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SUSTAINABLE DEVELOPMENT OF FUNCTIONAL URBAN AREAS OF VOIVODSHIP'S CAPITAL CITIES IN POLAND

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ABSTRACT: Current global threats and changes undoubtedly justify conducting studies of sustainable development (SD) in different aspects. Researching this phenomenon in urban areas is important to formulate more accurate and important conclusions for urban policy. The aim of the paper is to assess the diversity of SD of FUAs of voivodship's capitals in Poland, also with the level of development in different dimensions of sustainable development. The study, using the TOPSIS method, was conducted for 17 FUAs. This allowed us to assess that the level of differentiation of SDin studied FUAs is rather small. The highest levels of SD indices were observed in FUAs: Warsaw, Wrocław, the lowest in FUAs: Katowice-Gliwice and Łódź. Moreover, 65% of the studied units belong to the lower middle and lower-level classes of SD. It was also observed that the lowest result of SD indices was in the environmental-spatial dimension (in over 40% of studied FUAs).

KEYWORDS: functional urban areas, sustainable development

Introduction

More than half of the world's population lives in cities, and the rate of urbanisation is still increasing. Therefore, urban areas are an important subject of development policy, for example, in the framework of the European Union (EU). Under this policy, cities are seen from a broader perspective, along with their functional surroundings (mainly connected to the city by commuting to work, school, etc.). These functional urban areas (FUAs) become an important stakeholder and addressees of development policy, e.g. in accordance with the National Urban Policy 2030 (Council of Ministers, 2022). Furthermore, FUAs in Poland were established in connection with a new instrument of the EU cohesion policy in perspective 2014-2020 – the ITI (integrated territorial investments). During that programming period, 24 FUAs functioned in Poland, including 17 of the capitals of voivodeships (which are the objects of the research study in this paper). From an EU perspective of 2021-2027, it is planned to extend the scope of implementation of the ITI, which will also cover other functional urban areas, mainly in medium-sized cities which are losing their socio-economic functions. It is planned that approximately 80 FUAs will operate in Poland in this perspective. Thus, it is still important to analyse the development conditions and needs of FUAs in order to conduct effective development policy and achieve sustainable development (SD) goals. Moreover, the topic of sustainable development of functional urban areas is poorly described in the literature. Therefore, the paper will fill the research gap by contributing to the study and providing a better understanding of the sustainable development of FUAs.

Considering the above, the key objective of this research is to evaluate the sustainable development diversity in functional urban areas of capital cities in Poland's voivodeships. This evaluation will encompass all dimensions of sustainable development, i.e., social-institutional, economic, and environmental-spatial. Such an assessment will facilitate pinpointing FUAs, which require reinforcement to promote sustainable development. This is important from the point of view of shaping the directions of development and financing of functional areas towards their sustainable development. The research objective was achieved using the TOPSIS method, including data from the Polish statistical office (Statistics Poland).

The article comprises with 7 main sections. After this introduction, the literature was reviewed to outline the main concepts of SD and FUAs. In the next section, a general characterisation of the studied FUAs was made. Then, the applied research methodology was defined, and thereafter, the obtained results were analysed and discussed. The paper ends with conclusions.

An overview of the literature

Sustainable development is a fundamental aspect of modern global development practices. The notion of sustainable development emerged during the latter half of the 20th century. In 1972, a report titled "The Limits to Growth" (Meadows et al., 1972) was published, highlighting concerns of environmental damage as a result of over-exploitation of natural resources, population growth, rapid industrial expansion, agricultural practices, and unrestrained consumerism. One of the initial and most widely accepted definitions of sustainable development was formulated in the Brundtland Report. It describes sustainable development as a process of transformation that aims to ensure compatibility with the exploitation of resources, investment direction, technological orientation, and institutional change. This transformation should result in enhanced potential to meet the aspirations and current and future needs of humanity while promoting harmony (United Nations, 1987).

In 2015, all member states of the United Nations (UN) pledged to work towards the sustainable development goals (SDGs) outlined in the 2030 Agenda for Sustainable Development (United Nations, 2015). The Agenda comprises 17 goals that address vital issues for both humanity and the planet, known as the 5Ps. These include people, such as poverty, hunger, equality, and health, the planet, with sustainable consumption, production, and management of natural resources, as well as tackling climate change. In addition, prosperity involves economic, social, and technological progress in harmony with nature, peace entails creating inclusive, just, and violence-free societies, and partnership involves the Global Partnership for Sustainable Development. Goal 11, in particular, focuses on developing cities to ensure they are inclusive, safe, resilient, and sustainable.

