



ARTICLE



<https://doi.org/10.1057/s41599-023-02423-1>

OPEN

The quality of life in Czech rural and urban spaces

Oldřich Ryppl ¹✉, Karel Macků¹ & Vít Pászto ¹

Quality of life is a frequently discussed topic among scientists, politicians and the general public; it touches on a wide range of scientific disciplines and is discussed in various contexts. Its relation to specific conditions of the external environment, which shape the individual and society, makes it possible to look at it through a geographical lens and study its spatial differentiation. The study aimed to explore and assess the relationships between the objective dimension of the quality of life and the degree of municipal membership in a rural and an urban continuum. Methodologically, the study builds on global and local analyses of the phenomena. Spatial autocorrelation indicated that quality of life data tends to cluster. A positive geographically weighted correlation implied that increased quality of life corresponds with increasing urban space membership. Further, a typology and quantification of the occurrence of the defined types was made. Through this, it was found that the potential for a high quality of life is in the intermediate spaces (suburbs) lying between urban and rural spaces.

¹Palacký University Olomouc, Faculty of Science, Department of Geoinformatics, 17. listopadu 50, 771 46 Olomouc, Czechia. ✉email: oldrich.rypl01@upol.cz

Introduction

Quality of life. Quality of life (QoL) is a vast and difficult-to-grasp concept in postmodern society due to its multidimensionality and complexity. It is linked to human existence and the meaning of life itself and to the search for the key factors of being and understanding oneself (Ira and Murgaš 2008). “To try to live one’s life well” is an archetypal human desire, described from ancient times (Murgaš and Klobučnik 2016), and documented through the principles of hedonism and eudaimonia (see Fayers and Machin 2007; Diener and Suh 1997). Quality of life is a multidisciplinary concept, as it touches on several disciplines (mainly sociology, psychology, medicine, economics and geography) and is discussed in various contexts. Each discipline, therefore, views the quality of life from its perspective and attributes different characteristics to it. Given the multidisciplinary nature of the concept, its diversity can be highlighted, but pitfalls arise when attempting to formulate key concepts and definitions and when trying to anchor it unambiguously. According to Ira and Murgaš (2008), “definitions of quality of life reflect varying degrees of integrity in viewing human life”. In some cases, quality of life is understood by answering the simple question “How good is your life?” (University of Toronto 2003).

Emerson (1985) refers to the quality of life as “the satisfaction of an individual’s values, goals, and needs by the use of his or her attributes or the manner in which he or she conducts his or her lifestyle”. For Meeberg (1993), quality of life means “a sense of overall life satisfaction, which is determined by the mentally aware individual’s assessment”, provided that “his or her living conditions are in no way threatening to his or her life and are adequate for the satisfaction of his or her basic needs”. Liu (1976) composes the quality of life from economic, political, environmental, health, educational, and social factors; including income, housing quality and education level. According to Murgaš and Klobučnik (2016), it is a concept that aims to “grasp social and economic reality”. They associate quality of life with the concept of a “good life”, which they consider as its benchmark — thus, quality of life assessment means the evaluation of how “good” life is. For this paper, we grounded our research by adopting this view.

According to Ira and Murgaš (2008), an immanent feature of quality of life is its duality. Andráško (2013) defines basic dualism using the dimensions: objective (attempts to describe the actual state of society and its environment) and subjective, which is oriented to the attitude and opinion of the individuals. There is no doubt about the existence of these dimensions — several authors agree on this, despite different terminological labels (e.g. Massam 2002; Pacione 2003; Macků et al. 2020), and this dichotomy is generally accepted (Ira and Andráško 2007).

The subjective dimension is determined through the collection of each person’s subjective factors (opinions, attitudes, individual value systems and empathy). Data describing the subjective dimension are obtained, for example, based on a questionnaire (primary data). The objective dimension is formed by “the external, geographical environment in which a person lives his or her life” (Murgaš 2018). It is usually divided into social, economic and environmental domains, which are populated by statistical indicators. These can be collected by statistical surveys, censuses or derived from geographical data. As the objective dimension of quality of life is further explored in this study, its measurement deserves more attention.

Due to concept abstraction, the objective quality of life cannot be directly measured; therefore the approach of decomposition of the concept into its measurable components and the different processes involved in the formation of quality of life is generally accepted. Measures representing the complex phenomena of the quality of life can be in the form of aggregated datasets, such as

an index or profile (see Rogerson 1995). The objective quality of life consists of a set of domains that can be understood as the main components that co-create the whole (Marans 2015). In relation to indicators, domains are their sets, or aggregates (Pacione 2003).

As Ira and Andráško (2007) state, a prerequisite for the application of geography in quality of life research is the belief that “the level of quality of life varies not only from person to person but also from place to place”. Despite the distinctness of each individual’s living space, “there are certain ways of defining territories where day-to-day human activities intersect and are concentrated – e.g. research on the quality of life of people inhabiting a specific territory”. A similar perspective is found in Helburn (1982), who states that “quality of life is always more or less related to a particular territory and tends to vary from place to place”. The existence of a geographical dimension to quality of life is pointed out by Massam (2002), Dissart and Deller (2000), among others.

The specific conditions of the external geographical environment (demography, health, safety, environment) affect people positively or negatively – thus, together with their personal well-being, these conditions play a part in shaping people’s quality of life (Helburn 1982; Pacione 2003; Veenhoven 2000). Related to this, the concept of “livability” is sometimes used, representing a comprehensive expression of the conditions of a place to live in. Veenhoven (2006) in his fourfold matrix of four qualities of life distinguishes “livability of the environment” (or simply “livability”) and “life-ability of the person”. From his statements, it is possible to understand the term “livability” concerning the environment, while “life-ability” in relation to a man. Livability is the result of a combination of life chances and outer qualities. Veenhoven (2014) defines livability as “the degree to which a living environment fits the adaptive repertoire of a species”. Applied to human society, it denotes the fit of institutional arrangements with human needs and capacities. Liveability is also investigated by Okulicz-Kozaryn (2013), who identifies it with the objective dimension of quality of life. It follows that livability can be seen in relation to any place – whether cities or villages. It is evident that a favourable environment positively affects health and, indirectly, the quality and length of a person’s life. This implies that quality of life is a phenomenon with significant spatial manifestation, dependent on the contextual determinants, and thus, its spatial differentiation can be studied. Therefore, some authors do not use the term “objective quality of life”, but rather refer to the *quality of place* as an objective assessment (see e.g. Florida 2002; Trip 2007; Murgaš 2018).

There are different types of landscapes. From a sociological perspective, the greatest differences can be observed between urban and rural areas. Assuming that the objective quality of life is shaped primarily by the quality of place, the quality of life must be immanent to the disparity across urban and rural populations – urban and rural spaces differ not only in the nature of settlement and architecture but also in the prevailing livelihoods, lifestyles and culture, as well as a variety of socio-economic factors.

Rural and urban space. The definition of the city (or urban space) is explored by several authors and public entities. However, their opinions on the concept of a city differ, both regionally (also in relation to the importance and size of the settlement) and in terms of their professional focus (urban planners, sociologists, statisticians, lawyers).

One fundamental definition is from Ratzel (1882), who identifies the city as “a dense concentration of people and houses,

covering an area of considerable size and located at the junction of important trade routes". Mayer (1971) refers to a city as a place where people meet, carry out their activities and return to with daily regularity. Frey and Zimmer (2001) describe it as a bounded, administratively defined, continuous urbanised area. In the Czech environment, Chalupa and Tarabová (1990) define a city as a settlement of a "non-agricultural character with certain specific features", which differs from a rural settlement mainly in its functions (e.g. administrative and transport functions, public services and amenities). According to Sýkora (1993), urban space is characterised by a high or higher population density, compact and continuous development, and special demographic, occupational and social structures among the population, with a concentration of administrative and service functions (overlapping beyond the urban area) and high internal differentiation (diversity). The only non-descriptive, quantitative definition of a city is based on the Czech Municipalities Act (Czech Republic 2000) — a municipality is a town/city if it "has at least 3000 inhabitants and if the President of the Chamber of Deputies so determines after the opinion of the Government".

The ambiguous definition of urban space introduces complications analogous to the definition of rural space. Taking into consideration the Czech environment and the perception of a rural landscape, the countryside or rural space can be defined as a continuously delimited space that includes a natural landscape and rural settlements. According to Perlín's (1998) description, rural space (simplified as countryside) is "a territory consisting of a mosaic of settlements and the landscape between them". Binek (2007) adds that rural areas are "characterised by lower intensities of socio-economic contacts and lower density of links between the various entities that move in rural space". Slepíčka (1981) defines rural space as the sum of forests, agricultural land, water areas, suburbs, rural settlements, dirt roads and local roads.

Delimitation of urban and rural space. In addition to the lack of a single and clear definition of rural and urban space, the situation is further complicated by mutual overlaps of the two spaces. Due to the increasing intermingling of urban and rural characteristics (e.g. caused by suburbanisation), the emergence of intermediate space brings complications in determining the threshold limits for a clear classification of an area into rural (or urban) space.

