



Study on Residents' Quality of Life in the Context of Urban Shrinkage: Analysis Based on Subjective and Objective Data

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Abstract: Urban shrinkage has become a global phenomenon. However, the impact of urban shrinkage on residents' lives has not received enough attention from scholars and urban policymakers. This paper explores the extent to which urban shrinkage has an impact on residents' quality of life, and the ways in which it does so. Taking a typical shrinking city, Yichun, as an example, the statistical data and microblog data are used to quantitatively assess the impact of urban shrinkage on residents' objective and subjective quality of life and analyze the spatial-temporal evolution of residents' objective and subjective quality of life. The results indicate that urban shrinkage affects residents' quality of life, but the variation trend of objective quality of life is not necessarily consistent with that of subjective quality of life. In addition, the degree of urban shrinkage has a significant effect on residents' quality of life. The more severe the urban shrinkage, the more significant the impact on residents' quality of life. **DOI:** [10.1061/\(ASCE\)UP.1943-5444.0000597](https://doi.org/10.1061/(ASCE)UP.1943-5444.0000597). © 2020 American Society of Civil Engineers.

Author keywords: Residents' quality of life; Urban shrinkage; Subjective and objective data; Yichun City.

Introduction

In the context of globalization and deindustrialization, urban shrinkage has become a global phenomenon and has attracted the widespread concern of scholars and policymakers all over the world (Großmann et al. 2012; Xie et al. 2018). Over 25% of the world's big cities are considered to be shrinking cities, with some cities in China also experiencing this course (Großmann et al. 2012). Urban shrinkage is not synonymous with urban decline (Weaver et al. 2016). Urban population decrease can reduce the density of the same, thus reducing the degree of congestion and improving the quality of the environment and residents' life satisfaction (Kyttä et al. 2016). However, some scholars also believe that population decrease will affect the sustainable development of cities, which is not conducive to the improvement of residents' quality of life (Couch et al. 2005). From the perspective of city coevolution, urban shrinkage, that is, a decrease in population, will inevitably cause changes in other aspects of a city, such as economic development and social impact (Barthélemy and Flammini 2009; Li et al. 2016, 2020). However, the social impact of urban shrinkage has not received enough attention. On this basis, the current paper examines how residents' quality of life can change in the context of urban shrinkage in China.

In studies on cities and regions in the 1980s, some scholars paid attention to urban shrinkage (Van den Berg et al. 1982). German scholars Häußermann and Siebelm first proposed the concept of the *shrinking city* in 1988 (Häußermann and Siebel, 1988). After that, scholars began to discuss its definition (Lee et al. 2016; Alves et al. 2016). The process of city shrinkage is such that in a densely populated region of more than 10,000 people, due to economic or structural crises, the region suffers from continuous population loss for over 2 years (Wiechmann 2008). This definition has been widely accepted in academic circles. Based on this, growing numbers of scholars have conducted studies on the theories related to shrinking cities (Döringer et al. 2019). In addition, some scholars hold the view that similar to urban growth, urban shrinkage is a regularly occurring, normal phenomenon (Gao 2017); some scholars have also put forward relevant coping strategies (Batunova and Gunko 2018). On the basis of the spatial distribution of the population, relevant scholars have classified the patterns of urban shrinkage into the *perforated* type (Schetke and Haase 2008) and the *doughnut* type (Blanco et al. 2009), as well as some special spatial patterns (Pacione 2004; Martinez-Fernandez et al. 2012). In terms of the study object, to date, existing studies have paid more attention to the phenomenon of urban shrinkage in industrial cities and resource-based cities (Martinez-Fernandez et al. 2012; Jaroszevska 2019), which attention is gradually expanding to cover regional and global cities (Martinez-Fernandez et al. 2016). From the perspective of study scale, studies on shrinking cities have gradually shifted from a macroperspective—such as a comparison between the degrees of the shrinkage of East Germany and West German (Bontje 2004) and the shrinkage of *rust belt* areas in America (Schilling and Logan 2008)—to the microperspective. In terms of research content, studies on shrinking cities have gradually extended from a focus on their definition, processes of change, action mechanisms, and so forth (Zhang et al. 2019; Rieniets 2009) to the influential effect and management strategy of urban shrinkage (Du et al. 2019; Jaroszevska 2019; Batunova and Gunko 2018). Overall, studies on shrinking cities show the characteristics of range extension, a wide audience, and diversity of participants.

Previous studies have indicated that urban growth is not an essential requirement for residents to obtain satisfaction from life (Dassopoulos et al. 2012); in fact, some research has found that

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Note. This manuscript was submitted on October 1, 2019; approved on April 8, 2020; published online on June 18, 2020. Discussion period open until November 18, 2020; separate discussions must be submitted for individual papers. This paper is part of the *Journal of Urban Planning and Development*, © ASCE, ISSN 0733-9488.

urban stresses decrease in areas of population loss (Baldassare and Wilson 1995; Van Dalen and Henkens 2011), therefore enabling people to obtain opportunities for a better life (Kauko 2011; Hollander et al. 2009; Carmon 1999). In addition, residents' perception of the environment has been found to be closely related to their own happiness (Kytä et al. 2016). Delken (2008) studied the subjective quality of life of urban residents in Germany, finding that the overall degree of satisfaction in shrinking cities was no less than that of other cities. Indeed, it is even higher in some aspects. Schetke and Haase (2008) conducted an evaluation of the social environment of shrinking cities in East Germany from various perspectives; the conclusions revealed that while the process of urban shrinkage significantly affected the living and social environment, it had no significant impact on residents' overall quality of life. Hollander (2011) conducted a survey on the quality of life in 38 urban communities and processed the data using quantitative methods, such as descriptive statistics. The results indicated great differences in the quality of life of different shrinking cities, and that in some areas where the population and housing decreased, the quality of life increased. The findings of a Portuguese research team indicated that urban shrinkage caused by the process of deindustrialization is not conducive to the improvement of residents' life satisfaction and happiness (Barreira et al. 2017). Barreira et al. (2019) argue that urban safety, employment accessibility, and *shrinkage atmosphere* are the most significant factors that contribute to residents leaving shrinking cities.

