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Green Economy from a Regional Perspective – a Polish Case Study

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ABSTRACT:
The article presents the elaboration and specification of the green economy concept, where resource scarcity, global climate change and environmental degradation are paving a new path towards sustainable development. The article addresses the issue of implementing the principles of green economy at the regional level. The implementation of a green economy at a regional level provides an excellent space for scientific deliberations. The aim of the research is to identify and assess the level of regional disparities in green economy development across Polish regions using a synthetic measure. The basis for the analysis was a set of substantively and statistically analyzed diagnostic variables from the years 2012-2022. The synthetic indicator of the green economy was calculated for every Polish region (NUTS 2) and the regions were ranked based on their score from highest to lowest. As a result of the analysis, the regional polarization and the ordering of regions in Poland in terms of the synthetic metric - green economy development - were discussed.

Keywords: green economy, green growth, sustainable development, taxonomic methods.

1. Introduction

In recent years, the concept of a green economy has become a leading perspective in the transformation of modern world economies, having been singled out as one of the paths towards sustainable development (Stanković et. al., 2024; Houssam et. al., 2023; Ospanova et. al., 2022). Its presumed advantage lies in the greater specificity and operationalization of sustainable development as it synthesizes environmental protection and economic growth in a skillful and coherent manner. Although the term 'green economy' seems to favor a certain narrowing of the field of view to economic processes, the adjective 'green' implies the constant presence of environmental criteria. The 'green economy' has thus become a sweet-spot solution to the dilemmas so far accompanying the concept of sustainable development - that is, the attempt to reconcile often conflicting social, economic and environmental interests. These dilemmas were reflected in the controversial approach to the prioritization of environmental protection over either social or economic development (Ślebocka, Tylman, 2014).

Analyzing the underpinnings of green-economy development is a very stimulating and timely research problem. All the more so considering that regions play a particular role in the process of transformation towards a green economy as this is where the most tangible initiatives are clustered. From the perspective of a region, a green economy means an economically justified, socially acceptable and environmentally friendly use of resources

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aimed at sustaining development in the long term (Gunay et. al., 2023; Godlewska, Sidorczuk-Pietraszko, 2019). The issue of implementing a green economy at the level of the European Union (EU) as a whole and individual countries has already been the subject of quite a rich literature, also with regard to the issue of measuring progress in their implementation. However, the application of this concept to the level of regions has been investigated to a lesser extent.

In Poland specifically, the pursuit of a green economy has been launched and implemented mainly as a byproduct of EU regulations, although as far as political declarations are concerned, Poland's development strategies have since 2000 emphasized the need to transform the Polish economy towards a green economy. Both *Poland 2025 - a long-term strategy for sustainable development* (Polska 2025…, 2000) and the National Development Strategy 2020 (Strategia Rozwoju Kraju 2020…, 2012) refer by name to the concept of sustainable development and stress the need for pro-environmental transformation of the economy. In the domain perspective, it is the ecological policy of the state, which is one of the so-called integrated policies. In the spatial perspective, these are supra-regional strategies, regional development strategies and operational programs for the use of structural funds created by voivodeship governments. These regional strategies and operational programs have become one of the main tools for implementing the concept of sustainable development in the spatial dimension in the conditions of Poland's membership in the EU (Sidorczuk-Pietraszko, 2020). The details of such ecological modernization are also addressed in the National Strategy for Regional Development 2030 (NSRD) (Uchwała nr 102 Rady Ministrów…, 2019), which is one of the integrated strategies relating to the regional aspect of Poland's development. This document recognizes the problems of climate change and the role of environmental resources in regional development, as well as the need to respect the needs of future generations. Moreover, the concept of regional smart specialisations has become an important policy instrument in relation to the pro-ecological modernisation of the economy in Poland.

The issues discussed in this article are important for several reasons. First, they enable identifying theoretical assumptions of the green economy concept. Secondly, through them, the level of development of the green economy in Poland can be assessed and regional comparisons can be made. Another reason concerns the selection of indicators describing individual aspects of the green economy. Reliable, carefully selected and up-to-date data constitute a vital component in the implementation of environmental protection policies, economic instruments and activities supporting ecological innovations and investment in green technologies. In addition to that, these research results can be used by public and private entities in making strategic decisions, and considered in a broader context, they can enable tracking changes taking place in the environment, economy and society.

