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Assessment of sustainable development management based on multi-criteria methods on the example of municipalities in Poland in 2020-2023

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Abstract

In today's world, the principles of sustainability are playing an increasingly important role. Therefore, the purpose of this paper was to analyze the implementation of the concept of sustainability. In the theoretical part, a selected issue of sustainability was discussed based on the literature. The empirical part shows, based on the use of TOPSIS, VIKOR, and Hellwig methods, the state of implementation of sustainable development at the level of municipalities aggregated within NUTS1 regions in Poland. The analysis was based on sustainable development indicators published on the website of the Local Data Bank as a tool for the analysis of local government units (LGUs) in Poland provided by Statistics Poland. The research showed that better performance of sustainable development tasks was mainly observed in the macroregions with the largest metropolitan associations within their borders but regions with a lower level of development were also making high investment efforts to improve the situation on their territory. Furthermore, the rankings made it possible to identify the best and worst modes of acting towards sustainable development across all types of municipalities aggregated within the macroregions. The best-performing regions included the southern macroregion, the south-western macroregion, and the Masovian Voivodeship, while the worst-performing were the eastern, central, and northern macroregions.

Keywords: sustainable development; Poland; TOPSIS method; Hellwig method; VIKOR method;

JEL classification: Q01; C44; O21; Q56

1. Introduction

When considering development, particular emphasis is placed on sustainability. According to the World Bank (2017), this is due to the dynamic environment observed today. The ability to adapt to a changing environment has become particularly important in the context of events such as the COVID-19 pandemic or the ongoing wars (in Ukraine and Israel). These events, which are tests on a global and local scale, have highlighted the importance of sustainable development (Ministry of Development and Technology 2023). Belz and Peattie (2010) argued that reducing the negative impact of human activity on the environment is now seen as one of the priorities facing the modern world. As a global holistic concept, sustainable development is seen as an opportunity in terms of ensuring the well-being of citizens (Piwowarski et al., 2018). This concept is considered to integrate the various challenges and problems faced by societies around the world (Lindfors, 2021). The prosperity of current and future generations is seen as a key aspect of this approach. Therefore, the idea of sustainable development is used to determine the state of social development resulting from the various development documents (Costanza et. al., 2014; Schleicher et. al., 2018).

Consequently, the authors of the present study considered it appropriate to attempt an indicator-based assessment of sustainability for the period of 2020-2023. The present study aimed to analyse the level of implementation of tasks focused on meeting selected sustainable development goals of regions at the NUTS1 level in Poland. The analysis of selected sustainability indicators was carried out based on multi-criteria linear ordering methods.

2. Literature Review

In the current discourse, sustainability seen as a development paradigm is discussed from a number of viewpoints. Attention to the issue of sustainability has been given by international aid agencies, planners, and development and environmental activists (Ukaga et al., 2011). Attempts to define the concept of sustainability have been made by researchers in economics, urban planning, and economic science (Pabiś, 2017). Despite its popularity and presence in international discourse, the concept of sustainable development is for some still vague in terms of its concept, principles, and pillars (Ametepey 2023). There is a lack of consistency in the definition of this concept in the literature. This is due to the multiplicity of its notions, as, according to research, some 200 definitions of the term can be identified (Parkin 2000). Mensah (2019) argues that sustainable development, to understand the concept and its aspects more precisely, can be considered both from the point of view of the individual components of the term i.e. 'sustainable' and 'development', and the whole semantic unit.

The very concept of development has been interpreted differently by different researchers. Among other things, it is understood as a process that aims at an evolutionary change from the current to a desired state (Abuiyada, 2018). As Dembach (1998) suggests, in the term sustainable development, the second part of the phrase refers to aspects such as security, peace, human rights, or progress in the socioeconomic sphere. Furthermore, the term sustainable development refers to the environmental aspects of both conservation and restoration of natural resources. According to Schaefer and Crane (2005) sustainable development is most often defined by a definition derived

from the Brundtland Commission Report, where it is understood to mean development that seeks to meet the needs of the present generation without compromising the ability to meet those of the future. Freiman (2006) sees sustainable development in terms of a political picture of the future, a framework that enables the development management process. Sustainable development is identified with the idea of improving and maintaining a well-functioning structure of human development in social, economic, and environmental terms (Gray, Milne 2013).