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The Agenda 2030 shows that sustainable development is a multidimensional concept, and its study can cover various levels. In the literature, the definition of sustainable development is presented at least in two ways: narrow (nature-centric) and broad (holistic, integrating various dimensions) (Kiełczewski, 2021). In a narrow approach, sustainable development is understood in terms of eco-development as a long-term management of natural environment resources, i.e. sustainability of natural capital (Meadows et al., 1972; Spash, 1999). In a broad approach, it is highlighted that sustainable development includes not only the natural assets but also other dimensions, e.g., economic, socio-cultural, spatial, and institutional (Barbier, 1987; van Bergh & Nijkamp, 1991; Poskrobko, 2013). It is emphasised, moreover, that sustainable development may be understood as an "integrated dimension". It can be defined as a positive state of change combining the other dimensions in a coherent, non-contradictory way, i.e., social, economic, environmental, institutional (ethical and political), and spatial. (Kiełczewski, 2021; Borys, 2011; Bedrunka & Malik, 2012). The multidimensionality of the concept of sustainable development is also reflected in this research study.

The literature regarding urban areas is rich and covers different topics of sustainable development, i.e.: environmental (Jovanović et al., 2012; Lorek, 2015; Karatas & Kilic, 2017), development policy and planning (Wang et al., 2011; Csete & Horváth, 2012; Tylman, 2015, Mersal, 2016), city regeneration (Ozturk et al., 2010; Strzelecka, 2011), transportation (Zuidgeest & van Maarseveen, 2006; Grondys et al., 2017; Wang et al., 2019), general urban sustainable development models (Mörtberg et al., 2013; Liu et al., 2014; Graczyk, 2015; Mierzejewska, 2015; Chizho et al., 2021; Shawly, 2022) and assessment of urban SD (Foroozesh et al., 2022; Tang et al., 2019; Li et al., 2009). Within urban studies, the important aspect of research is also the spatial expansion of cities (Gao & O'Neill, 2020; Colsaet et al., 2018; Wei & Ye, 2014). This research highlights that urban land expansion is one of the key drivers for many environmental, economic and societal changes in cities and in their neighbouring, functional areas.

Functional urban areas are node regions with a dominant position in the central city, which perform specific functions in relation to its surroundings. In general, it is emphasised that FUAs are based on local labour markets in terms of linkages between places of work and residence as the basic mechanisms integrating the functional territory, as well as different functional economic interactions, commuting to schools, etc. between the city and its neighbouring zone (Sýkora & Mulicek, 2009; Karlsson & Olsson, 2006). The common EU-OECD definition is based on population density and mobility (a commuting zone) (Dijkastra et al., 2019). In Poland, FUA's delimitation of voivodship capital cities was based on the method of Śleszyński (2013), that was using three types of criteria (indicators): functional (number of people commuting to work, number of migrants from FUA core (voivodship capital city), socio-economic (share of people working in non-agricultural occupations, share of business entities, share of business entities classified in high-order services) and morphological (population density, share of completed dwellings). From the point of view of administrative boundaries, in Poland, FUAs consist of local government units that meet those criteria.

Among the study research available in the literature, related to sustainable development in FUAs can be identified following topics, e.g.:

- variability of the level of development of FUAs in terms of sustainable development (Szafranek, 2018) and in some dimensions of SD (Szarek-Iwaniuk, 2021; Savchenko & Borodina, 2020),
- the role of EU, national policy and its instruments in the sustainable development of FUAs (Szafranek & Kociuba, 2018; Kociuba, 2015),
- the relations between the idea of sustainable development and the instruments of its implementation (Kociuba & Szafranek, 2018),
- an impact of integrated territorial investments on the sustainable development of urban functional areas (Kociuba, 2018),
- the sustainable land transformation process, the land use efficiency and sustainable growth pattern (Williams et al., 2010; Schiavina et al., 2022),
- sustainable mobility/ transport systems in FUAs (Wolny et al., 2017; Wang et al., 2019; Marando et al., 2022).

The diversity of sustainable development in FUAs isn't sufficiently explored in the literature. Therefore, this article will fill the existing gap in that regard. In studying sustainable development as a multidimensional phenomenon, should be used synthetic, comprehensive measures, that best

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reflect the effects of changes, also in various SD dimensions (Federici, 2007; Szafranek & Kociuba, 2018).

FUAs in Poland

The research study included FUAs of voivodeship capitals in Poland. These areas were obligatorily created in frame of the European Union financial perspective 2014-2020 in order to implement the integrated territorial investments (ITI) instrument. Additionally, in Poland the ITI instrument was implemented also incities and their functional areas of a regional and subregional importance. In total 24 FUAs were established (see Figure 1)[1]. Due to the availability of data and their comparability, the research was concentrated only on voivodeship cities and their functional areas.