In green-economy development research, and particularly in comparative spatial analyses, it is helpful to use multivariate statistical methods which enable the determination of a synthetic measure (metric). This measure replaces an otherwise numerous set of features of the studied objects (e.g. region) with one aggregated variable. The use of synthetic measures also helps capture the multidimensional phenomenon of the green economy as well as both group and linearly rank the studied objects.

The aim of the article is to assess the regional differentiation of the level of green

economy development in Poland in the years 2012-2022 using a synthetic measure. The first part of the article discusses the theoretical foundations of research on the green economy and describes the methods of constructing a synthetic indicator, as well as the method of using the results of linear ordering to classify objects (regions) into typological groups. The second part is empirical. The article uses a dual approach to measuring the advancement of the green economy by, first, showcasing changes in specific indicators covered by the synthetic measure and ranking regions, and second, by grouping regions assigning them to four typological groups.

2. The Green economy concept

The concept of a green economy was formulated in the late 1990s. The term 'green economy' was first used in a 1989 report *Blueprint for a Green Economy* (Pearce, Markandya, Barbier, 1989; Barbier, Markandya, 2012), developed for the UK Government to provide expert knowledge on the state of the sustainability discussion and the implications of the concept for measuring economic development and assessing projects and policies. The green economy concept borders on neoclassical and environmental economics, also incorporating aspects of ecological and sustainability economics (Ryszawska, 2013). Among the concepts related to the pro-environmental transformation of the economy, the green economy is the broadest in terms of its subject scope as it covers both the low-emission economy, the circular economy and the bioeconomy . It focuses on the perception of threats resulting from the expansive economic and social activities of humans, which irreversibly destroy the natural environment and deplete its limited resources (Bąk, 2022).

The green economy is very attractive to governments and businesses as it aims to provide a simultaneous solution to both unemployment and environmental issues with new green industries and tools for mitigating environmental damage (Loiseau et. al., 2016).

There is no single comprehensive definition of the term 'green economy' in the literature. Although there are no strict criteria for its definition, according to many supporters and proponents of this idea, it is a response to the global problems of environmental degradation caused by expansive human activity. One of the most widely cited definitions of the green economy was proposed by the UNEP (2011). According to UNEP, a green economy is one that "results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities". The prerequisites of a green economy are investments leading to reduced gas emissions and fewer pollutants, a more efficient use of energy and raw materials, and protecting biodiversity and the ecosystem - all of which act also as income and employment boosters. Meanwhile, a definition proposed by OECD (2011) sees the green economy as growth that not only supports green management but also facilitates sustainable development by ensuring environmental sustainability and maintaining the conditions for continuing social progress. The EU has set ambitious targets for reducing greenhouse gas emissions, aiming for at least a 40% reduction by 2030 compared to 1990 levels and becoming carbon-neutral by 2050 (Wyrwa et. al., 2023). Statistics Poland, drawing from the input of OECD and other environmental organizations such as the United Nations Environment Program (UNEP) and the European Environment Agency (EEA), has attempted to adapt the definition of the green economy to Polish conditions. And so, in Poland, a green economy

came to be defined as one in which economic growth and development take place while maintaining access to natural capital and ecosystem services on which human well-being depends (GUS, 2022).

The concept of the green economy stems from the belief that economic development is structurally linked with the policy of protecting natural resources and the quality of the natural environment (Barbier, 2016). Viewed as such, a green economy implies a transition to an economic model based on sustainable production, exchange, consumption and sharing of economic and social benefits with particular care for the natural environment. Today, the green economy is treated by many researchers as a way of *operationalizing* the concept of sustainable development in relation to the economic area. (Sarkodie et. al., 2024). However, where sustainable development postulates for long-term implementation of development processes in a society-economy-environment macrosystem, the green economy focuses on the relations between the economy and the environment. Having said that, similarly to the concept of sustainable development itself, it is by no means a set of fixed rules (UNDESA, 2012), and its essence is rather to pinpoint courses of action that might smoothen the *sensitization* of an economy to environmental constraints as well as to suggest a pathway as to how that goal might be best achieved (Sidorczuk-Pietraszko, 2020).

