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ASSESSING THE QUALITY OF LIFE OF REGIONAL CENTRES IN POLAND IN THE CONTEXT OF SMART AND SUSTAINABLE CITIES

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Abstract:
The article addresses the issue of quality of life in cities based on developed methodology. A multidimensional approach was adopted, namely 28 subindices characterizing seven dimensions affecting the quality of life in 18 provincial cities in Poland. The developed methodology consisted of two stages. In the first stage, using the indicators, the values of quality-of-life indices for the studied dimensions were determined. In the second stage, using these results, the values of the total quality-of-life indices in the studied cities were measured. Then, rankings for the cities in question were created. In addition, based on the values of the dimension indices and total indices, the levels of quality of life were determined. Relationships between parameters characterizing the sizes of studied cities and their wealth and the determined quality of life were also measured. The Gray Rational Analysis method was used for ranking, and three objective analytical methods were used to determine index weights: Equal weight, Entropy and CRITIC, and the Laplace's criterion. The results indicate that living standards in the studied cities vary widely, both in terms of the value of the total index and the indices of individual dimensions. The best living conditions were found in Warsaw (the capital of Poland), Białystok and Olsztyn, and the worst in Kielce and Szczecin.

Key words: *urban quality of life, urbanization, smart sustainable cities, ranking assessment*

INTRODUCTION

In view of the global processes of globalization, metropolization and exurbanization, cities must constantly develop. This is due to the need to ensure an adequate standard of living for residents and create favourable conditions for economic, scientific, cultural, and social development. The economic and social changes that have been taking place for many years mean that cities are seeing a strong emphasis on implementing modern solutions to ensure their development while respecting the environment and ensuring safety [1]. This expectation is fulfilled by the concept of sustainable cities and, when smart technologies are included, smart sustainable cities [2, 3, 4]. Sustainable and smart cities should, among other things, using innovative solutions, provide a high standard of living and convenient development conditions for residents. The implementation of this concept obliges city authorities to take measures to provide the best possible living conditions for residents and promote economic and social development [5]. These processes should also be implemented while respecting the environment [6].

The issue of quality of life in cities is becoming one of the most important social and economic issues of modern cities [7, 8]. Dynamic urbanization and the associated needs to provide residents with adequate infrastructure, safety, work, access to education and culture are forcing authorities to make, oftentimes, very expensive investments. This problem affects both developed and developing countries. These processes are also taking place in the European Union, in which a number of countries (including Poland) are counted among the developing economies, where urbanization processes proceed with greater dynamics than in developed countries [9]. The nature of these changes also varies greatly. Indeed, in highly developed countries, aging populations, emigration, security or issues related to the employment of emigrants are becoming an increasing problem for cities.

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There is a research gap regarding the evaluation of the quality of life in cities of a developing country located in the EU in the context of the concept of a sustainable and smart city. Taking this condition into account, the paper presents the developed methodology and results of research on the quality of life in selected cities in Poland, as a country with a developing economy.

When considering the role and importance of cities, and a sustainable economy for the development of the EU, the following research question were formulated: *What is the standard of living in Polish cities, being the capitals of the regions in which they are located?*

In order to answer these question, a research methodology was developed based on a set of 28 indicators characterizing (quantitatively) the quality of life in the studied cities in 7 dimensions of their activities, as well as a two-level assessment of this quality, based on Multi Criteria Decision Making (MCDM) methods. The use of MCDM-type methods makes it possible to perform a ranked comparative assessment of the quality of life in the studied cities, treated as a multi-criteria issue. It should also be noted that the assessment carried out is based on objective indicators, giving the possibility of real and independent evaluation of the studied problem. The Gray Rational Analysis method was used for the ranking evaluation, and three analytical methods were used to determine the weights of the indicators (criteria for evaluating the quality of life in cities): Equal weight, Entropy and CRITIC, and the Laplace's criterion. The proposed methodology represents a new two-level approach to evaluating the multi-criteria problem of assessing the quality of life in a group of cities in Poland.

MATERIALS AND METHODS

Study object

The research was conducted for 18 cities located in Poland. These are provincial cities (Białystok, Zielona Góra, Gorzów Wielkopolski Gdańsk, Katowice, Kielce, Kraków, Lublin, Łódź, Olsztyn, Opole, Poznań, Rzeszów, Szczecin, Bydgoszcz, Toruń, Warsaw and Wrocław), which are administrative centres for their regions. With Poland's total population of 36.75 million [10], the studied cities collectively now house more than 7,660,422 residents, or about 21% of all Polish citizens.