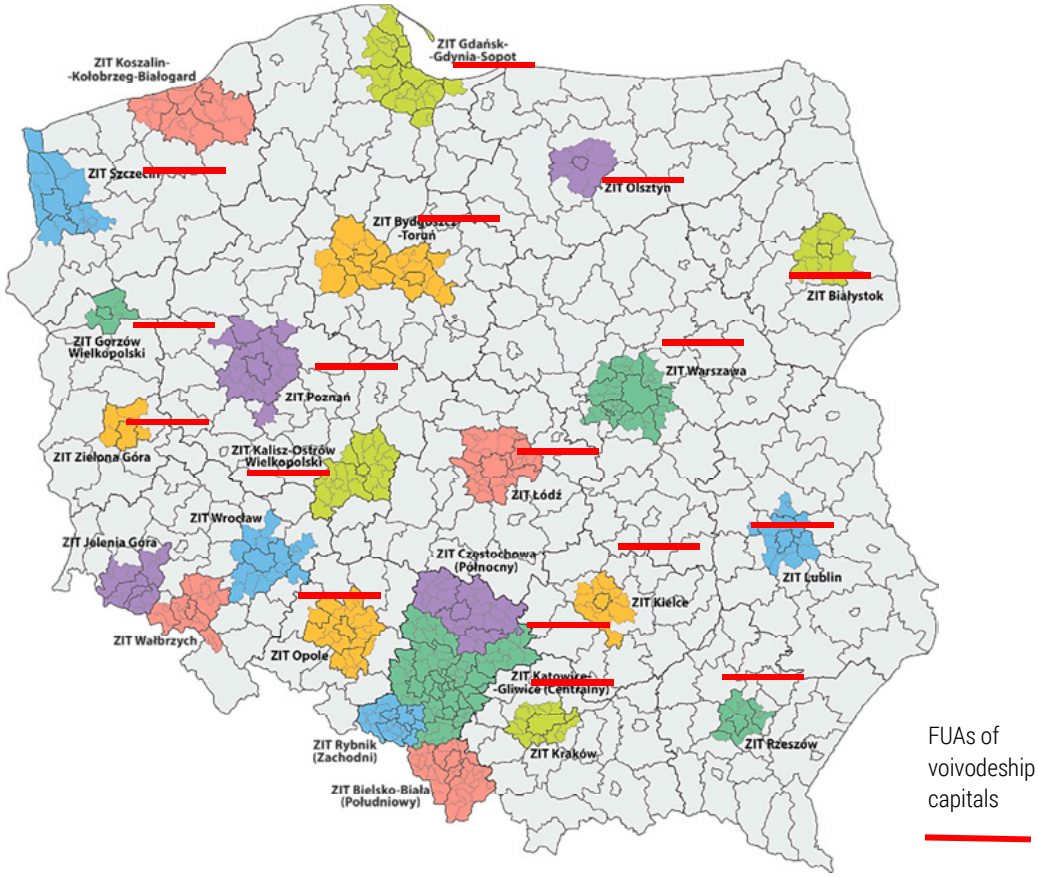

Figure 1. Functional urban areas of voivodeship capitals in Poland in 2014-2020

Source: author's work based on Statistics Poland (2024a).

Analysing selected statistical data in studied FUAs, it is observed quite diverseits socio-economic situation (Table 1).

In terms of number of local government's units included in each FUA, the coefficient of variation (cov) is high – 84.5%, which proves that these areas in Poland in were very diverse in this respect. The largest number of local government units was observed in FUA Katowice-Gliwice (81) and the least in the FUA Gorzów Wielkopolski (5), average for Poland was ca. 21 units. In the case of population density and the area in square kilometres, cov took values of 54% and 62%, which indicates strong variability of the examined features. The largest area of FUA was in Katowice-Gliwice (5,578 km^2), but the most densely populated was FUA Warszawa (962 in hab./km^2). The smallest area of FUA was in Gorzów Wielkopolski (770 km^2), and the least populated was FUA Opole (140 in hab./km^2). The

[1] According to Statistics Poland (2024b), at the end of 2022, there were 58 FUAs in Poland. However, due to changes in the borders of some of them and the lack of comparative data, the research in this paper was based on the typology from the 2014-2020 EU programming period.

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average size of the FUA of voivodship capitals in Poland was 2,270 km^2, and the population density was 369 in hab./km^2. In the analysed, FUAs were observed with very high variability (more than 721%) in terms of change in a total number of inhabitants. On the one hand, these data may be distorted by the effects of the COVID-19 pandemic. On the other hand, they showed that some urban areas (like Wrocław, Rzeszów, Kraków, etc.) are very attractive places to live and can be considered as growth poles in their regions. The biggest positive population change per 1,000 inhabitants was in FUA Wrocław (6.6), and the arithmetic mean in all FUAs was 0.6 people. The biggest population loss was in FUA Łódź (-6.5).