Investments that curb harmful emissions of gasses and pollutants, pro-environmental social behavior and protection of biodiversity on one hand, and ensuring economic activity, management efficiency and economic growth on the other hand, are both of key importance for the implementation of the green economy concept. For this reason, the term 'green economy' is also closely linked with OECD's 'green growth' and 'sustainable development' (OECD, 2011; Adamowicz, 2021). According to OECD, green growth means striving for economic growth and development while preventing environmental degradation, loss of biodiversity and unsustainable use of natural resources. Green growth leads to the decoupling of the products of economic activity from the products of environmental activity, and it also seeks to position environmental investment as the driving force of economic growth. The World Bank, for its part, defines green growth as a growth pattern that is efficient in its use of natural resources, clean in that it minimizes pollution and environmental impacts, and resilient in that it accounts for natural hazards and the role of environmental management and natural capital in preventing disasters (World Bank, 2012). According to the Global Green Growth Institute (GGGI), green growth is a new and revolutionary development paradigm that sustains economic growth while ensuring climate and environmental sustainability. It is aimed at stimulating poverty reduction, job creation, social inclusion and ecosystem sustainability, while mitigating climate change, supporting biodiversity, and ensuring access to clean water and energy (GGGI, 2019).

The green economy is currently perceived by the EU as a strategic approach to systemic challenges related to the overexploitation and degradation of the environment, ensuring resource security, employment and competitiveness. The concept of the green economy indicates a broader perspective of activities in the field of pro-ecological modernization of the economy - a change in the economic system will allow for the simultaneous implementation of economic, environmental and social goals. The European Commission emphasises that climate change, although it poses a huge challenge, also

generates favourable conditions for building a new economic model. The new Cohesion Policy for 2021-2027 sets five main priorities focused on investments in regional development. These investments will be driven primarily by the pursuit of shaping Europe, firstly, smarter (through innovation, digitalisation, transformation of economies and support for small and medium-sized businesses), secondly, greener and carbon-free (through implementing the principles of the Paris Accord, investing in energy and renewable sources and combating climate change), thirdly, more connected (through strategic transport and digital networks), fourthly, more social (through the creation of quality jobs, development of education, social inclusion and equal access to healthcare) and fifthly, closer to societies (through supporting local development strategies and sustainable development of urban areas throughout the European Union) (Forging a sustainable future together, 2024).

3. Methods

Multivariate statistical methods were used In this research, enabling the development of a synthetic measure for the green economy. Many methods for developing synthetic measures can be found in the literature (Hellwig, 1968; Hwang, 1981; Cieślak et. al., 2019; Strahl, 1990; Malina, 2004; Młoda, 2006; Zeliaś, Lipieta, 2000, Barska et al. 2022). Most often, two groups of methods are used to construct a synthetic indicator - reference and non-pattern. In the case of reference methods, a reference object is defined against which, when calculating taxonomic distances, the distance for all examined objects is determined. In the patternless method, the synthetic variable is determined mainly by operating on the normalized values of a set of features (including the arithmetic mean) (Panek, 2009, p. 420). Standard-free measures were used in this research.

The subject of this research were all Polish regions (NUTS 2) in the years 2012-2022. The territorial scope included all regions (voivodeships) of Poland (NUTS 2) in 2012-2022. The analysis covers all 16 Polish regions. Explanatory variables were selected on the basis of substantive, statistical and form al criteria. The first stage of creating a synthetic measure was to establish partial indicators whose selection was determined mainly by their relevance to the green economy and the scope of available statistical data. The research used statistical data from Poland's Central Statistical Office and the Ministry of Agriculture and Rural Development.

