The Spatial Patterns of Sustainable Development at the Local Level

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Abstract

Globalisation – characterised by dynamic economic growth, increasing exploitation of the natural environment, and deepening social inequalities – brings negative consequences and is strongly perceptible also in local communities. A new approach to development policy based on the idea of sustainable development must be incorporated into local governments' strategies, programmes, and actions. We adopted exploratory approach to determine the level and identify the spatial patterns of sustainable development of Polish poviats. The aggregated (synthetic) indicators of economic, social, and environmental development were developed to analyse the spatial patterns of the poviats' development trends. Our research shows that in Poland there are overwhelmingly more poviats characterised by lower development than those better developed in all three analysed categories. Hierarchical analysis using the Ward's method revealed that Polish poviats can be divided into three relatively homogeneous clusters in terms of development levels. The largest group consists of poviats characterised by the relatively lowest level of sustainability in economic and social areas, and the highest – by environmental development. Analyses using the Moran method made it possible to determine the so-called spatial regimes of clusters. The captured spatial relationships indicate that selected poviats have a significant impact on the level of development in the neighbouring poviats.

Keywords

Sustainable development; indicators; economic, social, environmental development; local level; clusters of poviats

Introduction

Globalisation, as a process mostly external to localities and local systems, strongly influences them, which means that local communities more and more often must face challenges that move freely beyond borders and affect economic, social, and environmental development. A global response to these three-dimensional problems was the adoption by the United Nations of the resolution Agenda 2030 in September 2015. The aim of the document was to define a new approach to development policy based on the idea of sustainable development, thus ensuring economic growth and equal access to development benefits for all social groups while combating climate change and protecting natural resources at the same time. The challenges related to the implementation of the sustainable development paradigm are, therefore, multidimensional issues that should be taken into account in policies implemented at all administrative levels. Therefore, in the public debate, the issue of the growing recognition of the important role of local governments in active participation in the implementation of the goals of the 2030 Agenda is raised more and more often (Barber, 2013; Fiorino, 2010; Portney, 2013; Szajczyk, 2017).

To address the current challenges and promote sustainable development effectively at the local level, appropriate strategies, methods, and guidelines – based on sound and robust knowledge – are required (Keiner, 2006). Local governments are expected to play a leading role in achieving the sustainable development by assessing the local situation, identifying the needs and resources, developing partnerships with stakeholders, and implementing appropriate policies and projects (Lucci, 2015; Reddy, 2016; Satterthwaite, 2017). Thus, local policymakers must be well-informed about the areas where economic, environmental, and social issues are the weakest.

In this light, the purpose of the study presented in the article is to shed light into the state of the art of sustainable development at the local level in Poland. Although there are many studies on

sustainable development (including Polish ones), there is a lack of studies defining spatial patterns of this phenomenon. The main contribution is to deliver deeper insight into homogeneous groups of poviats (clusters) and their spatial distribution in Poland. Given the growing role of local governments in promoting sustainable development, our findings are of practical importance: they make it possible to identify conditions that will be common and specific to certain territorial units with similar characteristics. The identification of clusters may be used to create new or modify the existing policies focused on triggering sustainable development at the local level.

The approach adopted in the study was exploratory. The research presented in this article focused on the main research question: what are the spatial patterns of the level of sustainable development, including clusters of poviats with similar level of sustainable development? To answer this question, aggregate (synthetic) indicators representing three dimensions of sustainable development were elaborated.

The rest of the article is organised as follows. In the first section, the concept of sustainable development is presented with special attention to issues that provide background to proposed economic, social, and environmental development indicators. The second section is devoted to a review of methods and indicators for determining the progress of sustainable development at the local scale in Poland, implemented in previous studies. In the third section, methodological assumptions and analysis procedure are presented. The fourth section discusses the results of the study, which included an analysis of spatial patterns of sustainable development at the local level as well as a cluster analysis. The last section presents our conclusions.

The concept of sustainable development

Although the United Nations Brundtland Commission defined sustainable development in 1987 as “meeting the needs of the present without compromising the ability of future generations to meet their own needs,” a literature review reveals the lack of a comprehensive theoretical framework to understand the concept and its complexity. Many authors point out that the used definitions of sustainable development are not clear and unambiguous (Gow, 1992; Mozaffar, 2001), and that “the topic remains confusing” (Redclift, 1994) and “contradictory” (Redclift, 1987). In the most general approach, sustainable development has been defined as a broad solution to existing problems, aimed at economic growth while ensuring a better quality of life for all citizens and respecting the natural environment, which is often difficult to reconcile (Hopwood et al., 2005).

Despite the lack of a uniform definition of sustainable development, one particularly prevalent description of ‘sustainability’ in the literature employs three interconnected ‘pillars’, namely environmental, economic, and social. This concept has gained widespread acceptance and is widely used in publications on sustainable development (Purvis & Robinson, 2019). As Thompson (2017) stresses, much of the sustainable development discourse is organised around a three-wheeled rubric without being overly disciplined about how it works and not translating into a more comprehensive understanding of sustainable development. The adoption of such a tripartite allows the analysis of the phenomenon from the perspective of balancing trade-offs between seemingly equally desirable goals within all three categories. The usual model of sustainable development thus consists of three separate but connected and intertwining circles, which means that each dimension is at least partially independent of the others (Hopwood et al., 2005).

The **economic dimension** covers a wide range of issues, from trade and investment to employment growth and private sector development. In the literature, sustainable development in this dimension focuses on the model of efficient allocation of available resources. The idea is also to facilitate and promote the use of these resources to ensure long-term benefits and profitability at the level of the entire economy.

Economic environment and entrepreneurship

Sustainable economic growth requires the creation of appropriate conditions to facilitate the activity of economic entities, including, in particular, the stability of legal regulations, institutional support, and filling access to public infrastructure (Parker, 2018). Thus, sustainable economic

development is related to the economic environment, i.e. conditions conducive to the establishment and stable development of companies, using these to lift people out of poverty and bolster economic and environmental resilience. These solutions are designed to raise incomes and decrease household costs by increasing resource efficiencies, improving access to jobs and services, and creating new employment opportunities. Local communities possess unique assets to address their individual challenges and provide favourable environment to economic growth.

The potential of the local economy

The potential of the economy, which enables economic growth, is a very controversial indicator in discussion on sustainable development. Some researchers recognise that in developed countries, economic growth is always associated with environmental burdens, which is why these authors advocate the need for degrowth (Victor, 2010; O'Neill et al., 2018; Pothen & Welsch, 2019). That is why terms such as 'green growth', 'circular economy', and 'inclusive development' have been coined in parallel with the concept of sustainable development. They all have neoliberal basis and presuppose growth of economies (Costanza et al., 2012; Elmqvist et al., 2014; Gupta & Veglin, 2016; Hickel & Kallis, 2020; Schröder et al., 2020). The condition of companies, their competitiveness, and readiness for further development (i.e. the level of investments) located in a given local unit is crucial for its economic growth potential. Major benefits of business in the local economy include a boost in employment and discretionary income in the community, as tax income increases for local governments.