Table 1. General information about FUAs of voivodship capitals in Poland (in 2020)

FUA	Number of units (local governments) included in FUA	Area in km^2	Density of population	Total change of population per 1,000 inhabitants	Own income of local government units per capita	Registered unemployed per 100 people of working age	Share of protected areas in total area [%]
Białystok	10.0	1728.0	244.0	2.3	3156.0	5.2	30.3
Bydgoszcz-Toruń	24.0	3744.0	227.0	-2.0	3211.0	3.8	28.0
Gdańsk-Gdynia-Sopot	30.0	3080.0	428.0	4.0	4041.0	3.5	38.6
Gorzów Wielkopolski	5.0	770.0	205.0	-3.1	3104.0	3.1	51.9
Katowice-Gliwice	81.0	5578.0	482.0	-6.3	3616.0	3.3	14.4
Kielce	12.0	1341.0	252.0	-3.8	3127.0	5.1	86.4
Kraków	15.0	1275.0	848.0	5.7	4414.0	3.4	18.4
Łódź	30.0	2499.0	424.0	-6.5	3757.0	5.2	14.9
Lublin	16.0	1582.0	346.0	-0.6	3110.0	5.0	15.7
Olsztyn	7.0	1452.0	162.0	2.4	3796.0	3.3	57.1
Opole	21.0	2369.0	140.0	-2.5	3644.0	3.8	43.5
Poznań	23.0	3082.0	342.0	4.8	4252.0	2.1	18.0
Rzeszów	13.0	1047.0	359.0	6.2	3157.0	6.5	19.1
Szczecin	15.0	2799.0	245.0	-1.9	4116.0	3.2	7.5
Warszawa	40.0	2935.0	967.0	4.6	5900.0	2.8	49.4
Wrocław	15.0	2339.0	401.0	6.6	4743.0	2.5	6.1
Zielona Góra	6.0	964.0	196.0	0.3	3415.0	3.7	24.2
Arithmetic mean	21.4	2269.6	368.7	0.6	3797.6	3.9	30.8
Coefficient of variation (cov, in %)	84.5	53.9	61.6	721.6	19.6	30.1	68.9

Source: author's work based on Strateg (2023).

The studied areas are distinguished by average variability in terms of the situation in the labour market. Cov of registered unemployed people per 100 inhabitants of working age was 30.1%. The highest index was in FU Rzeszów (6.5) and the lowest in FUA Poznań (2.1). This reflects the lower level of development of the eastern part of the country compared to the western part. The mean value for all FUAs was 3.9 people.

Regarding indicators of own incomes of local government units per capita, studied FUAs weren't much different. Cov in that regard was only ca. 20%, and the arithmetic mean was 3,798 PLN/per capita. The highest income per capita was observed in FUA Warszawa (5,900 PLN) and the lowest in FUA Gorzów Wielkopolski (3,104 PLN), which is also the smallest among the studied objects.

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FUAs in Poland include both urban and rural areas. When comparing the share of green protected areas in the studied units, a large variation can be observed (cov = 69%). The largest share of the protected area is in FUA Kielce (86.4%). It may result from the fact that parts of 4 landscape parks are located within the borders of this FUA. The smallest share of protected areas occurs in FUA Wrocław (6.1%), which is one of the largest agglomerations in Poland. The mean value for the share of protected areas is, in general, ca. 31%.

Research methods

In this paper, to access the diversity of sustainable development of FUAs of voivodship capitals in Poland was used the Technique for Order of Preference by Similarity to the Ideal Solution (TOPSIS) method (Hwang & Yoon, 1981) for each studied FUA was built synthetic sustainable development (SD) indices. Subsequently, a linear ordering of studied objects was done, and they were assigned to development classes. The general level of diversity of SD indices was described by the coefficient of variation. The advantage of the TOPSIS method is that it uses two reference points: a positive ideal solution (pattern) and a negative ideal solution (anti-pattern) as reference points for the considered variants. It makes it possible to find certain regularities in the development of the studied units in a more accurate way. The main advantages of this method include simple, rational, comprehensible concepts, intuitive and clear logic, ease of computation and good computational efficiency (Hung & Cheng, 2009). In general, the TOPSIS method is rated very well in terms of functionality and is recommended in decision-making processes (Roszkowska et al., 2018). In economic sciences, this method is used to study the differentiation of various phenomena, also sustainable development, e.g., Balcerzak and Pietrzak (2016), Roszkowska et al., (2017), Tang et al., (2019), Foroozesh et al., (2022).

In this paper, the procedure for determining the SD indices and level of sustainable development diversity in studied FUAs in detail included the following steps (Roszkowska et al., 2017):

1. Construction of a data matrix containing variables describing the sustainable development in FUAs of voivodship capitals in Poland in various dimensions, taking into account the availability of data in public statistics as well as substantive and statistical verification of studied phenomena.

$$X=[x_{ik}], \quad (1)$$

where:
x_{ik} – value of the k-th variable for the i-th FUAs (k=16, i=17).

