



# Identification of shrinking cities in Poland using a multi-criterion indicator

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**Abstract.** Urban shrinkage, characterised by long-term demographic, socio-economic and spatial changes, has been studied extensively, including via research into causes, typologies, and planning responses. However, while understanding and measuring urban shrinkage processes is crucial if policymakers are to respond adequately to cities' challenges, multi-criterion studies on shrinkage trajectories are still required for the spatiotemporal complexity to be captured correctly. This study reviews methods by which urban shrinkage is studied and concludes with a selection of multi-criterion methods that offer more in-depth insight than population-based methods. Finally, a multicriteria analysis, adapted from Milbert (2015), is applied to measure urban shrinkage in Poland in the years 2006 to 2021. This incorporates six variables with a view to shrinking and growing cities being assessed and assigned to one of five categories.

The research provides insights into Poland's most recent urban shrinkage processes. Results show that, over the analysed period, urban shrinkage was a phenomenon that increased and intensified in Poland, affected a growing number of urban centres of medium size, and was to be noted on the peripheries of metropolitan areas. Such research outcomes contribute to a better understanding of urban shrinkage in Poland, provide a basis for further research, and inform policymakers as they seek to formulate more-targeted strategies to address the specific challenges that urban shrinkage raises.

**Keywords:** urban shrinkage, multi-criterion indicator, urbanisation trends, urban data analysis, Poland.

## Introduction

The contemporary debate on urban population decline emerged in the second half of the 20th century, when urban shrinkage became a common transformation pathway for many large cities across Europe and North America. The term shrinking cities was first used by German researchers Hausermann and Siebel in the 1980s (originally as *Schrumpfende Stadt*) – with a view to a name being given to long-term demographic and economic changes taking place in urban areas of the Ruhr region (Hausermann & Siebel, 1988). Since then, the term has become a frame of reference for a wide range of topics (Haase et al., 2014), gaining wide use in urban-studies research, including within the fields of geography, social economics, urban planning, etc. The concept has been elaborated and reflected on in many research projects, such as COST Action TU 0803 'Cities Regrowing Smaller' (CIRES) and The Shrinking Cities International Research Network (SCiRN), as well as in global publications (Oswalt, 2005; Oswalt & Rieniets, 2007; Pallagst et al., 2009; Martinez-Fernandez et al., 2009, 2012, 2016; Großmann et al., 2013; Haase et al., 2013, 2014, 2021).

However, the challenge lies in defining this urban phenomenon (Bernt et al., 2014; Haase et al., 2014; Kantor-Pietraga, 2014; Sroka, 2022). Most research has been linked broadly to demographic aspects of shrinkage, with population change being the main indicator. CIREs, for example, defines shrinkage as a depopulation of more than 0.15% each year in a period of a minimum of five years. In contrast, Turok and Mykhnenko (2007) refer to it as a loss in population within consecutive five-year periods. Additionally, a population change relative to the national population was included to illustrate shrinkage in the country. However, researchers offer broad acknowledgment that urban shrinkage surpasses simple population decline and cannot be analysed adequately using a single indicator (Haase et al., 2013; Stryjakiewicz, 2014a). As noted by Wolff and Wiechmann (2014): “*there are many examples where the demographic and the economic development do not go hand in hand. Cities losing population can keep a strong economic structure and development*” (Wolff and Wiechmann, 2014, p. 1). Against this background, SCIRN has developed a definition that includes, aside from population loss, signs of economic transformation with some symptoms of a structural crisis (Bern, 2018). This approach implies that a variety of economic and social indicators should be considered when identifying shrinking cities.

However, a meta-analysis of the literature on urban shrinkage conducted by Döringer et al. (2019) indicates that it is rare for urban-studies research to explore multiple indicators. They found no universal definition of ‘urban shrinkage’, while: “*Two-thirds of the given definitions focus on population decline as the major dynamic. One-quarter of the articles also mention the dimension of economic decline. In contrast, multidimensional definitions are barely used*” (Döringer et al., 2019, p. 6). Moreover, research that grasps many dimensions of urban shrinkage is usually conducted as a case study (Döringer et al., 2019). Conversely, multi-criterion investigations are rarely shown in nationwide analyses as they pose a major challenge given the robustness and availability of data. Thus, with the different spatiotemporal aspects, trajectories and contexts of urban shrinkage being as they are, capturing it poses a challenge for theoretical and empirical studies (Haase et al., 2017). These are the reasons for the present article seeking to address this identified gap and focus on the methodological aspects of encapsulating the phenomenon of urban shrinkage in a broader, multi-criterion manner and on a national scale.

In contemporary Poland, urban shrinkage became apparent in the early 2000s, when the first symptoms of the economic ‘shock therapy’ became visible. Thus, while urban demographics were a common subject of Polish research over a number of decades, the first diagnosis under the heading of urban shrinkage was arrived at by Zborowski (2002), Parysek (2004) and Jędraszko (2005). As mentioned above, broader comparative studies then followed, with the above topic representing an element of international research incorporated into such projects as *CIREs* and *Shrink Smart* (Krzysztofik et al., 2011, 2012a; EU, 2023), in the period between 1990 and 2010. Furthermore, identification and analysis vis-à-vis Poland’s shrinking cities was engaged in by Krzysztofik and Szmytkie (2011), Krzysztofik et al. (2011, 2012, 2014), Stryjakiewicz et al. (2012a, b), Zborowski et al. (2012), Stryjakiewicz et al. (2014, 2016), Kantor-Pietraga (2014), Jaroszevska (2019), Sroka (2021), Śleszyński (2017, 2019), and Musiał-Małago (2018a, b).

And notwithstanding recent influxes of migrants (notably from war-torn Ukraine), the forecasts for Poland’s demographic future remain alarming. The most recent estimates in population predictions from *Statistics Poland* (GUS, 2023) still have the country

in an ongoing population decline, in cities in particular. The prediction for the rate of decline in some medium-sized cities is one of the estimates achieving the highest value (GUS, 2023). However, the up-to-date predictions are based on population statistics alone, thus failing to offer any more comprehensive or insightful understanding of the situation.

The research detailed here has proceeded on the assumption that urban-policy responses to processes of urban shrinkage (whether at state, regional or local levels) should be grounded in a more-nuanced assessment of the present circumstances. In line with the definition of urban shrinkage as a multifaceted phenomenon, a complementary study and prediction with a multi-factor approach would allow for a more-comprehensive picture of shrinkage processes. Consequently, future policy responses could consider the broader factors contributing to depopulation, with a crucial emphasis on understanding the dynamics of this phenomenon. This study, therefore, endeavours to offer a thorough exploration of urban shrinkage while encompassing a temporal perspective of fifteen years (2006-2021) with a spatial focus on cities across the territory of Poland.

Specifically, the two objectives addressed by the paper (one empirical and the other methodological) (Fig. 1) are guided by questions as follows:

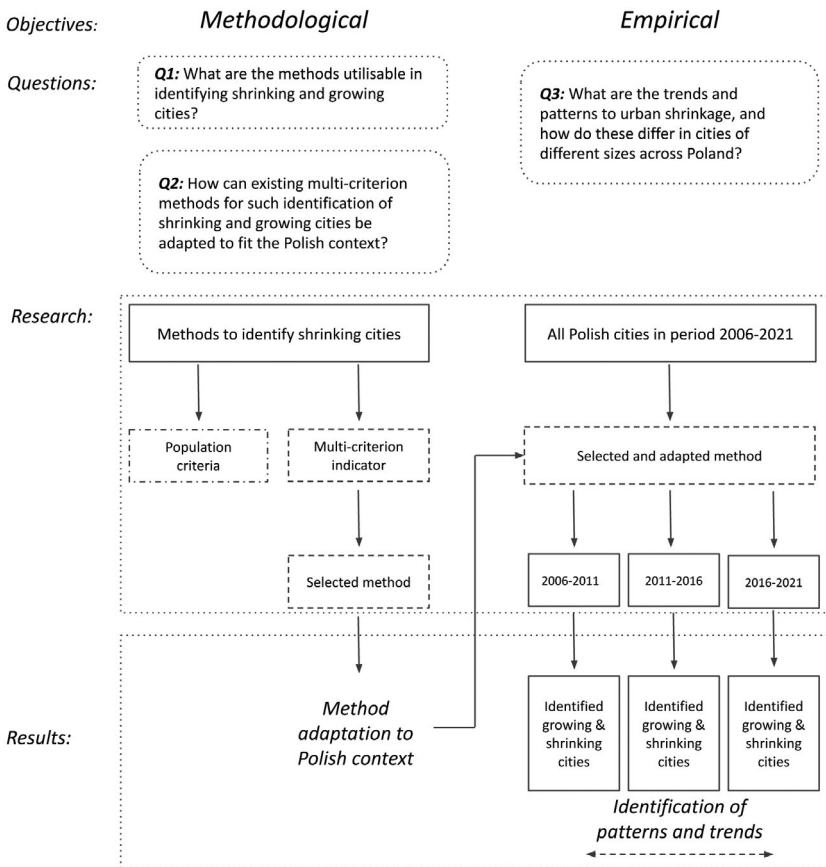


Fig. 1. Structure of research stages

Q1: What are the methods utilisable in identifying shrinking and growing cities?