Each of the individual areas of sustainability covers a variety of issues. Considering social sustainable development, aspects such as the rule of law, gender equality, elimination of social barriers or human rights should be mentioned. In the area of economic sustainable development, areas such as the production system, control of consumption, and the level of demand for services or products can be highlighted. Furthermore, environmental sustainability, on the other hand, refers to issues related to natural resource limitation, environmental resilience, strategic use of natural resources, climate change, or biodiversity (Ametepey 2023). As Hák, Janoušková, and Moldan (2016) indicated, in the age of globalisation, maintaining the principles of balance between economy, society and the environment due to the planet's limited resources is an extremely difficult task. Sustainable development is a type of dynamic harmony during the interaction taking place between a population and the environment that ensures its existence. Sustainable development occurs when a society that depends on the environment demonstrates its full potential but does not burden the environment adversely and irreversibly (Ben-Eli 2015). Improving the quality of life and satisfying social desires by transforming the natural environment using resources of a social, economic, and environmental nature is the idea of sustainable development. The measures taken in the social, economic, and ecological areas, through their correlation with natural resources, aim to maintain both short- and long-term balance, thus referring to intergenerational justice (Stoddart, 2011; Zadęcka 2021).

The literature indicates that sustainable development should be a non-fragmented process characterised by integrated decision-making (Kolka 2016). Despite the fact that sustainability is seen in terms of a global task, its achievement is possible by taking initiatives at the local level (Sobol, A. 2015). A fundamental role in the implementation of the concept of sustainable development should be played by local governments, following the words of Patrick Geddes: "act locally, think globally". The focus on local sustainability is dictated by the principle of subsidiarity, assuming that it is local government units that can most effectively respond to the needs of the local community.

Marcelino-Sadaba et. al. (2015) also indicated that the implementation of the concept of sustainable development should be initiated at the local level. In terms of sustainable development, local government units act as planners and have a key role in this process. They are also responsible for adapting global and national goals and visions to the specificities of the local community (Palm et. al., 2019). In light of current standards, local government units are responsible for eliminating social and economic problems, thereby influencing local development. Sustainable development contributes to the creation of society's well-being. Wealth manifests itself as social development, economic growth, environmental improvement, and through technological progress (Borys 2010). According to Lindfors (2021), sustainability can be analysed using a variety of methods.

However, the most common in this respect are multicriteria methods. In the literature, sustainability issues are discussed using methods such as Weighted Catfish, AHP, PROMETHEE, TOPSIS, and VIKOR. Liladhar Rane et al. (2023) viewed multi-criteria methods as important tools for sustainability considerations. They emphasized that decisions based on MCDM methods can affect a more sustainable future considered from both environmental and social perspectives.

The literature provides examples of the use of multi-criteria methods in the context of sustainable development, considered from different points of view. First and foremost, reports refer to the assessment of various categories that determine sustainable development. Ahmadi et. al. (2013), using TOPSIS and weighted entropy methods, attempted to assess pollution levels in selected sectors of the Iranian economy. The object of interest of Zhou et. al. (2018), discussed based on the TOPSIS method, was the eco-efficiency of Chinese cities. Furthermore, Silvy Rocha Pazy et al. (2021) created an analytical panel to analyse the implementation of sustainability principles in Brazilian municipalities using the TOPSIS method. The method was also used to assess sustainable development in EU countries through the implementation of decent work and economic growth (Goal 8) (Bieszk-Stolorz, Dmytrów 2023).

Furthermore, Stecyk (2019) used a combination of AHP and TOPSIS methods for the expert analysis of sustainable development in selected local government units in the West Pomeranian Voivodeship. Multi-criteria methods (TOPSIS and VIKOR) were also used by Piwowarski et al. (2018) to compare the levels of sustainable development implementation in European Union countries. The aforementioned methods were also used to classify selected areas in northern Greece in terms of social sustainability (Papathanasiou et. al. 2016). In the context of sustainable development, ranking using TOPSIS and VIKOR methods was used, among other things, to collate strategies for the manufacturing industry, the construction industry, or to analyze and prioritize the risks of financing green infrastructure in China (Singla et. al. 2018; Zhao, 2023; Dai, Solangi 2023).

Using AHP, VIKOR, and DEA methods, Suganthi (2018) conducted research on sectoral investments undertaken in relation to sustainable development. A modified VIKOR method, i.e. Temporal VIKOR, which takes into account the variability of the data, was also used to analyse sustainability in the context of the goals (Wątróbski et. al. 2023). Linear ordering tools also include the Hellwig method. Janulewicz and Bujanowicz-Haraś (2016) used it to analyse the implementation of sustainable development at the level of 66 Polish subregions.