An indicator system for urban sustainable development must reflect the current status of the urban economy and should embody the social, economic, ecological, environmental, and institutional aspects (Li et al., 2009). In Poland, relevant methodology was created by the Polish statistical office – Statistics Poland, which includes different indicators in four dimensions (Statistics Poland, 2015):

- Social – in aspects of: demographic changes, public health, living conditions, education, access to the labour market, consumption patterns, public safety,
- Economic – in aspects of: economic growth, employment, innovation, transportation, production patterns,
- Environmental – in aspects of: climate changes, energy, air protection, biodiversity, land use, waste and water management,
- Institutional & political – in aspects of SD financing, trade globalisation, cohesion policy, civil society and equality in management.

In the literature, there is also an approach of environmental-spatial dimension of SD, which combines elements of space with the environmental aspect, e.g. green area, urbanization, or aspects of spatial planning (Dembicka-Niemiec, 2017).

The starting point for the selection of variables was the above-mentioned methodology of Statistics Poland (2015). However ultimately, the selection of variables depended on the availability, reliability and completeness of statistical data at the FUA level, which, unfortunately, are limited in public statistics. If it was possible, variables of similar meaning but available for FUA were included in this research. The principle followed here was that the individual indicators used to measure the concept

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of SD should reflect the needs of local communities in the field of environmental protection, quality of life, economy, resources of the region, etc. (Roszkowska et al., 2014; Tang et al., 2019). As a result, taking into account substantive and statistical verification, 16 variables were included in the study, divided into 3 SD dimensions: social-institutional, economic, and environmental-spatial (Table 2). The data came from the public, official database – STRATEGY for the year 2020 (Strateg, 2023). The variables Z2, Z4, Z5 and Z12 were classified as destimulants and the others as stimulants. Due to the lack of an objective criterion for assigning weights to individual variables, the same weights were used for all of them.

Table 2. Variables included in the research study are divided into SD dimensions

Dimension of sustainable development	Variable number	Variable name
Social & institutional	Z1	Net international migration per 1,000 population
	Z2	Registered unemployed per 100 people at working age
	Z3	Number of dwellings completed per 1,000 population
	Z4	Electricity consumption in households per capita [kWh]
	Z5	Number of beneficiaries of social assistance per 10,000 population
	Z 6	Number of foundations, associations and social organizations entered in the REGON register per 10,000 residents
Economic	Z7	Employed per 1,000 people at working age
	Z8	Length of bicycle infrastructure per 10,000 km residents
	Z9	Entities of the national economy entered in the REGON register declaring conducting business in sections J-N per 1000 population
	Z10	Own income of local government units per capita
	Z11	Investment expenditure of local government units per capita
Environmental & spatial	Z12	Urbanization index [%]
	Z13	Percentage of area with enforceable local spatial development plans in the overall area of FUA
	Z14	Municipal wastewater discharged per capita [dam^3]
	Z15	Share of protected areas in total area [%]
	Z16	Expenditure on environmental and water-related fixed assets per capita

Source: author's own calculation based on Statistics Poland (2015) and Strateg (2023).

2. Normalisation of the values of variables to bring them to comparability, according to the following formulas:

- for stimulants:

$$z_{ik} = \frac{x_{ik} - \min\{x_{ik}\}}{max\ \{x_{ik}\} - \min\{x_{ik}\}}, \quad (2)$$

- for destimulants:

$$z_{ik} = \frac{\max\{x_{ik}\} - x_{ik}}{max\ \{x_{ik}\} - \min\{x_{ik}\}}, \quad (3)$$

3. Calculation of the Euclidean distance of the studied FUAs from the development pattern z+ = (1,1...,1) and the development anti-pattern z- = (0,0...,0) according to the following formulas:

$$d_i^+ = \sqrt{\sum_{k=1}^{16} (z_{ik} - z_k^+)^2}, \quad (4)$$

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$$d_i^- = \sqrt{\sum_{k=1}^{16}(z_{ik} - z_k^-)^2}, \quad (5)$$

4. Determination of the SD index (q_i) in each of seventeen FUAs using the following formula:

$$q_i = \frac{d_i^-}{d_i^- + d_i^+}, \quad (6)$$

where:
d_i^- – distance from the anti-pattern of development for the municipality,
d_i^+ – distance from the pattern of development for the municipality,
q_{it} – value of the synthetic measure for the municipality (SD index).

Higher values of the SD index [0, 1] indicate a higher level of sustainable development of FUA and thus determine a higher position in the ranking.