Data

The research on assessing quality of life in the surveyed cities was based on a set of 28 indicators characterizing 7 dimensions. Data from the Local Data Bank database [11] for 2022 were used for the study. The indicators used for the study, meeting the criteria for their selection, are shown in Table 1.

Table 1
Summary of indicators used for the study

Dimension	Indicator	Indicator designation
Housing	Average floor area of housing per capita	I1
	Number of housing units per 1,000 inhabitants	I2
	Average price per m^2 of residential units	I3
	Number of apartments equipped with central heating, %	I4
	Number of residents with access to sewerage (% of total city population)	I5
	Number of residents with access to water supply (% of total city population)	I6
Protection and health of residents	Number of beds in hospitals (per 10,000 population)	I7
	Number of doctors (total working staff) per 10,000 population.	I8
	Number of deaths of people under 65 due to cardiovascular diseases per 100,000 population of that age	I9
Demography education and social services	Migration balance per 1,000 people	I10
	Demographic old-age dependency ratio	I11
	Number of places in nurseries, wards and children's clubs per 1,000 children under 3 years of age	I12
	Number of children in kindergartens and other forms of preschool education per 1,000 children aged 3-5 years	I13
	Net enrolment rate (elementary school)	I14
	Number of public libraries per 10,000 population	I15
	Number of sports facilities per 10,000 people	I16
Economy	Number of entities entered in the REGON register per 10,000 population	I17
	Average gross salary, PLN	I18
	Registered unemployment rate, %	I19
Safety of residents	Number of traffic accidents per 100,000 population.	I20
	Number of total police recorded crimes per 1,000 residents	I21
	Detection rate of perpetrators of crimes ascertained by the Police, %.	I22
Environment	Share of green areas in total area, %	I23
	Volume of water consumption per capita	I24
	Index of average exposure to PM2.5 dust	I25
Transport infrastructure	Length of bicycle paths per 100 km^2 of city area	I26
	Number of passenger cars per 1,000 inhabitants	I27
	Length of bus lanes, km	I28

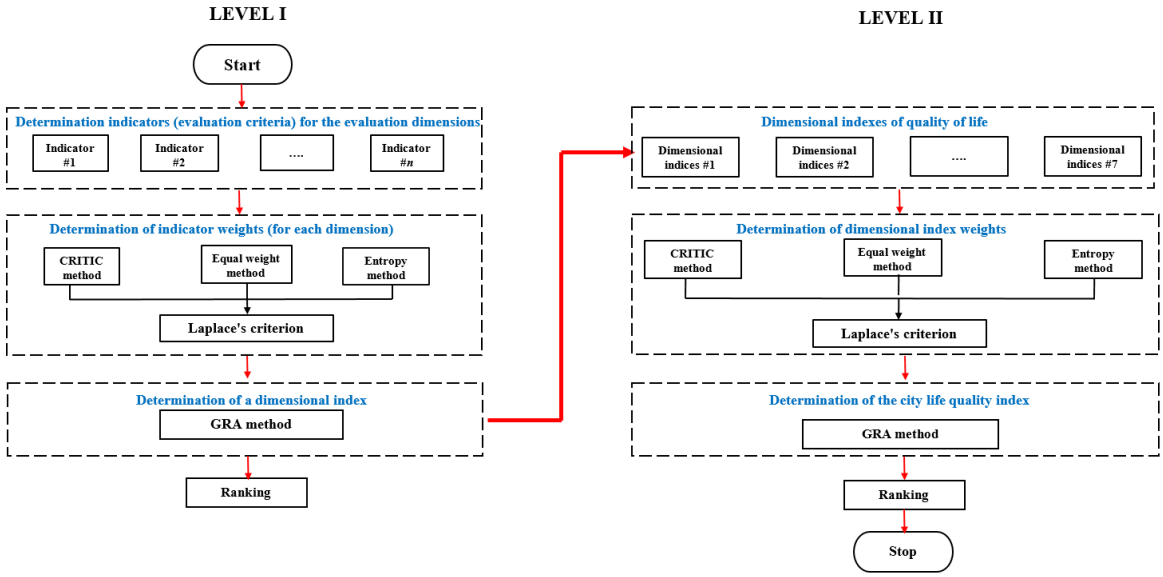


Fig. 1 General scheme of the research procedure for the implementation of the main part of the study

Characteristics of the research methods used

The general scheme of the research procedure for implementing the main part of the study is shown in Figure 1.

Grey Relational Analysis (GRA) method

The GRA method, as an extension of Gray systems theory, is an immensely useful measurement tool, especially in situations of limited data availability. The method is used to solve problems that rely on multiple variable criteria and aims to determine the similarity of the alternatives being compared.