Improving residents' happiness is one of the important goals of urban planning and construction. For the planning of shrinking cities, more attention should be paid to the residents' quality of life, the quality of urban space, and their satisfaction. The current paper takes Yichun City in Northeast China as the study object. Yichun is a typical shrinking city in China that has attracted the attention of numerous scholars (Gao and Long 2017). While studies on this city have, to date, focused on the identification of the urban shrinkage phenomenon, the process of shrinkage, and solutions to shrinkage-related problems (Zhang et al. 2019; Rieniets 2009; Du et al. 2019), they have neglected the social impact of urban shrinkage. In combination with existing studies and relevant concepts of life quality (Marans and Kweon 2011; Bradburn 1969), the current authors believe that in order to evaluate residents' quality of life more comprehensively and accurately, research should be undertaken from both objective and subjective perspectives. Residents' objective quality of life is a comprehensive reflection of the living conditions that cities provide for residents, while residents' subjective quality of life tends to show residents' satisfaction with the living environment and emotional perspective. In light of this, the current paper explores the relationship between the process of urban shrinkage and residents' quality of life from the perspectives of residents' subjective and objective quality of life. Moreover, the big data, that is the data of Sina microblog, have been used to get the residents' subjective attitude to the quality of life. Traditional field survey is difficult to obtain a large amount of subjective data, and big data provide a great help. The following two questions will be discussed: (1) Does urban shrinkage imply a decrease in residents' quality of life? Is change in residents' subjective quality of life consistent with that in their objective quality of life? (2) Will the degree of urban shrinkage have different impacts on residents' subjective and objective quality of life, respectively? Combining residents' objective quality of life with the subjective means that the current study was able to conduct a comprehensive analysis, deepening existing research content and expanding research depth. Thus, the paper's conclusions arguably satisfy actual needs, which can be used as reference points for the coping strategies of shrinking cities.

Study Area and Methodology

Study Area

The research area of this paper is Yichun City, Heilongjiang Province, China, which is located in the northeast of Heilongjiang Province (Fig. 1). Yichun City is in the list of the first batch of resource-exhausted cities and is a city with significant shrinkage in northeast China. Population of Yichun City has been declining continuously since 2000. During the period of 2000–2016, its population decreased by 115,800, which is remarkably representative and typical in China. It is also a city very close to international shrinkage of shrinking cities and the motivation of shrinkage (in 2008, the primary industry output accounts for 38%, and the secondary industry output accounts for 22%). Yichun City contains 15 municipal districts: Yichun District, Nancha District, Youhao District, Xilin District, Cuiquan District, Xinqing District, Meixi District, Jinshantun District, Wuying District, Wumahe District, Tangwanghe District, Dailing District, Wuyiling District, Hongxing District, and Shangganling District.

Methodology

Measurement of Residents' Objective Quality of Life

Current literature on the evaluation system of urban residents' quality of life mainly selects indicators from the perspectives of the economy, environment, social insurance, residence, and so forth (Marans and Kweon 2011; Kitcher 2015; Barreira et al. 2017, 2019). In the process of urban shrinkage, the government is faced with the problems of imbalances in revenue and expenditure, increased liabilities, and lack of infrastructure maintenance, among other aspects. Considering the particularity of Yichun as a forestry resource-based city and arguing that the aspect of forestry resources will also affect residents' quality of life by affecting industrial development, the measurement used to assess residents' objective quality of life (ROQL) in the current paper was based on a general index of life quality. In combination with the features of urban shrinkage and the characteristics of Yichun City, 21 indices were selected from the four perspectives of income and consumption, city environment, urban infrastructure, and urban social development (Table 1), aiming to fully reflect residents' objective quality of life (Barreira et al. 2017; Barreira et al. 2019; Kitcher 2015; Hartt 2018; Hoekveld 2012; Zhang et al. 2014).

The current study applied dimensionless processing to the original data using the 0–1 standardization method. Reverse indices were transformed into positive indices using this method. The analytic hierarchy process (AHP) is widely used in previous research, but it has a subjective judgment error. Compared with AHP, the mean square deviation decision method can effectively reduce the error brought by subjective judgment. Therefore, an accurate and objective mean square error decision-making method was applied to determine the weight of the index, and residents' objective quality of life was calculated according to the weight (Lin et al. 2017), as follows:

Calculate the standardized value Z_{ij} of indicator i :

$$\text{Positive indicator: } Z_{ij} = \frac{x_{ij} - x_{ij\min}}{x_{ij\max} - x_{ij\min}} \quad (1 \leq i \leq n, 1 \leq j \leq m) \quad (1)$$

$$\text{Negative indicator: } Z_{ij} = \frac{x_{ij\max} - x_{ij}}{x_{ij\max} - x_{ij\min}} \quad (1 \leq i \leq n, 1 \leq j \leq m) \quad (2)$$