The financial condition of local governments

The availability of financial resources is fundamental to the functioning of local government units and a condition for whether their statutory tasks can be performed. The financial situation of local government units determines the quality of public services and the quantitative and qualitative conditions of the social and economic infrastructure. When in a more advantageous financial situation, local government units are better positioned to implement investments that capitalise on favourable economic, social, and environmental developments, which, as a consequence, can translate into higher standards of living for the local population (Malinowski, 2022).

Moreover, economic development, as one of the dimensions of sustainable development, is most often measured with the GDP indicator. However, this indicator is not available to local economies. A good proxy for assessing the level of economic development at the local level is the financial condition of local governments.

The **social dimension** of sustainable development considers humans and their well-being as the central issue of sustainable development. Various studies emphasise different areas that build the social dimension of sustainable development, but they are common to most studies (Murphy, 2012) and include health protection, the promotion of universal access to quality education, ensuring a decent living (meeting housing needs), ensuring safety, and providing care to those who need it. This dimension places particular emphasis on the need to pursue justice and inclusiveness, which guarantee social equality. Achieving social equality in a particular community will be reflected in poverty levels, employment and income distribution, gender, ethnic and age integration, health, access to public services, financial and natural resources, etc.

Poverty

"No Poverty" is the top priority among 17 Sustainable Development Goals. Although the scale and structure of the problem of poverty differs significantly between developed and developing countries, poverty generally leads to various types of exclusion. Ensuring social inclusivity in well-developed societies to a large extent depends on the provision of material resources for the poorest citizens. Income inequality quickly grows into the inequality of well-being, which negatively affects social mobility – the basis of society's structure. Inequality is a social characteristic of a certain social state of individuals, certain segments of the population, which reflects their civil status, political

and legal rights, and their relation to the means of production and its results. Inequality has social and economic aspects. As pointed out by Zhou et al. (2021), income poverty leads to capacity poverty and thus multidimensional constraints (educational, health, cultural, etc.) that may restrict human lives. In consequence, poverty impedes sustainable development.

Demographic trends

The literature shows broad consensus that policy and institutional settings are key in shaping the prospects of poverty reduction; the rate of population growth also matters. Recent studies have found that low dependency ratios (as fertility declines) create an opportunity for increasing productivity, savings, and investment in future growth. They reveal that lower fertility is associated with better child health and schooling, and better health and greater labour-force participation for women (Das Gupta, 2011).

The provision of basic needs

Satisfying basic human needs is at the core of the development part of sustainable development. The concept of needs is embedded in the definition of sustainable development, which contains (…) the concept of "needs," in particular the essential needs of the world's poor, to which overriding priority should be given (WCED, 1987, p. 43). Thus, satisfying basic human needs constitutes necessary preconditions for sustainable development. Basic human needs should be understood as the most fundamental foundations of human development, reasons for acting and living in society, which do not need justification and are non- negotiable (known, for example, from Maslow's hierarchy of needs) (Rauschmayer et al., 2008). OCED (1987) indicates employment, food, energy, housing, water supply, sanitation, and health care as basic human needs.

Out of all three dimensions, the **environmental dimension** of sustainable development seems to be the most thoroughly and coherently described in the literature. This area combines development with clear issues of responsible management of natural resources and the prevention/mitigation of the negative effects of climate change.

Climate change – natural disasters

Environmental problems faced by modern societies include extreme weather phenomena, unprecedented global warming, and environmental disasters caused by increasing levels of CO2 and other toxic emissions. The global warming, observed over the past century and projected to accelerate over coming decades, causes the intensity of extreme weather events. The impacts of climate change on meteorological phenomena and environmental consequences are well-documented (e.g. Helmer & Hilhorst, 2006; Stott, 2016). Extreme weather events, which affect local communities, include heat waves, cold waves, floods, droughts, hurricanes, heavy rain, and snowfalls. The intensity and frequency of extreme precipitation events are very likely to increase over many areas, including Europe. Even relatively small-scale atmospheric phenomena, such as thunderstorms, tornadoes, hailstorms, and lightning, lead to numerous damages such as the destruction or total loss of property, the destruction of infrastructure, the damage done to agricultural crops, and – in extreme cases – deaths (Clark et al., 2022). The number of hot and very hot days will continue to rise, and the number of cold and very cold days will continue to decrease over nearly all land areas. Mid-continental areas will generally become dryer, which is likely to result in an increase in the risk of summer droughts and wildfires (van Aalst, 2006).

Industry-related environmental burdens

There is no doubt that the industry generates a significant burden on the natural environment. Two issues seem to be particularly significant in this matter i.e. air and water pollution. A complex interaction of the dispersion and emission of toxic pollutants from manufactories leads to air pollution. Industrial processes emit huge amounts of organic compounds – namely carbon monoxide, hydrocarbons, and chemicals – into the air (Munsif et al., 2020). Due to the introduction of

dust particles, gases, and smoke into the atmosphere, air quality levels in many areas are worse. Previous studies have proven the harmfulness of emissions in specific industries, including the iron and steel industry, cement industry, and coal-fired power industry. Nevertheless, regardless of the type of activity, all industrial plants are, to a greater or lesser extent, emitters of greenhouse gases and pollutants released into the air (Lamb et al., 2021). Industrial activity also involves the production of wastewater. Although the European Union has introduced stringent standards in this regard, the development of industries and extensive urbanisation means increased water consumption and pollution resulting from problems of waste disposal. In most cases, industrial wastewater is discharged into the surrounding environment. In various cases, some of these wastewaters are untreated or not properly treated before being discharged, leading to the contamination of both water bodies and groundwater.

Human-activity-related environmental burdens

The daily existence of citizens of modern societies is also a burden on the environments surrounding them. In general, the culture of consumption is associated with greater exploitation and pollution of the natural environment. At the local level, effective waste and waste management is critical in this respect. Therefore, in the context of promoting sustainable development, waste generated by communities should be managed and disposed of as effectively as possible, assuming the least negative impact on the environment. An inevitable consequence of human activity is the production of all kinds of waste (food, electronic, solid, etc.) People are discarding growing quantities of waste, and its composition is more complex than ever before, as plastic and electronic consumer products diffuse. Another aspect resulting from human activity that burdens the environment is the production of wastewater. Water and sewage management is one of the most important elements of ecological policy implemented at the local level (Piasecki, 2019). Proper water and sewage management promotes the implementation of sustainable development principles.

In conclusion, the environmental dimension of sustainable development requires policymakers to act in a way which will reduce carbon dioxide emissions and other pollutants into the atmosphere, prevent deforestation and water pollution, develop clean energy sources, and protect fauna and flora (cf., e.g., Haque, 2000; Mikulčić et al., 2020).