The application of the GRA method involves the following calculation steps [12, 13, 14, 15]:

1) To define a multi-criteria problem with alternatives (*i = 1, 2, ..., m*) and evaluation criteria (*j = 1, 2, ..., n*):

$$\chi_i = \left(\chi_i(1), \chi_i(2), \chi_i(3), \dots, \chi_i(n)\right) \tag{1}$$

2) To determine reference series for each criterion:

$$\chi_0 = \left(\chi_0(1), \chi_0(2), \chi_0(3), \dots, \chi_0(n)\right) \tag{2}$$

3) To normalize criterion values:

for stimulants (when higher is better):

$$\chi_i(k) = \frac{\chi_i^0(k) - min\chi_i^0(k)}{max\chi_i^0(k) - min\chi_i^0(k)} \tag{3}$$

for the destimulants (when lower is better):

$$\chi_i(k) = \frac{max\chi_i^0(k) - \chi_i^0(k)}{max\chi_i^0(k) - min\chi_i^0(k)} \tag{4}$$

where:

$\chi_i(k)$is the value of criterion after the normalization procedure,

$\chi_i^0(k)$ is the value of criterion before the normalization procedure,

$ax\chi_i^0(k)$ and $min\chi_i^0(k)$ are the smallest and largest values of the *k*-th response before the normalization procedure respectively.

4) To determine the grey relational coefficient: the grey relational coefficient (GRC), which is the similarity index between the reference series and the alternative series:

$$\varepsilon\left(\chi_0(k), \chi_i(k)\right) = \frac{\Delta_{min} + \xi\Delta_{max}}{\Delta_{0i}(k) + \Delta_{max}} \tag{5}$$

5) To calculate the Gray relational grade (GRG). If all criteria have equal weight, the GRG can be calculated using equation (11). For different weights of criteria, the GRG can be calculated using equation (12).

$$\gamma(\chi_0, \chi_i) = \frac{1}{n}\sum_{k=1}^{n} \varepsilon(\chi_0(k), \chi_i(k)) \tag{6}$$

$$\gamma(\chi_0, \chi_i) = \sum_{k=1}^{n} w_i(k)\varepsilon(\chi_0(k), \chi_i(k)) \tag{7}$$

where:

w_i is the weight of the *j-th* evaluation criterion.

6) To assess the level of quality of life in the studied cities based on the value of the GRG index, which will be further referred to as the quality of life index – QoL_{index}.

High level

$$QoL_{index} \geq \overline{QoL_{index}} + s_{QoL_{index}} \tag{8}$$

Medium high level

$$\overline{QoL_{index}} + s_{QoL_{index}} > QoL_{index} \geq \overline{QoL_{index}} \tag{9}$$

Medium low level

$$\overline{QoL_{index}} > QoL_{index} \geq \overline{QoL_{index}} - s_{QoL_{index}} \tag{10}$$

Low level

$$QoL_{index} < \overline{QoL_{index}} - s_{QoL_{index}} \tag{11}$$

where:

QoL_{index} is the quality-of-life index,

$\overline{QoL_{index}}$ is the mean value of assessment index QoL_{index} is the standard deviation from the mean value of the assessment index QoL_{index}.

Equal-weight method

The values of the indicator weights are therefore determined based on this equation:

$$w_j = \frac{1}{n} \; for \; j \in \{1, 2, \dots, n\} \tag{12}$$

where:

w_j is the weight of the *j*-th evaluation indicator,

n – the number of evaluation criteria taken into account.

Entropy Method

The steps involved in determining the weights of indicators in this method are as follows [16, 17]:

1) To construct a decision matrix.

$$X = \begin{bmatrix} x_{11} & x_{12} & x_{13} & \cdots & x_{1n} \\ x_{21} & x_{22} & x_{23} & \cdots & x_{2n} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ x_{m1} & x_{m2} & x_{m3} & \cdots & x_{mn} \end{bmatrix} \quad (13)$$

2) To calculate the normalized decision matrix.

$$X^* = [r_{ij}]_{m \times n} \quad (14)$$

where:

r_{ij} is the data of the jth evaluated indicator, $r_{ij} \in (0, 1)$. Normalization of indicators that are stimulants follows this equation:

$$r_{ij} = \frac{x_{ij} - \min\limits_j(x_{ij})}{\max\limits_j(x_{ij}) - \min\limits_j(x_{ij})} \quad (15)$$