Roszkowska and Filipowicz-Chomko (2020) applied the Hellwig method in the context of sustainable development to analyze the educational aspect of European Union countries. The method was also used to assess the sustainable development of districts located in the Silesian Voivodeship (Szylar et. al. 2017). In connection with the above, the following questions arise:

- How did local government units (at NUTS 1 level) cope with implementing the concept of sustainable development in 2020-2023?
- Which local government units can be considered exemplary and which ones anti-exemplary in terms of implementing the principles of sustainable development?

3. Research metodology

The research focused on the analysis of sustainability-related activities implemented between 2020 and 2023, i.e. during the COVID - 19 pandemic, the post-pandemic dynamic economic reality, and the geopolitical issues related to the conflict between Russia and Ukraine, among others. The discussion on the implementation of the sustainable development goals was undertaken based on the data available in an online database Local Data Bank (BDL), which is one of the tools offered by the Statistics Poland.

Table 1: Indicators used in the study divided into 6 sustainable development goals

Stimulants		
Environment protection	**P1** - Industrial and municipal sewage treated and discharged into water or soil during the year *[dm³]*	Entrepreneurship: **E1** - Number of economic entities in higher-order services (section J-R) per 1000 population *[-]*
	P6 - Cemeteries *[ha]*	**E2** - Number of national economy entities in the REGON register per 1000 population *[-]*
	P7 - Municipal forests *[ha]*	**E3** - Number of commercial companies with foreign capital participation per 10,000 population *[-]*
	P8 - Legally protected areas in total *[ha]*	**E4** - National economy entities - section J *[-]*
	P9 - Recreational parks *[ha]*	**E5** - National economy entities - section K *[-]*
	P10 - Total area (ha) *[ha]*	**E6** - National economy entities - section L *[-]*
	P11 - Total area (square kilometer) *[km²]*	**E7** - National economy entities - section M *[-]*
	P12 - Total area of parks, green areas, and neighborhood green spaces *[ha]*	**E8** - National economy entities - section N *[-]*
	P13 - Total area of parks, green areas, and neighborhood green spaces per capita *[m²]*	**E9** - National economy entities - section O *[-]*
	P14 - Total area of green areas per capita *[km²]*	**E10** - National economy entities - section P *[-]*
	P15 - Total area of street green areas *[ha]*	**E11** - National economy entities - section Q *[-]*
	P16 - Share of legally protected areas in the total area *[%]*	**E12** - National economy entities - section R *[-]*
	P17 - Share of parks, green areas, and neighborhood green spaces in the total area *[%]*	**E13** - National economy entities registered in the REGON register *[-]*
Demographic processes	**D1** - Total population (as of June 30) *[person]*	**E14** - Commercial companies with foreign capital participation - private sector *[-]*
	D2 - Total population (as of December 31) *[person]*	**E15** - Commercial companies with foreign capital participation - public sector *[-]*
	D3 - Population aged 18 *[person]*	Finances: **F1** - Revenues for financing and co-financing EU programs and projects *[PLN]*
	D4 - Population aged 19 *[person]*	**F2** - Total revenues *[PLN]*
	D5 - Population aged 20-24 *[person]*	**F3** - Own revenues per 1 inhabitant *[PLN]*
	D8 - Working-age population *[person]*	**F4** - Total own revenues *[PLN]*
	D9 - Pre-working-age population *[person]*	**F5** - Investment expenditure per 1 inhabitant *[PLN]*
	D10 - Natural increase *[-]*	**F6** - Total investment expenditure *[PLN]*
	D11 - Natural increase per 1000 population *[-]*	**F7** - Asset expenditure per 1 inhabitant *[PLN]*
	D14 - Internal migration balance per 1000 population *[person]*	**F8** - Total asset expenditure *[PLN]*
	D15 - Total internal migration balance *[person]*	
	D19 - Check-ins abroad *[person]*	
	D20 - Total population density *[person]*	
Human capital	**H2** - Children aged 3-5 *[person]*	
	H3 - Total children aged 0-3 *[person]*	
	H4 - Number of foundations registered in the REGON register *[-]*	
	H5 - Number of associations and social organizations registered in the REGON register *[-]*	
Infrastructure	**I1** - Length of exploited water supply network (distribution and transmission) *[km]*	
	I2 - Length of sewer network *[km]*	
	I3 - New apartments put into use *[-]*	
	I4 - Usable area of apartments put into use per 1 inhabitant *[m2]*	
	I5 - Usable area of apartments put into use *[m2]*	
	I6 - Public pharmacies *[object]*	
	I7 - Public libraries and branches *[object]*	
	I8 - Permanent cinemas *[object]*	
	I12 - Tourist accommodation in tourist accommodation facilities *[place to stay]*	
	I13 - Cultural facilities - number of events *[places]*	
	I14 - Cultural facilities - number of event participants *[person]*	
	I15 - Cultural facilities in total (cultural centers, houses and cultural centers, clubs and community centers) *[object]*	
	I16 - Library points *[object]*	
	I17 - Tourist accommodation facilities *[object]*	
	I18 - Viewers in permanent cinemas *[person]*	
Destimulants		
	P2 - Industrial and municipal sewage requiring treatment discharged into water or soil during the year in total *[dm³]*	
	P3 - Industrial and municipal sewage requiring treatment discharged into water or soil during the year per capita *[m³]*	
	P4 - Water consumption for national economy and population per capita *[m³]*	
	P5 - Water consumption for national economy and population during the year in total *[dm³]*	
	P18 - Selectively collected municipal waste during the year in total *[t]*	
	P19 - Municipal waste collected during the year in total *[t]*	
	D6 - Share of population aged 65 and over in the total population *[person]*	
	D7 - Post-reproductive population *[person]*	
	D12 - Total permanent migration *[person]*	
	D13 - Total permanent migration per 1000 population *[person]*	
	D16 - Foreign migration balance per 1000 population *[person]*	
	D17 - Total foreign migration balance *[person]*	
	D18 - Check-outs abroad *[person]*	
	H1 - Registered unemployed in total *[person]*	
	I9 - Population per 1 public pharmacy *[person]*	
	I10 - Population per 1 library branch *[person]*	
	I11 - Population per 1 cultural facility *[person]*	
	F9 - Total expenditure *[PLN]*	