Methods and indicators for determining the progress of sustainable development at the local scale in Poland

Intensive discussion – both in the scientific community and political decision-makers – on the necessity to meet the goals of sustainable development has led to a discussion on the methods of its measurement. The problem indicated in the first part of the article with the lack of a universal definition of sustainable development results in the lack of a universal model and commonly recognised typologies of sustainable development indicators. In order to assess the current state of sustainable development, analyses most often use a set of simple or aggregated statistical indicators (Dziekański, 2014). As Bal-Domańska (2015) points out, “it allows for a comprehensive approach to numerous thematic areas that make up the concept of sustainable development.” The indicators that enable the measurement of the implementation of the concept of sustainable development are to answer the question about to what extent the development in the case under study corresponds to this idea (Borys, 2010).

Multiple initiatives have helped to advance the measurement of sustainability, developing new indicators and models to support decision-makers in creation and implementation evidence-based sustainable development policies. It should be stressed, however, that a great progress has been made in the use of sustainability indicators mostly at the national and regional level (Palmisano et al., 2016; Paolotti et al., 2019; Ferretti et al., 2020). Much less attention has been paid to the local level context.

Several Polish studies related to measurement of sustainable development at the sub-national level have been conducted with the use of different methods. Roszkowska and Filipowicz-Chomko (2016) proposed an analysis of 16 indicators to construct the general measure of the level of

human development. Implementing a multidimensional comparative analysis (the TOPSIS linear ordering method and Ward's non-linear ordering method), they identified the level of social development of Polish voivodeships in the context of progress in implementing the concept of sustainable development.

Ogrodnik (2017) measured the sustainable development of regional and subregional cities of the Podlaskie region. Her analysis based on the PROMETHEE method's multi-criteria decisions supports methods for balanced analysis urban development. The indicators identified in the study included (along with economic, social, and environmental areas) institutional-political domain. Although the study's results were very informative and practical for decision-makers, the analysis covered only three cities with poviat rights.

The assessment and ranking of sustainable development in economic, social, ecological, and spatial aspects, as well as in the overall approach, was conducted by Koszel and Bartkowiak (2018). The synthetic indicator (mega-aggregate) was created using the Hellwig model method, which made it possible to present the situation of regional/local differentiation of the level of sustainable development included in four domains simultaneously: economic, social, ecological, and spatial. However, the study was limited to only 345 communes and cities forming eight Polish metropolitan areas.

The most recent studies on sustainable development at the local level were conducted by Mikuła (2020). The method used is similar to the one adopted in studies presented in this paper (multidimensional comparative analysis based on synthetic indicators of economic, social, and environmental development), although no in-depth analysis of spatial patterns was executed. Moreover, the set of indicators used in Mikuła's study differs from the ones selected for our analysis.

Sustainable development at the local level – methodological assumptions

In order to determine the level of and spatial patterns of sustainable development level at the local scale in Poland as well as identify clusters of units, we conducted an in-depth statistical analysis of aggregated indicators. The spatial scale of the study includes all Polish poviats, including cities with poviats rights (county status). The methodology used to create these indicators is discussed below.

First, a set of variables, reflecting three dimensions of sustainable development of poviats and cities with poviat rights, was selected. The selection of diagnostic features had to meet certain statistical, substantive, and formal criteria, as well as ensure the appropriate information value of the variables. We followed a recommendation to concentrate on indicators that express the idea of sustainable development, specifying the area of sustainable development that the indicators describe (Borys, 2010). Preliminary statistical analysis of variables was conducted to examine the relationship between them (Pearson's linear correlation coefficient was used). Features demonstrating a strong correlation (correlation coefficient value ≥ 0.7) were not included in further analysis. Eventually, 48 variables representing three dimensions of sustainable development were selected.

Variables were defined as stimulants (reducing the occurrence of problems in each category) marked (+) or destimulants (increasing the occurrence of problems in each category) marked (-). Therefore, the lower results of the indicator indicate greater problems in the analysed areas. Most of the features reflect the situation for 2019 (except for the "climate change-natural disaster" variables, which consider few years period). Statistical data was retrieved from the Local Data Bank of the Central Statistical Office (GUS).

The selection of indicators for the analysis was carried out in accordance with the components of the economic, social, and ecological dimensions of sustainable development described in section "The concept of sustainable development" of this article. Nevertheless, we had to make several assumptions in the process of selecting indicators.

Firstly, when it comes to indicators reflecting the economic dimension of sustainable development, we presumed that the good economic condition of a given county may, on the one hand, be an opportunity to achieve the well-being of society and, on the other hand, may contribute to a lower impact on the environment (in the case of "wise" investments in pro-ecological or socially-inclusive solutions). The idea of sustainable development is not to stop the process of economic

growth (as such), but to ensure its balance in social and ecological dimensions. As J. Hickel (2021, p. 99) writes in his book titled *Less Is More*: "It's not growth that's the problem, it's growthism: the pursuit of growth for its own sake, or for the sake of capital accumulation, rather than to meet concrete human needs and social objectives." We can expect that irresponsible economic growth will be reflected in lower levels of aggregated social and ecological indicators, and the other way round in the case of responsible economic growth. Therefore, indicators such as "Number of companies employing 250–999 employees per 1000 inhabitants" or "Sold production of industry per capita" are treated as a stimulant and not destimulants. By that logic, we are aware that classifying some other indicators as stimulants or destimulants may be controversial and not obvious. For example, the indicator "Commune and county roads with a hard surface for 10,000 inhabitants" is treated as a stimulant, because, in our view, it is an indicator of greater spatial accessibility and, therefore, favours social inclusion.

Secondly, the selection of some indicators may not be obvious, for instance the "Own incomes of communes per capita" indicator as part of the "The financial condition of local governments". This is a measure that is often used in research to determine the wealth of a given local government unit. The communes' own income consists of shares in personal and corporate taxes of citizens/entities located in a given commune, paid to the central budget. This kind of income is not included in poviat budgets and that is the reason why we included this indicator to identify wealth at the local level.

Thirdly, some indicators are not relativised. We decided that some values included in absolute values would better reflect the scale of the problems. This applies to the indicators proposed to measure the level of the environmental development. Climate-change-related threats and environmental pollution – such as the emission of dust pollutants, untreated industrial wastewater discharged, or pollutant loads in wastewater discharged into water or soil – should be considered regardless of the size of the poviat, the number of its inhabitants or enterprises operating within it, because they simply constitute a burden on the natural environment.

Finally, in many cases, our selection was limited by the availability of data. For example, among the social dimension indicators there is one that refers to the access of children to nurseries, but there is no indicator on the access to kindergartens. The reason for this is that this kind of data is not being gathered by the GUS. Moreover, some indicators that would perfectly fit to sustainable development status analysis are collected by the GUS but not for local levels (i.e. NUTS 4 or 5). For example, we are aware that "Emission of dust pollutants" included in the aggregate indicator of ecological dimension is not the best possible estimator of air pollution and does not specify the share of the so-called low emissions (coal-firing) and those from transportation in total emissions. Emission is simply the mass of substances released directly into the environment, both from natural (e.g. volcanic eruptions) and anthropogenic sources (e.g. fuel combustion). It would be desirable to use the immersion indicator, which reflects the amount of a dust or gas pollutants in a given volume of air unit. However, we did not find databases that systematically collected this data for the local level.