For the construction of a synthetic measure, the authors, based on the analysis of the literature, came up with a total of 10 indicators to assess Poland's green economy from a regional perspective (Table 1). In studies exploring the regional aspect of the green economy, the authors tend to rely on their own sets of indicators or synthetic metrics built upon data retrievable at a regional level (Sidorczuk-Pietraszko, 2020, p. 94).

Table 1. Variable characteristics

Variable	Name
X1	Expenditures on fixed assets for environmental protection - per capita
X2	Industrial and municipal sewage requiring treatment discharged into water or land during the year - total per capita
X3	Water consumption for the needs of the national economy and population during the year - per capita

X4	Waste collected separately in relation to total waste
X5	Emission of gaseous pollutants - total emissions per km²
X6	Share of degraded areas in total area (%)
X7	Share of green areas in cities in total area (%)
X8	Share of electricity production from renewable sources in total electricity production (%)
X9	Certified organic farms - share of agricultural land in total agricultural land
X10	Share of certified organic farms in the total number of organic farms

Source: own elaboration.

Subsequently, the partial variables were subjected to statistical verification, meaning their discrimination power and capacity (i.e. the degree of correlation with other variables) were examined. The coefficient of variation was used to determine the discrimination power of the variables (differentiation of variables). It was assumed that those for which the coefficient value was less than 10% would be eliminated from the set of diagnostic variables. After performing appropriate calculations, the variable X10 was removed from the set of variables. However, to examine the degree of correlation of variables, an analysis of the matrix of Pearson correlation coefficients was performed. It was assumed that if the correlation coefficient exceeds the threshold value r*=0.7, one of the variables will be removed from the set of diagnostic variables. The analysis revealed that the correlation coefficients were lower than 0.7, therefore all variables were qualified for further research.

The next step was to determine the nature of the variables in terms of their impact on the described phenomenon, that is the division of variables into: *stimulants*, *destimulants* (inhibitors), and *nominants* . The variables X1, X4, X7, X8, X9 were classified as *stimulants*, X2, X3, X5 – as *destimulants;* there were no *nominants*. The three *destimulants* were subsequently transformed into *stimulants*.

In multivariate analysis, it is important to render individual partial variables mutually comparable. Thus, normalization of the variables was performed. Various normalization procedures are presented in the literature (e.g. standardization, unitarization, quotient transformation). In this study, unitarization of variables was carried out (Strahl 1998, p. 272):

$$z_{ij} = (x_{ij} - min\, x_i) \,/\, (max\, x_i - min\, x_i) \quad (1)$$

Where :

z_{ij} - normalized value of the j-th variable in the -ith region,

x_{ij} – empirical value of the j-th variable in the i-th region,

$min\, x_i$ – minimum value of the j-th variable,

$max\, x_i$ – maximum value of the j-th variable.

The last stage consisted in the aggregation of partial indicators and the determination of a synthetic metric. Based on the standardized variables, synthetic measures of the Polish regions' green economy were calculated:

$$z_i = \frac{1}{n}\sum_{j=1}^{n} z_{ij} \quad (i = 1, 2, 3, \ldots, m) \quad (2)$$

where :

n – numeric variables ,
z_{ij} – normalized values of the j-th variable for the i-th region.

The results of linear ordering also constituted the basis for the classification of regions into homogeneous groups that differ from each other in terms of the achieved level of green economy development. The regions were divided into four homogeneous groups according to the following principle:

Group I (very high level of green economy development): $z_i \geq \bar{z}_i + S_{z_i}$

Group II (high level of green economy development): $\bar{z}_i + S_z > z_i \geq \bar{z}_i$

Group III (moderate level of green economy development): $\bar{z}_i > z_i \geq \bar{z}_i - S_{z_i}$

Group IV (low level of green economy development): $z_i < \bar{z}_i - S_{z_i}$

4. Results and discussion

A total of 10 indicators were proposed, the analysis of which could help guide support for activities aimed at improving the efficiency of using elements of the natural environment in the context of the green economy (Table 1).