5. In this step a linear order and typology of the studied FUAs was made, taking into account the values of SD indices. Typology by classes of development was made using the arithmetic mean () and standard deviation (s_q) of the values of SD indices, including:

- Class 1 (high level), $q_i \geq \bar{q} + s_q$,
- Class 2 (upper middle level), $\bar{q} + s_q > q_i \geq \bar{q}$
- Class 3 (lower middle level), $\bar{q} > q_i \geq \bar{q} - s_q$,
- Class 4 (lower level), $q_i < \bar{q} - s_q$. (7)

6. Determination of the degree of variability of sustainable development in FUAs based on the coefficient of variation (cov):

$$cov = \frac{s_q}{\bar{q}}. \quad (8)$$

The procedure described above was also repeated to create the synthetic index of sustainable development in all its individual dimensions: social and institutional, economic, environmental and spatial, in order to assess and compare which dimensions are the best and worst developed in each studied FUA.

Results of the research

The results of the research show that the level of SD in studied FUAs isn't very dispersed. The coefficient of variation for SD indexes was only 18.2%, which indicates that the diversity of sustainable development in the studied FUAs wasn't significant (Table 3).

The analysis of obtained results indicates that the functional area with the highest level of sustainable development is Warsaw (SD index: 0.611), and the lowest is FUA Łódź (0.315). The result of Łódź is 51% of the result of the FUA Warsaw and 70% of the mean SD index value for all FUAs (which is 0.447). The low result of FUA Łódź may indicate the still existing problems and barriers to the development of this city, initiated with political changes in Poland in 1989. Their result was the loss of economic functions (the collapse of the textile industry in the 90s of the last century) and a deep crisis in this city. Regarding the city of Łódź itself, Cudny (2020) pointed out that "despite the passage of 20 years from the beginning of the political transformation, Łódź has not regained its previous growth dynamics and still does not have a sufficiently defined strategy for further socio-economic development. It should be emphasised that the transformation process initiated in 1989 is still ongoing and cannot be considered completed yet".

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Table 3. SD index and class of development in FUAs of voivodship's capitals in Poland

FUA of voivodeship's capital	SD index (ranking)	Class of development
Warszawa	0.611	1
Wrocław	0.595	1
Poznań	0.524	2
Kraków	0.523	2
Szczecin	0.481	2
Rzeszów	0.467	2
Olsztyn	0.441	3
Opole	0.434	3
Kielce	0.428	3
Lublin	0.425	3
Białystok	0.420	3
Zielona Góra	0.419	3
GorzówWlk.	0.415	3
Gdańsk-Gdynia-Sopot	0.395	3
Bydgoszcz-Toruń	0.388	3
Katowice-Gliwice	0.320	4
Łódź	0.315	4
Standard deviation	0.081	n/a
Arithmetic mean	0.447	n/a
Coefficient of variation	0.182	n/a

Source: author's work based on Strateg (2023).

FUA Wrocław also has a high SD index (0.595, i.e. 97% of the highest index), which, together with FUA Warszawa, has been classified in the highest, first class of sustainable development. Above the average, i.e. in the second SD class (upper middle), are observed: Poznań, Kraków, Szczecin and Rzeszów, where the SD index ranged from 0.524 to 0.467. In this group, the result of FUA Rzeszów, which is located in the Podkarpackie voivodship, one of the poorest in Poland (about 70.7% of Polish GDP per capita (Statistics Poland, 2021) may be surprising. However, Rzeszow is one of the most dynamically developing cities, which e.g. in 2020 took the second place in Poland in the Ranking of Sustainable Development of Local Government Units (The Warsaw Institute Review, 2023). In the lowest, fourth development class, apart from FUA Łódź, is included FUA Katowice-Gliwice (0.320). It is an area located in Upper Silesia and is one of the most urbanised and polluted in Poland. The remaining urban areas are classified in the third development class (lower middle), in which the SD index ranges from 0.441 to 0.388, so the differences between them are small, about 12%. In this group, noteworthy is the high level of SD index in FUA Olsztyn, which is located in Warmińsko-mazurskie voivodship (which GDP per capita is the second lowest in Poland (68.4% of the Polish average value (Statistics Poland, 2021). However, the analysis of statistical data of FUA Olsztyn shows quite good development conditions, e.g.: (1) it has a lower than FUAs average share of the unemployed per 100 people at working age (3.3, the average value: 3.9), (2) own income of municipalities forming FUA Olsztyn are at the level of the FUAs average value (c.a. 3,796 PLN), or (3) FUA Olsztyn has a quite large share of environment protected areas (over 57%, average value: 30.8%).

According to the level of the SD indices in each dimensions of sustainable development, is quite various (Table 4).

