**1**	0,487	3	0,678	**1**	0,724	**1**	0,621	2	0,584	3	0,609	3
Podlaskie	0,424	7	0,468	7	0,42	6	0,46	10	0,442	7	0,506	7	0,491	4	0,473	5	0,483	5	0,609	4	0,517	4	0,537	5	0,5	6	0,476	7
Pomorskie	0,344	10	0,371	13	0,362	10	0,421	13	0,352	12	0,392	13	0,359	15	0,312	14	0,311	14	0,394	11	0,421	8	0,396	11	0,361	13	0,305	15
Śląskie	0,217	15	0,268	14	0,144	**16**	0,153	**16**	0,193	15	0,238	14	0,37	13	0,354	12	0,222	15	0,317	15	0,287	14	0,233	15	0,245	15	0,248	**16**
Świętokrzyskie	0,352	9	0,432	9	0,484	3	0,543	6	0,375	10	0,43	12	0,377	14	0,369	10	0,394	10	0,409	10	0,395	11	0,427	10	0,497	7	0,434	11
Warmińsko-mazurskie	0,311	13	0,413	10	0,357	11	0,502	9	0,445	6	0,518	6	0,414	10	0,397	8	0,399	9	0,454	7	0,424	7	0,518	7	0,492	8	0,506	5
Wielkopolskie	0,588	**1**	0,554	5	0,351	12	0,57	4	0,582	**1**	0,49	8	0,427	9	0,578	3	0,394	11	0,362	13	0,399	10	0,483	8	0,527	5	0,444	10
Zachodniopomorskie	0,335	12	0,404	12	0,389	9	0,433	12	0,36	11	0,488	9	0,396	11	0,36	11	0,381	12	0,43	8	0,358	12	0,387	12	0,444	11	0,476	8

Note: *The legend: KAB – the value of the Natural asset base; R - voivodship position in the ranking. Bold font indicates the first (1) and the last (16) place.*
Source: *Own elaboration*.

Table 3. *The values of the Environmental and resource productivity of the economy for all voivodships between 2005 and 2018*

Voivodship	2005		2006		2007		2008		2009		2010		2011		2012		2013		2014		2015		2016		2017		2018	
	ERP	R	ERP	R	ERP	R	ERP	R	ERP	R	ERP	R	ERP	R	ERP	R	ERP	R	ERP	R	ERP	R	ERP	R	ERP	R	ERP	R
Dolnośląskie	0,49	4	0,493	6	0,484	5	0,515	6	0,392	9	0,402	8	0,385	9	0,471	7	0,452	8	0,38	10	0,38	10	0,316	10	0,37	11	0,316	12