Normalization of indicators that are destimulants follows this equation:

$$r_{ij} = \frac{\max\limits_j(x_{ij}) - x_{ij}}{\max\limits_j x_{ij} - \min\limits_j x_{ij}} \quad (16)$$

3) The entropy for each indicator is calculated based on this equation:

$$e_j = -\frac{1}{\ln n} \sum_{i=1}^{n} r_{ij} \ln r_{ij} (i = 1, 2, \ldots m) \quad (17)$$

4) The level of entropy variation for each evaluation indicator is determined from this equation:

$$d_j = 1 - e_j \quad (18)$$

5) Calculation of indicator weights:

$$w_j = \frac{d_j}{\sum_{j=1}^{n} d_j} \quad (19)$$

CRiteria Importance Through Intercriteria Correlation (CRITIC) method

The following course of action was used to estimate the weights using the CRITIC method [13, 18]:

1) To construct a decision matrix (equation 13).

2) To normalize the decision matrix (equation 14).

3) To calculate the standard deviation for indicators in the normalized decision matrix:

$$\sigma_j = \sqrt{\frac{\sum_{i=1}^{n} (r_{ij} - \overline{r_{ij}})}{n-1}} \quad (20)$$

4) To calculate correlations between attributes of the normalized decision matrix:

$$r_{jk} = \frac{\sum_{i=1}^{n} (r_{ij} - \overline{r_{ij}})(r_{ij} - \overline{r_{ij}})}{\sqrt{\sum_{i=1}^{n} (r_{ij} - \overline{r_{ij}})^2 \sum_{i=1}^{n} (r_{ik} - \overline{r_{ik}})^2}} \quad (21)$$

To calculate indicator weights according to equation:

$$w_{ij} = \frac{C_j}{\sum_{i=1}^{n} C_j} \quad (22)$$

in which:

$$C_j = \sigma_j \sum_{i=1}^{n} (1 - r_{jk}) \quad (23)$$

where:

C_j is a measure of the information capacity of *the j-th* criterion.

RESULTS

Determination of dimensional indices of quality of life

In the first stage, it was necessary to determine the weights of the indicators characterizing the various dimensions included in the study (level I of evaluation). For each dimension, the sum of the weights of the sub-indicators was 1. The values of the weights were determined on the basis of three objective methods and, finally, on the basis of the Laplace's criterion.

The determined values of the weights of each indicator (for each dimension), according to the adopted methodology (Section 2), are shown in Table 2.

Table 2

Summary of indicator weighting values used for the study

Dimension	Indicator	Value of weights				The sum of the weights for the dimension (area) under study
		Equal method	Entropy	CRITIC	The value of the weights determined by the Laplace criterion	
Housing	I1	0.167	0.169	0.158	0.164	1
	I2	0.167	0.166	0.210	0.181	
	I3	0.167	0.178	0.231	0.192	
	I4	0.167	0.163	0.162	0.164	
	I5	0.167	0.161	0.122	0.150	
	I6	0.167	0.163	0.117	0.149	
Protection and health of residents	I7	0.333	0.291	0.415	0.346	1
	I8	0.333	0.339	0.401	0.358	
	I9	0.333	0.370	0.184	0.296	
Demography education and social services	I10	0.143	0.140	0.174	0.160	1
	I11	0.143	0.143	0.135	0.162	
	I12	0.143	0.135	0.119	0.141	
	I13	0.143	0.140	0.137	0.134	
	I14	0.143	0.143	0.148	0.138	
	I15	0.143	0.148	0.171	0.158	
	I16	0.143	0.152	0.116	0.107	
Economy	I17	0.333	0.355	0.230	0.306	1
	I18	0.333	0.325	0.330	0.329	
	I19	0.333	0.320	0.440	0.364	
Safety of residents	I20	0.333	0.438	0.217	0.329	1
	I21	0.333	0.295	0.451	0.360	
	I22	0.333	0.268	0.331	0.311	
Environment	I23	0.333	0.315	0.281	0.310	1
	I24	0.333	0.304	0.368	0.335	
	I25	0.333	0.382	0.351	0.355	
Transport infrastructure	I26	0.333	0.248	0.195	0.259	1
	I27	0.333	0.227	0.428	0.329	
	I28	0.333	0.525	0.377	0.412	

The largest values of the weights, for the dimensions adopted for the study (level I), were characterized by the following indices:

- average price per m^2 of residential units (dimension "Housing"),
- number of physicians (total working staff) per 10,000 residents (dimension "Protection and health of residents"),
- demographic old-age dependency ratio (dimension "Demography education and social services"),

- registered unemployment rate, % (dimension "Economy"),
- number of crimes, ascertained by the police in total per 1,000 residents (dimension "Safety of residents"),
- PM 2.5 average exposure index (dimension "Environment"),
- length of busways (dimension "Transport infrastructure").