Q2: How can existing multi-criterion methods for such identification of shrinking and growing cities be adapted to fit the Polish context?

Q3: What are the trends and patterns to urban shrinkage, and how do these differ in cities of different sizes across Poland?

In striving to answer these questions, our study focused on three key outcomes. Firstly, Section 2 provides a review of selected methods used in diagnosing and classifying urban shrinkage – above all with a view to a most suitable multi-criterion method being selected. Section 3 then seeks to present and explain methods used to conduct an empirical study of Polish cities through the years 2006-2021 inclusive. Section 4 then presents the results of the multi-criterion assessment of urban shrinkage actually made. In this way, the most recent statistical and geospatial data will be applied in offering a complete overview of the shrinkage process as it has been affecting today's Poland.

## Review of Methods

This chapter presents a literature review of methods used to diagnose and classify the various types of urban shrinkage. It summarises the literature as to how the relevant processes have been defined, elaborates on commonly used variables and classification methodologies and alludes to research gaps remaining within the domain. The review extends to 44 papers in total, with 10 of global scope, 17 relating to Europe and a further 17 seen as explicitly focused on Poland.

## Definitions

The first definition of urban shrinkage (*Schumpfungsprozess*) was developed in 1988 by Haussermann and Siebel, and summarised the problem as follows:

*"... [it] does not lie in individual developments. Only the interaction of population losses with selective migration of qualified young workers, unsuccessful integration of immigrants, negative economic developments, high unemployment, declining municipal financial leeway, dissolution of the city structure and thinning out of the supply of goods and services results in an urban crisis in which negative developments can intensify into a vicious circle."*(Haussermann & Siebel, 1988, p. 10).

The work of Haussermann and Siebel did not aim at quantifying the phenomenon, even as it represented a broad description of causes and effects that paved the way for further studies. Literature aiming to quantify the phenomenon of urban shrinkage can be viewed in at least two fundamental ways (Strykiewicz, 2014a). The older and more traditional approach regards this process as a progressive depopulation. However, a decrease in the number of residents does not *per se* equate to the decline of a city, and conceivably might even lead to an improvement in living standards and/or quality of life (Strykiewicz, 2014a). On that basis, a second, more multidimensional perspective was developed whereby shrinkage came to be viewed as a process linked to the social, spatial and economic restructuring of urban centres, as accompanied by or accompanying a steady decline in population (Zborowski, 2012).

## A review of the methods used to classify urban shrinkage

In the study of the phenomenon of shrinking cities it is population that has been used as the main indicator of city trajectories, partly given the availability of data availability and consistency with previous research. Broadly speaking, all comparative studies have been based predominantly on indicators relating to population (Van den Berg et al., 1982; Cheshire & Hay, 1989; Cheshire, 1995; Turok & Mykhnenko, 2007). Yet, as has been noted already, there are many examples wherein demographic and economic development are not found to correlate. Cities with declining populations can retain strong economic structure and go on developing (Wolff & Wiechmann, 2014). Thus, as Section 2 indicates, there are many socio-economic factors shaping this urban phenomenon that will need to be included as processes of urban shrinkage receive proper study.

The shrinking of cities must therefore be regarded as being or involving a specific kind of interaction between matters of a demographic, social, economic and spatial nature discernible with the aid of indicators. Wolff and Wiechmann (2014) gave a comprehensive description of all potential factors underpinning shrinkage, as grouped in five thematic areas. It is then often the scope of a given study that seems to shape the selection of indicators. Indeed, the availability or comparability of data is a common concern, while the theoretical basis sees demographic and economic indicators treated as most important (Wolff and Wiechmann, 2014). Furthermore, classifications are most often ordered by reference to severity, temporality and speed of shrinkage (Haase et al., 2017). Research on causes of shrinkage is sometimes combined with classifications or typologies. A review of classifications arrived at for urban shrinkage is thus offered below, in Table 1.

## Selection of a multi-criterion method

As previously mentioned, there have been only a limited number of studies that use a multi-criterion approach in the evaluation of urban shrinkage. One such study, conducted by Jaroszewska in 2019, focused solely on two specific years – 2003 and 2013. Another analysis, inspired by the Milbert method and undertaken by Sroka, spanned a 23-year period from 1995 to 2018. Finally, Śleszyński developed a multi-criterion assessment that covered two distinct 10-year periods – 2004 to 2014 and 2008 to 2018 – as documented in studies from 2017 and 2019.

We decided to focus on the method developed by Milbert (2015) from the Federal Office for Building and Regional Planning (later called *BBSR*) in Germany. According to research conducted by the *BBSR* in the years 1997-2001, a steep growth in shrinkage processes was most prominent among medium-sized cities in East Germany (Gatzweiler et al., 2003; Gatzweiler & Milbert, 2009). Consequently, the German government decided to step in and implement a bespoke urban-renewal strategy to stem further decline. The strategy included the *Stadtumbau Ost* Programme and the complementary *IBA Saxony-Anhalt 2010* Programme and was oriented towards selected medium-sized cities facing the highest rates of urban shrinkage. Projects were implemented in the years 2002-2017, allowing many cities in eastern German states to embark upon a new path of stable de-growth despite the continuous depopulation trends present in the region (Bernt, 2019; Pällagst et al., 2021). The German approach shows that problem identification and monitoring are critical for informed planning but can lead to positive results.

**Table 1.** A review of selected methods used in the classification of urban shrinkage

Scope	Analysed timeframe	Project name (Source)	Method description	Variables	Proposed classification
World	1950-2000	<i>Shrinking Cities</i> (Oswalt & Rieniets 2006; Bernt, 2018)	Subject: Selected world cities over 100,000 inhabitants; Definition: a densely populated urban area, min. 10,000 inh., population losses over large parts for more than 2 years, undergoing economic transformations, with symptoms of structural crisis. Population losses are considered significant if they amount to at least 10% in total or are of more than 1% annually	Population change	Classified shrinking cities
	N/A	<i>SCRW</i> (Wiechmann, 2008; Pallagst, 2009)	Subject: Selected urban centres of over 10,000 inhabitants around the world; Definition: depopulation of 1% or more in a period of 2 years at minimum, or over 10% in the whole period	Population change	N/A
Europe	1990-2010	<i>C/RES</i> (Strykiewicz 2014a; Strykiewicz & Jaroszeńska, 2016; Wiechmann & Wolff, 2013)	Subject: 7,035 European cities with over 5,000 inh. – criteria of a minimum of 50% of the population living at an urban density over 1,000 inh./km <sup>2</sup> , built-up area covering at least 50% of an entire municipality; definition: depopulation over a period of 5 years minimum, with more than 0.15% of the population lost each year.	Population change	A division into types: a) permanently shrinking b) short-term shrinking c) episodic shrinking
	1960-2005	Mykhnenko and Turok (2007)	Subject: 310 European cities of 200,000+ inh.; definition: absolute change in population in successive five-year periods (a referencing of change nationally was also included to illustrate shrinkage in the country)	Population change	A division into 3 types: a) recently shrinking b) shrinking over the medium term c) long-term shrinking
World	2000-2015	Urban Audit (Florczyk et al., 2019)	Subject: World Functional Urban Areas (of more than 50,000 inhabitants); definition: annual rate of population changes between 2000 and 2015 at FUA level on the global scale	Population change	5-level classification: a) ( $\infty$ , -0.50%) b) (-0.50%, -0.15%) c) (-0.15%, 0.15%) d) (0.15%, 0.50%) e) (0.50%, $\infty$ )
Germany	1998-2020 continuously in relation to a division into 5-year periods	BBSR (Milbert, 2015, 2020)	Subject: 4,507 German communes ( <i>Gemeinde</i> ), including those with a city ( <i>Stadt</i> ) status; definition: shrinkage as relative to the situation nationally in respect of 6 demographic and socio-economic variables (for detailed explanation, see Chapter 4)	Average annual population development in %; average annual total migration balance per 1,000 inhabitants; average annual development of the working-age population (20 to 64 years) in %; average annual development of socially-insured employees at the workplace in %; average annual change in the unemployment rate in percentage points; average annual development of the business tax base per inhabitant in %	A division into 5 types: a) above-average growth b) growth c) stability d) shrinkage e) above-average shrinkage