Source: authors.

The study covered all types of municipalities in Poland (n = 2477 municipalities: urban, urban-rural, and rural) whose primary data were aggregated to NUTS1 macroregions (research sample N= 7) as an average of all municipalities of a given type located within the administrative borders of the macroregions. The first stage of the research focused on a literature review using the triangulation method. The second stage of the research made it possible to carry out a comparative analysis of selected indicators designed to reflect the level of achievement of the six sustainable development goals: environmental protection; demographic processes; human and social capital; infrastructure; entrepreneurship; local government finance and development management.

A detailed list of the indicators subjected to the assessment is presented in Table 1. First, the indicators presented in Table 1 were considered from the perspective of the voivodeships, which presented aggregated data from the SDGs area for the three types of municipalities (urban, urban-rural, and rural) located in its area. Indicators for which the coefficient of variation was V< 10% were then excluded from the study. Finally, after rejecting the indicators that did not meet the above-mentioned criterion, data conversion was performed and the results of each indicator for NUTS 1 macroregions (calculated as an average value for the voivodeships included in the macroregion) were presented.

The final stage of the research was to determine a composite measure using the indicators shown in Table 1 based on three multicriteria methods to rank the options and select the most favourable option: TOPSIS, VIKOR, and Hellwig. The ranking in which the NUTS1 regions ranked was constructed using three MCDM methods. Using the TOPSIS method, an ordering of alternatives according to the similarity to the ideal solution and negative ideal solution was developed. In the VIKOR method, the ranking allowed a compromise solution to be determined. In contrast, in the compilation prepared using the HELLWIG method, this indicator was determined based on the distance from the standard (Koszel, Bartkowiak 2018; Bąk 2018; Liladhar Rane et al. 2023).

4. Results

The determination of the level of implementation of sustainable development measures is performed only by means of an analysis of composite indicators created using the TOPSIS, HELLWIG, and VIKOR multi-criteria methods. The effectiveness of the SDG actions can also be verified by a detailed analysis of the indicators and development areas of individual municipalities located in NUTS 1 macroregions provided by the Statistics Poland within the Local Data Bank. Between 2020 and 2023, i.e. at a time of turbulent economic changes caused by the COVID-19 pandemic and the war between Ukraine and Russia, sustainability measures have become an additional challenge facing local government units in Poland.