Since a verbal description of rural characteristics is not sufficient to answer the question "where does rural/urban space begin and end?", it is necessary to look for a clear and obvious indicator to enable quantification. The problem of defining a sharp boundary between urban and rural areas is also noted by Binek (2007). He argues that if it is necessary to divide the territory into urban and rural areas, the following issues need to be decided:

- the identification of a critical settlement size boundary (i.e., the boundary between the largest rural and the smallest urban settlement), which can be measured by the population, or the comprehensive functional size of a settlement;
- the decision on the choice of the type of boundaries separating urban and rural settlements (e.g. administrative boundaries, boundaries based on urban features or on land-use).

Pásztó et al. (2016) make a similar point in this regard, suggesting that determining the municipality membership of urban and rural spaces is not a "trivial" task, primarily because of the so-called rural-urban continuum (i.e., the blurred transition from one type to the other, which is influenced by ongoing suburbanization). However, the usual approach, in terms of input

indicators, uses two characteristics – total population and population density. This is also because population data in different units and levels are reliably available worldwide.

One internationally accepted methodology for defining rural areas is the OECD methodology, which uses the proportion of the population living in a certain area as the main criterion. If the population density in an area under consideration is less than 150 inhabitants/km² (OECD 2006), the area is rural; otherwise, it is designated as urban. At the regional level, rural space is divided into three subgroups — predominantly rural, significantly rural, and urban. In the revised OECD (2011) methodology, the former significantly rural subgroup is referred to as intermediate space, reflecting the intermediate spaces discussed above.

European Union Member States have adopted the OECD definition for their use (e.g. national rural development programmes), often modifying some of the parameters of the methodology to fully reflect their regional heterogeneity. For example, in the Czech Republic, the population density threshold has been modified, reduced to 100 inhabitants/km² and calculated at the level of the municipality with extended powers (MEP; see Binek 2007 or Perlín 2009).

The study by Dijkstra and Poelman (2014) uses a population grid with a resolution of 1 km² to identify urban and rural areas. The study builds on OECD methodology and was developed for the European Commission, which is generally accepted for rural and urban classifications. In the consecutive procedure, urban cells are classified first (the population density of the respective grid cell must be greater than or equal to 300 inhabitants/km² and the sum of the population in the respective cell and the surrounding cells of the same density must exceed 5000). Second, this is followed by identifying rural cells (population density less than 300 inhabitants/km²). A rural area is then defined as a municipality that contains more than 50% of the cells classified as rural. It is therefore clear that the authors increased the population density threshold to twice the original level (i.e. from the original OECD value of 150 inhabitants/km² to 300 inhabitants/km²).

The definition of urban and rural space in the Czech Republic is the subject of Perlín (2010), whose study divides municipalities into three categories (distinctly rural, predominantly rural and urban) according to population density and employment structure. The definition of rural areas is also addressed in the methodology of the Czech Statistical Office (CZSO 2008), where the definition of rural areas is described in a total of eight variants (for different values of population density and population). For example, in the Rural Development Programme of the Czech Republic (see Ministry of Agriculture of the Czech Republic 2007), the value of 2,000 inhabitants was used (a village with a population of less than 2,000 is considered rural).

The common feature of a number of methodologies are the method of delineation based on Boolean logic. Pásztó et al. (2016) argue that in this way, clearly defined but strict criteria (the choice of one or two indicators) do not always reflect the real situation and do not capture the issue of complex rural areas. On the other hand, they appreciate the simplicity of the method, as well as the availability and obtainability of the indicators themselves (population, population density).

An alternative approach to the above is the fuzzy approach. Fuzzy logic is a mathematical approach used to smooth sharp transitions between two states so that one state transitions gradually into the other. It has been used in a wide range of scientific disciplines (Novák 1989; Zimmermann 2001), including geosciences – and especially in questions of uncertainty in geodata (Kubiček 2012; MacEachren et al. 2005).

The application of the fuzzy approach in determining the membership of Czech municipalities in rural or urban spaces is

discussed by Pászto et al. (2015, 2016). They intend to present an alternative method of determining the municipality membership that allows the capture of their transient characteristics more appropriately (i.e. to determine the membership degree to one or the other space) and thus remove the misleading rural-urban dichotomy. Simplifying the landscape (metropolitan and large cities, medium-sized cities, small towns, villages, open countryside, wilderness) into just two categories of urban and rural is a gross oversimplification, which is inappropriate as it fails to reflect individual specific characteristics at this level. According to Pászto et al. (2016), it is not essential to categorically label a municipality as rural or urban, but to quantify the degree to which a municipality belongs to a rural or urban space on a scale of 0–1. It is also possible to assign a vague verbal label to the fuzzy transitions considered (e.g. “urban”, “more urban”, or “rural” and “more rural”), while at the same time still having quantitative measure available. When comparing different municipalities, as opposed to a dichotomous approach, it is thus possible to claim that one municipality is more rural (or more urban) than another. The fuzzy membership degree in the form described in the above study is used and considered in the quality of life assessment in urban and rural areas, which is the subject of this paper.

Quality of life differentiation in urban and rural space

Studies of the spatial differentiation quality of life that simultaneously consider urban and rural spaces, and are carried out from the municipal to the regional level, often use data and products from national statistical offices (such as Bernini and Tampieri, 2017; Bertolini and Pagliacci, 2017; Székely 2006). Alternatively, data is gained from government commissions and organisations (Campanera and Higgins 2011) and specialised institutes (Gerdtham and Johannesson 2001). European data at the level of cohesion regions (Lenzi and Perucca 2018) and the level of countries measured by GDP (Shucksmith et al. 2009; Sørensen 2014) are usually used.

From an analytical point of view, it is possible to distinguish between a group of studies using regression models (linear regression, probit, logistic regression) on the one hand, and a combination of different analytical approaches based on the interaction of spatial and non-spatial analyses on the other hand.

In general, researchers tend to focus mainly on the subjective dimension of quality of life, while studies of the objective dimension are in the minority — it is specifically considered by Bertolini and Pagliacci (2017), Campanera and Higgins (2011), Ma et al. (2020) and Székely (2006).

Common criteria for defining urban and rural space are population or population density (sometimes both). Some authors leave the choice of space to the respondent (Shucksmith et al., 2009) or are guided by the statutes of a municipality (Székely 2006).

Bertolini & Pagliacci (2017) applied three ways of defining urban and rural space (originally described by Mazziotta and Pareto, 2016). The first is the Eurostat methodology based on the population density criterion. The second is the multivariate approach adopted by Camaioni et al. (2013), where a set of 24 variables (covering socio-demographic features, economic structure, land use, remoteness, e.g. based on distance to a larger settlement) is subjected to principal component analysis (PCA). Then, an ideal urban region is identified, which becomes the benchmark to which the other regions’ statistical distance calculations are related. The third way is through the concept of the urban-rural continuum and applying fuzzy logic to a set of input variables (agriculture, population density and land use) whose output is a numerical value of the membership ranging from 0 to

1 (value “0” means a completely urban space, value “1” means a completely rural space; see Pagliacci, 2017).

A completely different perspective on how urban and rural space is defined is provided by Ma et al. (2020). This approach differs from other approaches in the concept of urban and rural space as two systems, where the relevant quality of life and specific spatial features are defined at their level (by a specific choice of indicators). Thus, it is not the traditional definition of quality of life and rural/urban space at a global level and an examination of their interrelationships across spaces.

Most reviewed studies using the subjective dimension have found a higher quality of life in rural spaces (Bernini and Tampieri 2017; Knight and Gunatilaka 2010; Sørensen 2014; Winters and Li 2017). In contrast, an objective quality of life assessment leads to varying results. For instance, Bertolini and Pagliacci (2017) and Campanera and Higgins (2011) pointed to a higher objective quality of life in rural spaces, while Ma et al. (2020) showed comparable levels across urban and rural spaces. It should be noted, however, that these objective findings are always firmly linked to the country or region under study. Both the choice of the set of indicators and the very nature of the area described (the degree of urbanisation, the level of civic amenities and infrastructure, and the settlement structure) have a key influence on results. Appendix 1 table provides more information on the studies and their aspects.

Objectives

The previous chapter made a clear connection between the topics under consideration. The authors’ efforts to compensate for the lack of studies based on an objective assessment of quality of life concerning urban and rural spaces resulted with the following set of sub-objectives:

- A. Choice of quality of life assessment approach by applying objective expression as an aggregate index;
- B. Choice of urban and rural space definition approach, with respect to non-dichotomous expressions, an inclination to a fuzzy approach;
- C. Developing and implementing a methodological procedure to assess the relationship between the quality of life and a municipality’s membership in rural and urban spaces;
- D. Critical evaluation of the key findings concerning the geographical context of the analysed phenomena based on the construction of a typology.

The main research questions are defined as follows:

1. To what extent does the quality of life of the Czech population living in urban and rural spaces differ?
2. Is the quality of life higher in urban or rural spaces?
3. What is the position of the intermediate space in this respect?

The key to answering these questions will be the methodological procedure presented and the interpretation of the results from the analyses performed.