Variable X1 characterizes expenditure on fixed assets for environmental protection per capita. As such, it determines spending on devices meant for the purification and pre-treatment of industrial and municipal sewage and mine water, as well as on-site water treatment devices for industrial purposes and devices for the disposal of solid and liquid waste, e.g. incinerators, per capita. In 2022, compared to 2012, this indicator increased in Poland by more than one third (39%). In Lubuskie in 2022, expenditure on fixed assets amounted to PLN 402.00 and was 9.2% higher than the national average and the region ultimately ranked 5th out of 16. Despite the reported increase in expenditure on environmental protection, its persistent low share in relation to GDP indicates the need for further investment in this area to markedly improve the condition of the environment and prevent its degradation resulting from economic activity.

Variable X2 is a total amount of industrial and municipal sewage requiring treatment that was discharged into water or land during the year per capita. The analysis shows that the scale of sewage management problems in Poland remains significant as the amount of generated sewage increases each year even if the effectiveness of its treatment is systematically improving. In Lubuskie, this indicator stood at 69% (39.2 m³) against Poland's average of 56.8 m³.

Variable X3 is water consumption for the needs of the national economy and population during the year per capita. For several years, a decreasing trend has been observed in terms of water consumption for the needs of the national economy and population per capita. Although this is not a very sharp or spectacular decline, it is still commendable. In 2022, compared to 2012, a decrease of 11.7% was reported throughout the country, and a 14.4% drop in Lubuskie. The decreasing trend over the following years

indicates that the national economy is implementing water-saving policies and the Polish population is increasingly guided by the principles of saving water.

Variable X4 is waste collected selectively in relation to total waste. The increase in this indicator shows the growing advancement in the waste selection process. Throughout Poland, in 2022 compared to 2012, this indicator increased almost fourfold. In Lubuskie, it stood at 36.2% in 2022 and was slightly lower than the average for Poland (39.9%).

Variable X5 is the total emission of gaseous pollutants per km². More than 99% of such emissions were carbon dioxide and 0.1% each were sulfur dioxide, carbon monoxide and nitrogen oxides. The predominant sources of emissions of industrial gaseous pollutants were entities operating in the field of production and supply of electricity, gas, steam, hot water (67%) and industrial processing plants (31%). In Poland in 2023, this indicator was 651.14 tons per km², a decrease by 6.3% compared to 2012. In Lubuskie it was 4.5 times lower, which is primarily due to the regions' relatively poor industrialization overall.

Variable X6 is the share of degraded areas in the total area (%). In Poland, this indicator stood at 0.025 in 2022, while in Lubuskie it was 0.046 - the highest in the country. X7 is the share of green areas in cities in the total area (%). Greenery not only moderates the temperature and heat load but also clears the air of pollutants and muffles noise. In Poland in 2022, this share was 4.8%, which means an increase of 4% compared to 2012. Unfortunately, in Lubuskie, the opposite trend was reported, showing a decrease of almost 12 percentage points (with this indicator being 4.21% in 2022).

Variable X8 is the share of electricity production from renewable sources in total electricity production (%). In 2022, compared to 2012, the share of energy from renewable sources in gross final energy consumption increased by over 100% and amounted to 21%. In this respect, a systematic increase was recorded in Poland. Energy obtained from renewable sources in Poland in 2020 came mainly from solid biofuels (71.61%), wind energy (10.85%) and liquid biofuels (7.79%). The total this energy in Poland in 2020 was 524,113 TJ. A large disparity was reported across regions, with the highest value having been observed in Warmińsko-Mazurskim (95.6%,) and the lowest in Opole (5.6%); it was 35.7% in Lubuskie.

Variable X9 is certified organic farms - the share of agricultural land in total agricultural land. An organic farm is a production unit using a farm management and food production system, combining the most environment- and climate-friendly processes which ensures a high degree of biodiversity. Currently, approximately 20,000 businesses in Poland are organic producers. Comparing the data for 2020 with 2013, which was the most favorable year in that sense, the number of organic producers decreased by as much as 25%. This indicator was in Poland in 2022 - 2.64 and 6.98 in Lubuskie (3rd out of 16).