Due to the multiplicity of areas included in the SDG policy, it becomes difficult to uniformly determine the impact of the presented events on the situation of municipalities in macroregions in Poland. One of the main themes related to sustainable development is environmental protection, represented by 19 indicators. An ecological approach has become one of the priorities of all the macroregions, which, from 2020 to 2023, reduced the amount of waste and wastewater on their territories and increased, among other things, the areas of parks and green spaces, so important for the natural balance between the activities of the inhabitants and the nature. Of particular interest here is the indicator

showing the total amount of industrial and municipal wastewater that need treatment that are discharged to water or to the ground per capita per year, which, based on a scale of 1 inhabitant, allows for a direct comparison between the macroregions studied. Most macroregions recorded a similar result over the years studied, typically varying between 1 and 2 m3 of wastewater per capita. However, the southern macroregion, which is a highly industrialised territory with, e.g., the Katowice conurbation (the centre of Silesian industry and services) within its administrative boundaries, with a population of around 3 million, and Krakow, which is the second most populous city in Poland, was characterized by a marked reduction in the average volume of wastewater discharged to water or land. This level decreased by 48.32% in 2023 compared to 2021 (from a value of approximately 132 m3 to 89 m3 of wastewater per capita, respectively).

Furthermore, the increasing values for indicators concerning, per capita, total green areas, street green areas, and the percentage of parks, greens, and residential green areas in the total area also showed an increase in the macroregions' efforts to protect the environment. Sustainable development also focuses on demographic processes, which is one of the key elements of the SDG transformation, as the inhabitants of the LGUs are not only the main driver of the economy, but also the beneficiary of the solutions used. Poland's demographic problems of an ageing population and a low birth rate were also evident in the macroregional study. The effects of these problems can be seen particularly in the working, post-working, and pre-working age populations. The percentage of the post-working age population in the macroregions increased in each of the periods studied, while it declined in the other two groups. The birth rate per 1,000 inhabitants is more optimistic only in urban municipalities.

In 2020, the macroregions affected by the pandemic had a very low birth rate (2.4 to 7.6), but in 2021 there was a marked improvement in the ratio of births to deaths (4.1 to 9.2). The situation stabilised in the following years and the region with the lowest natural increase in 2020-2023 was the macroregion of Mazowieckie voivodship, which recorded between 2.4 and 4.1 times more births than deaths over the years. The central region remained the leader in terms of the rate of natural increase in urban municipalities during the period studied. In the other types of municipality, the natural increase was much worse in each of the periods studied, with negative values in each macroregion.

Directly related to the demographics of the regions, one area of SDG action is human capital, which in the study comprised five indicators (H1-H5). Among the macroregions analysed, there were similar upward or downward trends in selected indicators between 2020 and 2023. Each region saw a fall in unemployment over the years studied, but also in the number of children aged 3 to 5 and under 3. The right infrastructure is essential for effective sustainability efforts. The number of water supply, sewerage, pharmacies, libraries, and cultural facilities available is proportional to the population of the macroregion in which such infrastructure is used. Therefore, the longest water supply network (more than 7395 km in 2020 and more than 7921 km in 2023) or the number of pharmacies (between 750 and 798) was observed in the southern macroregion. The eastern macroregion has the shortest (about 2,300 to 2,400 km) water supply network and the lowest number of pharmacies at 324 outlets in 2023. Despite the differences in the population, population density, the area of the macroregion or the level of development, all the areas analyzed showed a very similar indicator, which represents

the usable floor space of completed dwellings per capita (from 0.4m2 to 0.6m2 in 2020-2023). Infrastructural projects and activities in other areas of sustainable development of local government units require an effective fiscal policy of local governments. A detailed analysis of the entrepreneurship and finance indicators shows that the Eastern macroregion, i.e. a region with a relatively low level of development, had some of the lowest own revenues of all types of municipalities.

However, an additional financial boost for the eastern macroregion was provided by revenues earmarked for the financing and co-financing of EU projects, which, especially in the case of rural municipalities, were one of the largest among regions in Poland in the period 2020-2023. The intensification of development-related activities in the eastern macroregion was also reflected in the per capita investment expenditure of the municipalities. For urban municipalities, the average investment expenditure per capita ranged from PLN 981.8 to PLN 1,319.1, which was on a par with other macroregions or often higher. The performance of urban-rural and rural municipalities in the eastern macroregion shows that the region's per capita investment performance was among the highest in the period studied. Among the outstanding regions in terms of the stability and development potential of the financial results, the central and south-western macroregions and the Mazowieckie Voivodship stand out, as they had the best results in terms of both revenue and expenditure (especially investment expenditure) across different types of municipalities.