1990-2010	Jaroszewska (2019)	Subject: 829 Polish cities (2,948 administrative boundaries of local- ( <i>gmina</i> - level) units of administration and cities); definition: in line with <i>CIRÉS</i> (see above)	Population change	Classification for the entire period as: a) growing, b) stable c) shrinking for 5-year sub-periods; a) shrinking permanently, b) short-term shrinking, c) episodic shrinking, d) no shrinkage
2003, 2013	Jaroszewska (2019)	Subject: 279 Polish cities; definition: shrinkage defined by reference to national levels, as regards 10 selected demographic, socio-economic and life-quality variables. Values for two years (2003 and 2013) were compared to create a 9-level typology (A-I), which reflects levels of economic and demographic development	Number of individuals of post-productive age per 100 individuals of working age; natural growth per 1,000 inhabitants; migration balance per 1,000 individuals;% of registered unemployed in the population of working age; employed per 1,000 inhabitants; municipal own revenues per capita; amount of housing allowance paid per capita;% of dwellings equipped with central heating; dwellings per 1,000 inhabitants;% of homes from municipal resources with arrears in housing payments	Division into 9 levels of development: A-D – shows high level of economic and demographic development E – the average level F-I – shows a low level of economic and demographic development
2004-2014	Śleszyński (2017)	Subject: 913 Polish cities ( <i>gmina</i> -level units) enjoying urban or urban-rural status); definition: a multi-criterion method defines medium-sized cities losing their socio-economic functions. It includes a combination of 7 variables analysed over a ten-year period. Each variable is counted as a change relative to the national average over the same period of time	Population changes; forecast population size; changes in numbers unemployed; changes in share of own income within municipal budgets; changes in numbers of nights spent; changes in numbers of economic entities registered; changes in numbers of seats of largest companies. All relative to the average change for the country as a whole during the same period	Classified into 4 levels: a) crisis cities b) cities of declining potential c) stagnating cities d) at risk of marginalisation
2008-2018	Śleszyński (2019)	As above	As above	As above
1995-2018	Sroka (2021)	Subject: 853 Polish cities; definition: Inspired by the Milbert method (see above), with different indicators used (6 demographic and socio-economic variables selected), and a specific classification method (instead of quintile, mean and standard deviation proportionality was referred to). Counted for the entire period between 1995-2018	Population changes supplemented by an indicator describing the number of years with a population decrease; average annual net internal migration rate per 1,000 inhabitants; ratio of the population aged 65 and over to the total population; proportion of the population that is of working age; number of private-sector economic entities per 1,000 inhabitants; number of newly constructed dwellings per 1,000 inhabitants	The division into size types (large, medium, and small cities) and shrinkage level for the entire period: a) symptoms of structural crisis b) shrinking
2000-2016	Musiał-Malago (2018)	Subject: 39 Polish cities (over 100,000 inh.); definition: under the <i>SG/RN (CIRÉS)</i> definition, 30/39 had been shrinking for at least 5 years in a row. 30 cities selected as shrinking were then classified using 10 demographic and socio-economic variables	Population change (primarily); population density in cities; proportion of the population of post-productive age; natural growth per 1,000 inhabitants; migration balance per 1,000 inhabitants; deregistration from cities per 1,000 inhabitants; entities registered in the REGON system; employed per 1,000 inhabitants; unemployment rate; number of apartments for which building permits were issued per 10,000 inhabitants; vacant properties per 1,000 dwellings	A division into 4 types of shrinkage: a) moderate-level, b) medium-level, c) strong-level, d) highest level
2006-2016	Institute of Urban and Regional Development – <i>IRMiR</i> (Janas et al., 2019)	Subject: Polish <i>gminas</i> and cities; definition: studies show the relationship of shrinking cities with the surrounding cities; surrounding <i>gminas</i> , and flows between cities and metropolitan areas, migration trends to and from Poland, etc.	Population change; natural growth rate; migration rates; age structure and ageing processes of the population; proportion of the population of pre-productive age; burden on the population by individuals of post-productive age	Shrinkage analysed over a broad spectrum of aspects: a) natural population trends b) age structure 3) internal migrations, 4) external migrations
Poland				

The Milbert multi-criterion method captures this multidimensionality with a selection of six demographic and socio-economic indicators based on the causal relationship as exemplified by Mayer and Knox (2010). While the *CIRES* methodology is based on the absolute measures defining shrinkage, the multi-criterion method of Milbert (2020) is based on measures relative to statistics for a country as a whole. A correlation and reliability analysis of the selected demographic and socio-economic indicators was conducted for all German municipalities (Gemeinden in German) for the observation periods 1997-2001 and 2003-2008. Cronbach's alpha reliability analysis conducted for 2008-2013 showed satisfactory results in  $\alpha = 0.748$  (Milbert, 2015). Moreover, the choice of indicators was selected in line with the availability of statistical information at the municipality level.

Milbert (2015) chose to focus on the encapsulation of short-term, current processes through study in relation to five-year periods. To track longer-term or structurally consolidating tendencies of growth or shrinkage, repeated short-term measures were taken. A follow-up analysis in 2009 (Gatzweiler & Milbert, 2009) confirmed the phases to the urbanisation trend and the effectiveness of shifting the constant time window instead of extending the period. This approach is favoured since it allows for better observation of the natural alternation of growth and shrinkage phases, over a sequence of several time windows.

It remains to be clarified whether decreases or increases in the individual six indicators should be viewed in absolute or in relative terms. In his research, Sroka (2021) modified the quintal division of each indicator into a division using mean and standard deviation. However, Milbert justifies the use of quintal division with the distribution of measures in five years representative of phases with economic peaks and drops. In such phases, the outer quintile (20%) can hardly be determined via clearly positive or negative developments. Therefore, all indicators are 'adjusted cyclically', i.e., corrected for the nationwide trend. Growth and shrinkage are then nothing more or less than a relatively more favourable or more negative development of cities and communities as compared with the national trend (Milbert, 2015, 2020).

## Methodology

In line with our review of methods as documented in the previous section, we concluded that a classification of urban shrinkage in general, and ours for Poland in particular, had to be based on a multi-criterion approach, a timeframe divided into five-year periods, with calculation in relation to all nationally available spatial units and a maximum number of Polish cities covered (GUS, 2023; Geoportal, 2023). On that basis, the original method developed by Milbert (2003, 2015, 2020) was adapted to the Polish territorial division and statistical data in a manner made clear below in further parts of this paper. An overview of the socio-economic processes and patterns in the entire country's settlement network produced selected statistical data for each municipality area (*gmina* in Polish), with these then used to develop a five-level typology ranging from growing to shrinking cities.