Variable X10 is the share of certified organic farms in the total number of organic farms. In Poland, this indicator in 2022 was 71.71%, and 64.53% in Lubuskie. Food certification at the stage of agricultural production, processing and distribution gives consumers confidence that food products marked with the European organic logo, (the so-called "Euroleaf") were made in accordance with the regulations in force in organic farming.

Having analyzed the standalone metrics, multivariate statistical methods were used to determine a synthetic measure of the green economy. Table 2 shows the values of

synthetic measures for every Polish region in the years 2012-2022. The conclusion can be drawn that there is significant regional variation in the level of green economy development in Poland. In 2012, the synthetic measure "green economy" ranged from 0.283 (Śląskie) to 0.795 (Warmińsko-Mazurskim). However, in 2022 it ranged from 0.322 (Śląskie) to 0.772 (Warmińsko-Mazurskim). Throughout the entire examined period, the value of measures for regions that scored the highest values was more than twice as high as the value of measures for regions that scored the lowest values.

The average value of the synthetic measure of the green economy in Poland in 2012-2022 was 0.539. The highest level of this measure was identified in the following regions: Warmińsko-Mazurskim (values ranged between 0.742 and 0.831), Podlaskie (values ranged between 0.586 and 0.690) and Pomorskie (values ranged between 0.547 and 0.678). The lowest values were reported in the following regions: Silesia (values ranged between 0.282 and 0.354) and Świętokrzyskie (values ranged between 0.290 and 0.501). In the period under study, most regions recorded an increase in the value of the synthetic indicator, which means favorable changes in the area of the green economy (e.g. in Opolskie, Zachodniopomorskie and Pomorskie). Having said that, some of the regions recorded a decline in the value of the metrics which may hint at wrong decisions in the area of implementing the idea of the green economy (e.g. in Świętokrzyskie). The value of the measure scored by Lubuskie should be assessed positively. In the analyzed period, Lubuskie's score was higher than Poland's average (Table 2.).

Table 2. Values of synthetic meters

Voivodeship	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2012 - 2022
Dolnośląskie	0.375	0.366	0.413	0.429	0.379	0.369	0.415	0.440	0.425	0.400	0.453	0.406
Kujawsko-Pomorskie	0.631	0.660	0.659	0.677	0.634	0.597	0.605	0.586	0.562	0.552	0.545	0.610
Lubelskie	0.548	0.536	0.566	0.544	0.551	0.564	0.675	0.674	0.665	0.674	0.682	0.607
Lubuskie	0.571	0.588	0.634	0.600	0.590	0.581	0.567	0.582	0.579	0.608	0.648	0.595
Łódzkie	0.554	0.530	0.574	0.532	0.552	0.526	0.540	0.546	0.572	0.550	0.524	0.545
Małopolskie	0.528	0.501	0.508	0.520	0.525	0.472	0.481	0.494	0.489	0.477	0.574	0.506
Mazowieckie	0.474	0.493	0.488	0.525	0.515	0.472	0.496	0.541	0.473	0.512	0.529	0.502
Opolskie	0.361	0.445	0.477	0.469	0.492	0.446	0.431	0.459	0.386	0.450	0.461	0.443
Podkarpackie	0.601	0.627	0.545	0.559	0.556	0.571	0.604	0.619	0.609	0.561	0.591	0.586
Podlaskie	0.586	0.594	0.616	0.638	0.602	0.624	0.683	0.690	0.673	0.641	0.671	0.638
Pomorskie	0.547	0.580	0.583	0.601	0.602	0.631	0.616	0.630	0.678	0.641	0.644	0.614
Śląskie	0.283	0.282	0.333	0.343	0.352	0.354	0.343	0.346	0.311	0.292	0.299	0.322
Świętokrzyskie	0.436	0.501	0.491	0.414	0.379	0.334	0.343	0.375	0.376	0.301	0.290	0.385
Warmińsko-Mazurskie	0.795	0.810	0.731	0.742	0.750	0.765	0.762	0.761	0.753	0.831	0.787	0.772
Wielkopolskie	0.486	0.477	0.519	0.552	0.466	0.488	0.528	0.577	0.549	0.556	0.626	0.529
Zachodniopomorskie	0.494	0.538	0.526	0.550	0.535	0.623	0.620	0.596	0.591	0.551	0.561	0.562

Source: own study.