The present analysis only assessed the performance of macroregions within the identified areas, which is only a preliminary analysis of the performance of municipalities in macroregions in implementing the SDGs. To fully assess the actions of the above-mentioned local government units in the implementation of the Sustainable Development Goals, it was necessary to create a composite indicator based on the indicators studied, using the TOPSIS, HELLWIG and VIKOR multi-criteria methods. This allowed for the inclusion of all SDG areas in the analysis of the effectiveness of the actions of individual units and also made it possible to classify the macroregions in Poland based on the results of the municipalities within their administrative borders.

By combining the six areas of sustainable development into composite indicators using the TOPSIS, VIKOR, and HELLWIG methods, it was possible to produce rankings of the best performing macroregions in terms of sustainable development measures, by three types of municipality and as an average for all types of municipality within the macroregions. Among municipalities, the clear leaders were those in the southern macroregion and the Masovian Voivodeship, ranked either 1st or 2nd depending on the method used. The opposite was found for the municipalities in the eastern macroregion, as their average score placed the region in 7th place for the period 2020-2023. Taking into account the results of urban-rural and rural municipalities in the presented macroregions, it can be seen that the position of the leader of the ranking, i.e. the macroregion that performed best in terms of sustainable development tasks, was not so obvious.

The difficulty in identifying regions that clearly underperform or overperform on the SDGs between 2020 and 2023 is mainly due to the use of different multicriteria methodologies, with slightly different steps in the calculation of the composite indicator

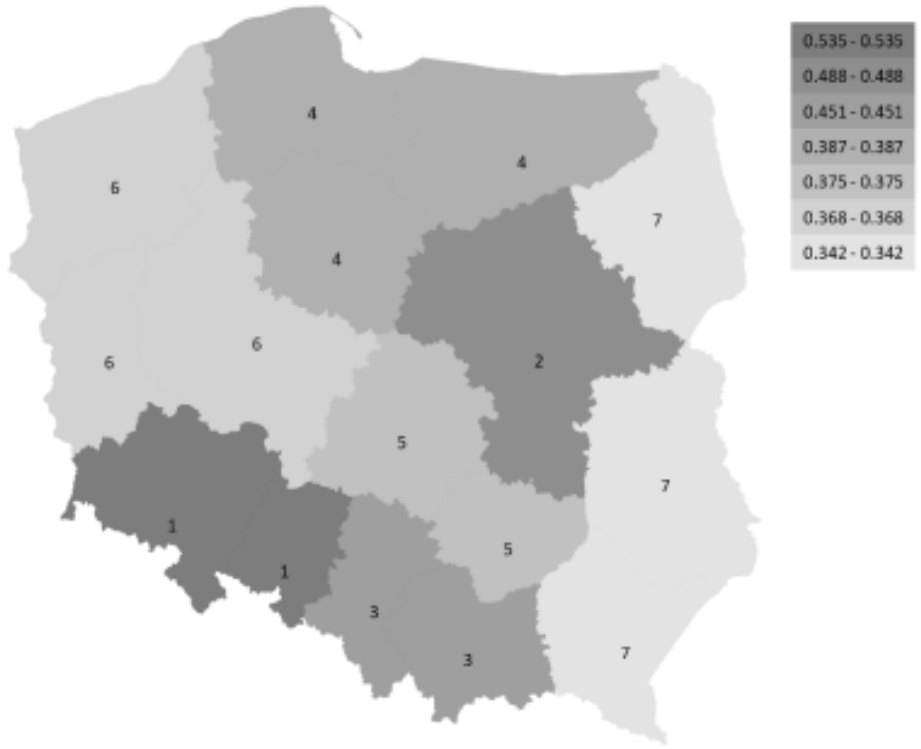
to determine the ideal solution. Determining the average values of the composite indicator based on the indicators previously calculated for each type of municipality included in the macroregions made it possible to prepare the ranking of the macroregions by all types of municipalities in 2020-2023. Based on the TOPSIS method, the south-western macroregion took the lead of the ranking, followed by the Masovian Voivodeship and the southern macroregion.