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Table 4. SD index and class of development in FUAs of voivodship's capitals in Poland in dimensions of sustainable development

SD dimensions	Social-institutional dimension			Economic dimension			Environment-spatial dimension		
FUA of voivodeship's capital	SD index	Class	Ranking	SD index	Class	Ranking	SD index	Class	Ranking
Białystok	0.550	2	7	0.364	3	10	0.307	3	15
Bydgoszcz-Toruń	0.480	3	13	0.400	3	6	0.241	4	17
Gdańsk-Gdynia-Sopot	0.502	3	12	0.339	3	13	0.314	3	14
GorzówWlk.	0.523	3	11	0.397	3	7	0.295	4	16
Katowice-Gliwice	0.393	4	16	0.197	4	17	0.317	3	13
Kielce	0.419	4	14	0.252	4	15	0.583	1	1
Kraków	0.592	2	6	0.456	2	5	0.501	1	3
Łódź	0.350	4	17	0.245	4	16	0.338	3	12
Lublin	0.535	2	9	0.372	3	9	0.369	3	9
Olsztyn	0.593	2	4	0.351	3	12	0.338	3	11
Opole	0.409	4	15	0.386	3	8	0.513	1	2
Poznań	0.593	2	5	0.554	1	3	0.407	2	8
Rzeszów	0.538	2	8	0.356	3	11	0.478	2	5
Szczecin	0.527	3	10	0.498	2	4	0.424	2	7
Warszawa	0.639	1	2	0.729	1	1	0.483	2	4
Wrocław	0.713	1	1	0.627	1	2	0.445	2	6
Zielona Góra	0.603	2	3	0.307	3	14	0.342	3	10
Arithmetic mean	0.527	n/a	n/a	0.402	n/a	n/a	0.394	n/a	n/a
Standard deviation	0.095	n/a	n/a	0.138	n/a	n/a	0.095	n/a	n/a
Coefficient of variation	0.180	n/a	n/a	0.342	n/a	n/a	0.240	n/a	n/a

Source: author's work based on Strateg (2023).

The data in Table 4 show that the biggest diversity of level of synthetic indices in the dimensions of sustainable development occurs in the economic dimension – approx. 34%, then in the environmental and spatial dimension – 24% and finally in the social and institutional dimension – 18%. In that last dimension, the best result was observed in FUA Wrocław (0.713), and the worst was in FUA Łódź (0.350, which was over 50% less). In the economic dimension, the highest index was in FUA Warszawa (0.729), and the lowest was in FUA Katowice-Gliwice (0.197). In this case, the difference between the best and the worst result was over 70%. This shows the significant economic advantage of FUA Warsaw over other areas. In the environment & spatial dimension, the best result was recorded in FUA Kielce (0.583), and the worst was in FUA Bydgoszcz-Toruń (0.241), and the difference between these two results was almost 60%. It was also observed that in two dimensions, economic and social & institutional, the SD indices have exceeded the level of 0.7; in the third one, they haven't exceeded 0.6. Moreover, the index in the environmental & spatial dimension was observed as the lowest result in seven of the studied functional areas (ca. 43%), economic in five FUAs (ca. 32%), and social & institutional in four of them (25%) (Table 5). In one case – FUA Lublin, all dimensions of SD were ranked at the same position.

In general, the results of the study show that even large metropolitan areas such as Warsaw, Wroclaw and Krakow are developing in a sustainable way. What's more, the low level of economic growth in the voivodship need not be an obstacle to achieving good results in the sustainable development of FUAs (e.g. Rzeszow and Olsztyn). What's more, the differences in the SD index values between the best and the worst result can be considered as an average so that the FUAs do not differ significantly in terms of the SD index. At the same time, it can be emphasised that the highest index in the Warsaw FUA (0.6) is also a rather average result, as the maximum index level in the TOPSIS

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method is 1. Moreover, 65% of the analysed units belong to the lower middle and lower class of sustainable development. This shows that efforts to achieve sustainable development goals need to be intensified in all FUAs.

Table 5. The highest and the lowest SD index of dimensions of sustainable development in each studied FUA

FUA of voivodeship's capital	Dimension of SD – the highest SD index	Dimension of SD – the lowest SD index
Białystok	social & institutional	environment & spatial
Bydgoszcz-Toruń	economic	environment & spatial
Gdańsk-Gdynia-Sopot	social & institutional	environment & spatial
Gorzów Wlk.	economic	environment & spatial
Katowice-Gliwice	environment & spatial	economic
Kielce	environment & spatial	economic
Kraków	environment & spatial	social & institutional
Łódź	environment & spatial	social & institutional
Lublin	the same ranking	the same ranking
Olsztyn	social & institutional	economic
Opole	environment & spatial	social & institutional
Poznań	economic	environment & spatial
Rzeszów	environment & spatial	economic
Szczecin	economic	social & institutional
Warszawa	economic	environment & spatial
Wrocław	social & institutional	environment & spatial
Zielona Góra	social & institutional	economic

Discussion, limitation and future research

The study of urban functional areas in Poland is a relatively new research approach, and the literature on the diversification of sustainable development particular in FUAs isn't extensive. The discussion was therefore also extended to similar research regarding in general urban areas.