In order to assess the relative position of individual regions, a ranking was developed. The regions have been ordered from highest to lowest value of the synthetic "green economy" measure. The values and the ordering results are shown in Table 3.

Table 3. Ranking of Polish regions in 2012-2022

Voivodeship	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2012 - 2022
Dolnośląskie	14	15	15	14	15	14	14	14	13	14	14	14
Kujawsko-Pomorskie	2	2	2	2	2	5	6	7	9	8	10	4
Lubelskie	7	8	7	9	8	8	3	3	4	2	2	5
Lubuskie	5	5	3	5	5	6	8	8	7	5	4	6
Łódzkie	6	9	6	10	7	9	9	10	8	10	12	9
Małopolskie	9	11	11	12	10	12	12	12	11	12	8	11
Mazowieckie	12	12	13	11	11	11	11	11	12	11	11	12
Opolskie	15	14	14	13	12	13	13	13	14	13	13	13
Podkarpackie	3	3	8	6	6	7	7	5	5	6	7	7
Podlaskie	4	4	4	3	4	3	2	2	3	3	3	2
Pomorskie	8	6	5	4	3	2	5	4	2	4	5	3
Śląskie	16	16	16	16	16	15	15	16	16	16	15	16
Świętokrzyskie	13	10	12	15	14	16	16	15	15	15	16	15
Warmińsko-Mazurskie	1	1	1	1	1	1	1	1	1	1	1	1
Wielkopolskie	11	13	10	7	13	10	10	9	10	7	6	10
Zachodniopomorskie	10	7	9	8	9	4	4	6	6	9	9	8

Source: own study.

The analysis of the results shown in Table 3 points to a high level of diversity across Polish regions. In most regions, the position in the ranking saw dynamic changes (a few spots up or down). For example, in the first years of the analyzed period, Kujawsko-Pomorski ranked 2nd, only to finish 10th in 2022. Only four regions (Dolnośląskie, Mazowieckie, Podlaskie, Śląskie) saw their position fluctuate by a maximum of 3 spots. However, throughout the period under study, the leading position was held by the Warmińsko-Mazurskie, owing among others to low industrialization. As far as Lubuskie is concerned, its most favorable score was 3rd in 2014 while its worst was 8th in 2018 and 2019.

Table 4 shows the results of the classification of regions into homogeneous groups based on the level of green economy development. In 2012, Group 1 (very high level) included only one region – Warmińsko-Mazurskie. In 2013, it was joined by Kujawsko-Pomorskie (until 2016) and briefly also by Subcarpathia which in the following years returned to Group II. In 2022, the largest group was Group II (high level) with a total 7 regions out of 16. Lubuskie's high position in the ranking is correlated with low water consumption, low emissions of gaseous pollutants per m² and a high share of electricity production from renewable sources in total electricity production (%).

Table 4. Division of regions into four homogeneous groups

Voivodeship	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2012 - 2022
Dolnośląskie	IV	IV	IV	IV	III	IV	IV	IV	III	IV	III	IV
Kujawsko-Pomorskie	II	I	I	I	I	II	II	II	II	II	III	II
Lubelskie	II	II	II	II	II	II	I	I	II	I	II	II
Lubuskie	II	II	II	II	II	II	II	II	II	II	II	II
Łódzkie	II	III	II	III	II	II	III	III	II	II	III	II

Małopolskie	II	III	III	III	III	III	III	III	III	III	II	III
Mazowieckie	III	III	III	III	III	III	III	III	III	III	III	III
Opolskie	IV	III	III	III	III	III	III	III	4	III	III	III
Podkarpackie	II	I	II	II	II	II	II	II	II	II	II	II
Podlaskie	II	II	II	II	II	II	I	I	I	II	II	II
Pomorskie	II	II	II	II	II	II	II	II	I	II	II	II
Śląskie	IV	IV	IV	IV	IV	IV	IV	IV	IV	IV	IV	IV
Świętokrzyskie	III	III	III	IV	IV	IV	IV	IV	IV	IV	IV	IV
Warmińsko-Mazurskie	I	I	I	I	I	I	I	I	I	I	I	I
Wielkopolskie	III	III	III	II	III	III	III	II	II	II	II	III
Zachodniopomorskie	III	II	III	II	II	II	II	II	II	II	II	II

Source: own study.