## Subjects

Poland's administrative system features the provincial/regional voivodship (*województwo*), the unit at county level (*powiat*), which can include individual cities, and the unit



at local-authority level (*gmina*). GUS data are fragmented and did not allow us to conduct a sound analysis based on individual-city data without omitting a portion of those for which data were not available. Indeed, due to far-reaching data fragmentation in the analysed period between 2006 and 2021 at the level of the city (or town) unit (known as *miasto* in Polish), an attempt at such a delimitation was discarded. One solution would be to estimate the missing data using computational methods. We decided to search for more continuous and robust data on a different administrative level. On that basis, given the availability of data, and for reasons of nationwide comparability, our method uses the smallest local-government unit, i.e. the *gmina*, which is on level 6 from the point of view of *Statistics Poland*. That unit is either a city (*miasto*, level 6, kind 1 in GUS), has a city part within an urban-rural municipality (*gmina miejsko-wiejska*, level 6, kind 3 in GUS) or is a rural municipality (*gmina wiejska*, level 6, kind 2 in GUS). In 2021, Poland had 2,477 municipalities: 302 cities, 662 urban-rural and 1,513 rural. For our research we utilised data for all the aforementioned municipality types. During the process of analysis and conclusion-drawing we narrowed the study area to cities represented by urban *gminas* (kind 1) or those in the urban-rural category (kind 3). We further had to consider the changing number of spatial units into which Poland was divided across different years. To ensure data consistency, we thus selected 964 cities, for which we were able to extract data during the research period. In this way, it was possible to achieve accurate comparison and analysis of our data without any discrepancies.

It is important to mention that the urban-rural *gmina* (level 6, kind 3) is deemed to consist of a part that is urban (level 6, kind 4) and a part that is rural (level 6, kind 5). However, because not all the datasets were available for both kinds 4 and 5, we used data from the 'parent' municipality to do our research. However, values for the urban part (level 6, kind 4) were used to identify the size type of a city (small, medium, or large). We followed the approach taken by Milbert (2020).

The fundamental criterion for categorising cities by size is naturally their number of inhabitants. When comparing the basic categories, namely the division of urban localities into small, medium-sized or large, certain questions arise regarding the criteria used (Runge, 2012). It is worth mentioning that in public statistics (including the *Demographic Yearbook*) and the subject literature, there are also seven size-classes identified for urban localities. These classes are as follows: below 5,000 inhabitants, 5,000-10,000 inhabitants, 10,000-20,000 inhabitants, 20,000-50,000 inhabitants, 50,000-100,000 inhabitants, 100,000-200,000 inhabitants, and above 200,000 inhabitants. For this research, we followed the simplified division and categorised as follows (after GUS): below 20,000 inhabitants – a small city, 20,000-100,000 – medium city, and above 100,000 inhabitants – large city. When analysing urban population data, it is important to establish a consistent reference point for size classification. We opted to base our categories on the beginning of each five-year period, even though populations may fluctuate in size over time. This helped us ensure accuracy and consistency in our analysis.

### Research timeframe

There were a few reasons underpinning the selection of a timeframe between 2006 and 2021. Firstly, the selection aimed to capture the most-recent processes of urban shrinkage (data for the year 2022 were still not complete as of 10th July 2023, and employment

statistics were missing for a complete calculation), by reference to three five-year sub-periods. Secondly, since shrinkage is a highly dynamic process, its empirical study needs to be located within a particular socio-political and historical context. Due to the significance of spatial changes following Poland's political and economic transformation, as well as in the wake of the May 2004 EU accession, the analysis captures after Poland joined the Union, so as to avoid a before-after comparison. It is worth adding that the absorption of EU funding was not commenced with immediately post-accession. As of the end of 2005, only 4.35% of funding allocated to Poland for the 2004-2006 period had been utilised (Żuber, 2005).

## Data

Statistical data used in the analysis were obtained from the database of *Statistics Poland*. Due to the spatial scope, long timeframe, and multiple indicators, the volume of data extended to more than 235,000 data input records (6 variables, for 2,477 municipalities, for each of 15 years). Data manipulation required the use of tools such as *Python* programming language with analytics libraries (*Pandas*, *NumPy*, etc.). Six variables encompassing indicators of a social, demographic, and economic profile were defined after Milbet (2015) (Tab. 2). Equivalents of these factors were searched for among data available in GUS BDL statistics. Most of the variables were straightforward and were equivalent to German ones, though differences in the tax systems and data collected by the German and Polish statistical offices enforced changes as follows, with a view to the methodology being adapted successfully to Polish conditions (see Tab. 2).

Following downloading of the datasets, raw data were extracted and transformed with *Python* scripts, connecting the statistical ID with the spatial ID (called TERYT). Finally, results were loaded to output files – in our case in CSV (comma separated values) format<sup>1</sup>. Each spatial unit was checked in terms of the completeness of data. Due to changes in ad-

**Table 2.** Variables selection

Original German criteria (Milbert, 2015)	Polish equivalents in GUS BDL data (Author's choice)	Subject ID in GUS	Variable ID in GUS
average annual population development in %	annual average population development in %	'P2137'	72305
average annual total migration balance per 1,000 inhabitants	net migration per 1,000 inhabitants	'P1350'	1365234
average annual development of the working-age population (20 to 64 years) in %	annual average change in working age population in %	'P1342'	152
average annual development of socially insured employees at the workplace in %	annual average change of employed persons in %	'P2172'	54821
average annual change in the unemployment rate in percentage points	annual average change of unemployed persons in % points	'P1944'	10514
average annual development of business tax base per inhabitant in %	annual average change in <i>gminas</i> own income per inhabitant in %	'P2622'	76070

Source: Authors based on Milbert (2020).

<sup>1</sup> The detailed research results are available at: <https://rcin.org.pl/dlibra/publication/276466>

**Table 3.** Number of city size type in every analysed period

	2006-2011	2011-2016	2016-2021
Large cities	39	39	39
Medium-sized cities	180	184	180
Small cities	745	741	745

ministrative boundaries, certain units had to be combined/unified to achieve continuity of data. The urban units were classified into one of three size types (under the GUS classification), by reference to the population in the first year of a period. The populations used in the size classification related to the city classified here as the urban gmina (kind 1), or else the urban part within a rural-urban gmina (kind 4).

### Statistical and geospatial analysis

Analysis of statistical data was conducted in reference to the three five-year periods: (I) 2006-2011, (II) 2011-2016, and (III) 2016-2021. In the case of most variables, the calculation of the average development was achieved using the geometric mean of changes between years. In the case of the variable 'Unemployment', guidance from Milbert resulted in a different division being used to express the variety of cities and the changes they experienced as regards unemployment (see Milbert, 2020). After these corrections, a summary of the indicators with different units of measurement and a spread of the division into quintiles is made. Based on an assumed normal distribution, the limits of the outer quintiles are always such that the relative distance from extreme values and outliers does not play a role. The affiliation of units to a quintile is translated into points for each indicator. There are 0 points for being below the 1st or lowest quintile, 1 point for being in the range between the 1st and 2nd quintile, 2 points for being in the range between the 2nd and 3rd quintile, 3 points for being in the range between the 3rd and 4th quintile, and 4 points for being above the 4th or top quintile. Thus, the more favourable the developments are and the more often the indicators are in an upper quintile, the higher the overall score. A *gmina* can achieve a maximum of 24 points and a minimum of 0. Obtained results were then assigned to five types of cities:

- (A) growing by an above average amount (24-19 points),
- (B) growing (18-14 points),
- (C) stagnating (13-11 points),
- (D) shrinking (10-6 points),
- (E) shrinking by an above average amount (5-0 points)

This classification was translated directly from Milbert (2020) and was repeated for each five-year period.

Further statistical analysis of the calculation outcomes includes a box plot of the types, various analyses of geographical distribution (of urban localities that are large, medium, or small) by type (A-E), charts and tables with average score per city size type, and a summary on population per city size and type. The classifications were then moved to QGIS for visualisation. Additionally full data outcomes are provided in Appendix A.

## Results

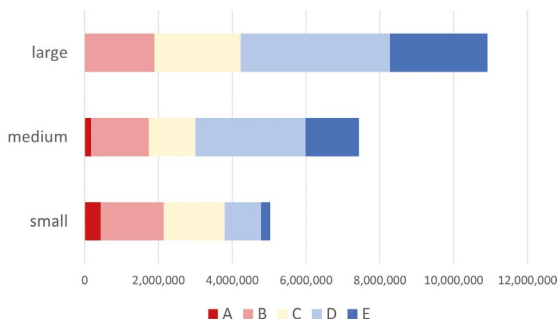
This section shares the findings of our research conducted on Polish cities from 2006 through to 2021 using our multi-criterion approach adapted from Milbert (2015, 2020). The results are presented for each five-year subperiod and include information on (I) the number and population of urban localities affected by urban shrinkage, (II) the types of cities most affected according to size, and (III) the spatial distribution of shrinking cities. Visual aids such as graphs and charts are included to facilitate understanding of the statistical and geospatial analysis. In addition to the detailed information shared in the previous section, the research also provides a comparative analysis for all the subperiods studied. This reveals spatiotemporal trends and patterns of urban shrinkage with respect to city size.