The determined index weights made it possible to determine indices for each dimension included in the quality-of-life assessment (so-called dimension indices). The values of these indices for each dimension characterizing the quality of life for each city are shown in Figure 2.

The results indicate that the cities studied are characterized by significant differences in living conditions in the studied dimensions (areas) of their activities.

Cities-leaders, in the various dimensions included in the quality-of-life assessment, include: Gorzów Wielkopolski (housing), Warsaw (economy), Olsztyn (environment), Lublin (protection and health of residents), Białystok (safety of residents and transport infrastructure) and Rzeszów (demography education and social services). Among the aforementioned cities, those which are large regional centers, i.e. with a population between 150,000 and 500,000, predominate. Of the small regional centers, the leader in the area of housing is the aforementioned Gorzów Wielkopolski, and the only metropolitan leader is Warsaw.

Among the studied group of cities of different sizes, one can be distinguished that achieved the best evaluation results in more than one area. That city is Białystok, which obtained the highest evaluation index values and, as a result, is the leader in quality of life in areas related to public transportation and safety of residents. On the other hand, we can also distinguish cities that scored the best in one of the assessed dimensions and the worst in another. Such cities include Białystok and Gorzów Wielkopolski. Białystok achieved the lowest rating in the economy dimension, while Gorzów Wielkopolski (which is the leader in the housing dimension) achieved the worst rating in the very important dimension of protection and health of residents.

For the dimensions Housing and Population, Generations, Education and Social Services, the difference in assessment values (i.e. the index for this dimension) for the leaders and runners-up is minimal. For the Housing dimension, the assessment index value for Gorzów Wielkopolski is 0.697, and for Warsaw – 0.683. On the other hand, for the Demography, Education and Social Services dimension, Rzeszów scored 0.662, and Zielona Góra – 0.649.

The first dimension for which a sub-assessment was made was housing. This dimension is extremely important, because in the 21st century, access to housing is a fundamental element affecting the well-being of residents. High housing prices and, at the same time, an insufficient number of housing units cause problems in meeting basic housing needs, and as a result have a negative impact on security and stability, which in turn affects, for example, the propensity to have offspring [19, 20, 21]. The highest score (0.697) and the leading position for Gorzów Wielkopolski is primarily due to the lowest average price per 1 m^2 of housing that occurred among the analysed cities.

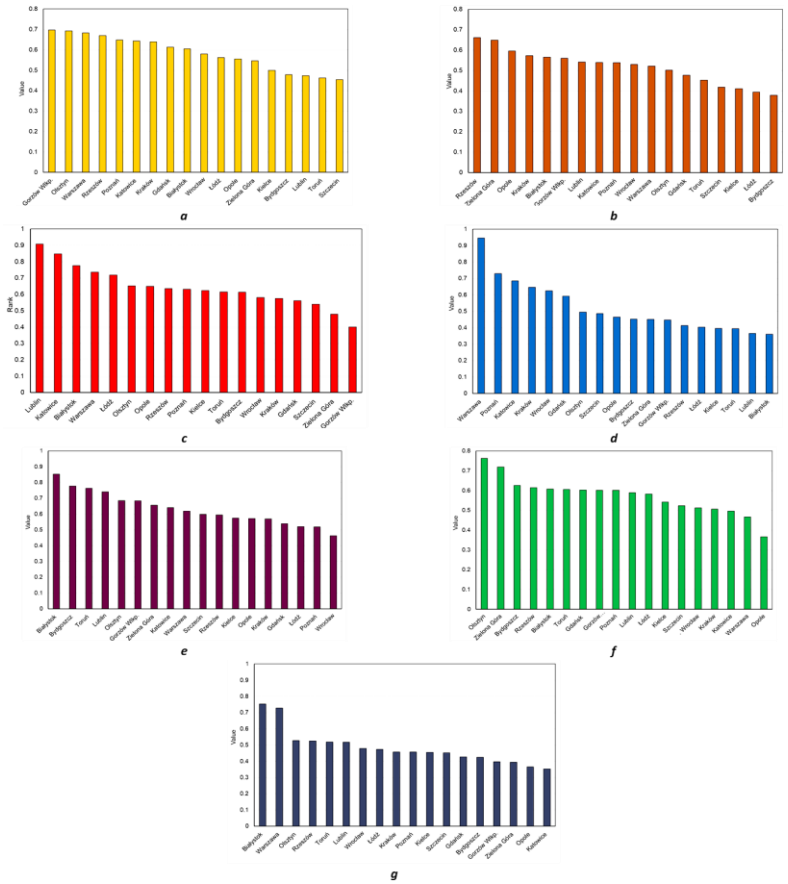


Fig. 2 Values of index for studied cities (a-Housing, b-Demography, education and social services, c-Protection and health status of residents, d-Economy, e-Safety of residents, f-Environment, g-Transportation infrastructure)