5.Conclusion

The conducted research indicates spatial differences in the level of advancement of the green economy of Polish regions in the years 2012-2022. In the majority of the country's regions, there is a systematic improvement in indicators although there are voivodeships where the situation deteriorated over the years.

The analysis of change trends in selected indicator and the synthetic indicator confirmed that the level of *greening* of the Polish economy is indeed on the rise. The study demonstrates that, at a general level, most regions in Poland in 2022 have made advances in building a green economy compared to 2012. Having said that, the progress of individual regions varies depending on their socio-economic characteristics. This is the result of the natural and historical conditions. Regional factors such as the level of industrialization and the availability of natural resources have an impact on the level of development of the green economy. Low-industrialized regions with, among other things, low levels of gaseous pollutant emissions and high use of natural resources are characterized by a high level of development of the green economy (Warmińsko-Mazurskie, Podlaskie). In turn, industrialized voivodeships that emit high levels of gaseous pollutants and poorly use natural resources (including a low share of electricity production from renewable sources in total electricity production) are characterized by a low level of development of the green economy (Śląskie).

A higher or lower position in the ranking can be considered a way of assessing the effects of managing regional development in the aspect of the green economy. This is an important source of information for managers about existing disproportions and may indicate the desired directions of intervention and support. The obtained results confirmed the usefulness of synthetic measures for assessing complex phenomena. They can be an important source of information for local government authorities on disproportions between units.

As a result of the conducted research, a number of applicable conclusions and the resulting recommendations for socio-economic practice and regional policy can be drawn. The first such conclusion concerns the role of regional governments in the implementation of development policy. Although the role of the central government in establishing and pursuing development policy, including the green-economy policy, remains significant, it does not in any way undermine the impact of regional authorities and communities on the

changes occurring in the area of pro-environmental modernization of regional economies. Regional authorities can develop and implement integrated green economy action plans or strategies, as well as programmes focusing on one or more of the objectives of sustainable development and green growth, such as environmental protection programmes, waste management programmes, low-emission economy programmes, revitalisation plans, environmental education initiatives and others. The awareness of global and lasting trends will allow regional authorities to channel efforts into regional programs that are best equipped to streamline the transition towards the green economy. This is expressed by the principle of *subsidiarity*, one of the cornerstones of the EU's regional policy. This, however, requires a certain readjustment of initial conditions translating into improved knowledge about the pending problems and their driving forces as well as the readiness to assume responsibility for the region's long-term development and access to appropriate funds and instruments. The autonomy of regions and their ability to pursue their own development policies is strongly supported by the EU. In the current financial perspective, which is the period of developing the European Green Deal, there has been an increased emphasis on low-emission and resource-efficient transformation of economies. Regions will thus be provided with greater funds than before for *greening* the economy. As such, they will have better opportunities to carry out this transformation in a way that best addresses regional needs and conditions. Another conclusion concerns improvement of information systems, including public statistics. Access to adequate data is the sine qua non of implementing a facts-based policy - both at the stage of determination and formulation of goals, choice of instruments, and assessment of the effectiveness of the implementation of pursued actions. With regard to individual problem areas of the green economy at the regional level, the situation here proves markedly different and broader knowledge about the existing disparities would allow for better diversification of undertakings.

Awareness of environmental threats and climate risk, consisting in gathering knowledge and disseminating information on the green economy, are a worthy prelude to practical action. This stage of proactive prevention of undesirable changes and mitigation of undesired outcomes is already observed in Poland and has reached different levels of advancement depending on the region. The implementation of green-management concepts requires of the investment and educational support. Scientific research is therefore necessary to better understand the implementation status and possible forms of green management as one of the pivotal manifestations of sustainable development. Further research should also address how local policies are aligned with national and European directives and how effectively they are translated into concrete actions.

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