### Urban centres in Poland shrinking or growing in the years 2006-2011

In the analysed period, 53% of Poland's urban population could be considered resident in urban centres that were shrinking. The number of cities affected by such shrinkage (in types D and E combined) is 311 out of a total of 964 under analysis. That means nearly one-third of all Polish cities experiencing shrinkage in the 2006-2011 period.

Cities of more than 100,000 inhabitants were among the centres most affected by shrinkage in 2006-2011, in terms of both number and population size (Fig. 2). Over 61% of the population resident in large urban localities could simultaneously be termed residents of localities of this kind that were shrinking (assigned to types D and E). This further shows that, out of 39 of Poland's largest urban centres at that time, 77% (or 30 cities) were in the shrinking categories. Localities affected most severely by this were: Tarnów and Włocławek (score 4), followed by Bytom, Elbląg, Łódź and Radom (score 5). However, the average score for the large city in the 2006-2011 period was 13.

Likewise, our medium-sized urban centres (of 20,000-100,000 inhabitants) had almost 60% of their total population living in localities that could be classed as shrinking in the 2006-2011 period, though the overall population involved was smaller than in the case of the largest urban centres. Within a total of 180 medium-sized cities in Poland, over half (95) were classified as shrinking. It is worth adding that there were 30 such localities in which the degree of shrinkage could be viewed as strong. Among all the shrinking



**Fig. 2.** Urban population in Poland in 2006-2011 period, in line with growth or shrinkage types (A-E), as well as size or urban locality (large, medium, small)

Source: The authors, on the basis of GUS data and their own calculations.

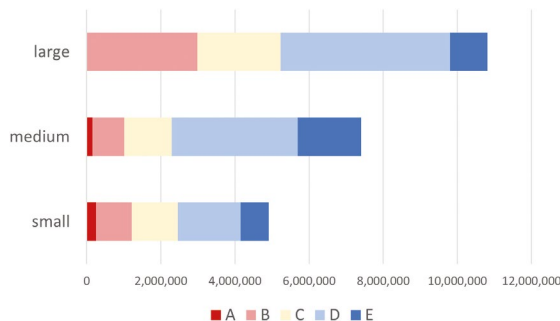
urban centres of medium size it was Konin, Kamienna Góra and Stalowa Wola whose scores were lowest (at 3). These were then followed by Prudnik, Kluczbork, Bartoszyce, Szczytno, Pabianice, Łowicz, Krosno, Jarosław and Przemyśl (score 4), while the average score for a medium-sized city as of 2006-2011 was 13 (meaning the same value as was noted for the group of large urban centres).

In general, the most optimistic situation could be said to characterise the last size group – involving the small urban centres of under 20,000 inhabitants. There, the percentage of cities that were growing was highest (at 45%), while the percentage that were shrinking was lowest. Thus only 24.5% of the inhabitants of localities in this category could be said to live in localities that were shrinking. Nevertheless, since the number of localities qualifying for this size category is large, that still leaves a large absolute number of urban centres in the shrinking category. Among 746 such localities, 39 were undergoing marked shrinkage (type E), while a further 186 were shrinking (type D). Among them was Zdziezowice (Opole Voivodeship) achieving a 0 score in the period, followed by Ozimek and Żychlin on 2, and Olszyna, Stronie Śląskie, Dobrodzień and Gorzów Śląski all with a score of 3.

### Urban centres in Poland shrinking or growing in the years 2011-2016

In the analysed period the percentage of the Polish urban population living in urban localities earning the description “shrinking cities” was greater than before, at 57%. Numbers of cities affected by shrinkage (in either type D or E) jumped from 311 in 2006-2011 to 504 in 2011-2016. That means that over a half of all Poland’s urban centres were shrinking as of 2011-2016 – a considerable increase beyond what was noted in the first time period (Fig. 3).

By this period, the type of urban centre most likely to be shrinking was no longer a member of the grouping for the largest centres, but rather involved medium-sized or smaller localities. Indeed, the situation of the 39 Polish cities of the “large urban centre” category was better than before. While, in 2006-2011 these were among the centres most affected by shrinkage, by 2011-2016 only 27 remained in the relevant categories (types D and E), with only 7 experiencing above-average shrinkage. Among the most severely affected were again: Tarnów (score 3), and Włocławek and Bytom (score 4), followed by Zabrze and Sosnowiec (score 5), and Ruda Śląska and Legnica (score 6) which overall shows an in-



**Fig. 3.** Urban population in Poland in the 2011-2016 period, as assigned by growth or shrinkage type (A-E), and size of urban locality (large, medium, small)  
 Source: Authors based on GUS data and own calculations.

crease in score compared with 2006-2011. In this period 51% of the population in these cities overall could be deemed resident in a shrinking centre (assigned to types D and E).

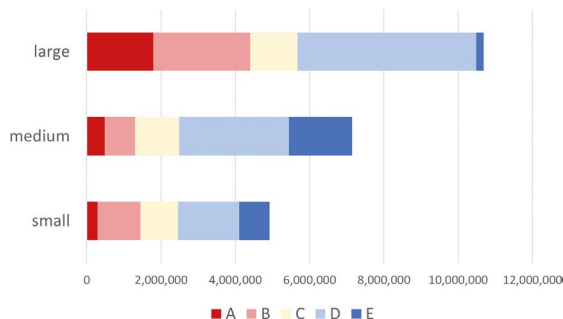
In turn, the medium-sized urban centres then had 69% of their total population living in localities classed as shrinking, suggesting an issue of almost the same magnitude as with the “large” category of locality. Out of a total 184 urban localities of medium size, 119 could be classified as shrinking, i.e. 65% and indicative of a steep increase (major worsening) compared with the previous period. Furthermore, 41 of the shrinking localities could be seen as subject to a strong effect (assignment to type E). However, among the latter, only Przemyśl remained from the previous period, being joined by Chełm, Kraśnik, Jasło and Tarnobrzeg in the lowest-scoring group (score 3).

Once again in this period, it was the small localities that had the highest percentage (25%) of overall population residing in centres that could be termed growing. That said, the “shrinking” categories can be seen to have experienced a doubling to almost 50% compared with 2006-2011. Thus, among the 741 small centres identifiable during this period, 358 were shrinking and 101 subject to strong shrinkage (type E). Among these, Hel and Jastarnia in Pomorskie Voivodeship had 0 scores in that period, with Mirsk, Pieniężno, Drohiczyn and Szczuczyn scoring 2; as followed by a group of 12 small localities all scoring 3, i.e. Ciechanowiec, Dęblin, Frombork, Hrubieszów, Łeba, Lesko, Leżajsk, Lipiany, Przedecz, Przemków, Resko and Ustka.

#### Urban centres in Poland shrinking or growing in the years 2016-2021

In the most recent analysed period, the percentage of the Polish urban population living in shrinking cities decreased slightly to 53% comparing with the previous period. However, the number of urban centres affected by shrinkage (in both types D and E) was still higher – at 508 in relation to the 2016-2021 period. That means that over half of all Polish urban centres continued to shrink in the years 2016-2021, i.e. the same percentage as in the period before.

The situation for 39 large urban centres of Poland proved to be better than in the former period. While again, 27 of them experienced shrinkage (as previously), only 2 went through strong processes of shrinkage (type E). Where numbers of cities are concerned, 69% of the 39 of large size were found to be shrinking.



**Fig. 4.** Urban population in Poland in the 2016-2021 period, as categorised by growth and shrinkage type (A-E), and size of urban locality (large, medium, small)

Source: the authors, based on GUS data and own calculations.

This time, among the localities experiencing the most-severe shrinkage were Legnica and Wałbrzych (score 6) followed by Częstochowa, Sosnowiec, Kalisz and Łódź (score 7). Although, the average score for large centres undergoing shrinkage was again 13, the lowest-scoring examples were not so low anymore. In this period 47% of the population of large cities lived in shrinking cities (type D and E).