This value is more than 50% lower than in Warsaw, among other cities. In addition, in this city, 100% of the population enjoys access to basic, for the 21st century, sanitary facilities in the form of sewage and water supply. Gorzów Wielkopolski compares slightly worse with cities such as Poznań (34.7 m^2) or Warsaw (33.5 m^2) in terms of the average usable area of an apartment per person, which is only 29.3 m^2. The availability of apartments in Gorzów Wielkopolski is also somewhat lower than in the largest Polish cities such as Kraków (559), Warsaw (570.3) and Wrocław (562), as it amounts to only 485 apartments per 1,000 people. The city with the lowest score for this dimension is Szczecin (0.454). In this case, the biggest problem seems to be, among other things, one of the lowest values for the percentage of the population with access to sewerage and water supply (only 86.4%).

Another dimension, very important from the point of view of society, especially an aging society (and Poland is slowly being counted among such a group), is the dimension of protection and health status of the population. The problem of aging population is steadily growing, causing the group of seniors living in cities to become more numerous. For proper health care, both staffing and availability of hospital beds are essential. An aging society is characterized by an above-average risk of illness and very often the need for long-term hospitalization. In this dimension, the best conditions are found in Lublin, which scored 0.909 (Fig. 2). It has both the highest number of available hospital beds per 10,000 residents (51.86) and the highest number of active doctors per 10,000 population (151.8). The city fares slightly worse in terms of the number of deaths of people under 65 from cardiovascular diseases per 100 thousand residents of that age. The lowest evaluation value for this dimension was obtained by Gorzów Wielkopolski (0.401), where the number of active physicians per 10 thousand population is less than 42. At the same time, in this city as many as 171 people per 100 thousand population die from cardiovascular diseases before the age of 65, while in Lublin it is "only 55" people. The smallest number of deaths from this cause occurs in Warsaw, the capital city of Poland, and is only 33.4.

The next dimension included in the assessment was "Demography, education and social services." It characterizes demographic processes and the structure of the population of the studied cities, and consequently relates to the distribution of basic public services. Efficient and effective delivery of these services is the basis for modern society. Rzeszów (0.662) and Zielona Góra (0.649) received the highest ratings in this area, while Łódź and Bydgoszcz received the lowest (0.395 and 0.379, respectively) (Fig. 2). For this dimension, the result of the assessment was influenced by indicators depicting, among others, the migration balance, which shows whether a city attracts new people or more people leave it, as well as the demographic old-age dependency ratio, which shows how many people of working age fall into 100 people of working age. The city that attracts the biggest number of new residents is Warsaw. Rzeszów is in fourth place in this respect, and Zielona Góra is in sixth. In terms of the demographic burden, on the other hand, Rzeszów is in the most favourable situation as there are only 19.8 people over 65 years of age per 100 residents, compared to more than 28 in Łódz. It was also very important to consider indicators relating to the satisfaction of basic needs such as the provision of places for children in nurseries, wards and children's clubs. In this regard, Opole is the most favorable, with 317 places per 1,000 children under 3. Zielona Góra has 250 such places, and Rzeszów – 204. The worst situation is in Gdańsk, where there are only 95 such places.

From the point of view of the economic dimension, the best city to live in, by far, is Warsaw (Fig.7), whose evaluation index for the Economics dimension is 0.946. Warsaw is the capital of the country, with the highest average wages, one of the lowest (after Poznań) unemployment rates, and has the highest number of business entities per 10,000 population, which generate high GDP and provide jobs. The second city in the ranking, Poznań, received a score of 0.73, and the third – Katowice – 0.685. The worst scores (i.e. the lowest index values for this dimension), were given to Toruń (0.394), Lublin (0.365) and Białystok (0.36), respectively. These are cities characterized by the lowest numbers of business entities per 10,000 people, average basic salaries, and some of the highest unemployment rates.