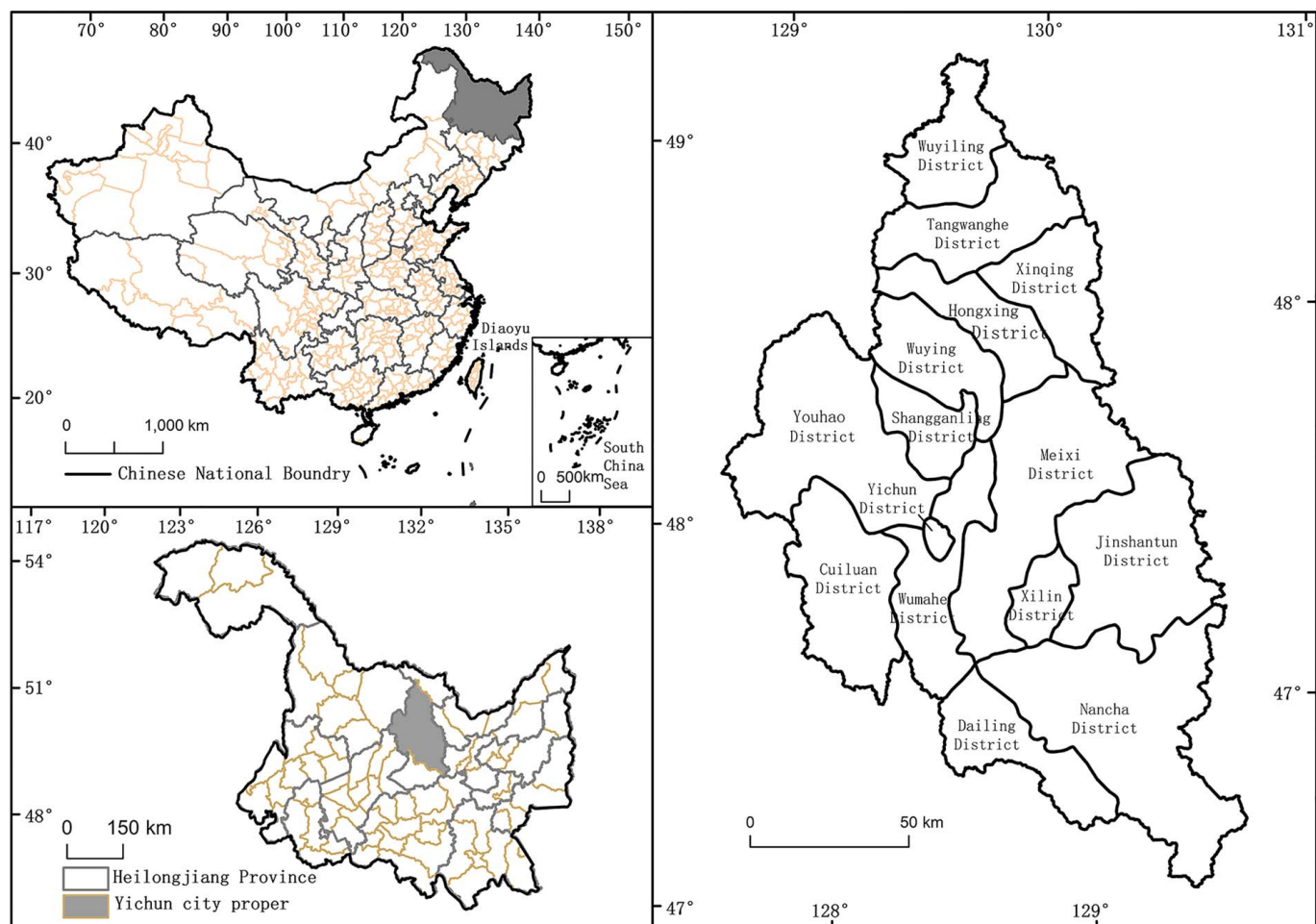


Fig. 1. Study area.

Table 1. Index system for the measurement of residents' objective quality of life

Target layer	Criterion layer	Index layer	Index attribute
Objective quality of life (Z)	Income and consumption (A ₁)	A ₁₁ GDP per capita	+
		Average wage of staff and workers (A ₁₂)	+
		Government consumption per capita (A ₁₃)	+
		Industrial liability per capita (A ₁₄)	-
		Industrial profit and tax per capita (A ₁₅)	+
	City environment (B ₁)	Public green land area per capita (B ₁₁)	+
		Greening rate of built-up areas (B ₁₂)	+
		Amount of domestic garbage clean-up per capita (B ₁₃)	+
		Population density (B ₁₄)	-
		Dust removal rate (B ₁₅)	+
		Utilization ratio of solid industrial waste (B ₁₆)	+
		Forestry resource area per capita (B ₁₇)	+
	Urban infrastructure (C ₁)	Road area per capita (C ₁₁)	+
		Gas popularizing rate (C ₁₂)	+
		Postal business amount per capita (C ₁₃)	+
		Number of public toilets per capita (C ₁₄)	+
		Water popularizing rate (C ₁₅)	+
	Social development (D ₁)	Number of middle school students in every 10,000 people (D ₁₁)	+
		Death rate (D ₁₂)	-
		Proportion of employees (D ₁₃)	+
		Urbanization rate (D ₁₄)	+

Calculate the mean of the random variables:

$$E(X_j) = \frac{1}{n} \sum_{i=1}^n Z_{ij} \quad (3)$$

Calculate mean square error:

$$E(X_j) = \frac{1}{n} \sum_{i=1}^n Z_{ij} \quad (4)$$

Calculate weight of indicator X_j :

$$W(X_j) = \frac{\sigma(X_j)}{\sum_{j=1}^n \sigma(X_j)} \quad (5)$$

Index of objective quality of life:

$$F = \sum_{j=1}^n x_j w_j \quad (6)$$

In Eqs. (1) and (2), Z_{ij} = standardized value of the index; x_{ij} = index value; $x_{ij\max}$ and $x_{ij\min}$ = maximum value and minimum value of the index, respectively. In Eq. (3), $E(X_j)$ = average value. In Eq. (4), $\sigma(X_j)$ = mean square error. In Eq. (5), $W(X_j)$ = weight of each index. In Eq. (6), F = index of residents' objective quality of life; x_j = standardized value of each index; and w_j = weight of each index. The greater the index denoted by F , the higher the residents' objective quality of life; the opposite scenario denotes a lower objective quality of life.

Measurement of Residents' Subjective Quality of Life

Most studies have, to date, measured residents' subjective quality of life through traditional questionnaires. This instrument carries the advantages of high representativeness, extensive population coverage, and relatively objective and reliable data, among other aspects. However, such questionnaires have restrictions in terms of high costs, limited topic coverage, and a smaller number of samples, among others. Owing to the collection of huge amounts of data and a dynamic process, big data analysis can compensate for the shortcomings of traditional questionnaires, to some extent, and make it possible to conduct a long-term analysis. In existing research results, through analysis on microblog texts and on the basis of this, residents' subjective life quality is evaluated. Using existing research results as a reference, the current study conducted an emotion analysis of Sina microblog data for the municipal districts of Yichun City, extracted during the period of 2012–2016, and conducted an evaluation of residents' subjective quality of life (RSQL). A total of 50,834 Sina microblog texts of Yichun were collected from 2012 to 2016, including 1,165 for the year 2012; 7,464 for 2013; 13,284 for 2014; 12,354 for 2015; and 16,562 for 2016. The microblog texts were grabbed from the Sina social platform, including the information of date, geographical coordinates and

texts. With the help of the test processing function of ROST Content Mining 6 (hereinafter referred to as Rost software), an emotion analysis including emotional distribution statistics, emotional fine granularity, and emotional value was conducted on the extracted Sina microblog data. Through the segmentation criteria of Rost software, positive emotion was divided into general positive emotion (with a score of 0–10), moderate positive emotion (with a score of 10–20), and high positive emotion (with a score of over 20). Negative emotion was divided into general negative emotion (with a score of –10 to 0), moderate negative emotion (with a score of –20 to –10), and high negative emotion (with a score less than –20). The expression denoting residents' subjective quality of life was as follows:

$$S = \frac{1}{n} \sum_{j=1}^n x_{it} \quad (7)$$

where S = residents' subjective quality of life in the same district in the same year; and x_{it} = emotional score from the microblog data of district i in year t . The higher the value of S , the higher the residents' subjective quality of life, while the opposite scenario denotes a lower subjective quality of life. Based on the analysis conducted using Rost software, examples of positive and negative emotion obtained from the microblog data are shown in Table 2.