The medium-sized cities had 65% of their total population residing in the context of a situation of shrinkage as of 2016-2021. That was a more favourable circumstance than in 2011-2016, though only slightly so. Nevertheless, this was the second five-year period in a row wherein it was this group of localities that proved to be most affected by the phenomenon of shrinkage. Moreover, the numbers living in shrinking urban centres of medium size are almost as great as those in the large cities subject to shrinking. Out of a total of 180 medium-sized urban centres, 111 were classified as shrinking – a figure of 61% and a minor decrease compared with the previous period. Over the time in question, 38 of all the urban centres characterised by shrinkage were doing this at an above average rate. Among the cases in point were Stalowa Wola with the lowest score (of 3), followed by Olkusz, Oświęcim, Racibórz, Kędzierzyn-Koźle, Bartoszyce, Bełchatów, Piotrków Trybunalski, Puławy Sanok and Jarosław (score 4). The average score for the group of medium-sized shrinking localities is a mere 4, which stands in contrast to the score for the large urban centres – lowest Figure 6. There is a furthermore a highlighting of the difficulties these urban centres were facing, as revealed in all the previously classified indicators. At the same time, there was a slight increase from 6 in 2011-2016 to 13 in 2016-2021, in the number of medium-sized urban localities growing significantly, and thus assigned to type A).

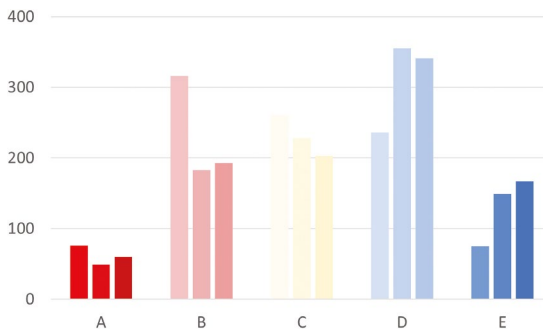
The percentage of population residing in growing urban centres of small size rose from 25% to almost 30%, but the population of these centres remained at 50%. Thus, in the 2016-2021 period, among 745 such small cities and towns overall, 371 are seen to be shrinking, with 127 assignable to the strong shrinkage category. Among these localities, we find Chodzież, Recz, Łeba and Leżajsk, all with scores of 2. Equally, no longer was it possible to find small localities for which the score was actually zero. Moreover, most of the localities previously qualifying for the severe shrinkage category are now seen to have been “promoted” to type D. Among centres described as shrinking severely, there is a group of no fewer than 20 small ones scoring 4. These localities are Bierutów, Byczyna, Goraj, Hrubieszów, Kępice, Kock, Korfantów, Łaszczów, Lipiany, Lipsk, Lipsko, Lubowidz, Przemków, Radzyń Podlaski, Słupca, Świeradów-Zdrój, Tolkmicko, Wąsosz and Włodawa.

### **2006-2021 spatiotemporal changes characterising Polish urban centres that are shrinking or growing.**

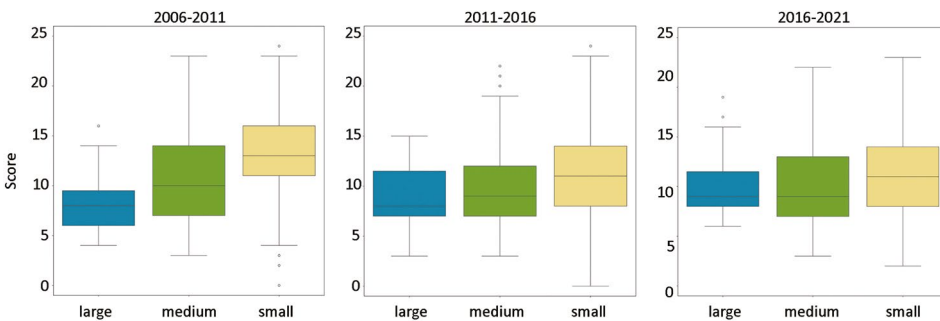
Comparison of the outcomes from the three subperiods shows spatiotemporal patterns of urban shrinkage within the spectrum of 15 years. While the urban population of Poland accounted for 61% of the national total in 2006, by the end of 2021 that had actually dropped to 59%, confirming a downward trend. In 2006 the urban centres under investigation here were inhabited by 23,346,297 people, with this number in steady decline through subsequent years, to reach 22,751,998 people at the end of 2021. To put urban shrinkage in the national context, the overall population of Poland can be noted to have dropped by 0.12% in 2021 – below the 38.1 million people noted in 2006. This confirms

tendencies for population transformations in cities and other urban areas to be more marked than in the country overall.

Within the broader context, the total number of Polish urban centres earning the description “shrinking” grew over the analysed period from 311 in 2006-2011, via 504 in 2011-2016, to 508 in 2016-2021 (Fig. 5). It confirms a trend that was signalled in population predictions from the Central Statistical Office (GUS, 2023), and by other researchers (Śleszyński, 2017, 2019,; Sroka, 2021; Jaroszewska, 2019). However, when size type is considered, shrinkage is not seen to be affecting urban centres equally but is rather most common in small and medium-sized localities cities and in later periods. The number thus rises over the years, even as there is a decline in cases of the largest cities shrinking. This proves that, while the early 2000s were challenging for the largest urban centres, later years have allowed them to bounce back economically, gradually attracting capital and people from the more peripheral areas of the country. A box plot analysis of the average score per type of urban locality in fact shows a growing difference (Fig. 6). Thus, while the score for large localities started on the lower level, it showed improvement later. At the same time, localities in the medium and small categories presented scores that have gone on declining gradually.



**Fig. 5.** Changes in the numbers of urban localities included in each group in the five-year periods between 2006 and 2021  
Groups show the following types: A – above-average growth, B – growth, C – stability, D – shrinkage, E – above-average shrinkage



**Fig. 6.** Box plots of scores for urban centres in the different periods and as assigned to size-types of urban centres (large, medium or small)



A look at the spatial distribution of classified urban centres during the first five-year period makes it apparent that most growth occurred around the metropolitan regions of the largest Polish cities (Fig. 7). Conversely, the concentration of shrinkage is not as noticeable when all three periods are looked at. While a concentration of growing urban centres most often characterised Wielkopolskie, Mazowieckie and Małopolskie Voivodeships (the administrative divisions at regional/provincial level), the occurrence of localities that are shrinking is more dispersed across the entire country. However, post-industrial Silesia is one region in which shrinkage is evident, along with other areas where industries were located during the communist era. Additionally, there is a concentration of shrinking urban localities of small and medium size in Sudety Mountains region of Lower Silesia (Dolnośląskie Voivodeship) in SW Poland, as well as in the NE area of Warmińsko-Mazurskie and Kujawsko-Pomorskie Voivodeships, as well as in Central Poland's Voivodeship of Łódź (Łódzkie).