Kujawsko-pomorskie	0,686	**1**	0,722	**1**	0,716	**1**	0,695	**1**	0,677	**1**	0,649	**1**	0,678	2	0,717	3	0,635	3	0,576	4	0,574	3	0,487	7	0,566	5	0,568	5
Lubelskie	0,282	10	0,275	12	0,278	12	0,318	13	0,308	12	0,349	11	0,297	13	0,322	12	0,343	12	0,26	15	0,29	13	0,293	12	0,336	12	0,411	10
Lubuskie	0,403	8	0,405	9	0,401	10	0,423	9	0,409	8	0,455	7	0,483	7	0,591	5	0,538	6	0,556	5	0,565	4	0,631	2	0,575	4	0,535	7
Łódzkie	0,46	5	0,538	3	0,477	6	0,506	7	0,372	10	0,311	12	0,328	11	0,381	11	0,4	10	0,367	11	0,376	11	0,322	9	0,38	10	0,368	11
Małopolskie	0,282	11	0,314	10	0,469	7	0,388	10	0,628	3	0,398	9	0,463	8	0,44	9	0,423	9	0,467	8	0,463	9	0,447	8	0,507	8	0,489	8
Mazowieckie	0,272	12	0,25	13	0,262	13	0,361	11	0,252	13	0,235	15	0,254	15	0,257	13	0,245	**16**	0,329	12	0,202	**16**	0,194	15	0,277	**16**	0,177	**16**
Opolskie	0,439	6	0,412	8	0,418	8	0,533	5	0,473	6	0,514	5	0,487	6	0,46	8	0,469	7	0,486	7	0,523	6	0,535	6	0,551	7	0,577	4
Podkarpackie	0,263	13	0,29	11	0,285	11	0,358	12	0,231	11	0,168	10	0,168	10	0,436	10	0,395	11	0,327	13	0,258	14	0,274	13	0,393	9	0,315	13
Podlaskie	0,533	2	0,519	5	0,565	2	0,625	2	0,675	2	0,647	2	0,64	3	0,754	**1**	0,762	2	0,66	**1**	0,623	2	0,684	**1**	0,671	**1**	0,702	**1**
Pomorskie	0,365	9	0,416	7	0,413	9	0,468	8	0,464	7	0,471	6	0,503	5	0,561	6	0,577	5	0,556	6	0,469	8	0,559	5	0,662	2	0,646	2
Śląskie	0,408	7	0,562	2	0,556	3	0,574	3	0,574	5	0,625	3	0,584	4	0,624	4	0,616	4	0,64	2	0,642	**1**	0,598	3	0,624	3	0,642	3
Świętokrzyskie	0,202	14	0,228	15	0,219	14	0,284	15	0,243	14	0,287	13	0,231	**16**	0,253	14	0,319	13	0,383	9	0,508	7	0,307	11	0,268	14	0,416	9