All indicators selected for analysis are presented in the table below.

In order to normalise the variables, the unitarisation method was used. The procedure of the unitarisation of variables is based on the following formula:

for stimulants:

$$X = \frac{x_{ij} - \min\limits_{i} x_i}{\max\limits_{i} x_i - \min\limits_{i} x_i}$$

for destimulants:

$$X = \frac{\max\limits_{i} x_i - x_{ij}}{\max\limits_{i} x_i - \min\limits_{i} x_i}$$

where:

X – means the normalised, unified, or standardised value of the feature for each unit,

x_{ij} – means the value of the j-th feature for the tested unit,

max – means maximum value of the j-th feature,

min – means minimum value of the j-th feature.

Table 1. Features-compounded indicators used to create general indices for the three areas of challenges

Economic development indicator	
1. Economic environment and entrepreneurship	– (x_1) Number of companies employing 0-9 employees per 1000 inhabitants (+) – ($x2$) Number of companies employing 10-49 employees per 1000 inhabitants (+) – ($x3$) Companies newly registered (+) – ($x4$) Number of companies employing 250-999 employees per 1000 inhabitants (+) – ($x5$) Number of entities of the national economy employing more than 1000 employees per 1000 inhabitants (+) – ($x6$) Foreign capital per capita of working age (+) – ($x7$) Number of entities with foreign capital per 1000 inhabitants (+) – ($x8$) Deregistered companies per 1000 inhabitants (-)
2. The potential of the local economy	– ($x9$) Sold production of industry per capita (+) – (x_{10}) Investment outlays in enterprises per capita (+) – (x_{11}) Gross value of fixed assets in enterprises per capita (+) – (x_{12}) Share of registered unemployed in the working age population (-) – (x_{13}) Working age population in total population (+) – (x_{14}) Working per 1000 inhabitants (+)
3. The financial condition of local governments	– (x_{15}) Own incomes of communes per capita (+) – (x_{16}) Own income of poviats per capita (+) – (x_{17}) Share of investment expenditure of municipalities and poviats in total expenditure (+)
Social development indicator	
1. Poverty	– (x_{18}) Number of benefits paid in relation to a particular social problem (-) – (x_{19}) Number of municipal dwellings whose tenants are in arrears with payments for the flat (-) – (x_{20}) Number of housing allowances paid (-) – (x_{21}) Beneficiaries of social welfare per 10000 inhabitants (-)
2. Demographic trends	– (x_{22}) Demographic dependency rate for the elderly (-) – (x_{23}) Percentage of people aged 65 and over in the total population (-) – (x_{24}) Internal migration balance (+) – (x_{25}) International migration balance (+)
3. The provision of basic needs	– (x_{26}) Number of clinics per 1000 inhabitants (+) – (x_{27}) Flats per 1000 inhabitants (+) – (x_{28}) Users of sewerage and water supply installations as % of total population (+) – (x_{29}) Percentage of children cared for in nurseries (+) – (x_{30}) Number of crimes per 1000 inhabitants (-) – (x_{31}) Commune and poviat roads with a hard surface for 10000 inhabitants (+) – (x_{32}) Hospital beds per 1000 inhabitants (+)
Environmental development indicator	
1. Climate change – natural disasters	– (x_{33}) Local climatic hazards (2018-2019)(-) – (x_{34}) Income of local governments from the recovery of the effects of natural disasters (2014-2019) (-) – (x_{35}) Assistance granted to households due to damages caused by natural or environmental disaster (2014-19) (-)
2. Industry-related environmental burdens	– (x_{36}) Emission of dust pollutants (-) – (x_{37}) Pollutant loads in wastewater discharged into water or soil (-) – (x_{38}) Industrial wastewater discharged during the year wastewater discharged directly into water or soil requiring treatment (-) – (x_{39}) Untreated industrial wastewater discharged during the year (-) – (x_{40}) Industrial wastewater containing substances particularly harmful to the aquatic environment, discharged during the year (-) – (x_{41}) Emission of gaseous pollutants (-)
3. Human-activity-related environmental burdens	– (x_{42}) Landfills per 100 km^2 in total (-) – (x_{43}) Mass of municipal waste generated per capita (-) – (x_{44}) Waste collected selectively in relation to total waste (+) – (x_{45}) Area of active landfills where municipal waste is neutralised (+) – (x_{46}) Industrial and municipal wastewater treated in% of wastewater requiring treatment (+) – (x_{47}) Water consumption for the needs of the national economy and population per year (-) – (x_{48}) Loads of pollutants in the wastewater after treatment (-)

Source: own elaboration based on Polish Central Statistical Office database.

The aggregated indicators of development in economic, social, and environmental areas in Polish poviats and cities with poviat rights were determined in accordance with the standardised

sum method. Each of three indicators assumes a value in the range [0,1]. A higher value of the indicator means a more favourable situation of the object, while a lower value means a unfavourable one. The aggregate (synthetic) measure was calculated according to the following formula:

$$AI_i = \frac{1}{k}\sum_{j=1}^{k} x_{ij} (k = 1,2,3 \ldots k)$$

where:
AI_i – means aggregated indicators of development in each area,
x_{ij} – means features of the structure of the synthetic indicator,
k – means the number of partial indicators used in the construction of the aggregate indicator of the given area.

To identify spatial patterns of the level of economic, social, and environmental development, first we adopted Ward's hierarchical method in order to classify poviats according to their level of sustainable development reflected by aggregated indicators for the economic, social, and environmental level of development. The use of this taxonomic method enabled us to identify poviats with a similar level of the studied characteristics, and thus **combine units into clusters that are relatively homogeneous in terms of the studied variables**. The method uses an analysis of variance approach to estimate the distance between clusters and aims at minimising the sum of squared deviations within clusters. The measure of differentiation of the cluster in relation to the average values is ESS (Error Sum of Squares). For the purposes of this analysis, the Euclidean measure of the distance between the elements of the set was used.

Further analyses focused on determining the spatial autocorrelation of the degree of sustainable development in three areas. According to Bivand (1980), autocorrelation takes place when the occurrence of one phenomenon in a spatial unit increases or decreases the probability of the occurrence of a given phenomenon in neighbouring units. Therefore, we defined clusters of poviats whose **level of development in the three studied areas is related to each other**. We used the local version of Moran statistics, which is the most popular analysis of LISA (Local Indicators of Spatial Association) (Anselin, 1995). Unlike the global Moran statistics, it determines the local spatial autocorrelation and thus determines the similarity of a spatial unit to its neighbours as well as examines the statistical significance of this relationship. The Moran I local statistics test confirms that the distribution of the values of aggregated indicators is not random.

The Moran method analysis made is possible to determine the so-called spatial regimes in which individual objects form the following groups:

- statistically significant **High-High** objects (objects with high values surrounded by objects with high values);
- statistically significant **Low-Low** objects (objects with low values surrounded by objects with low values);
- statistically significant **Low-High** objects (objects with low values surrounded by objects with high values);
- statistically significant **High-Low** objects (objects with high values surrounded by objects with low values).