Data and methods

Data. Our construction of the quality of life index (Fig. 1) was based on the approach of Murgaš and Klobočnik (2016) and their *Gold Standard of Quality of Life*, which can be understood as a benchmark for a good life (aspects considered are: desire to live, living a long life, living in a complete family, having children, being healthy, being educated, having a job, living in a healthy environment and being a good person — see Murgaš and Klobočnik 2016, p. 554). The quality of life index consists of 10 indicators (see Table 1). Unfortunately, the administrative resolution of input indicators is inconsistent due to the lack of

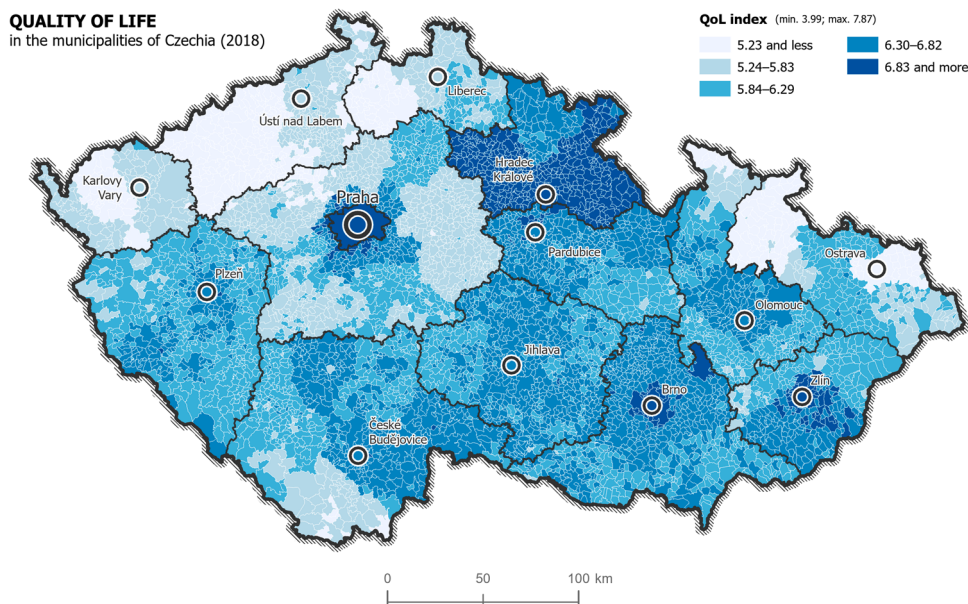


Fig. 1 QoL index in municipalities of Czechia (based on Murgaš and Klobučník 2016).

Table 1 Overview of QoL index indicators.				
No.	QoL partial indicator	Period	Territorial level	Source
1	Suicides	2014–2018	Districts	CZSO
2	Male life expectancy	2014–2018	Districts	
3	Female life expectancy	2014–2018	Districts	
4	Mortality	2014–2018	Municipalities	
5	Birth rate	2014–2018	Municipalities	
6	Divorce rate	2014–2018	Municipalities	
7	Population with completed tertiary education	2011	Municipalities	
8	Unemployment rate	2014–2018	Municipalities	
9	Emissions of solid pollutants, SO ₂ , NO _x , CO, VOC, NH ₃	2013–2015	Districts	CHMI
10	Generativity (proportion of blood donors)	2015	Regions	IHIS CR

availability of the input data. The data were obtained from the Czech Statistical Office (CZSO), the Czech Hydrometeorological Institute (CHMI) and the Institute of Health Information and Statistics of the Czech Republic (IHIS CR). The vast majority of indicators reflect a 5-year period (i.e. they were created as averages for the respective indicators over five consecutive years; the authors of the original index explicitly give the condition of 5-year averages), the exceptions being the population with completed tertiary education (monitored with a 10-year periodicity through the population census), the emission balance and generativity. In the case of the emission balance, only the period 2013–2015 is included because since 2016 the CHMI publishes data only at the regional level (at a higher administrative level). Information on blood donors is published in the Reports on the activities of healthcare facilities in transfusion services in the Czech Republic. However, the relevant information could not be found after 2015.

The dataset of municipalities’ degree of membership of urban and rural spaces (Fig. 2) was adopted from Pászto et al. (2015, 2016). Based on this, a distinction can then be made between municipalities showing the characteristics of a purely

rural space (the membership degree of a rural space is equal to 1), an intermediate space (i.e. municipalities with a value around 0.5 can be considered as membership of an intermediate, suburban, space) and a purely urban space (where the membership degree of a rural space is equal to 0). Thus, when comparing different municipalities with each other, in contrast to the dichotomous approach, it is possible to claim that one municipality is more rural (or more urban) than another.

Methods

After choosing the approach to the quality of life assessment (sub-objective A) and urban and rural space definition approach (B) comes the design and implementation of the methodological procedure, addressed under sub-objective C.

First, graphical and statistical methods have been used to assess the character of the input data. Given the finding that all the main variables do not show normal distributions (Kolmogorov-Smirnov test), non-parametric methods independent of the distribution of the data set are applied in our research.

The quality of life index was standardized to range between 0–10 (i.e., worst–best) through min-max normalization. In the case of urban-rural municipality membership, two new variables for the membership scale of 0–1 were created (“0” means absolute non-belonging to the specific space, “1” means absolute belonging to the specific space). The resulting value of the degree of membership of urban space is complementary to the degree of membership of rural space.

The spatial analysis started with the evaluation of spatial autocorrelation. The purpose is to explain the dependence of the occurrence of any values in space on the occurrence of the same phenomena in the vicinity (the null hypothesis expects a random distribution of values; the alternative points to the clustering of similar values in space). First, the global Moran’s I (Cliff and Ord 1973) for the quality of life index and the municipality membership of urban and rural space was calculated. A significant positive spatial autocorrelation indicates the occurrence of similar neighbouring values, while a significant negative value indicates the dispersion of values over a given distance. A value close to zero indicates no spatial autocorrelation. Subsequently, local Moran’s I (LISA) was

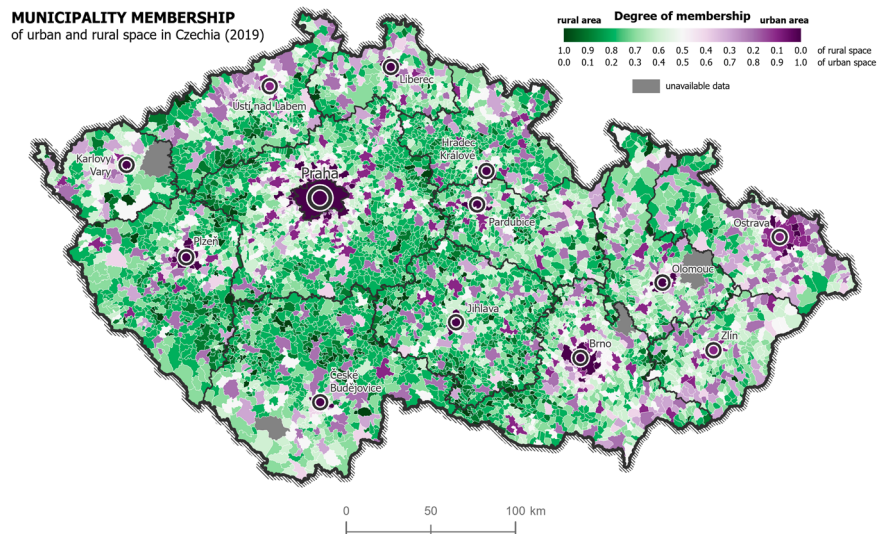


Fig. 2 Membership of the Czech municipalities to urban and rural space.

calculated, and specific spatial clusters were identified. A different sensitivity of autocorrelation was controlled by the bandwidth parameter settings. The k -nearest neighbours option was implemented, and different ranges were tested in the form of a vector of 50, 75, 100, 125, 150, 175, 200, 300, 400, 600, and 1,000 neighbours. The definition of clusters corresponds to a significance level of $\alpha = 0.05$, with False Discovery Rate correction applied. Based on the LISA outputs, it is possible to distinguish four categories of clusters:

- low–low (spatial concentration of low values);
- low–high (low value surrounded by high values — spatial outlier);
- high–low (high value surrounded by low values — spatial outlier);
- high–high (spatial concentration of high values).

In order to answer the defined research questions, interrelationships were examined, specifically using Spearman's correlation. Since the spatial autocorrelation is present in the data, the non-stationarity of the relationships between the main indicators was examined using the geographically weighted correlation as proposed by Kalogirou (2012), using a tricube kernel function and a specific bandwidth (in R using the *gwss* package). As in the case of spatial autocorrelation, the effect of the bandwidth parameter on the resulting correlation coefficient has been thoroughly investigated. An adaptive kernel with the bandwidth of 25, 50, 75, 100, 125, 150, 175, 200, 300, 400, 600 and 1000 k -nearest neighbours has been tested. Two bandwidth values were chosen for further interpretation — first, a band of 100 neighbours to capture more precisely local relationships (corresponding with the regional scope), and second, a band of 400 neighbours to capture the main spatial trends among the investigated phenomena. Interpretation of the resulting correlation coefficient was then carried out by the approach of de Vaus (2002), and with the generalization of the Spearman correlation coefficients of Yan et al. (2019) — the absolute coefficient values higher than 0.20 were considered meaningful. The definition of areas of correlation corresponds to a significance level of $\alpha = 0.05$.

Finally, a typology (based on bivariate mapping) was constructed to classify the municipalities of the Czech Republic into groups of elements according to the similarity of their characteristics in relation to the main phenomena. Three categories of quality of life have been distinguished (low, medium and high

quality of life levels) based on the division of continuous variables using the method of natural breaks into three intervals. The resulting groups are characterized by minimal within-group differentiation and, at the same time, by the greatest possible differences between the groups. The municipality membership of urban and rural space was also divided into three categories — the rather rural to rural space is delimited by an interval of 0.0–0.4 of a degree of membership of urban space; the intermediate space is given by the interval of 0.4–0.6 and rather urban to urban space was defined by an interval of 0.6–1.0. These essential individual categories for the typology design are listed in Table 2.