The research in the field of sustainable development of FUAs in Poland was conducted by Szafranek (2018). It is possible to note some similarities between both researches, e.g., the leading places in the FUAs ranking of large metropolitan centres (Warsaw, Wrocław, Poznań, Kraków) and high results of the SD index in the FUAs Olsztyn and Rzeszów (located in one of the less developed regions in Poland). The author Szafranek (2018), also pointed out that the disproportion in the level of development between FUAs decreased. This is consistent with the results of this paper, as the value of cov (18%) indicates low variability of the SD indices. However, it should be noted that there are differences in indices in SD dimensions (compared with Roszkowska & Karwowska (2014)). Low variability was observed in the social-institutional (18%) and environmental-spatial dimensions (24%) and medium variability (34%) in the economic one. This means that in the socio-institutional area, the researched areas are the most sustainable, which is similar to Foroozesh et al. (2022). Moreover, this research has shown that the level of SD in the studied FUAs is medium or low (from 0.6 to 0.3). This implies the need to take further actions towards building more sustainable areas (Li et al., 2009).

The obstacle in conducting this research and overall in measuring SD in FUAs is often the lack of a range of open-access statistical data. This problem appeared during this research, but it was also identified in similar studies (e.g. Visvaldis et al., 2013). However, ongoing research is important because it allows for monitoring of the directions and mechanisms of change. On that basis, appropriate tools of development policy can be implemented.

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Urban sustainable development is a difficult, long-term challenge that aims to develop a stronger synthesis of social, economic, and environmental factors (Li et al., 2009; Roszkowska et al., 2014; Tang et al., 2019). In this regard, research on the progress and directions of SD should be continued to support the decision-making process of urban managers and planners. Moreover, further research may include the development of a set of indicators with respect to SD (Li et al., 2009), also dedicated particularly to FUAs. Functional areas are a specific type of region, and the development processes that take place there have specific characteristics, conditions, and development problems (e.g., mobility issues). Such a set of indicators would help to learn about changes in sustainable development and conduct more comparative studies in this regard.

Conclusions

The research study in this paper allowed us to achieve the research objective, which was to assess the diversity of sustainable development of FUAs of voivodeship capitals in Poland, including also different SD dimensions (i.e., social-institutional, economic, environmental-spatial). In general, the SD indices indicate a low diversity of the studied units in terms of sustainable development. General SD indices are rather at medium and low levels, which shows that activities for sustainable development should be still continued in all FUAs. This is an important conclusion of the research for development policy. Currently, many FUAs in Poland are in the process of preparing development strategies, which are important tools in applying for EU funds in the 2021-2027 programming period. The research showed that in all FUAs, sustainable development tasks should be continued in all dimensions. However, most economic and environmental-spatial actions should be intensified. An interesting result of the research was also the observation that in almost half of the FUAs, the lowest result of sustainable development turned out to be in the environmental-spatial dimension, and this aspect should be especially important in achieving SD goals.

This research constitutes a new contribution to the literature regarding sustainable development of functional urban areas. The obtained result should be treated as a compromise between an attempt to obtain an assessment the level of sustainable development in FUAs and identified obstacles of the research method.

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Anna BUSŁOWSKA

ZRÓWNOWAŻONY ROZWÓJ MIEJSKICH OBSZARÓW FUNKCJONALNYCH OŚRODKÓW WOJEWÓDZKICH W POLSCE

STRESZCZENIE: Aktualne globalne zagrożenia i zmiany niewątpliwie uzasadniają prowadzenie badań nad zrównoważonym rozwojem w różnych aspektach. Badanie tego zjawiska na obszarach miejskich jest istotne dla formułowania trafnych i istotnych wniosków dla polityki miejskiej. Celem artykułu jest ocena zróżnicowania zrównoważonego rozwoju MOF ośrodków wojewódzkich w Polsce ogólnie oraz w głównych wymiarach zrównoważonego rozwoju: społeczno-instytucjonalnym, ekonomicznym i środowiskowo-przestrzennym. Badanie dotyczy 17 MOF ośrodków wojewódzkich w Polsce i wykorzystano w nim dane GUS. Do przeprowadzenia badań wykorzystano metodę TOPSIS. Pozwoliło to ocenić, że poziom zróżnicowania zrównoważonego rozwoju pomiędzy MOF jest raczej mały, a największy jego poziom reprezentują obszary funkcjonalne dużych ośrodków miejskich, np.: Warszawy, Wrocławia, etc. Ponadto aż 65% badanych obiektów należy do średniej niższej i niskiej klasy zrównoważonego rozwoju. Zaobserwowano także, że wśród wymiarów zrównoważonego rozwoju, najsłabszy wynik MOF osiągały w wymiarze środowiskowo-przestrzennym (ok. 40% MOF).

SŁOWA KLUCZOWE: miejskie obszary funkcjonalne, zrównoważony rozwój

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