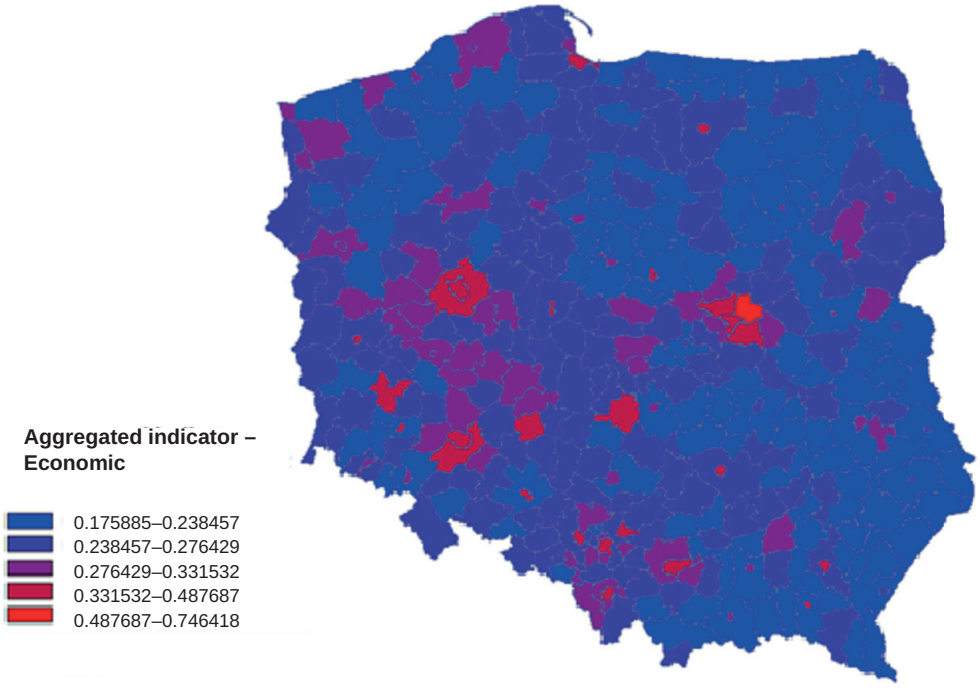
All statistical analyses (presented in the following subsections) were performed with the statistical package PQStat 1.8.2.142.

The spatial patterns of sustainable development at the local level

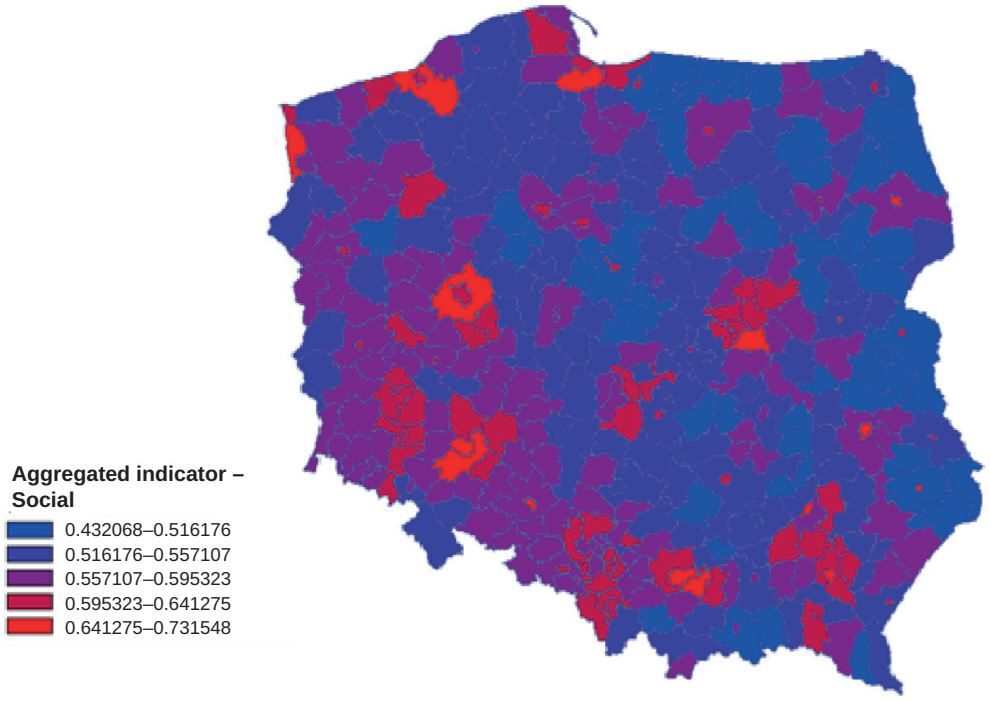
The results for all three aggregated indicators show that the differentiation of poviats can be considered insignificant (the coefficients of variation for economic, environmental, and social development are 19.55%, 8.1%, and 5.54%, respectively). Nevertheless, the range of means for the economic development index was 0.1759 to 0.7464, and the skewness of the distribution was 3.2749. This means that there are overwhelmingly more poviats characterised by lower sustainable development than those better developed in all three analysed areas. The main unit responsible for such asymmetry is Warsaw – the capital city, while the next in the ranking, namely the city of Poznań, already shows a much lower result (0.4877). It is worth noting that the distribution of the

results of all three aggregated indices differs significantly from the theoretical normal distribution, which means that the problems occur in a spatially non-uniform manner (result of the Kolmogorov-Smirnov test D = 0.1366, df = 380, p <0.0001).

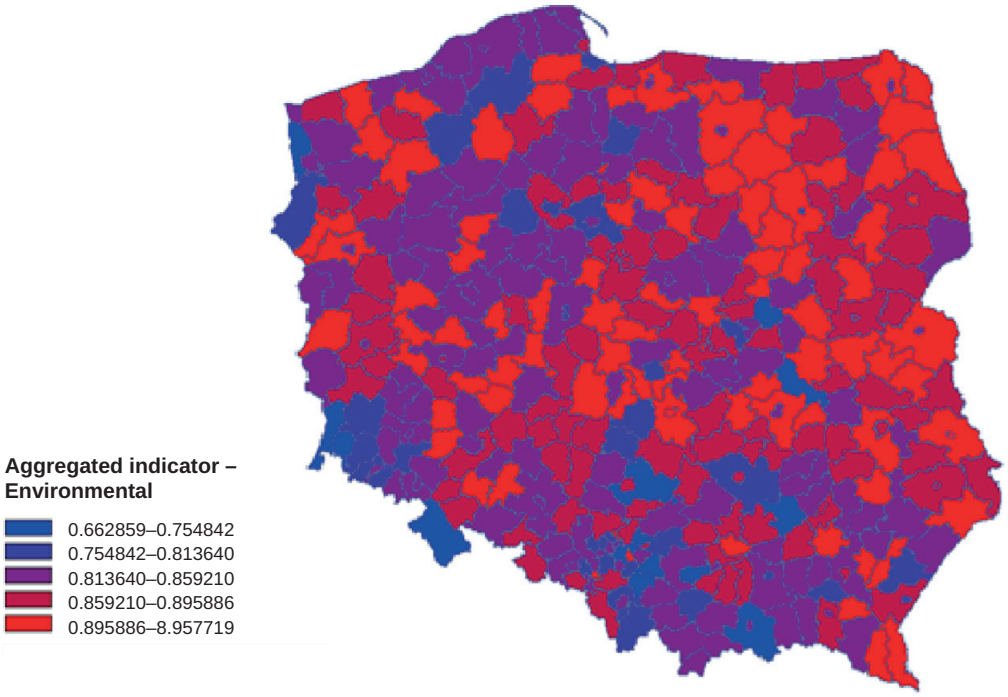
In general, the levels of sustainable development measured in three areas confirm the east-west division of the country, although in the case of social and environmental development, this division is visible but not so clear as in the case of economic development. The second conclusion concerns the explicit distinction of cities with poviat rights from poviats located peripherally to them. The maps below present the spatial distribution of the values of aggregated indicators for all three studied areas.