Warmińsko-mazurskie	0,491	3	0,527	4	0,501	4	0,537	4	0,577	4.	0,55	4	0,723	**1**	0,745	2	0,783	**1**	0,591	3	0,555	5	0,598	4	0,554	6	0,561	6
Wielkopolskie	0,178	15	0,233	14	0,207	15	0,285	14	0,231	15	0,26	14	0,268	14	0,252	15	0,252	15	0,287	14	0,206	15	0,18	**16**	0,235	15	0,225	15
Zachodniopomorskie	0,143	**16**	0,149	**16**	0,151	**16**	0,183	**16**	0,202	**16**	0,201	**16**	0,319	12	0,231	**16**	0,27	14	0,202	**16**	0,305	12	0,267	14	0,273	13	0,28	14

Source: *Own elaboration*.

Table 4. *The values of the Environmental quality of life for all voivodships between 2005 and 2018*

Voivodship	2005		2006		2007		2008		2009		2010		2011		2012		2013		2014		2015		2016		2017		2018	
	EQL	R	EQL	R	EQL	R	EQL	R	EQL	R	EQL	R	EQL	R	EQL	R	EQL	R	EQL	R	EQL	R	EQL	R	EQL	R	EQL	R
Dolnośląskie	0,43	3	0,513	2	0,516	2	0,428	3	0,507	2	0,507	2	0,504	2	0,501	2	0,506	2	0,51	2	0,518	2	0,52	2	0,562	2	0,568	2
Kujawsko-pomorskie	0,382	5	0,384	5	0,384	6	0,383	5	0,386	7	0,38	8	0,381	7	0,375	8	0,372	9	0,373	9	0,375	10	0,371	10	0,397	10	0,409	10
Lubelskie	0,243	15	0,241	15	0,241	15	0,243	15	0,252	14	0,247	15	0,25	14	0,253	14	0,257	13	0,265	13	0,268	13	0,27	13	0,289	13	0,313	13
Lubuskie	0,343	10	0,34	10	0,339	10	0,343	10	0,35	10	0,342	10	0,341	10	0,343	10	0,347	10	0,358	10	0,444	3	0,4545	4	0,4777	4	0,4494	5
Łódzkie	0,246	14	0,263	13	0,268	13	0,249	14	0,241	15	0,25	13	0,235	15	0,222	15	0,214	15	0,201	15	0,207	15	0,215	15	0,222	15	0,199	**16**
Małopolskie	0,376	7	0,375	7	0,377	8	0,378	8	0,39	6	0,396	4	0,392	5	0,393	5	0,396	5	0,401	5	0,406	6	0,4888	3	0,525	3	0,534	3
Mazowieckie	0,382	6	0,382	6	0,387	5	0,383	6	0,381	8	0,382	7	0,379	8	0,38	7	0,377	8	0,376	8	0,381	9	0,383	9	0,411	9	0,412	9
Opolskie	0,283	12	0,286	12	0,287	12	0,285	12	0,281	12	0,292	12	0,291	12	0,298	12	0,311	12	0,301	12	0,313	12	0,315	12	0,336	12	0,314	12
Podkarpackie	0,373	8	0,374	8	0,378	7	0,38	7	0,392	5	0,394	5	0,397	4	0,401	4	0,411	4	0,419	4	0,423	5	0,4276	6	0,4757	6	0,4797	7
Podlaskie	0,253	13	0,249	14	0,248	14	0,251	13	0,257	13	0,248	14	0,252	13	0,256	13	0,251	14	0,259	14	0,262	14	0,2624	14	0,2814	14	0,3054	14
Pomorskie	0,452	2	0,45	3	0,447	3	0,443	2	0,446	3	0,437	3	0,432	3	0,429	3	0,432	3	0,434	3	0,438	4	0,4395	5	0,4969	5	0,4888	6
Śląskie	0,741	**1**	0,744	**1**	0,743	**1**	0,735	**1**	0,726	**1**	0,733	**1**	0,729	**1**	0,725	**1**	0,726	**1**	0,719	**1**	0,717	**1**	0,7161	**1**	0,6997	**1**	0,6672	**1**
Świętokrzyskie	0,197	**16**	0,191	**16**	0,188	**16**	0,185	**16**	0,184	**16**	0,184	**16**	0,184	**16**	0,189	**16**	0,201	**16**	0,2	**16**	0,204	**16**	0,1955	**16**	0,2136	**16**	0,2065	15
Warmińsko-mazurskie	0,338	11	0,333	11	0,33	11	0,327	11	0,321	11	0,322	11	0,323	11	0,324	11	0,33	11	0,337	11	0,34	11	0,344	11	0,364	11	0,384	11
Wielkopolskie	0,363	9	0,361	9	0,36	9	0,368	9	0,371	9	0,374	9	0,375	9	0,374	9	0,379	6	0,383	6	0,389	7	0,3949	7	0,4274	7	0,4548	8
Zachodniopomorskie	0,397	4	0,393	4	0,39	4	0,389	4	0,396	4	0,388	6	0,384	6	0,383	6	0,379	7	0,383	7	0,389	8	0,3933	8	0,4199	8	0,5194	4

Note: *The legend: EQL – the value of the Environmental quality of life; R - voivodship position in the ranking. Bold font indicates the first (1) and the last (16) place.*
Source: *Own elaboration.*

Table 5. *The values of the Economic opportunities and policy responses for all voivodships between 2005 and 2018*