Results

The critical evaluation of the key findings regarding the geographical context of the analysed phenomena (i.e. sub-objective D) was based on the performed analytical outputs (interrelationships, spatial autocorrelation, geographically weighted correlation and typology) following the objectives and presented methodology.

Interrelationships. On the global level, there is no significant relationship between quality of life and urban/rural membership. The statistically insignificant correlation coefficient (with a value of 0.04) suggests that the global perspective seems insufficient, and the relationship between these two might only be observed on a local scale using the geographically weighted correlation method.

The relationships between partial indicators were further assessed at the global level. The correlation matrix displaying the values of the Spearman correlation coefficient at the level of individual phenomena and the whole integrated set is presented in Fig. 3. For example, higher values of the coefficient are observed for the population with completed tertiary education in pairs with each of the following: completed dwellings (0.37), population (0.31), share of urbanised area in the total area of the municipality (0.31). Indicators are mostly connected to urban settings, supporting the hypothesis that more educated people live and work in towns and cities, at least in the Czech context.

Spatial autocorrelation. In the case of the quality of life index, the global Moran's I reached a value of 0.78. At the significance level $\alpha = 0.01$, it can be concluded that the data indicates positive spatial autocorrelation (e.g. clustering of similar values).

Table 2 Defined categories of main phenomena.

Normalised QoL index		Municipality membership		
		of rural space	Space type	of urban space
Interval	QoL level	Interval		Interval
<0; 1)	low	<0; 0.1)	rather urban to urban	<0.9; 1)
(1; 2)		(0.1; 0.2)		<0.8; 0.9)
(2; 3)		(0.2; 0.3)		<0.7; 0.8)
(3; 4.7)		(0.3; 0.4)		<0.6; 0.7)
(4.7; 5)	medium	(0.4; 0.5)	intermediate	<0.5; 0.6)
(5; 6.48)		(0.5; 0.6)		<0.4; 0.5)
(6.48; 7)	high	(0.6; 0.7)	rather rural to rural	<0.3; 0.4)
(7; 8)		(0.7; 0.8)		<0.2; 0.3)
(8; 9)		(0.8; 0.9)		<0.1; 0.2)
(9; 10)		(0.9; 1)		<0; 0.1)

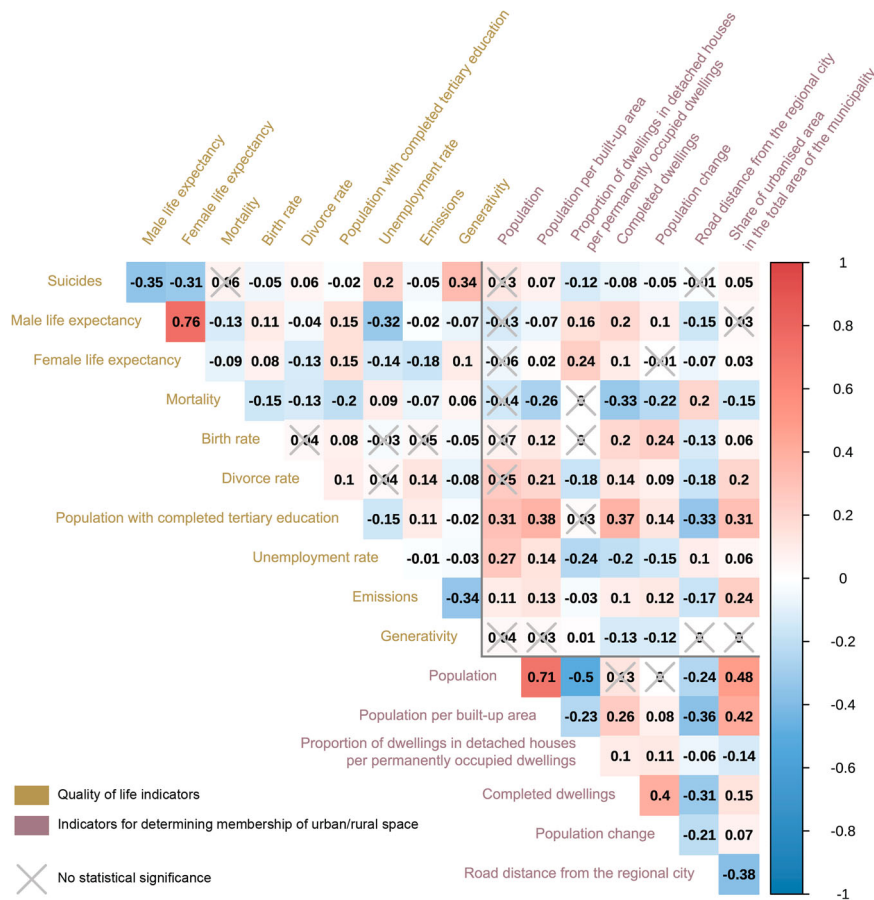


Fig. 3 Correlation matrix integrating QoL indicators and indicators for determining the municipality membership of rural and urban space.

The local Moran’s statistics (LISA) calculated for different bandwidth parameters are presented in Fig. 4. As the number of neighbours increases, the pattern in areas of low and high quality of life remains more or less unchanged, which is evidence of a

robust spatial trend. With an increasing number of neighbours, the areas of spatial outliers increase and are smoothed out.

For a more specific interpretation, a bandwidth of 100 neighbours was chosen to capture the regional perspective of

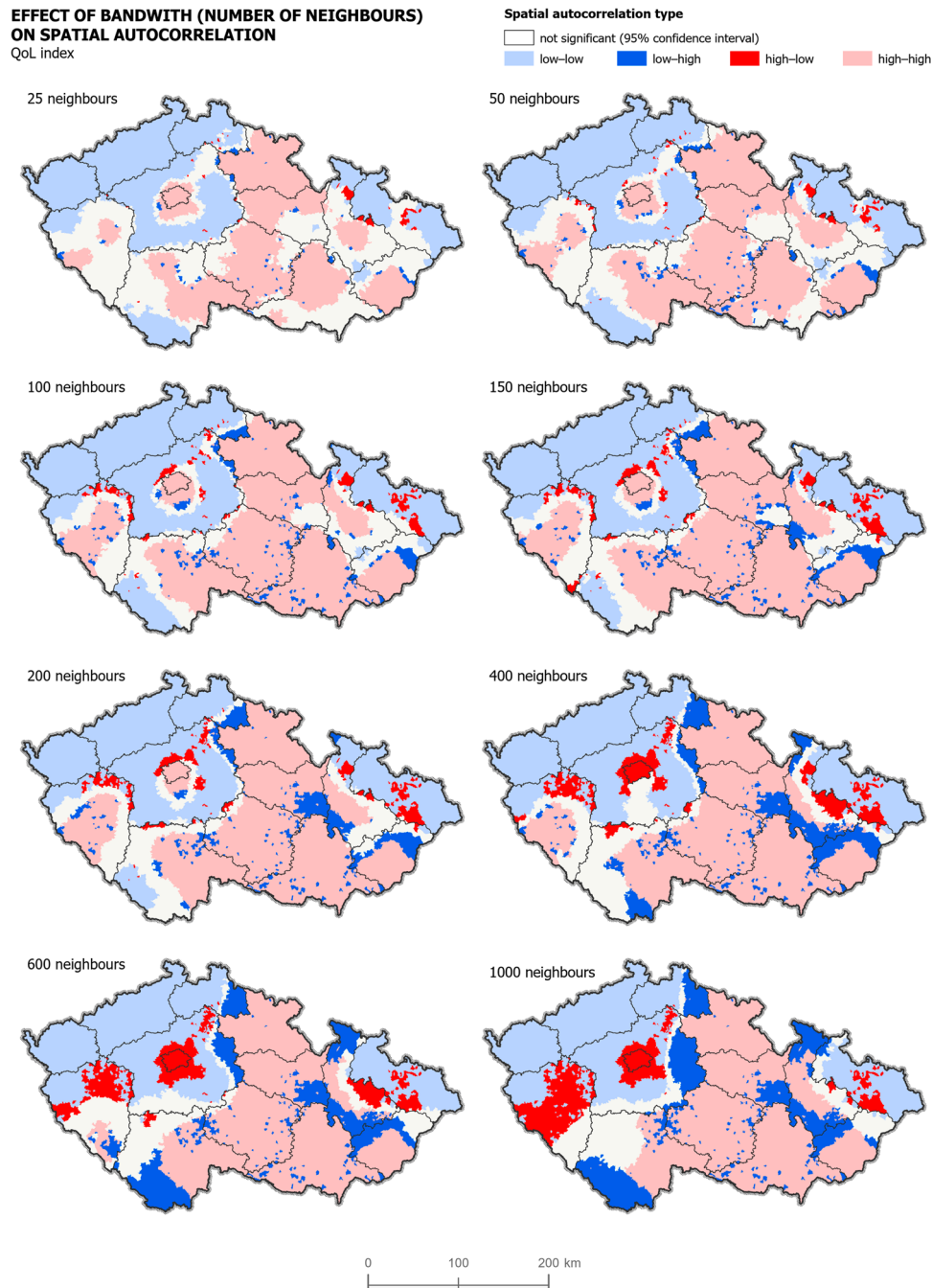


Fig. 4 Hot/cold spots of QoL as an output of LISA (effect of bandwidth — number of neighbours).

the analysis. Areas of low quality of life cover most of the Karlovy Vary, Ústí nad Labem, and Liberec regions, located in the north-west. A contiguous belt of low values surrounds the capital. The last significant cluster of low values is located in the northeast part of the country, the Moravia-Silesia region. These locations are well-known as deprived areas with significant economic and social problems. Alternatively, areas with a high level of quality of life include the territory of Prague and the regions of Hradec Kralove, Pardubice, Vysočina, Southern Moravia, Zlín, and the Pilsen and Olomouc regions; mostly regions in the central and south-east part of the country (with exceptions in the Prague and Pilsen region). Furthermore, spatial outliers were identified and were fragmented throughout the Czech Republic. In most cases, the areas classified as outliers represent the contact areas between the high and low-value areas. Territories of high quality of life

surrounded by low values are registered, for example, in the Moravian-Silesian Region (north-east of Czechia), on the periphery of the Pilsen Region and around Prague.