Relationship between Subjective and Objective Quality of Life Index

The comprehensive gray correlation degree is a dynamic gray process based on the gray system. It can analyze the continuous series to determine the correlation between indexes. Generally speaking, if the correlation degree is above 0.8, it proves that the correlation is very large. If the correlation degree is between 0.5 and 0.8, it indicates that the correlation is weak. If the correlation degree is less than 0.5, it indicates that there is no correlation between the two (Mitchell et al. 2013). The correlation degree of subjective and objective quality of life is calculated by the method of comprehensive gray correlation degree. The calculation formula is as follows:

$$p_{ij} = \gamma \varepsilon_{ij} + (1 - \gamma) \beta_{ij} \quad (8)$$

where p_{ij} = comprehensive gray correlation degree; and γ = coefficient; this paper selects 0.5. ε_{ij} = relative gray correlation degree; and β_{ij} = absolute gray correlation degree.

Data Sources

For the purposes of this study, 15 municipal districts of Yichun City were taken as the research object, and the spatial scale of the period 2012–2016 was unified. The data resources are shown in Table 3, where the relevant administrative divisions were drawn from National Geomatics Center of China. The basic data of each index in the index evaluation system of residents' objective quality of life were taken from the *Yichun Statistical Yearbook* (2013–2017) and

Table 2. Examples of emotion analysis in microblog texts

Emotion type	Microblog text examples	Emotional score	Publication location	Time of publication
Positive emotion	Huge crowds of people	13	Youhao District	2015
	The railway in Heilongjiang is well developed.	13	Nancha District	2013
	As an old large industrialized province, it requires economic development.			
Negative emotion	The desolation of Northeast China.	–6	Tangwanghe District	2013
	All banks look deserted.	–13	Yichun District	2012

the *China City Statistical Yearbook* (2013–2017). Sina microblog text data used to assess subjective life quality were collected from the Sina microblog data of Yichun City, published during the five years of 2012–2016. These data include key information such as the location of the microblog's publication, the microblog publisher's nickname, the date of microblog publication, the client-side of microblog publication, geocoding, and microblog text contents. The microblog data were reclassified into the data of the various municipal districts from 2012 to 2016 according to their time of publication and geographical location, and the microblog publication contents were mainly extracted for the purposes of emotional analysis. Sina microblog data were drawn from Yichun's public data provided by Beijing City Laboratory (BCL).

Results Analysis

Urban Shrinkage and Evolution Characteristics of Yichun City

Urban shrinkage is generally characterized by population loss, lower employment rate, economic recession, and declining spatial

quality, among other features. This paper discusses the urban shrinkage and evolution characteristics of Yichun City from the perspectives of population, economy, birth rate, and employment rate (Fig. 2). In terms of population, with the exception of Yichun District, the population change rates of other districts were all negative during the period of 2012–2016, with the degree of negative growth gradually increasing. The population growth rate of Yichun City decreased from 0.44% in 2012 to 0.20% in 2014 and showed negative growth during the period of 2014–2016.

In terms of the economy, apart from the GDP growth rate of Xilin District in 2012 being -0.44% , all of the other districts showed positive growth in 2012 and 2013; however, the growth rate showed signs of slowing down. In 2014, all 15 municipal districts of Yichun City showed negative growth. In 2016, Yichun District and Jinshantun District showed negative growth, and the other districts showed positive growth. In terms of birth rate, the birth rate of Xinqing District, Tangwanghe District, and Hongxing District showed a trend of slight increase during the period of 2012–2016, while that of the other districts manifested a declining trend. In terms of the employment rate, with the exception of Yichun District, the other 14 municipal districts showed a fluctuating, declining trend during the period of 2012–2016.

Table 3. Data sources and illustration

Data type	Data source	Illustration
Administrative districts of Yichun City	National Geomatics Center of China	—
Data used to calculate objective quality of life	<i>Yichun Statistical Yearbook</i> (2013–2017) <i>China City Statistical Yearbook</i> (2013–2017)	Data for each index in objective life quality evaluation index system
Data used to calculate subjective quality of life	BCL	Microblog data during the period of 2012–2016