One of the key aspects affecting the overall quality of life in cities is safety, which at the same time belongs to one of the basic needs of every human being. A safe city is one in which all residents have a sense of security, which stabilizes their lives and allows them to develop [23, 24, 25]. Among the cities studied, Białystok obtained the highest index value for this dimension, which was 0.853. Bydgoszcz (0.777), Toruń (0.764) and Lublin (0.741) also achieved very good results (Fig. 2). The lowest value of the index, on the other hand, was obtained by Wrocław – 0.462. This is due to the fact that Wrocław has the highest number of crimes recorded per 1,000 residents (34.89), with the lowest detection rate of perpetrators of these crimes (43.5%). Białystok, in turn, has the lowest number of crimes (18.97 per 1,000 residents) and the lowest number of traffic accidents per 100,000 population (19.8). The number of traffic accidents in Białystok is more than seven times lower than in Łódź (139.1).

Another dimension considered in the assessment was the environment, which, in light of the concept of sustainable development, is now the basis of civilization development. In this dimension, the evaluation index was determined based on three indicators, relating to air quality, access to green areas and water. The highest index value in the environment dimension was achieved by Olsztyn (0.763), and the lowest by Opole (0.367) (Fig. 2). A very good result was also obtained by Zielona Góra (0.719). Among the surveyed cities, Olsztyn is characterized by the largest share of green areas in the city area (more than 22%, while in Opole, it is only 4%) and one of the lowest indicators of average exposure to PM2.5 dust, which is 14 $\mu g/m^3$. Compared to other cities, it also performs very well in terms of water consumption per capita, which is

extremely important because it indicates a reduction in water intake from the environment. In Olsztyn, on average, each inhabitant consumes 65.2 m^3 per year, while in Szczecin, it is more than five times as much – 343.3 m^3, and in the city with the worst environmental assessment index – Opole – more than three times as much (238.6 m^3).

The last dimension (VII) for which a sub-assessment was made concerned transportation infrastructure, which plays a key role in the functioning and development of cities. This infrastructure determines the development potential, and the availability of bus lanes and bicycle paths, as well as the number of cars, affect the quality of life of residents. In this dimension, Białystok (0.754) and Warsaw (0.728) received the highest ratings, while Gorzów Wielkopolki (0.397), Zielona Góra (0.394), Opole (0.365) and Katowice (0.353) received the lowest scores (fig. 10). Białystok and Warsaw are the cities with the longest bicycle routes per 100 km^2 of the city, which are 161km and 142km there, respectively, compared to less than 31km in Zielona Góra. Białystok is also the city with the smallest number of passenger cars per 1,000 people – only 533, while in Katowice there are as many as 835. These results unfavourably testify to the reduction of this mode of transport and the transition to more environmentally friendly solutions. Katowice is a city located in the so-called Silesian agglomeration, with a highly developed network of rail, bus and streetcar connections between neighbouring cities

Assessment of overall quality of life in cities – level II assessment

The determined dimension index values for each city (Fig. 2) became the basis for determining the values of their weights for further analysis (Level II). The determined values of the weights for each evaluation dimension are shown in Figure 3.

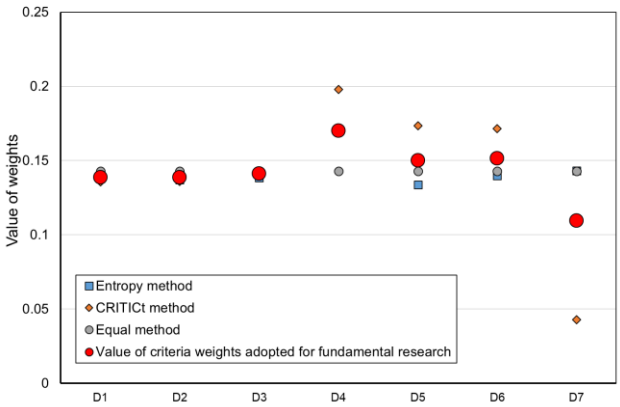
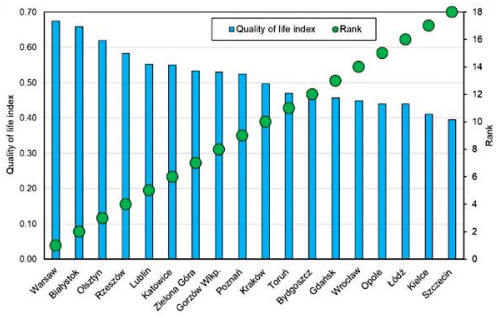


Fig. 3 Weights of studied dimensions for Level II of quality-of-life assessment

The largest weight value determined objectively (using analytical methods) was reported for the dimension of Economy, wages and labour (0.17), and the smallest – Transport infrastructure (0.110).