Map 1. Aggregated indicator for economic development



Map 2. Aggregated indicators for social development



Map 3. Aggregated indicator for environmental development

Cluster analysis

In this part, the results of cluster analysis are presented and discussed. The discussion goes beyond the indicators used in the analysis – we are looking for a possible, though not conclusive, explanation for the results obtained. First, we implemented hierarchical Ward method with Euclidean distance to identify poviats with similar level of development in three thematic areas. The results of the analysis show that the units can be divided into three distinct clusters. 171 poviats were qualified for the first cluster, and 160 and 49 poviats, respectively, for the second and third.

Table 2. Descriptive statistics for individual clusters (hierarchical method)

		Aggregated indicator – Economic		Aggregated indicator – Social		Aggregated indicator – Environmental	
		Average	S.D.	Average	S.D.	Average	S.D.
Cluster 1 (171 poviats)		0.23	0.02	0.53	0.03	0.88	0.03
Cluster 2 (160 poviats)		0.27	0.03	0.59	0.03	0.86	0.03
Cluster 3 (49 poviats)		0.31	0.09	0.60	0.05	0.78	0.05
ANOVA	F	110.7089		226.4073		93.254	
	df	2/111.9357		2/119.0323		2/122.9393	
	p	<0.0001		<0.0001		<0.0001	

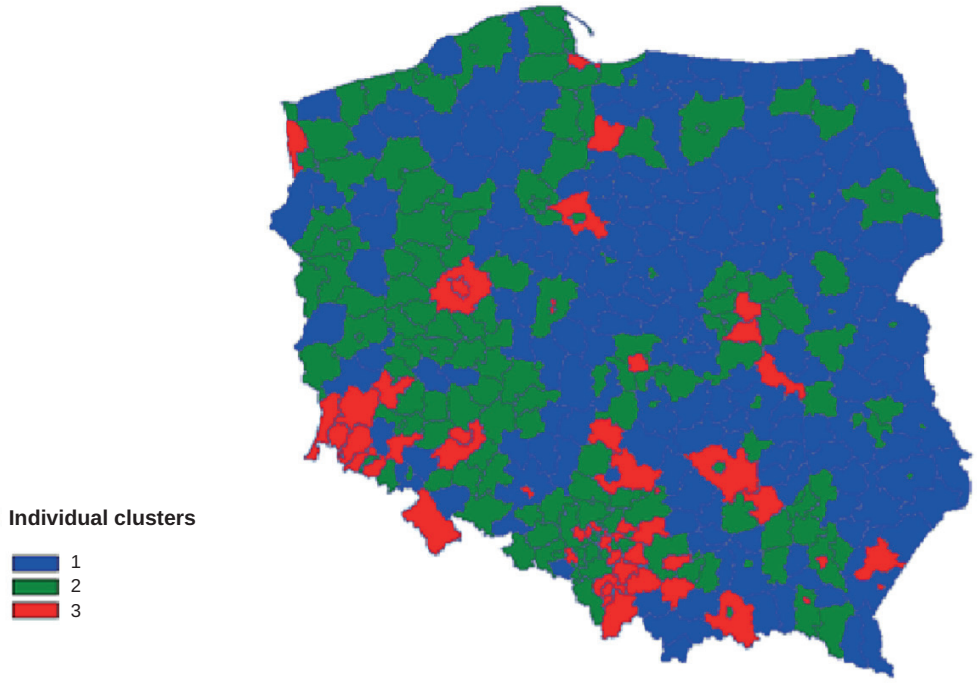
Source: Own calculations.

Cluster 1 includes most poviats characterised by relatively lowest level of sustainability in economic and social areas, while their environmental development remains the highest compared to poviats in the remaining clusters. These are less populated poviats, a large part of which is located in less developed Polish regions of eastern, central, and northern Poland. These regions are sparsely urbanised, characterised by low population density and low industrialisation, which, on

the one hand, creates unfavourable conditions for economic development and, on the other hand, does not significantly burden the environment with human activity.

The counties belonging to Cluster 2 can be called “average”, i.e. the level of sustainable development in all three analysed areas is somewhere between the poviats with lower levels of development and those that achieved a relatively high level of development. Poviats of this cluster are units mainly located in western and southern Poland, whose regions are generally characterised by a higher level of socioeconomic development. Many of the poviats included in Cluster 2 are located in the vicinity of large urban and industrial centres.

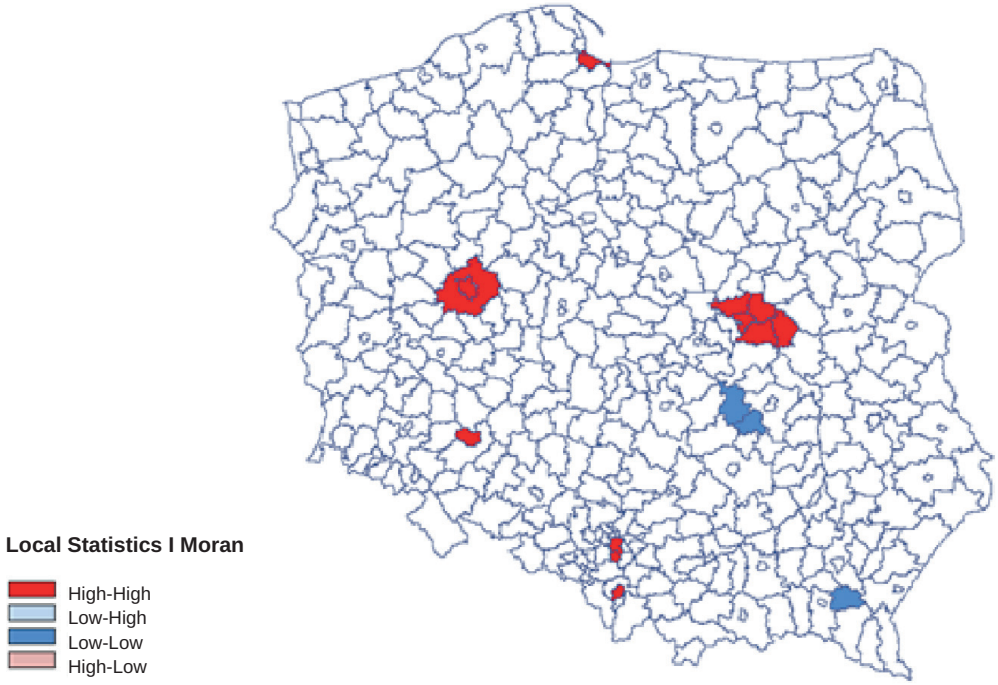
The third group (Cluster 3) includes poviats which are “leaders” in terms of economic and social development, while they struggle with problems related to environmental sustainability. This group includes mainly poviats forming agglomerations, larger cities, and typically industrial cities (located in Silesia and Lower Silesia). The spatial distribution of three identified clusters is presented on the map below.