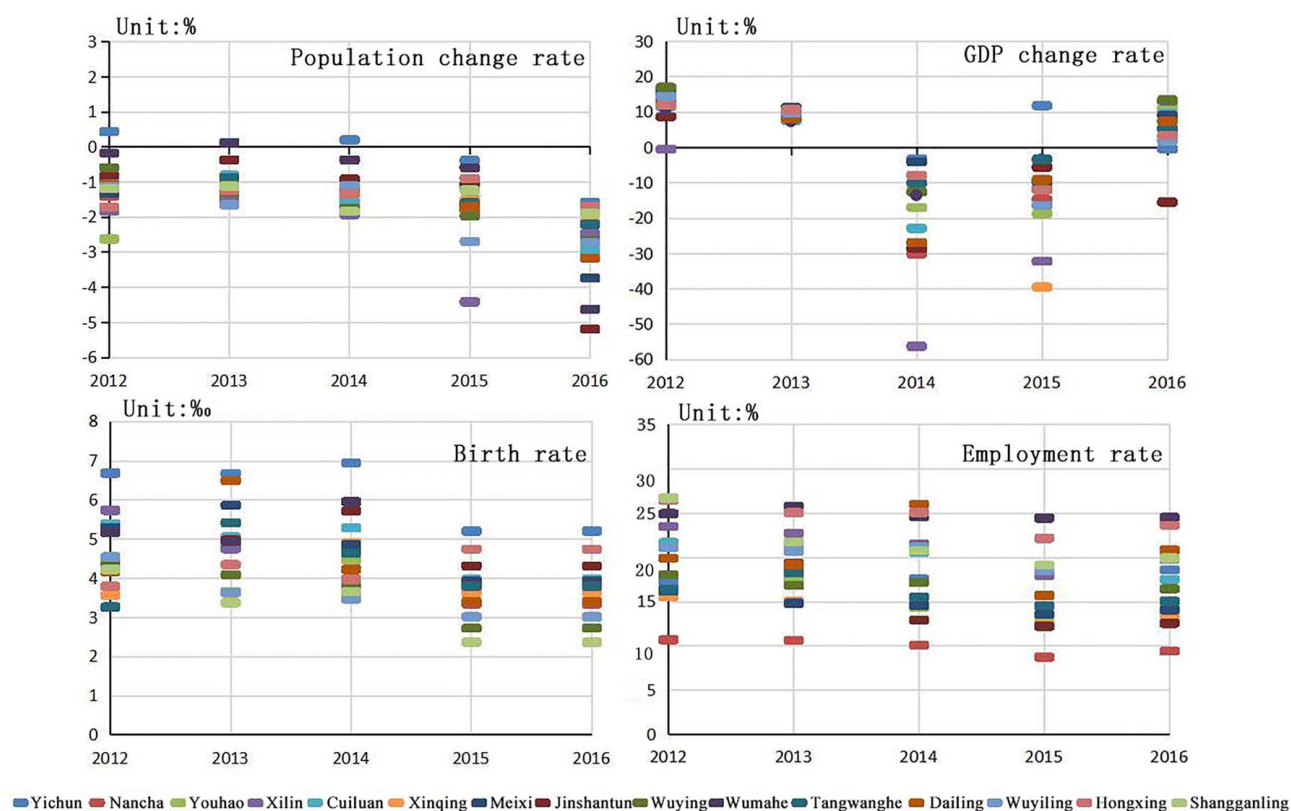


Fig. 2. Evolution of Yichun City's urban development in 2012–2016.

Based on the current status of urban development in Yichun City, the average annual population change rate was used as an index to measure the urban shrinkage of Yichun City from 2012 to 2016. All of the districts were classified into districts with slight shrinkage (the average annual population during the period of 2012–2016 having decreased by less than 1.8%), and districts with severe shrinkage (the average annual population during the period of 2012–2016 having decreased by over 1.8%), and these two types of districts are spatially and visually represented in Fig. 3. In the districts with slight shrinkage, population loss was found to have occurred in Yichun District since 2015, with most of the districts with slight shrinkage being concentrated around this district. Most of the districts with severe shrinkage were concentrated in the south-east of Yichun City. In Meixi District, Jinshantun District, and Dailing District, the degree of population shrinkage gradually increased, and the population of other districts with severe shrinkage generally showed a declining trend of constant velocity.

Spatial–Temporal Differentiation of Residents' Objective Quality of Life

Temporal Evolution Characteristics of Residents' Objective Quality of Life

By establishing an index system, this study evaluated residents' objective quality of life in different districts of Yichun City. The results show that this objective quality in different districts of Yichun City showed great fluctuation and differences over the course of time (Fig. 4). According to the field survey, the development of each district in Yichun city is not balanced and Yichun district is obviously superior to other districts. This unbalanced development leads to differences in regional supply capacity. Different supply capabilities mean different objective urban construction environments, which will cause regional differences in residents' objective quality of life. Based on the evolution of objective quality of life in different districts, the changes in objective

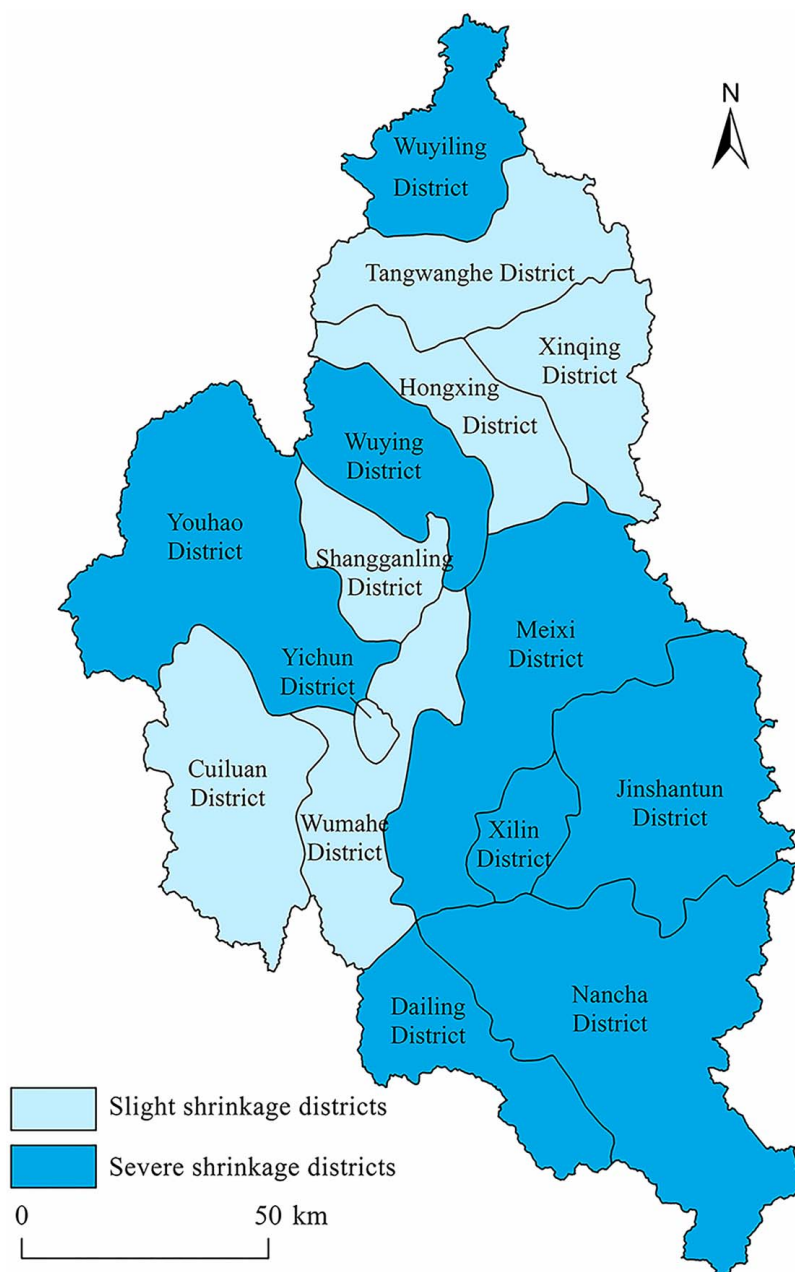


Fig. 3. Degree of shrinkage of each district in Yichun City during 2012–2016.

quality of life in 15 districts can be divided into four categories: the type of quality of life first increasing and then declining, the type of quality of life first declining and then increasing, the type of quality of life increasing with fluctuation, and the type of quality of life declining with fluctuation (Table 4).