Voivodship	2005		2006		2007		2008		2009		2010		2011		2012		2013		2014		2015		2016		2017		2018	
	EOPR	R	EOPR	R	EOPR	R	EOPR	R	EOPR	R	EOPR	R	EOPR	R	EOPR	R	EOPR	R	EOPR	R	EOPR	R	EOPR	R	EOPR	R	EOPR	R
Dolnośląskie	0,341	5	0,43	3	0,357	6	0,47	4	0,335	6	0,155	11	0,135	12	0,183	13	0,18	14	0,302	9	0,237	13	0,204	12	0,182	11	0,244	9
Kujawsko-pomorskie	0,585	**1**	0,232	12	0,128	**16**	0,314	10	0,309	9	0,253	5	0,116	14	0,19	11	0,196	10	0,364	6	0,272	8	0,14	**16**	0,135	14	0,25	8
Lubelskie	0,172	13	0,176	14	0,157	13	0,242	15	0,157	15	0,094	**16**	0,102	15	0,185	12	0,19	12	0,37	5	0,229	14	0,17	14	0,088	**16**	0,251	7
Lubuskie	0,257	8	0,286	10	0,226	11	0,324	9	0,318	8	0,144	15	0,119	13	0,169	15	0,177	15	0,262	12	0,309	7	0,28	7	0,182	12	0,228	10
Łódzkie	0,433	3	0,339	6	0,279	10	0,309	11	0,284	11	0,242	6	0,547	**1**	0,483	**1**	0,449	**1**	0,403	3	0,347	4	0,476	2	0,381	2	0,38	2
Małopolskie	0,407	4	0,273	11	0,325	8	0,357	8	0,288	10	0,145	14	0,16	11	0,194	9	0,206	8	0,256	14	0,347	5	0,4646	3	0,3333	3	0,3535	4
Mazowieckie	0,456	2	0,433	2	0,49	2	0,613	**1**	0,475	4	0,304	3	0,226	6	0,213	6	0,425	3	0,445	2	0,327	6	0,3784	4	0,2984	4	0,3959	3
Opolskie	0,222	10	0,338	7	0,49	3	0,403	5	0,488	2	0,151	12	0,183	9	0,251	5	0,235	6	0,389	4	0,258	10	0,4343	5	0,2925	5	0,2093	13
Podkarpackie	0,215	11	0,33	8	0,356	7	0,302	12	0,199	14	0,229	7	0,185	7	0,178	14	0,188	13	0,21	**16**	0,357	3	0,1656	15	0,2319	9	0,2061	14
Podlaskie	0,071	**16**	0,166	15	0,188	12	0,26	14	0,146	**16**	0,148	13	0,102	**16**	0,194	10	0,204	9	0,341	8	0,27	9	0,277	8	0,2538	8	0,2019	11

Pomorskie	0,2	12	0,324	9	0,306	9	0,275	13	0,401	5	0,333	2	0,252	4	0,196	7	0,218	7	0,26	13	0,219	15	0,229	11	0,284	6	0,218	12
Śląskie	0,335	7	0,429	4	0,395	4	0,56	2	0,52	**1**	0,268	4	0,166	10	0,195	8	0,191	11	0,269	11	0,242	12	0,285	6	0,269	7	0,257	6
Świętokrzyskie	0,162	14	0,186	13	0,144	15	0,394	6	0,325	7	0,211	8	0,314	3	0,477	2	0,428	2	0,343	7	0,183	**6**	0,264	10	0,114	15	0,131	**6**
Warmińsko-mazurskie	0,131	15	0,156	**6**	0,156	14	0,239	**6**	0,205	13	0,193	10	0,234	5	0,269	4	0,237	5	0,236	15	0,252	11	0,177	13	0,218	10	0,332	5
Wielkopolskie	0,243	9	0,395	5	0,359	5	0,363	7	0,246	12	0,196	9	0,185	8	0,169	**16**	0,136	**16**	0,288	10	0,4	2	0,268	9	0,163	13	0,184	15
Zachodniopomorskie	0,341	6	0,681	**1**	0,593	**1**	0,54	3	0,477	3	0,67	**1**	0,317	2	0,298	3	0,318	4	0,48	**1**	0,418	**1**	0,57	**1**	0,687	**1**	0,649	**1**

Note: *The legend: EOPR – the value of the Economic opportunities and policy responses; R - voivodship position in the ranking.*
Bold font indicates the first (1) and the last (16) place.
Source: *Own elaboration.*

Table 6. *The values of the Regional Green Economy Measure and rankings for all voivodships between 2005 and 2018*