Map 4. Three groups of poviats (hierarchical – Ward method with Euclidean distance)

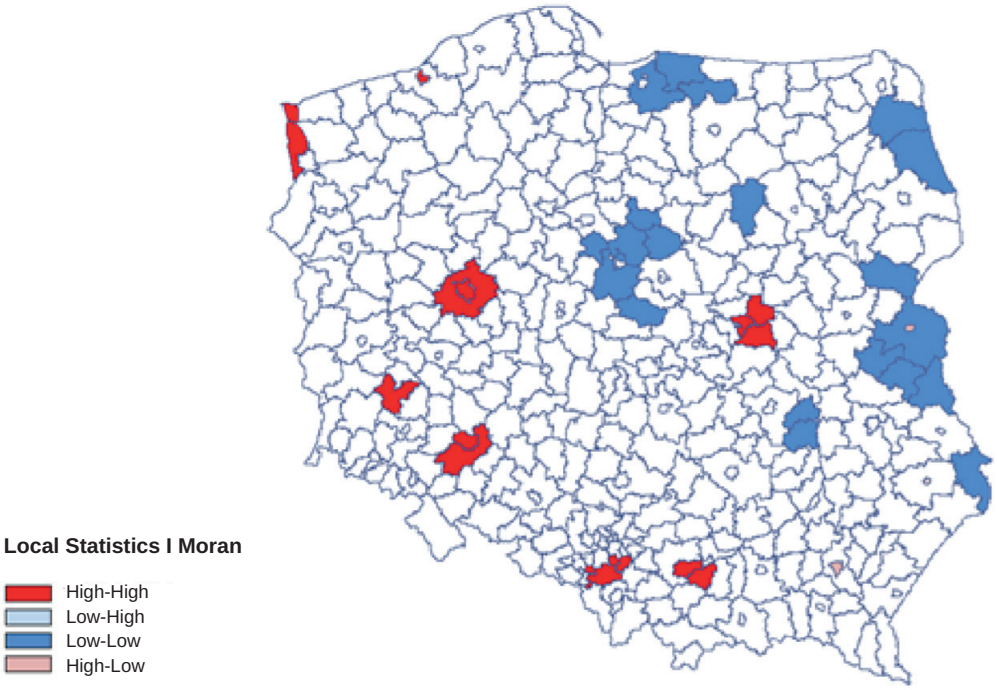
This section is devoted to the presentation and interpretation of cluster analysis conducted with the use of the Moran local statistic. In the **economic development** area, statistically significant so-called high-high clusters – i.e. groups of poviats located close to each other and characterised by relatively high economic development – are marked in red on the map. There are thirteen such poviats (Warsaw – city with poviat rights, the Otwocki poviat, the Piaseczyński poviat, the Pruszkowski poviat, the West Warsaw poviat, Poznań – city with poviat rights, the Poznański poviat, Sopot, Wrocław – city with poviat rights, Tychy – city with poviat rights, Gdańsk – city with poviat rights, Bielsko-Biała – city with poviat rights, and Katowice – city with poviat rights). They represent the most economically-developed poviats (along with the surrounding poviats). This proves the presence of spillover effect of large cities onto the surrounding areas, confirmed in previous studies on economic development processes (Dallhammer et al., 2019). It also proves that large cities and the surrounding poviats should be treated as a homogenous area, as the development of both is interdependent. Three low-low clusters, i.e. groups of least economically-developed poviats located in the vicinity, have been identified and marked blue on the map (the Przysuski poviat, the Szydłowiecki poviat, and the Brzozowski poviat). The results may be surprising due to the fact that one could expect the existence of many, relatively large spatial clusters of poviats struggling with economic challenges located in peripheral regions. This is mainly about the regions of eastern

Poland, whose economic backwardness results, on the one hand, from an unfavourable location in relation to the main trade routes and, on the other hand, is rooted in historical events (more than 120 years of belonging to tsarist Russia). These regions are characterised by the so-called long duration (Fr. *long durée*) processes according to F. Braudel's concept. The obtained results may indicate that even in the poorest regions of the country, the level of poviats' economic development varies. Finally, the study showed the lack of statistically significant clusters of low-high and high-low poviats, which means that at the local scale, there is no concentration of units characterised by extremely different levels of economic development.



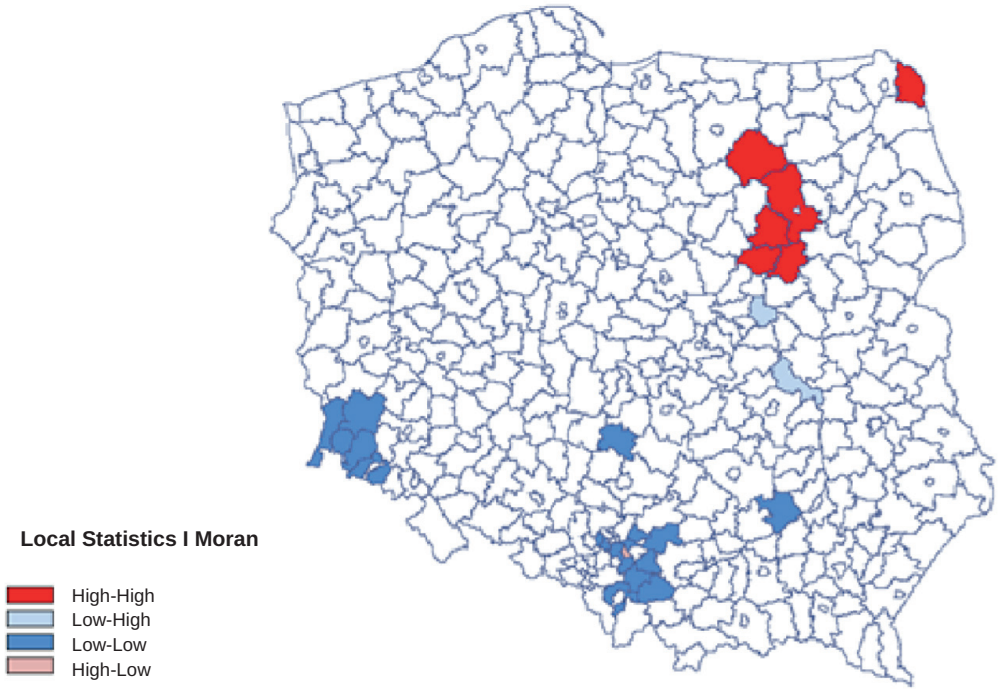
Map 5. Clusters of poviats according to economic aggregated indicator (Local Statistics I Moran)