The eastern, north-western, and central macroregions were identified as the worst-performing macroregions in terms of the Sustainable Development Goals, ranking 5th, 6th, and 7th respectively. In the ranking prepared by the HELLWIG method, which does not take into account the distance from the negative-ideal solution, the southern macroregion came first, the Masovian Voivodeship second and the south-western region was third. Among the regions with the lowest level of implementation of SDGs were the central macroregion (ranked last), the eastern macroregion (6th), and the northern macroregion (5th). The last method used, VIKOR, identified the Mazowieckie macroregion as the best-performing region in terms of sustainable development, ahead of the southern and north-western macroregions.

In the ranking determined by this method, the central macroregion came last, ahead of the southwestern and the northern, taking into account the average of all types. In conclusion, it can be said that the macroregion of Masovian Voivodeship and the southern macroregion showed the greatest stability in terms of the best results in the implementation of the SDGs across all municipalities in its territory. Furthermore, the central, eastern, and northern macroregions can be identified as those with the lowest level of implementation of sustainable development tasks. A detailed classification of the macroregions, taking into account the average performance in all municipalities, is shown in Figure 1.

Average result of the macroregion for all types of communes in 2020-2023						
NUTS 1 regions in Poland	Average synthethic indicator	TOPSIS Rank	Average synthethic indicator	HELLWIG Rank	Average synthethic indicator	VIKOR Rank
Southern macroregion	0.451	3	0.359	1	0.484	2
North-west macroregion	0.368	6	0.234	4	0.276	3
South-western macroregion	0.535	1	0.241	3	0.129	6
Northern macroregion	0.387	4	0.183	5	0.131	5
Central macroregion	0.375	5	0.093	7	0.124	7
Eastern macroregion	0.342	7	0.097	6	0.229	4
Macroregion Masovian Voivodeship	0.488	2	0.275	2	0.970	1

Ranking of macroregions according to the average result of all types of municipalities in 2020-2023 using the TOPSIS method