In the districts with the type of quality of life first increasing and then declining, residents' objective quality of life in Yichun District, Meixi District, and Hongxing District reached its highest level in 2015, the values for which were 0.76, 0.53, and 0.54, respectively, while that in 2016 showed a significant decrease. The residents' objective quality of life in Xilin District only increased by 13.46% during the period of 2012–2013 and after that showed a trend of continuous decline, decreasing from 0.59 in 2013 to 0.47 in 2016. In districts with the type of quality of life first declining and then increasing, the residents' objective quality of life in Shangganling District and Wuying District showed an overall trend of increase during the period of 2012–2016, with change rates of 23.26% and 7.14%, respectively, with both reaching rock bottom in 2013. The residents' objective quality of life in Cuiluan District decreased from 0.44 in 2012 to 0.36 in 2014 and then increased to 0.41 in 2016. That in Youhao District generally showed a stable trend. Residents' quality of life in 2012 was found to be basically the same as that in 2016, but in 2013 showed a significant decrease—from 0.50 in 2012 to 0.38 in 2013, with a change rate as high as -23.10% . In districts with the type of quality of life increasing with fluctuation, that in Wumahe District was found to be in a state of continuous increase during the period of 2012–2016, with the average annual growth rate of residents' objective quality of life being 62.25%. The change of residents' objective quality of life in Xinqing District and Tangwanghe District was basically the same, with the overall change rates during the period of 2012–2016 being 18.58% and 14.50%, respectively. In districts with the type of quality of life decreasing with fluctuation, overall, residents' objective quality of life in Nancha District decreased with a smaller amplitude during the period of 2012–2016, with a change rate of -7.50% and a mean value of 0.31. This was the district with the lowest mean value across the 15 municipal districts in Yichun City. This indicates that although Nancha District had a larger population base, it had a lower economic level and poorer environment quality, leading to lower objective life quality. On the whole, residents' objective quality of life in Jinshantun District

decreased rapidly during the period of 2012–2016, with a change rate of -20.55% and an overall mean of 0.47. The overall change rates of Dailing District and Wuyiling District were -12.27% and -10.44% , respectively, with overall mean values of 0.41 and 0.45, respectively.

According to the urban shrinkage types classified previously, the change trends of objective quality of life in districts with the same degree of shrinkage emerged as different. However, overall, the objective quality of life in districts with slight shrinkage showed an increasing trend (except for Cuiluan District), while districts with severe shrinkage showed a declining trend (except for Wuying District). This indicates that the degree of a district's shrinkage can have a certain influence on residents' objective quality of life, but that urban shrinkage does not necessarily imply a decrease in residents' objective quality of life.

Spatial Differentiation Characteristics of Residents' Objective Quality of Life

According to the current study's evaluation system used to assess residents' objective quality of life in Yichun City in 2012, 2014, and 2016, residents' objective quality of life was classified into five types, and a spatial visual representation was constructed (Fig. 5). In terms of space, in the three stages, residents' objective quality of life in Yichun District and Tangwanghe District was generally found to be higher than that of other districts. Yichun District has the highest population base out of all municipal districts of Yichun City, whose resource element agglomeration capacity is higher than that of other districts, with a relatively high level of

Table 4. Type classification of residents' objective quality of life in Yichun City

Type	Area
Quality of life first increasing and then declining	Yichun District, Hongxing District, Xilin District, and Meixi District
Quality of life first declining and then increasing	Cuiluan District, Shangganling District, Youhao District, and Wuying District
Quality of life increasing with fluctuation	Xinqing District, Tangwanghe District, and Wumahe District
Quality of life declining with fluctuation	Dailing District, Wuyiling District, Jinshantun District, and Nancha District

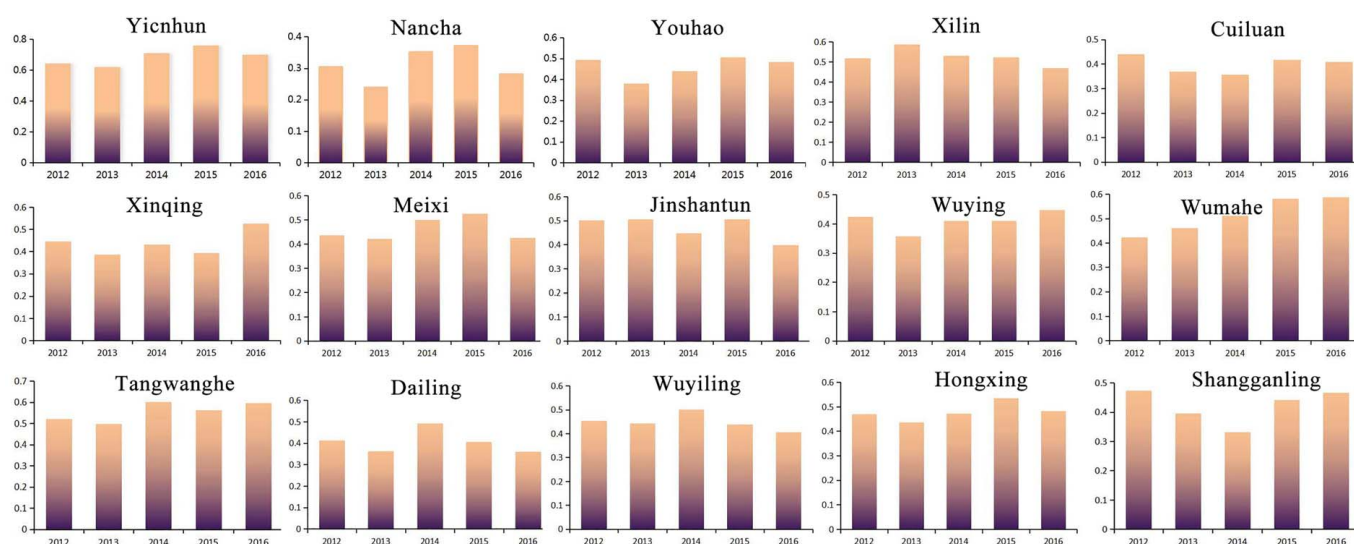


Fig. 4. Evolution of residents' objective quality of life in Yichun City during 2012–2016.