In the area of **social development**, statistically significant high-high clusters, i.e. poviats with high indicators, surrounded by poviats demonstrating high indicators, concerned a total of eighteen poviats. As in the case of economic development, clusters of units characterised by relatively high level of social development form poviats located around the largest Polish cities (Warsaw, Kraków, Poznań, Wrocław). In total, eighteen high-high clusters were identified (the Piaseczyński poviat, the Pruszkowski poviat, the Wielicki poviat, the Poznański poviat, the Pszczyński poviat, the Bieruńsko-Lędziński poviat, the Policki poviat, the Wrocławski poviat, and the Polkowicki poviat as well as cities with poviat rights: Rzeszów, Kraków, Warszawa, Poznań, Wrocław, Świnoujście, Tychy, Żory, Koszalin). On the other hand, most of the twenty identified low-low clusters of poviats are located in the east and north-east part of the country (the Przasnyski poviat, the Sierpecki poviat, the Zwoleński poviat, the Lipski poviat, the Bialski poviat, the Hrubieszowski poviat, tge Parczewski poviat, the Radzyński poviat, the Włodawski poviat, the Kutnowski poviat, the Augustowski poviat, the Sokólski poviat, the Siemiatycki poviat, the Elbląski poviat, the Lidzbarski poviat, the Braniewski poviat, the Aleksandrowski poviat, the Lipnowski poviat, the Włocławski poviat, and te Rypiński poviat). Statistically significant high-low objects, i.e. poviats with high social development, surrounded by units characterised by low level of social development, are marked in pink on the map, and in this case only two have been recognised: cities with poviat rights of Biała Podlaska and Zamość. This observation can be explained by the fact that both cities may be considered "developed islands" in very poor, peripheral regions, defined by the highest unemployment and poverty rates in the country, and the lowest availability of public infrastructure rates. No low-high clusters have been identified.



Map 6. Aggregated indicator for social area (Local Statistics I Moran)

In the domain of **environmental development**, statistically significant clusters of units with high level of environmental development, which are surrounded by units with a similar level of development appeared in the case of six poviats (the Ostrołęcki poviat, the Pułtuski poviat, the Wyszkowski poviat, the Makowski poviat, the Sejneński poviat, and the Szczycieński poviat). All of these clusters are located in north-eastern regions of Poland. This can be explained by the fact that these are the least populated areas of the country with a low level of industrialisation. The clusters of poviats that must deal with serious challenges related to environmental development (eighteen poviats in total forming low-low clusters) are located in Silesia and Lower Silesia – regions with a large population, highly urbanised with a high number of industrial plants (including mines). These are: the Chrzanowski poviat, the Olkuski poviat, the Oświęcimski poviat, the Wadowicki poviat, the Pajęczański poviat, the Staszowski poviat, the Zgorzelecki poviat, the Bielski poviat, the Bieruńsko-Lędziński poviat, the Jeleniogórski poviat, the Bolesławiecki poviat, the Lubański poviat, the Lwówecki poviat, and cities with poviat rights – Zabrze, Ruda Śląska, Sosnowiec, Dąbrowa Górnicza, Katowice). It is interesting that two low-high clusters are formed by Warsaw and the Kozienice with their adjacent poviats. The case of the first one can be explained by the fact that despite huge investments in environmentally-friendly infrastructure (e.g. sewage treatment plant, the purchase of electric buses, the organisation of new green spaces), Warsaw remains the second most polluted by PM2.5 atmospheric aerosols, with one of the lowest levels of environmental sustainability among the European Union's capitals (Czupich et al., 2022). The poviats adjacent to Warsaw – due to their very favourable financial condition – have also made many investments with a much smaller number of inhabitants and industrial plants located in their areas. The only case where a poviat with relatively high level of environmental development is surrounded by units of low environmental development (high-low) is the city of Mysłowice. The results could be explained by the fact that this city with poviat rights is called the "Polish Manchester", and is a part of the Silesian agglomeration, i.e. the most industrialised region in Poland.



Map 7. Aggregated indicator for environmental area (Local Statistics I Moran)

Conclusions

The key resource of local communities are institutions capable of making the right decisions, supervising and supporting the development process as well as solving problems and dealing with new challenges, the sources of which should be seen in the intensifying globalisation processes (Capello & Fratesi, 2013; Clark et al., 2010). Undeniably, the sustainable and long-term well-being of citizens must be based on the three pillars of sustainable development, which are: economic growth, environmental management and protection, and social inclusion. They are of fundamental importance and must be present in all development activities undertaken by local government units.

Our analysis proves several issues concerning spatial patterns of sustainable development in Poland. Firstly, in Poland, overwhelmingly more poviats are characterised by lower development than those better developed in all three analysed. Development processes occur with varying intensity and in a spatially uneven manner. Secondly, within Poland, three clusters of poviats in terms of the level of development in each of the three domains can be distinguished. The smallest group are poviats with a low intensity of economic and social problems, which, however, face relatively greater challenges related to environmental protection. Most of the poviats with low levels of environmental problems and significant problems in the economic and social spheres are units located in the less urbanised, less populated, and less industrialised eastern part of the country. Thirdly, identified spatial relationships indicate that some poviats have a significant impact on the level of development in the neighbouring poviats. Most of the clusters in which a high level of development is related to a high level of development of the surrounding units concerns the area of social development. The largest number of low-low type clusters (units with a low level of development surrounded by poviats also with a low level of development) was identified for the environmental area. Situations in which a given poviat is adjacent to units with clearly different development levels (high-low and low-high regimes) occur sporadically or not at all.

The presented results of the analyses of spatial differentiation of the economic, social, and environmental development progress should constitute useful knowledge necessary for designing more effective, tailor-made policies, mitigating threats, and solving complex problems. Planned measures should consider the presented evidence of a strong differentiation between poviats “coping with” economic and social challenges, and those lagging in these issues. Distinct spatial

differences on sustainable development levels between the peripheral counties of Eastern Poland, larger cities, and, finally, metropolitan centres should lead to a deeper reflection on the shape of the national policy and actions taken at the local level, followed by effective implementation of the principles of balanced spatial sustainable development.

Being aware of the limitation of the presented studies (i.e. subjectivity in choosing features to build synthetic indicators), we believe that the research should be treated as one of the proposals alongside other studies on the measurement of spatial patterns of sustainable development at the local scale in Poland.

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