Voivodship	2005		2006		2007		2008		2009		2010		2011		2012		2013		2014		2015		2016		2017		2018	
	RGEM	R	RGEM	R	RGEM	R	RGEM	R	RGEM	R	RGEM	R	RGEM	R	RGEM	R	RGEM	R	RGEM	R	RGEM	R	RGEM	R	RGEM	R	RGEM	R
Dolnośląskie	0,350	8	0,412	3	0,388	6	0,419	5	0,347	13	0,314	13	0,301	14	0,334	12	0,224	14	0,351	13	0,321	15	0,294	**16**	0,354	14	0,377	11
Kujawsko-pomorskie	0,499	**1**	0,449	2	0,409	4	0,480	3	0,444	3	0,433	3	0,402	4	0,399	5	0,403	5	0,431	5	0,410	6	0,381	9	0,391	10	0,423	7
Lubelskie	0,287	15	0,318	14	0,376	15	0,329	**16**	0,300	14	0,328	12	0,275	15	0,307	**16**	0,313	15	0,357	12	0,323	13	0,321	14	0,301	15	0,367	12
Lubuskie	0,365	6	0,376	11	0,352	11	0,411	6	0,379	8	0,368	10	0,355	9	0,373	9	0,376	9	0,433	4	0,435	4	0,432	4	0,443	5	0,448	4
Łódzkie	0,376	5	0,387	8	0,334	13	0,377	14	0,297	15	0,313	14	0,374	7	0,374	8	0,356	11	0,341	14	0,318	**16**	0,371	10	0,355	12	0,334	14
Małopolskie	0,391	4	0,381	10	0,397	5	0,449	4	0,446	2	0,396	6	0,385	6	0,391	6	0,378	8	0,436	3	0,447	2	0,497	**1**	0,510	**1**	0,501	**1**
Mazowieckie	0,413	3	0,409	4	0,412	3	0,489	2	0,412	5	0,395	7	0,349	12	0,360	10	0,408	4	0,411	7	0,386	9	0,410	5	0,414	8	0,410	9
Opolskie	0,295	14	0,314	15	0,362	9	0,387	12	0,369	9	0,294	15	0,352	11	0,325	13	0,378	7	0,377	11	0,328	12	0,366	12	0,383	11	0,356	13
Podkarpackie	0,352	7	0,391	6	0,448	2	0,407	7	0,353	12	0,394	8	0,402	3	0,411	4	0,371	10	0,409	8	0,441	3	0,371	11	0,416	7	0,402	10
Podlaskie	0,320	11	0,350	13	0,355	10	0,399	10	0,380	7	0,387	9	0,371	8	0,419	3	0,425	3	0,467	2	0,418	5	0,438	3	0,426	6	0,426	6
Pomorskie	0,340	10	0,390	7	0,382	7	0,402	8	0,416	4	0,408	4	0,386	5	0,374	7	0,384	6	0,411	6	0,387	8	0,406	7	0,444	4	0,414	8
Śląskie	0,425	2	0,501	**1**	0,459	**1**	0,505	**1**	0,503	**1**	0,466	**1**	0,462	**1**	0,474	**1**	0,439	**1**	0,486	**1**	0,472	**1**	0,458	2	0,459	2	0,455	3
Świętokrzyskie	0,228	**16**	0,259	**16**	0,258	**16**	0,351	15	0,282	**16**	0,278	**16**	0,275	**16**	0,322	14	0,336	13	0,334	15	0,323	14	0,298	15	0,273	**16**	0,297	**16**
Warmińsko-mazurskie	0,318	12	0,357	12	0,336	12	0,401	9	0,390	6	0,396	5	0,424	2	0,433	2	0,437	2	0,405	10	0,393	7	0,408	6	0,407	9	0,446	5
Wielkopolskie	0,343	9	0,386	9	0,319	14	0,396	11	0,358	11	0,330	11	0,314	13	0,343	11	0,290	**16**	0,330	**16**	0,349	11	0,313	13	0,338	13	0,327	15
Zachodniopomorskie	0,304	13	0,407	5	0,381	8	0,386	13	0,359	10	0,437	2	0,354	10	0,318	15	0,337	12	0,406	9	0,367	10	0,404	8	0,456	3	0,481	2

Note: *The legend: RGEM - value of the Regional Green Economy Measure; R - voivodship position in the ranking.*
Bold font indicates the first (1) and the last (16) place.
Source: *Own elaboration.*