Spatial autocorrelation was also examined for the second of the main phenomena. In the case of the municipality membership of rural and urban spaces, the global Moran's I criterion was 0.25, i.e. the degree of clustering is much lower than in the case of quality of life. The LISA showed the (expected) core areas of larger regional cities (Prague, Brno, Ostrava; Appendix 2) and the heterogeneous settlement pattern of the Czech Republic.

Geographically weighted correlation. Testing the geographically weighted correlation between quality of life and membership of urban space showed significant sensitivity to the setting of

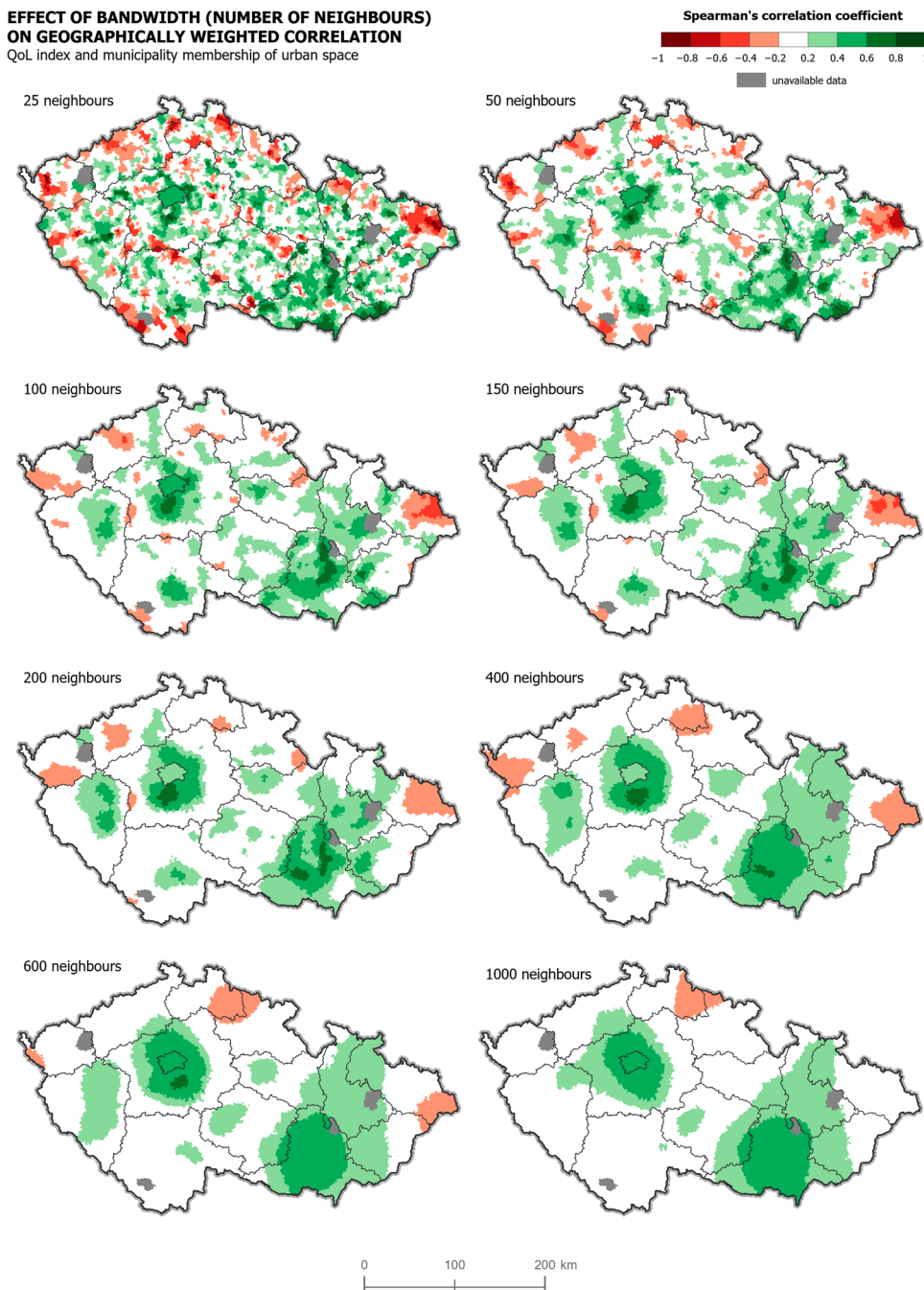


Fig. 5 Effect of bandwidth (number of neighbours) on the Geographically weighted correlation.

parameters describing the conceptualisation of spatial relationships. Depending on the settings of the neighbourhood, the spatial non-stationarity of the investigated correlation is captured in variable detail. Fig. 5 confirms that when a smaller number of neighbours (smaller bandwidth) are selected, the areas of statistically significant correlation become smaller and fragmented. When neighbours increase, these areas become more continuous and capture the main spatial trend. There is also a decrease in absolute values of the correlation coefficients as the number of neighbours increases — almost perfect and strong correlations (typical for fragmented areas due to low number of neighbours) turn into low, medium and significant correlations (larger continuous ranges), and provide a smoothed-out view of the spatial trend. In general, negative correlation is observed more with a smaller number of neighbours, and it disappears with increasing bandwidth.

For interpretation purposes, we chose a setting with 100 neighbours, which we consider a reasonable compromise — the areas of statistically significant correlation of the observed phenomena are not too fragmented, and at the same time, the correlation coefficient is not too low due to excessive smoothing.

A positive relationship between the quality of life index and membership of urban space (Fig. 6) has been mainly found in the core areas of regional cities such as Prague, Brno, Plzeň, Olomouc, České Budějovice, Pardubice and Zlín. In the south-eastern part of the country, the areas of positive correlation are more continuous, while in the rest of the country, they are more like isolated islands around major cities. The negative correlation occurs to a much-reduced extent, most significantly in the northeast (around the third biggest city, Ostrava) and in minor quantities in the northwest of the country.

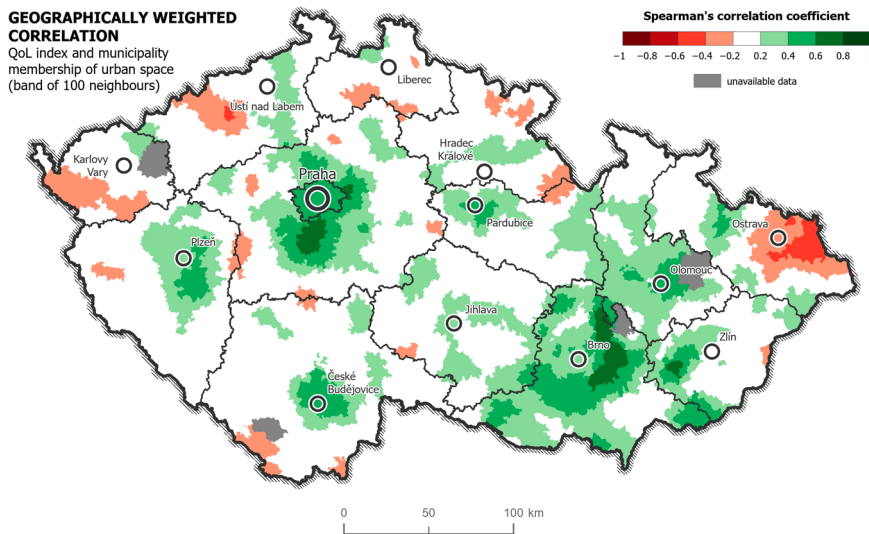


Fig. 6 Geographically weighted Spearman's correlation (band of 100 neighbours).