In the next stage of the study, taking into account the value of the weights for each dimension, total quality of life indices were determined for the cities under study. Based on these values, the ranking of these cities was created (Fig. 4a.) and the overall level of quality of life in these cities was measured (Fig. 4b).

a



b

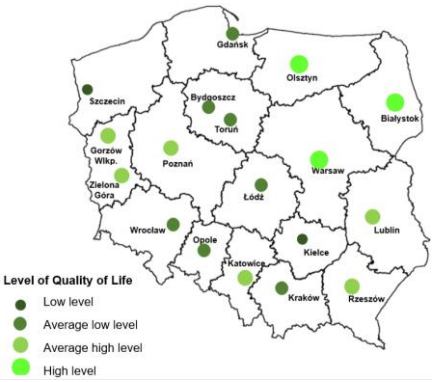


Fig. 4 Quality of life indices and ranking positions of studied cities (a) and Levels of quality of life in the studied cities (b)

The average value of the quality-of-life index in the studied cities was 0.514, which means that half of them achieved values lower than the average. These cities include Kraków, Toruń, Bydgoszcz, Gdańsk, Wrocław, Opole, Łódź, Kielce and Szczecin. The city with the best score in terms of the value of the total quality-of-life index is Warsaw, where the best conditions occurred only in the area of Economy, wages and labour. The worst conditions are found in Szczecin, which scored relatively poorly in most of the dimensions (areas) included in the analysis, and worst in housing. Warsaw scored 0.674, and Szczecin scored 0.394.

The study conducted in the second stage of the evaluation showed that Warsaw, Białystok and Olsztyn had the highest values of the total quality of life index, while Kielce and Szczecin had the lowest. The level of quality of life in Warsaw, Białystok and Olsztyn, was defined as high, and in Kielce and Szczecin – as a low level. Good living conditions are also found in Rzeszów, Lublin, Katowice, Zielona Góra, Gorzów Wielkopolski and Poznań. On the other hand, in Kraków, Toruń, Bydgoszcz, Gdańsk, Wrocław, Opole and Łódź, these conditions, as in the case of Kielce and Szczecin, require corrective actions. Based on the results, it can be concluded that, in general, the provincial cities located in the northeastern and eastern parts of Poland are cities with high (Warsaw, Białystok and Olsztyn) and medium-high (Lublin, Rzeszów) levels of quality of life. As for the rest of the country, on the other hand, it is difficult to notice any regularities.

CONCLUSION

The research methodology and the research can be seen as a new scientific approach to the study of this issue from two points of view. First, the work proposes a new course of research based on a two-level assessment of quality of life using the methods of MCDM and the Laplace's criterion.

The methodology developed made it possible to determine sub-indices of quality of life in each dimension, as well as an overall index (a city's quality of life index). Based on the values of these indices, the studied cities were ranked in terms of quality of life for each dimension and overall index.

Summarizing the research conducted and the results obtained, it can be concluded that:

- there is a clear variation in the ranking of cities for various dimensions included in their assessment. The best cities in the various dimensions examined include: Gorzów Wielkopolski (housing), Warsaw (economics, wages and labour), Olsztyn (Environment), Lublin (protection and health of residents) Białystok (safety of residents and transport infrastructure) and Rzeszów (population, generations, education and social services). Most of these cities (89%), are cities with populations between 150,000 and 500,000. Only Gorzów Wielkopolski is among the small regional centres, and Warsaw is among the metropolitan centres.
- The best position in the overall ranking of quality-of-life assessment (taking into account seven dimensions), is held by Warsaw, and the worst by Szczecin.
- A high level of quality of life was found in Warsaw, Białystok and Olsztyn, and a low level in Kielce and Szczecin.
- No significant relationship was found between the quality of life in the studied cities and their size and wealth.
- A positive, statistically significant correlation was found between city size and wealth and economic issues, wages and unemployment.
- A statistically significant negative correlation was found between city size and wealth, resident safety, and environmental issues.

It should be noted that city rankings are one of the most important empirical tools for comparing cities in terms of specific criteria. They can and should be used by city authorities as a strategic source of knowledge when shaping development policies and ensuring a high quality of life and achieving sustainable development goals. In the study presented in this paper, 18 provincial cities in Poland were evaluated in terms of various criteria, which made it possible to determine their ranking and level of quality of life (overall and in individual dimensions).

The results obtained should be used by stakeholders to formulate priority areas that require improvement measures aimed at improving the quality of life in these cities. In addition to the overall results, the presented approach also identifies areas that can be treated as priorities from the point of view of the examined quality of life. It would make sense for these results to be used by city and national authorities to implement sustainable development policies and the concept of smart cities more effectively.

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