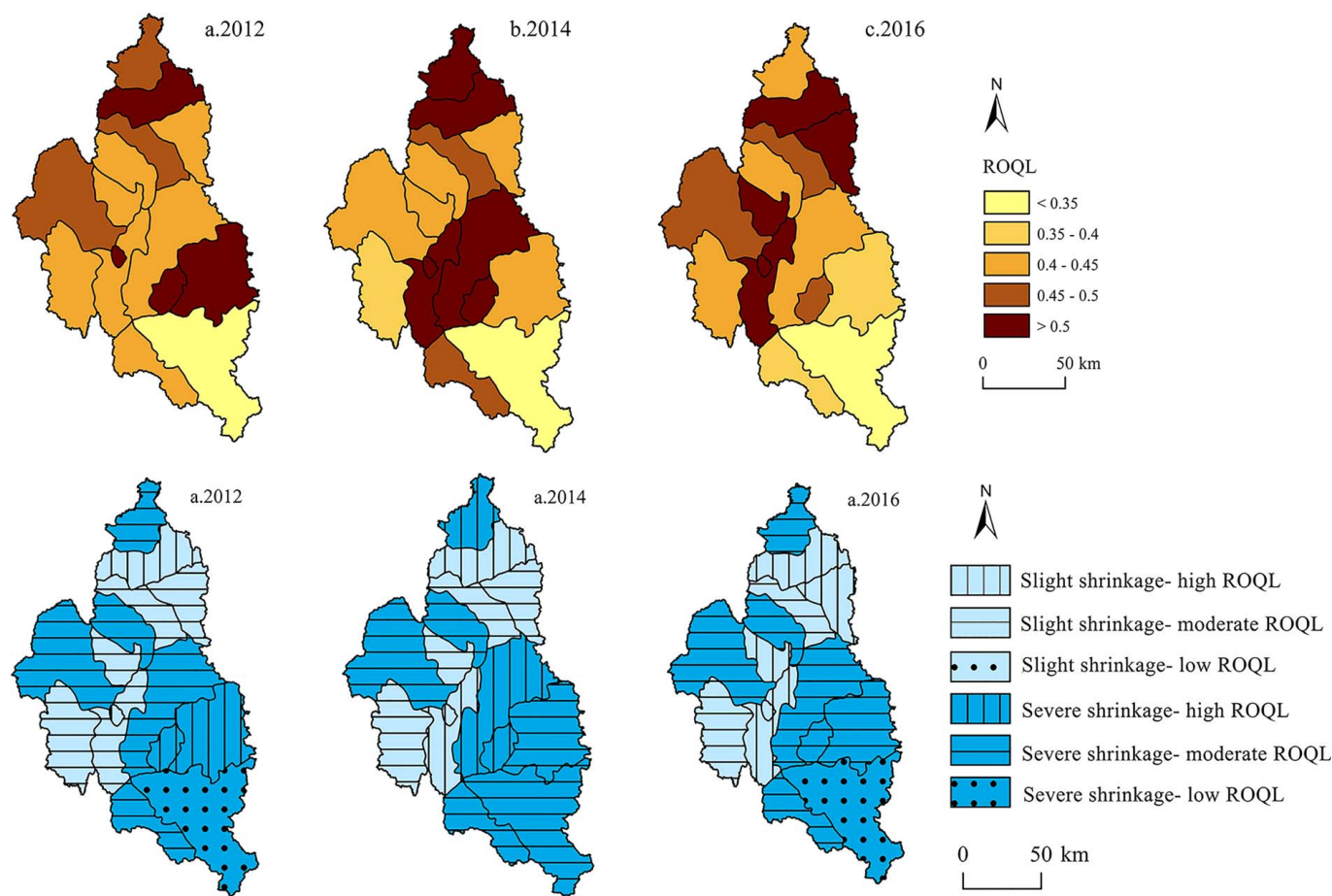


Fig. 5. Spatial-temporal differentiation and types of residents' objective quality of life in Yichun City during 2012–2016.

development. During the period of 2012–2016, this district's population growth rate was -1.61% , but the GDP growth rate was 19.03% , and residents' objective quality of life was not found to be significantly influenced by population loss. Residents' objective quality of life in Nancha District was generally lower than that of other districts during the period of 2012–2016, its population decreased by 9,715, with a change rate of -7.12% .

With the shrinkage degree of the different districts and the spatial distribution of residents' objective life quality types superimposed, the districts could be classified into six types (Fig. 5). The index of residents' objective quality of life in most of the districts with slight shrinkage was found to be higher than 0.4, while that in districts with severe shrinkage was lower than 0.4. These findings suggest that the decline in spatial quality caused by shrinking cities has some influence on the objective quality of life. Among the districts with slight shrinkage, there were no districts with a low quality of life in 2012, 2014, or 2016. Moreover, during the period of 2012–2016, Wumahe District and Xinqing District saw a shift from a low objective quality of life to a high objective life quality, indicating that slight urban shrinkage did not lead to a decrease in residents' objective life quality, but, rather, promoted the optimization and improvement of the objective regional environment. However, in 2012 and 2016, the type of severe shrinkage–low objective life quality appeared (in Nancha District), while residents' objective quality of life in Meixi District still increased to some extent in the context of severe urban shrinkage. These findings indicate that while severe urban shrinkage had a certain influence on residents' objective quality of life, the response of residents' objective life quality in different districts to different shrinkage degrees is not completely consistent.

Spatial-Temporal Differentiation of Residents' Subjective Quality of Life

Temporal Evolution Characteristics of Residents' Subjective Quality of Life

Through an analysis of the extracted microblog texts, the results indicate that residents' subjective quality of life in different districts of Yichun City in different years also showed greater fluctuation and differences over the course of time (Fig. 6). Here, quality of life can be classified into the type of first increasing and then declining, increasing with fluctuation, and declining with fluctuation (Table 5).