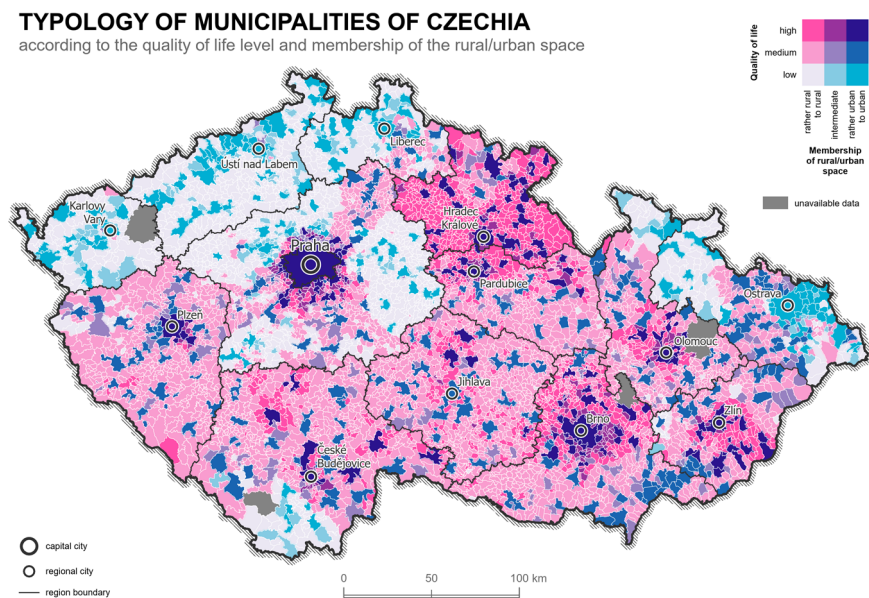


Fig. 7 Typology of municipalities of Czechia according to QoL level and membership of rural/urban space.

When the quality of life is assessed in relation to the rural space (instead of the urban space), it is sufficient to replace the signs of the correlation coefficient with their opposites. The absolute tightness of the relationship and the spatial distribution remain the same.

We conclude that a positive correlation between the quality of life index and urban space membership in many locations across Czechia points to a higher quality of life in more urban to urban spaces — as membership of urban space increases, the value of the quality of life index increases. Some notable exceptions are the areas of Ostrava (north-east part of Czechia), the south-western area of the Karlovy Vary Region (the most western part of the country), and smaller to medium-sized areas in the Ústí nad Labem and Liberec Region (north-west part of the country), where the relationship is the opposite — the value of the quality of life index decreases with increasing membership of urban space. Again, this supports the fact that specifically these regions are considered to be a deprived part of the country with major structural problems.

We note, however, that any values of correlation coefficients are not reached directly in the centres of core areas (larger cities) but

must always be related to the context of their surroundings (by the nature of the method used, e.g. the defined 100 nearest neighbours). That raises the question/hypothesis of whether a high quality of life is not dominated by so-called intermediate spaces with a slight tendency to belong to urban spaces (i.e. the suburbs).

Typology. The typology of Czech Republic municipalities according to the quality of life and membership of an urban/rural space is presented on the map in Fig. 7.

A high level of quality of life is typical in the Hradec Králové Region, Prague, Brno, Plzeň, Olomouc, České Budějovice, Pardubice and Zlín — both in their urban areas and in their hinterlands. The sharp transitions between the Hradec Králové and Pardubice regions and their surroundings are due to a favourable combination of quality of life indicators — particularly, a favourable emission balance, the highest proportion of blood donors and low mortality, divorce and unemployment rates. Low quality of life is typical for the Karlovy Vary Region, the Ústí nad Labem Region, a large part of the Liberec Region, the Moravian-Silesian Region and the

Table 3 Overview of typology types and their frequencies.

Type	Municipalities		Population (2018)		Area	
	Count	in %	Count	in %	Area (in km ²)	in %
QoL low, S rather rural to rural	1209	19.4	625,304	5.9	15,866	20.4
QoL low, S intermediate	161	2.6	227,021	2.1	2492	3.2
QoL low, S rather urban to urban	145	2.3	2,204,362	20.8	4726	6.1
QoL medium, S rather rural to rural	2822	45.2	1,331,781	12.6	29,470	37.8
QoL medium, S intermediate	233	3.7	363,833	3.4	3524	4.5
QoL medium, S rather urban to urban	214	3.4	1,835,175	17.3	6823	8.8
QoL high, S rather rural to rural	1107	17.7	529,563	5.0	9139	11.7
QoL high, S intermediate	203	3.2	244,589	2.3	1404	1.8
QoL high, S rather urban to urban	154	2.5	3,246,894	30.6	4455	5.7
Total	6248	100.0	10,608,522	100.0	77,898	100.0

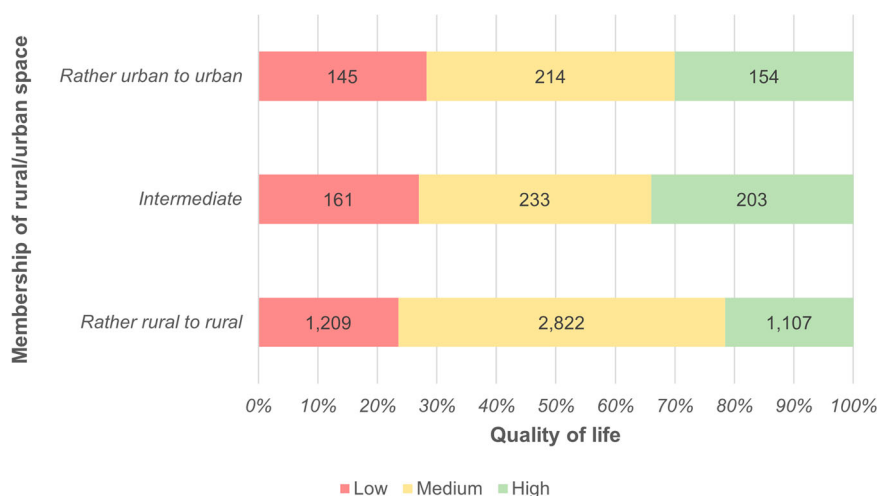


Fig. 8 Graphical comparison of QoL levels in individual spaces.

periphery of the Central Bohemian Region. At this point, it is worth noting that four regions show a high level of inter-heterogeneity based on the typology. These are the Central Bohemian Region, the South Bohemian Region, the Moravian-Silesian Region, and the Olomouc Region. This heterogeneity manifests itself in various combinations of high to low quality of life and rural/urban membership. For two regions (the South Bohemian Region and the Olomouc Region), a sudden change in the relationship is seen towards the borders. The Central Bohemian Region reflects the main “out-of-Prague” settlement directions (in terms of good quality of life and the urban nature of the municipalities), while the trend in the Moravian-Silesian Region changes from low values of both phenomena in the west to a relatively evenly dispersed good quality of life in both rural and urban areas (central part of the region), and to low quality of life in a more urban environment (which is structurally problematic — economically and socially).

Table 3 shows the number of municipalities classified in each type and the frequency in relation to population and area (space abbreviated as “S”). Considering the population, the largest part

of the population comes under the high quality of life and rather urban to urban space (3.25 million inhabitants, almost 31% of the total area). The second and third largest groups are: the low quality of life and rather urban to urban space (2.2 million inhabitants, approximately 21%) and the medium quality of life and the same kind of space (1.84 million inhabitants, 17.3%). Over 1.3 million inhabitants (i.e. more than 12% of the total area) live in areas of a medium quality of life and rather rural to rural space. Conversely, the quality of life in the intermediate spaces has the smallest part of the population. In the case of the low quality of life type, that is about 230 thousand inhabitants (more than 2%), the high quality of life covers almost 245 thousand inhabitants (2.3%), and the medium quality of life in intermediate space includes 364 thousand inhabitants (3.4%).

By calculating the proportions of individual quality of life levels in the defined spaces, it was finally determined which quality of life level dominates (is the most frequent) in the individual spaces. As the graph in Fig. 8 shows, in the more urban to urban spaces the medium level of quality of life prevails (42% share),

with the high and low levels being similar (both around 30%). In the intermediate space, the medium level prevails again, but the high level increases slightly. The low level of quality of life reaches a comparable amount as in the case of the previous space. The rather rural to rural space accounts for more than half of the medium quality of life, which is predominant here (the percentages of high and low quality of life are around 20%).

Discussion

The presented quality of life index, as an updated version of the index devised by Murgaš and Klobučník (2016), meets the original methodological criteria and describes the period 2014–2018 (compared to the originally described period 2001–2011). However, in its construction, we faced the following obstacles, which were the result of a lack of availability of data in the required timeframe and an insufficient level of detail in the data:

- Data on the population with completed tertiary education in the Czech Republic are collected only through the census conducted by the Czech Statistical Office once every ten years. It was, therefore, necessary to include older data from 2011 in the index, as the results of the census of 2021 were not available at the time of the index's construction.
- Data on blood donors (generativity indicator) published in the reports on the activities of health facilities in the field of blood transfusion services in the Czech Republic are not available for the years 2014 and 2016–2018. The same complications in constructing the index were probably faced by Murgaš and Klobučník (2016), who only recovered data for the years 2007, 2009 and 2011 from the period 2001–2011.
- Since 2016, the Czech Hydrometeorological Institute has published downloadable data on the emission balance, but only at the regional level, whereas before 2016, it also presented it at the (necessary) district level. Our constructed index, therefore, only considers the period 2013–2015.

However, despite the above, the presented quality of life assessment is sufficient and fulfils the purpose for which it was carried out. Furthermore, other studies are focusing on quality of life assessment. One could be the quality of life index proposed by Median and the Aspen Institute research agencies (Prokop 2018) or by Macků et al. (2023). Another direction for future research could be to validate the robustness of the findings through different approaches to quality of life assessment.