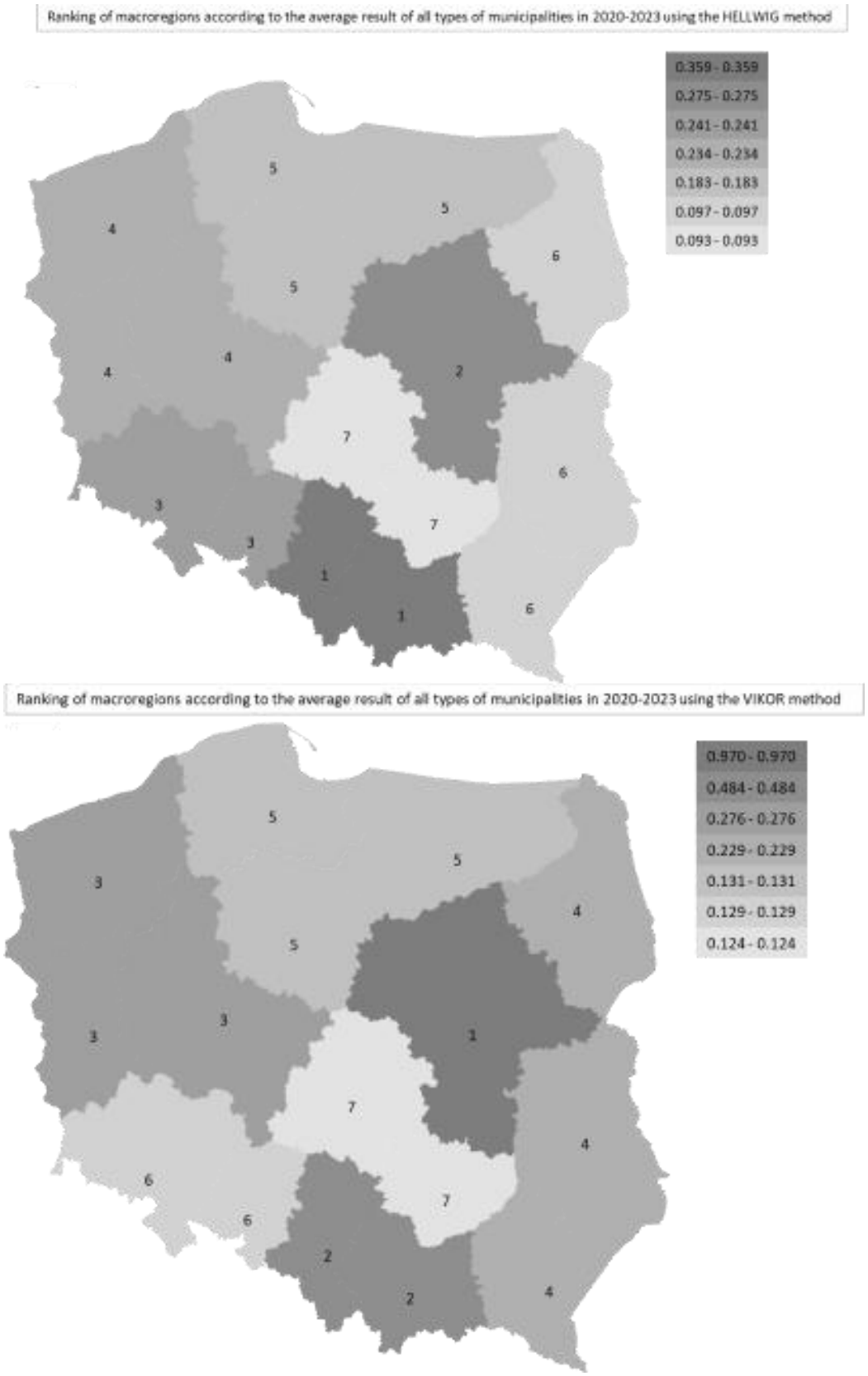


Figure 1: Graphical comparison of rankings based on the average result of all types of municipalities, using the TOPSIS, VIKOR and Hellwig methods

Source: authors.

5. Conclusions

The aim of the present article was to assess the level of implementation of sustainable development goals in 2020-2023, using multi-criteria methods, in all types of municipalities aggregated within NUTS 1 macroregions in Poland, which was fully achieved. An analysis of the average values of the indicators in each SDG area showed macroregions that were more or less effective in their implementation, both within a type of municipality and collectively, within the administrative boundaries of the macroregions. In the next stage of the research, all 86 indicators were used, from which a composite index was constructed using the TOPSIS, HELLWIG, and VIKOR multicriteria methods. Composite indicators (using three multi-criteria methods) were determined for the macroregions for the period 2020-2023 with a breakdown into urban, urban-rural, and rural municipal aggregates.

This allowed the identification of the best and worst-performing macroregions according to the type of municipalities within the region. In addition, the composite indicators were used to calculate an average value for the macroregion based on all types of municipalities, which made it possible to identify a leader and a negative leader in each area studied. The research showed that the challenges posed to LGUs in terms of sustainable development became more difficult to address in times of turbulent change due to the COVID-19 pandemic or geopolitical turmoil. A detailed analysis of the SDGs shows that municipalities located in macroregions with high population density, such as the southern macroregion with the Katowice agglomeration or the Mazovian Voivodeship macroregion with the Warsaw agglomeration, performed much better in terms of achieving the sustainable development goals. The analysis of individual areas showed marked disparities between the macroregions in terms of both environmental protection measures and infrastructure. It should be noted, however, that regions with weaker performance in the above-mentioned areas saw at the same time an increase in income (especially from EU programs) and an increase in investment expenditure. This was particularly evident in the eastern macroregion, which is attempting to implement measures to improve its situation in terms of achieving the SDG targets and to put it on a par with the performance of other macroregions, with the aforementioned actions in the financial sector.

These findings are consistent with the ranking of the macroregions in terms of the average score of all types of municipalities on their territory for the period 2020-2023, established using the TOPSIS and HELLWIG methods. In the first of them, the eastern macroregion ranked last (7th) and showed the worst performance in terms of tasks related to sustainable development. The TOPSIS method identified the south-western macroregion as the leader but the southern macroregion and the Masovian Voivodeship were right behind the leader, confirming some of the better results in meeting the sustainable development goals. The HELLWIG method, which does not take into account the distance to the worst solutions in its calculations, showed a slightly different ranking, but once again the southern macroregion and the Masovian Voivodeship were among the leading regions in terms of the implementation of tasks in the field of sustainable development, while the eastern macroregion was one of the last.

An analysis of the ranking prepared by the VIKOR method showed that, with the data pool provided, it yielded significantly more divergent results than the two previous multi-criteria methods. Despite the Masovian Voivodeship and southern macroregion being identified as the best-performing SDGs, the macroregion that performed the worst in terms of development in 2020-2023 using VIKOR was the central region, ahead of the south-western and northern macroregions. The eastern macroregion was ranked fourth in this ranking. In this situation, it is reasonable to consider that this method, although it belongs to the same group (multicriteria methods) as the TOPSIS and HELLWIG methods, is not the best choice for studying the data set presented.

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