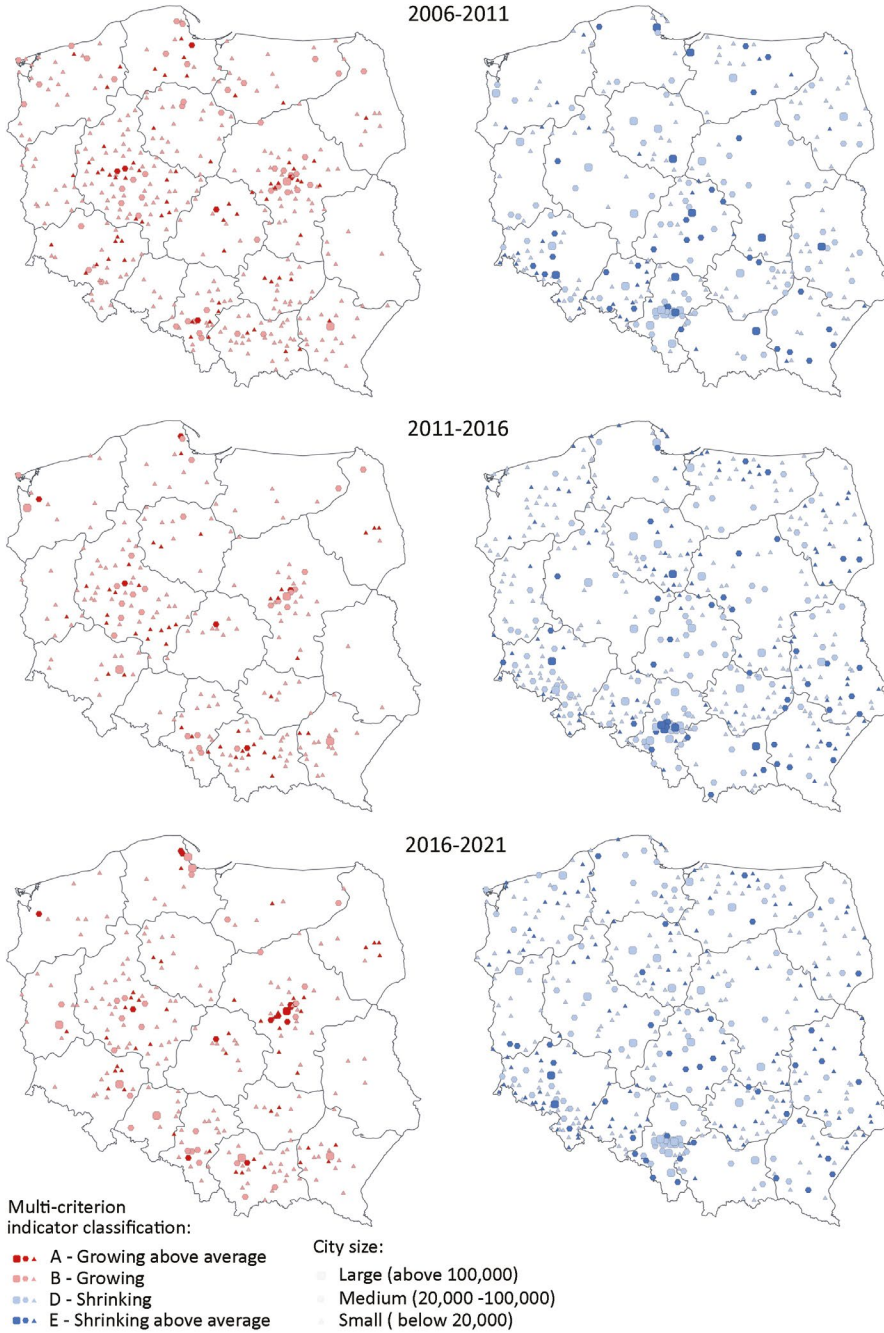
In the next period (of 2011-2016) an increase in numbers of shrinking localities and a decrease in numbers of those that are growing ones represents the first major visible change (Fig. 7). While growth then remained located around the same metropolitan areas as previously, shrinkage was a phenomenon spreading out across the country, especially among urban centres of small and medium size.

The last analysed period (of 2016-2021) saw these trends persist, albeit with more growth poles in the south, and fewer around Warsaw as capital of Poland (Fig. 7). Further intensification of the shrinkage phenomenon is evident on the peripheries of the voivodeships, away from the large metropolitan growth zones, and in certain post-industrial areas that continue struggling with the challenges post-transformation. At the same time, there are a few urban localities in the Silesian region (Śląskie Voivodeship) that are experiencing growth, and thus manifesting dynamics at play within the agglomeration there. Similarly, overlapping dynamics can be seen around the agglomeration in Pomorskie Voivodeship known as the Tri-City which mainly comprises Gdańsk, Gdynia and Sopot. There, we may find some strong growth poles in the vicinities of medium or small urban centres that go on shrinking.

Table 5 uses groupings of urban localities in line with their type, in each of the three periods, and thus allows us to note extremes. This classification shows the cities that retain their status in the classification (as groups 1, 3, 5), or which changed over the period (groups 2 and 4). The chart points to the existence of urban centres falling into the following five categories:

1. manifesting consistent strong growth [AAA],
2. changing over from shrinkage to growth [EEB | EEA | EDA | DEA | DDA | EDB | DEB | DDB],
3. manifesting stability throughout [CCC],
4. changing over from growth to shrinkage [AAD | AAE | BAE | ABE | BBE | BAD | ABD | BBD],
5. manifesting consistent strong shrinkage [EEE]

It is important to add that this list is not exhaustive, given its confinement to selected types considered of interest by the authors. Our aim was to show all urban localities capable of being regarded extreme in some ways. This leaves certain types not presented (e.g., BBB, DDD, CCB, etc.), as well as types potentially existing (in theory) but never exemplified in real-life cases (e.g., EEA, DDA, EDA, etc.). The outcomes expose the fact



**Fig. 7.** Classification of Polish urban centres that grew or shrank in the 2006-2011, 2011-2016 or 2016-2021 periods, by reference to a multi-criterion indicator. The maps show localities in different size categories manifesting: A – above-average growth, or B – growth (left), or else D – shrinkage, E – above-average shrinkage (right)

Source: the authors, by reference to data from GUS as processed using the method from Milbert (2020).

of there being hardly any case in which an urban centre came back from a strongly shrinking path to one characterised by growth. Gdynia is here the exception, in that its unique case sees a change from strong shrinkage (type E) in the first period to type D, and then finally to growth (in type B). The other four centres represent cases of change from a categorisation of type D to type B. Ostrów Lubelski is the only small urban centre (sic!) that managed the switch from shrinkage to growth. On the other hand, there are nine small localities that changed in the opposite direction – from growth to shrinkage, with Kamień Krajeński being the only case of a recent move from type B in the first two periods to the strongly shrinking type E. Świnoujście is the only medium-sized urban centre in the group. The group of strongly growing localities mainly comprises those of small size, with only two in the medium-size category. Interestingly, Wieliczka only moved into the medium-sized category in 2009, when its population increased to reach the required threshold. The group of strongly shrinking centres is larger, with 13 cases, of which most are in the medium-sized category. This just confirms the challenges faced by this group that have been exposed earlier in this article.

When the spatial distribution of the classified extremes are looked at (Fig. 8), it is clear that urban centres that have grown consistently are always located in close proximity to the Voivodeship capitals. Conversely, localities that have remained assigned to the

**Table 4.** Numbers of Polish urban centres of different categories displaying growth or shrinkage in the three consecutive five-year periods between 2006 and 2021

Period	A	B	C	D	E
2006-2011	76	316	261	236	75
2011-2016	49	183	228	355	149
2016-2021	60	193	203	341	167

**Table 5.** Classification status groups for all three periods from 2006 to 2021

1. Always growing strongly	2. Changed over from shrinkage to growth	3. Always stable	4. Changed over from growth to shrinkage	5. Always shrinking strongly
Aleksandrów Łódzki [M]	Gdynia [L] Nowy Sącz [M]	Drezdenko [S] Kępno [S]	Chełmek [S] Czaplinek [S]	Bartoszyce [M] Bogatynia [S]
Choroszcz [S]	Opole [L]	Międzybórz [S]	Dobra [S]	Chodzież [S]
Kąty Wrocławskie [S]	Ostrów Lubelski [S]	Międzyrzecz [S]	Jabłonowo Pomorskie [S]	Duszniki-Zdrój [S]
Nekla [S]	Tarnowskie Góry [M]	Milicz [S]	Kamień Krajeński [S]	Jarosław [M]
Niepołomice [S]		Nowa Dęba [S]	KłECKO [S]	Jaśło [M]
Ożarów Mazowiecki [S]		Oleśnica [M]	Opalenica [S]	Kędzierzyn-Koźle [M]
Siechnice [S]		Pyrzyce [S]	Pilawa [S]	Łowicz [M]
Szubin [S]		Sompolno [S]	Suchań [S]	Piekary Śląskie [M]
Wieliczka [M]		Szlichtyngowa [S]	Świnoujście [M]	Przemyśl [M]
Zduny [S]		Trzciel [S]		Skarżysko-Kamienna [M]
Żukowo [S]		Trzebinia [M]		Zdzieszowice [S]
		Ujście [S]		Żychlin [S]
		Wołów [S]		



**Fig. 8.** Selected Polish urban centres classified in the five groups for the whole 2006–2021 period. The classification includes groups (1–5) of urban centres depending on their type (A–E) in each analysed five-year period

type of strong shrinkage (E) throughout the analysed period are peripheral. Bartoszyce, Duszniki-Zdrój, Łowicz, Przemyśl, Jasło, Skarżysko-Kamienna and Żychlin are located close to either Voivodeship boundaries or the state border. Similarly, the spatial distribution of urban centres that have consistently proved stable (assigned to type C) is characterised by peripherality. Most such localities are in western Poland, located on the perimeter of either Wielkopolskie or Dolnośląskie Voivodeships.