The choice of input indicators can be the subject of discussion — not only in terms of their availability and spatial and temporal resolution, but also their relevance and relationship to the topic under study. Also, for this reason, we have tried not to complicate this step further and have not included additional variables. Therefore, in the case of quality of life, we have decided to choose one specific assessment approach on which we built methodology. However, we are fully aware that this approach represents one of many points of view. On the other hand, it is necessary to realize that different authors see the concept of quality of life through a different lens – both on understanding the term “quality of life” itself and on the way of assessing it. To this, Liu (1976) comments that there exists as many quality of life definitions as researchers dealing with this issue.

The parameterization of the spatial methods is always a subject for discussion — in particular, the question of the definition of spatial relationship in cases of spatial autocorrelation and geographically weighted correlation. As already indicated, testing both methods showed a significant sensitivity to the setting of parameters describing the conceptualization of spatial

relationships. In the case of geographically weighted correlations, the optimal number of 100 neighbours, which resulted from extensive testing, was chosen as a compromise solution to maintain the tightness of the relationships between the observed phenomena at a high level while allowing easier spatial interpretability. For spatial autocorrelation analysis, this optimum also provided homogenous and easily interpretable spatial clusters. It should be noted that the term neighbourhood and its perception are, to some extent, an individual matter. It is, of course, possible to use automatic optimization methods to select the numerically most appropriate parameter. In many cases, however, it is preferable to select the parameters by expert determination with the targeted detail of the analysis. As demonstrated in the Results chapter, in our case, the analysis outputs are quite robust, and they maintain an overall spatial trend that is only altered by changing the level of detail.

The study of the spatial differentiation of the quality of life in urban and rural spaces, using a fuzzy approach for their definition, can be described as rarely seen and almost unique in the Czech environment. Existing studies concerned with the objective dimension of quality of life are less frequent than studies of the subjective dimension. At the same time, they look at the quality of life in urban and rural environments separately or define such spaces according to traditional criteria (population, population density, state of the municipality). The fuzzy approach allowed us to consider both aspects and, in addition, to add the aspect of intermediate space.

Finally, it is regrettable that most quality of life assessments in the Czech Republic are one-offs, where the relevant index is not updated after the publication of the study, and thus their usefulness for potential analyses decreases every year. One exception is the quality of life assessment *Obce v datech – Municipalities in Data* (2022), published continuously since 2018. However, this approach was not used in our analyses due to the sub-indicators' absence (openness), and the data's spatial level was inadequate (MEP; municipality with extended powers).

We believe and demonstrate that the presented quality of life assessment in urban, intermediate and rural spaces is universal, generally valid, and replicated by other upcoming studies. Simply put, it is possible to replace the quality of life assessment with another one, i.e., one that will correspond to the specifics and intention of the researcher.

The fact that the indicators entered into the construction of the quality of life index are objective in nature also deserves a separate discussion. Indeed, quality of life is a very individual and subjective matter. However, it is almost impossible to obtain a valid and relevant sample of subjective feelings from the inhabitants of the regions. Thus, for quantitative spatial analyses characterizing relationships over the whole country (and thus not just idiographically in selected parts), the only option is to use “bulk” datasets from censuses or other statistical or spatial datasets.

Conclusion

The main goal of this paper was to present a methodology for objectively assessing the relationship between the phenomena of quality of life and the municipality membership of rural and urban space.

The introductory part of the paper was devoted to the complex issue of the concept of quality of life regarding its characteristic features and its geographical aspects. To the latter, attention has been drawn to rural and urban space definitions. Existing approaches regarding their definition were also presented – including the fuzzy approach and its application in defining the spaces under consideration and as a counterpoint (alternative) to

the classical dichotomous approach of urban versus rural. In the “Quality of life differentiation in urban and rural space” chapter, a clear connection of the topics under consideration was made, namely the presentation of already implemented studies into the spatial differentiation of quality of life in urban and rural space. Selected aspects from this wide field of studies have been summarised in the attached structured tabular overview.

The basis for the presented study was our quality of life assessment and an updated form of the dataset of membership of Czech municipalities of urban and rural space from the study by Pászto et al. (2015, 2016) — sub-objectives A and B were thus fulfilled. One indisputable advantage is the use of a fuzzy approach in determining the membership degree of municipalities in rural and urban space, which allowed us — in addition to the traditional aspects (quality of urban and rural life) — to add the aspect of intermediate space.

Within the exploratory non-spatial analysis, attention was paid to examining the links between the main phenomena and to a deeper examination of the interrelationships at the level of the indicators of the main phenomena and across all the indicators considered. Local relationships were examined due to the absence of a significant global relationship between the main phenomena. Sub-objective C was fully met.

The existence of a positive geographically weighted correlation of the main phenomena indicated that an increase in quality of life went with increasing urban space membership — this is also the answer to the second research question of the paper, whether quality of life is higher in urban or rural spaces, the answer to which was proved by the analysis results. However, there were also exceptions where this dependence is contradictory. Concerning the spatial behaviour of the geographically weighted correlation, it was also found that the highest absolute values of the correlation coefficient were generally not achieved in the centres of the core areas (i.e. larger cities) but in their surroundings (in the suburbs) — which induced the third research question regarding the predominance of high quality of life in intermediate spaces.

Based on the calculation of the proportions of each level of quality of life at the level of the defined spaces, it was found that the potential for a high level of quality of life is in the intermediate spaces – for their combination of favourable urban and rural characteristics (third research question answered). Thus, the first research question is answered as the expressed (in)coherence of the spatial pattern of the geographically weighted correlation was confirmed. Given that the second largest proportion of high quality of life levels is concentrated in cities, it can be assumed that over time, the potential for high quality of life is shifting from cities through the suburbs to their immediate surroundings.

In conclusion, the presented study has provided answers to research questions 1–3 and insight into spatial differentiation of quality of life in the (Czech) geographical context, with a special focus on the rural-urban continuum. Even the last sub-objective (D) was also fulfilled. This paper can serve as a potential methodology for studying the spatial differentiation of quality of life in the urban and rural spaces of any state, territory or region. To our knowledge, our methodological approach is highly innovative. In similar studies, it has never been used in research on the relationship between quality of life and urban/rural space membership. The study of the spatial differentiation of quality of life can be described as a little-noticed undertaking unique in the Czech environment.

Data availability

The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

Received: 9 July 2023; Accepted: 16 November 2023;

Published online: 03 January 2024

References

- Andráško I (2013) *Quality of Life – An Introduction to the Concept*. Masarykova univerzita
- Bernini C, Tampieri A (2017) Urbanization and its Effects on the Happiness Domains. *DEM Discussion Paper Series*, 17(10)
- Bertolini P, Pagliacci F (2017) Quality of Life and Territorial Imbalances: A Focus on Italian Inner and Rural Areas. *Bio-Based Appl Econ* 6(2):183–208. <https://doi.org/10.13128/BAE-18518>
- Binek J (2007) *Venkovský prostor a jeho oživení*. Georgetown
- Camaioni B, Esposti R, Lobianco A, Pagliacci F, Sotte F (2013) How Rural is the EU RDP? An Analysis through Spatial Fund Allocation. *Bio-Based Appl Econ* 2(3):277–300. <https://doi.org/10.13128/BAE-13092>
- Campanera JM, Higgins P (2011) Quality of life in urban-classified and rural-classified english local authority areas. *Environ Plan A: Econ Space* 43(3):683–702. <https://doi.org/10.1068/a43450>
- Czech Republic (2000) Zákon č. 128/2000 Sb., o obcích. In *Sbírka zákonů České republiky* (Vol. 38, pp. 1378–1800)
- Chalupa P, Tarabová Z (1990) *Geografie obyvatelstva, demografie, geografie sídel*. Masarykova univerzita
- Cliff AD, Ord K (1973) *Spatial Autocorrelation*. Pion
- CZSO (2008) *Varianty vymezení venkova a jejich zobrazení ve statistických ukazatelích v letech 2000 až 2006*
- de Vaus D (2002) *Analyzing social science data*. SAGE Publications
- Diener E, Suh E (1997) Measuring quality of life: Economic, social, and subjective indicators. *Soc Indic Res* 40(1/2):189–216. <https://doi.org/10.1023/A:1006859511756>
- Dijkstra L, Poelman H (2014) *A Harmonised Definition of Cities and Rural Areas: The New Degree of Urbanisation*
- Dissart J-C, Deller SC (2000) Quality of life in the planning literature. *J Plan Lit* 15(1):135–161. <https://doi.org/10.1177/08854120022092962>
- Emerson EB (1985) Evaluating the impact of deinstitutionalization on the lives of mentally retarded people. *Am J Mental Deficiency* 90(3):277–288
- Fayers PM, Machin D (2007) *Quality of Life: The Assessment, Analysis and Interpretation of Patient-reported Outcomes*. John Wiley and Sons
- Florida R (2002) *The Rise of the Creative Class: And How It's Transforming Work, Leisure, Community and Everyday Life*. Basic Books
- Frey WH, Zimmer Z (2001) Defining the City. In R. Paddison (Ed.), *Handbook of Urban Studies*. SAGE Publications. <https://doi.org/10.4135/9781848608375>
- Gerdtham U-G, Johannesson M (2001) The relationship between happiness, health, and socio-economic factors: results based on Swedish microdata. *J Socio-Econ* 30(6):553–557. [https://doi.org/10.1016/S1053-5357\(01\)00118-4](https://doi.org/10.1016/S1053-5357(01)00118-4)
- Helburn N (1982) Presidential address: Geography and the quality of life. *Ann Assoc Am Geogr* 72(4):445–456
- Ira V, Andráško I (2007) Kvalita života z pohľadu humánnej geografie. *Geografický Časopis* 59(2):159–179
- Ira V, Murgaš F (2008) Geografický pohľad na kvalitu života a zmeny v spoločnosti na Slovensku. *Geographia Slovaca*, 25
- Kalogirou S (2012) Testing local versions of correlation coefficients. *Jahrbuch Für Regionalwissenschaft* 32(1):45–61. <https://doi.org/10.1007/s10037-011-0061-y>
- Knight J, Gunatilaka R (2010) The Rural–Urban Divide in China: Income but Not Happiness? *J Dev Stud* 46(3):506–534. <https://doi.org/10.1080/00220380903012763>
- Kubíček P (2012) *Vybrané aspekty vizualizace nejistoty geografických dat* [Habilitation práce]. Masarykova univerzita
- Lenzi C, Perucca G (2018) Are urbanized areas source of life satisfaction? Evidence from EU regions. *Pap Regl Sci* 97(S1):S105–S122. <https://doi.org/10.1111/pirs.12232>
- Liu B-C (1976) *Quality of Life Indicators in U.S. Metropolitan Areas, 1970: A Statistical Assessment*. Praeger
- Ma L, Liu S, Fang F, Che X, Chen M (2020) Evaluation of urban-rural difference and integration based on quality of life. *Sustain Cities Soc* 54. <https://doi.org/10.1016/j.scs.2019.101877>
- MacEachren AM, Robinson A, Hopper S, Gardner S, Murray R, Gahegan M, Hetzler E (2005) Visualizing geospatial information uncertainty: What we know and what we need to know. *Cartogr Geogr Inf Sci* 32(3):139–160. <https://doi.org/10.1559/1523040054738936>
- Macků K, Burian J, Vodička H (2023) Implementation of GIS tools in the quality of life assessment of Czech municipalities. *ISPRS Int J Geo-Inf* 12(2):43. <https://doi.org/10.3390/ijgi12020043>
- Macků K, Čaha J, Pászto V, Tuček P (2020) Subjective or objective? How objective measures relate to subjective life satisfaction in Europe. *ISPRS Int J Geo-Inf* 9(5):320. <https://doi.org/10.3390/ijgi9050320>

- Marans RW (2015) Quality of urban life & environmental sustainability studies: Future linkage opportunities. *Habitat Int* 45:47–52. <https://doi.org/10.1016/j.habitatint.2014.06.019>
- Massam BH (2002) Quality of life: Public planning and private living. *Progr Plan* 58(3):141–227
- Mayer HM (1971) Definitions of City. In L. S. Bourne (Ed.), *Internal Structure of the City: Readings on Space and Environment*. Oxford University Press
- Mazziotta M, Pareto A (2016) Methods for constructing non-compensatory composite indices: A comparative study. *Forum Soc Econ* 45(2–3):213–229. <https://doi.org/10.1080/07360932.2014.996912>
- Meeberg GA (1993) Quality of life: A concept analysis. *J Adv Nurs* 18(1):32–38. <https://doi.org/10.1046/j.1365-2648.1993.18010032.x>
- Murgaš F (2018) Kvalita místa jako vyjádření objektivní dimenze kvality života. In V. Klímová & V. Žitěk (Eds.), *XXI. mezinárodní kolokvium o regionálních vědách*. Masarykova univerzita
- Murgaš F, Klobučník M (2016) Municipalities and regions as good places to live: Index of quality of life in the Czech Republic. *Appl Res Qual Life* 11(2):553–570. <https://doi.org/10.1007/s11482-014-9381-8>
- Ministry of Agriculture of the Czech Republic (2007) *Program rozvoje venkova České republiky na období 2007–2013*
- Novák V (1989) *Fuzzy Sets and Their Applications*. Adam Hilger
- Obce v datech (2022) *Obce v datech*. <https://www.obcevdtech.cz/>
- OECD (2006) *The New Rural Paradigm: Policies and Governance*
- OECD (2011) *OECD Regional Typology*
- Okulicz-Kozaryn A (2013) City Life: Rankings (livability) versus perceptions (satisfaction). *Soc Ind Res* 110(2):433–451. <https://doi.org/10.1007/s11205-011-9939-x>
- Pacione M(2003) Urban environmental quality and human wellbeing - a social geographical perspective. *Landscape Urban Plan* 65(1-2):19–30. [https://doi.org/10.1016/S0169-2046\(02\)00234-7](https://doi.org/10.1016/S0169-2046(02)00234-7)
- Pagliacci F (2017) Measuring EU urban-rural continuum through Fuzzy logic. *Tijdschrift Voor Economische En Sociale Geografie* 108(2):157–174. <https://doi.org/10.1111/tesg.12201>
- Pászto V, Brychtová A, Tuček P, Marek L, Burian J (2015) Using a fuzzy inference system to delimit rural and urban municipalities in the Czech republic in 2010. *J Maps* 11(2):231–239. <https://doi.org/10.1080/17445647.2014.944942>
- Pászto V, Burian J, Marek L, Voženilek V, Tuček P (2016) Fuzzy přístup při určování příslušnosti obcí do venkovského a městského prostoru. *Geografie* 121(1):156–186
- Perlin R (1998) *Venkov, typologie venkovského prostoru*. Univerzita Karlova
- Perlin R (2009) Vymezení venkovských obcí v Česku. *Obec a Finance* 14(2):38–42
- Perlin R (2010) Theoretical approaches of methods to delimitate rural and urban areas. *European Countryside* 2(4):182–200. <https://doi.org/10.2478/v10091-010-0013-5>
- Prokop D (2018) Kvalita života. *Kam Kráčíš Česko?*, 74–87
- Ratzel F (1882) *Anthropogeographie*. J. Engelhorn
- Rogerson RJ (1995) Environmental and health-related quality of life: Conceptual and methodological similarities. *Soc Sci Med* 41(10):1373–1382. [https://doi.org/10.1016/0277-9536\(95\)00122-N](https://doi.org/10.1016/0277-9536(95)00122-N)
- Shucksmith M, Cameron S, Merridew T, Pichler F (2009) Urban–rural differences in quality of life across the European Union. *Regl Stud* 43(10):1275–1289. <https://doi.org/10.1080/00343400802378750>
- Slepička A (1981) *Venkov a/nebo město – lidé, sídla, krajina*. Nakladatelství Svoboda
- Sørensen JFL (2014) Rural–urban differences in life satisfaction: Evidence from the European Union. *Regl Stud* 48(9):1451–1466. <https://doi.org/10.1080/00343404.2012.753142>
- Sýkora L (1993) Teoretické přístupy ke studiu města. In L. Sýkora (Ed.), *Teoretické přístupy a vybrané problémy v současné geografii*. Univerzita Karlova
- Székely V (2006) Urban Municipalities versus Rural Municipalities — Selected Aspects of Quality of Life in Slovakia. *Europa XXI* 15:87–102
- Trip JJ (2007) Assessing quality of place: A comparative analysis of Amsterdam and Rotterdam. *J Urban Affairs* 29(5):501–517. <https://doi.org/10.1111/j.1467-9906.2007.00362.x>
- University of Toronto (2003) *The Quality of Life Model*. Quality of Life Research Unit. http://sites.utoronto.ca/qol/qol_model.htm
- Veenhoven R (2000) The four qualities of life. *J Happiness Stud* 1(1):1–39
- Veenhoven R (2006) The Four Qualities of Life: Ordering Concepts and Measures of the Good Life. In M. McGillivray & M. Clarke (Eds.), *Understanding Human Well-being* (pp. 74–100). UNU Press
- Veenhoven R (2014) Livability Theory. In A. C. Michalos (Ed.), *Encyclopedia of Quality of Life and Well-Being Research* (pp. 3645–3647). Springer Netherlands. https://doi.org/10.1007/978-94-007-0753-5_1669
- Winters JV, Li Y (2017) Urbanisation, natural amenities and subjective well-being: Evidence from US counties. *Urban Stud* 54(8):1956–1973. <https://doi.org/10.1177/0042098016631918>
- Yan Z, Wang S, Ma D, Liu B, Lin H, Li S (2019) Meteorological Factors Affecting Pan Evaporation in the Haihe River Basin, China. *Water* 11(2):1–18. <https://doi.org/10.3390/w11020317>
- Zimmermann H-J (2001) *Fuzzy Set Theory — and Its Applications* (Fourth Edition). Springer

Author contributions

We confirm contribution to the paper as follows: study conception and design: OR, KM; data preparation and processing, analysis: OR; interpretation of results: OR, KM, VP; draft manuscript preparation: OR, KM, VP. All authors reviewed the results and approved the final version of the manuscript.

Funding

This paper was supported by the Internal Grant Agency of Palacký University Olomouc under project IGA_PrF_2023_017.

Competing interests

The authors declare no competing interests.

Ethical approval

This article does not contain any studies with human participants performed by any of the authors.

Informed Consent

This article does not contain any studies with human participants performed by any of the authors.

Additional information

Supplementary information The online version contains supplementary material available at <https://doi.org/10.1057/s41599-023-02423-1>.

Correspondence and requests for materials should be addressed to Oldřich Rypl.

Reprints and permission information is available at <http://www.nature.com/reprints>

Publisher's note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.



Open Access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons license, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons license and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this license, visit <http://creativecommons.org/licenses/by/4.0/>.

© The Author(s) 2024