**Discussion**

An increasing number of cities in Poland have been experiencing the shrinkage processes understood as denoting social, spatial, and economic restructuring, as accompanied by population decline (Zborowski et al., 2012). The phenomenon has been the subject of ongoing research worldwide and still poses theoretical and empirical challenges. Scholars in Poland have done extensive work to analyse the extent of this phenomenon in recent years (Krzysztofik & Szmytkie, 2019; Janas et al., 2019; Jopek and Musiał-Małago,

2021; Sroka, 2021). While relevant Polish discourse on urban shrinkage revolves increasingly around its socio-economic, demographic and spatial aspects, very few studies have attempted to analyse the entire territory of Poland by reference to a single multi-criterion approach (Jaroszewska, 2019; Śleszyński, 2017, 2019; Sroka, 2021). The work detailed here has thus presented a spectrum of methods by which urban growth and shrinkage may be analysed. With the aim of providing a comprehensive and holistic overview of the shrinkage phenomenon in Poland, we decided to select and adapt a single multi-criterion method.

Germany's *BBSR* institute has engaged in the continuous monitoring of urban growth and shrinkage in that country since the early 2000s, when the eastern regions began to face unprecedented challenges. A multi-criterion method developed by Milbert (2008, 2015, 2020) was used to help diagnose and assess the effectiveness of planning responses. Given the potentially similar scope of challenges in Poland, we decided to adapt the above method to analyse the contemporary situation, with findings then set against the existing research. The approach pertains, not to absolute decline or growth, but to a processing of nationwide statistics involving all the country's local-authority areas, and thus indicating relative growth and decline. The main findings of such a multi-criterion indicator analysis for Polish cities over the 2006-2021 period are as follows:

1. It has been rare for urban centres to return to a growth path having once experienced shrinkage. Some exceptions exist, but over the 15 years only five localities achieved some kind of re-growth. Most urban centres manifesting shrinkage do not go back to a path of growth.
2. Most cities characterised by strong shrinkage across all three five-year periods were assigned to the medium size category (meaning 20,000-100,000 inhabitants). In general, the shrinkage phenomenon as manifested in Poland can mostly be ascribed to the medium-sized cities.
3. Urban centres manifesting growth are mostly located around Poland's five main metropolitan centres.
4. In all the periods, shrinking localities have proved to be rather dispersed across Poland, albeit with a tendency for them to be located on the peripheries of the country's constituent voivodeships (units of administration at regional/provincial level), or else on the peripheries of the country as a whole.

The research concludes that 13 cities experienced severe shrinkage throughout the 15 years from 2006-2021. Nine of these falling within this study's "medium" size category are Bartoszyce, Jarosław, Jasło, Kędzierzyn-Koźle, Łowicz, Piekary Śląskie, Przemyśl and Skarżysko-Kamienna, while five (Bogatynia, Chodzież, Duszniki-Zdrój, Zdzeszowice and Żychlin) are here categorised as "small". These findings offer partial overlap with the outcomes of a multi-criterion study conducted by Śleszyński (2017, 2019), in relation to the periods 2004-2014 and 2008-2018. In the former period, cities like Przemyśl, Jarosław, Bartoszyce and Jasło were identified by Śleszyński (2017). However, from 2008-2018, the study found that Bartoszyce and Przemyśl were in a better position. From the point of view of our study, they have to be viewed as remaining crisis-hit. Śleszyński concludes that the issues of loss of function, significance in the settlement hierarchy, and overall economic crisis affecting Poland's medium-sized urban centre seems to represent an increasingly serious problem, requiring careful consideration in both practical and scientific spheres (Śleszyński, 2019). Additionally, forecasts from *Statistics Poland* (GUS, 2023) have shrin-

kage exerting its most-severe effects in the coming years on medium-sized urban centres. Predictions for example include a 39% loss of population for Konin, and one of 35.4% in the case of Tarnobrzeg, by 2050. While the research presented here offers no long-term forecasts, it does demonstrate a growing trend for the analysed period whereby medium-sized urban centres undergo shrinkage.

Reference to the outcomes of other multi-criterion research does not suggest any easy identification of similarities. Sroka (2021) resembled ourselves in researching urban shrinkage and in drawing inspiration from the multi-criterion approach of Milbert (2015), yet that study revolved around different indicators (see Tab. 1) and a different timeframe (1995-2018); and it also eschewed the division into separate five-year periods. Instead, the work opted for a summary approach to the most severely shrinking cities. According to Sroka (2021) 53 of the 190 medium-sized cities analysed could be assigned to the severe shrinkage category.

Compared with Sroka (2021), the research presented here benefits from the approach involving sub-division of the overall period, in this way offering a more-detailed analysis of shrinkage trends, and changes in numbers of shrinking localities, over the years. Similarly, Jaroszewska (2019) deploys a method different enough to obstruct any making of comparisons. She conducted an extensive study on urban shrinkage involving 829 urban centres, over a period extending from 1990 to 2010, and with additional socio-economic data on offer for 2003 and 2013. While it is impossible to compare outcomes, some general voivodeship-oriented similarities can be identified as regards the proportionality between urban centres that are either shrinking or growing.

Finally, it is possible to observe discrepancy of outcome as the results of the present study are set against the analysis based on population criteria that was conducted for the 2000-2020 period by Jopek and Musiał-Małago (2021). The latter authors identified Bytom and Wałbrzych as the urban centres showing the most severe shrinkage, though the multi-criterion approach used in this study reveals some differences. In the 2006-2011 and 2016-2021 period, Wałbrzych indeed scored relatively low (with the city assigned to type E). However, 2011-2016 brought a higher score due to low unemployment and high employment. Thus, despite its population decrease, this city ranked higher (being assigned to type D). Similarly, Bytom moved up the ranking due to low unemployment in the years 2016-2021 and is not even present among the urban centres found to be shrinking most. Such examples can be found as population-based analyses are compared with the multi-criterion approach, with this evidencing the difference in outcome attributable to the two methods of classification.

## Summary

The work detailed here has first involved a review of selected approaches to measuring urban shrinkage, with this leading to our ultimate adoption of a multi-criterion method by which to run an assessment in Poland. Inspired by a German study from Milbert (2015, 2020), this method offers a nuanced understanding of shrinking cities, given that it extends to diversified socio-economic indicators in a position to reveal variations in the proportion of shrinking or severely shrinking municipalities, as compared with measures based solely on population. This underscores the importance of a multidimensional ap-

proach if we are to gain a more accurate representation of urban shrinkage dynamics, as well as the need for diverse measurement methods if an early warning system drawing on weaker signals is to be put in place.

Building on existing research in Poland, this study enhances our understanding of urban shrinkage, supporting informed decision-making in urban planning and development. The focus on a five-year period allows for a detailed investigation into the trajectories of individual urban centres, and the emphasis on those of medium size (here identified as the ones most affected by urban shrinkage) is notable, considering the role played in the stabilisation of polycentric settlement systems. Indeed, this study confirms previous findings to the effect that urban localities of medium size are in need of strategic support.

This study points to avenues for further research, for example encouraging the exploration of spatial associations relating to structure and networks in urban localities of medium size. An extension of this kind would serve to uncover patterns and offer valuable insights for planning practitioners and local governments working to develop more-informed planning strategies. Additionally, the study opens up the possibility of the results of implemented urban renewal programmes being reviewed and evaluated by reference to their outcomes. Overall, the study contributes to the ongoing discourse on urban shrinkage, emphasising the need for a holistic and multidimensional approach to the understanding and addressing of this complex phenomenon.

Unless otherwise stated, the sources of tables and figures are the authors' on the basis of their own research.

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The co-authors together contributed to the completion of this article. Specifically, it follows their contribution: E.S.: Conceptualization, methodology, writing, reviewing and editing. M.B: data analysis, reviewing and editing. Both authors have read and agreed to the published version of the manuscript.