In the districts with the type of quality of life first increasing and then declining, with the exception of Xilin District, residents' subjective quality of life in the other four districts reached their peak value in 2015 and then showed a significant decline in 2016. Overall, only the subjective quality of life of residents of Yichun District in 2012–2016 showed a declining trend, and the index for this quality decreased from 5.68 to 4.70, with a change rate of -17.20% . Residents' subjective quality of life in Jinshantun District increased by a larger range during the period of 2012–2016, with a change rate of 43.39% , but the population mean was lower, at only 3.92. The overall subjective quality of life in Xilin District, Nancha District, Xinqing District, and Tangwanghe District all showed an increasing trend. In districts with the type of quality of life increasing with fluctuation, the change rate of residents' subjective quality of life in Cuiluan District in 2012–2016 was 42.78% . Residents' subjective quality of life in Wumahe District reached its peak value of 6.00 in 2015, with a population mean of 5.17. The change rate during the period of 2012–2016 was 5.58% . Due to the influence of

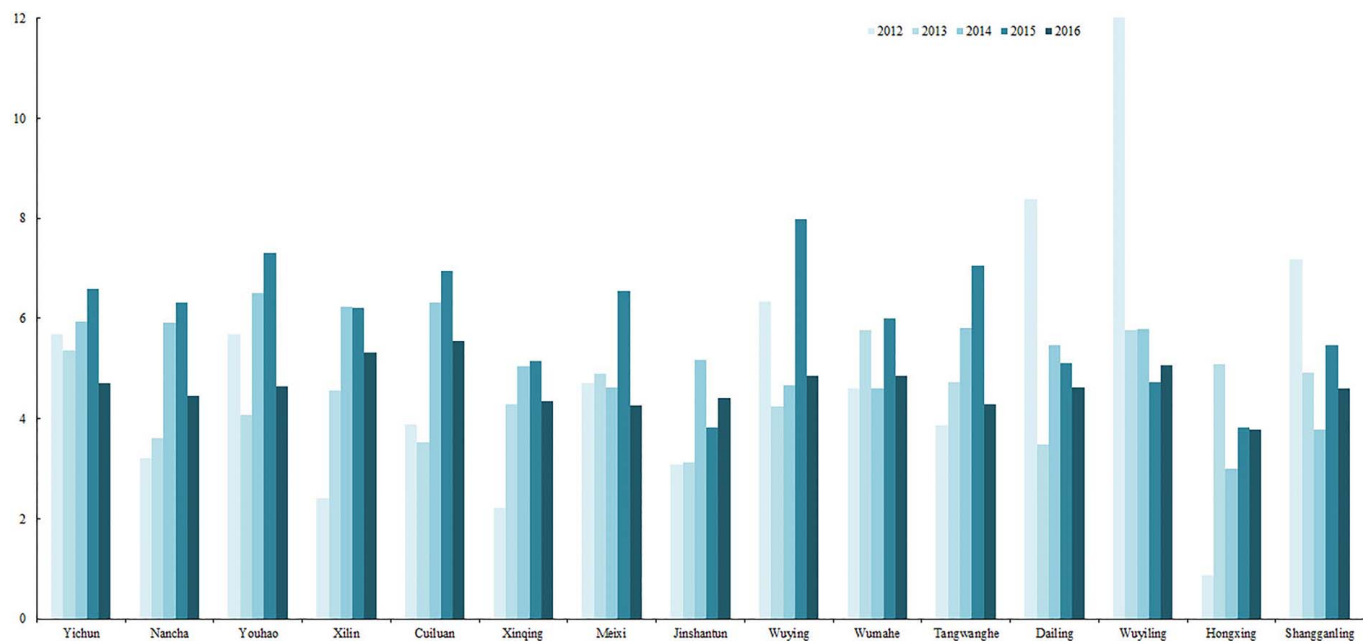


Fig. 6. Evolution of residents' subjective quality of life in Yichun City during 2012–2016.

Table 5. Type classification of residents' subjective quality of life in Yichun City

Type	Area
Quality of life first increasing and then decreasing	Yichun District, Nancha District, Xilin District, Xinqing District, Tangwanghe District, and Jinshanqun District
Quality of life increasing with fluctuation	Cuiluan District, Wumahe District, and Hongxing District
Quality of life declining with fluctuation	Youhao District, Meixi District, Wuying District, Dailing District, Wuyiling District, and Shangganling District

data collecting, the index for residents' subjective quality of life in Hongxing District was seen significantly to increase, rising from 0.87 in 2012 to 3.78 in 2016. It reached its peak value in 2013 and showed a declining trend since then. In districts with the type of quality of life declining with fluctuation, residents' subjective quality of life in Meixi District during the period of 2012–2016 showed a declining trend and a mean value of 5.01, decreasing by 0.31 and with a change rate of -9.32% . The indices of residents' subjective life quality in Shangganling District, Dailing District, Wuyiling District, and Wuying District decreased significantly, with change rates of -35.91% , -44.77% , -58.04% , and -23.41% , respectively.

Overall, fluctuation differences could be seen in residents' subjective quality of life among the different districts. The subjective quality of life in the districts with slight shrinkage generally showed an increasing trend (except for Yichun District and Shangganling District), while the subjective quality of life in over half of the districts with severe shrinkage showed a declining trend (except for Youhao District, Wuying District, Dailing District, and Wuyiling District). This indicates that the degree of Yichun City's urban shrinkage had a significant influence on residents' subjective quality of life, whereby a slight population loss had a lower influence on the former, severe population loss had a greater influence on the same. The results thus highlight that residents' subjective quality of life in the districts with different degrees of shrinkage showed certain differences.

Spatial Differentiation Characteristics of Residents' Subjective Quality of Life

According to the scores of residents' subjective quality of life in Yichun City in 2012, 2014, and 2016, this quality was classified into five types, and a spatial visual representation constructed (Fig. 7). From a spatial perspective, residents' subjective quality of life in Youhao District, Wuying District, and Dailing District showed an overall declining trend during the period of 2012–2016; it actually increased significantly in 2014, showing a declining trend thereafter. In 2016, the spatial distribution of residents' subjective quality of life showed a spatial pattern of increasing gradually from east to west. The subjective quality of life in Cuiluan District, Xinqing District, and Hongxing District showed an increasing trend, but with greater fluctuation. In particular, Xinqing District saw very significant fluctuation, with a change rate as high as 126.44% during the period of 2012–2014, but the score of residents' subjective quality of life decreased by 0.68 during the period of 2014–2016.

With the degree of shrinkage of the different districts and the spatial distribution of residents' subjective quality of life types superimposed, the districts could be classified into six types (Fig. 7), which types tended to be unified. By 2016, most districts had become the types with slight shrinkage-moderate subjective life quality, or severe shrinkage-moderate subjective life quality, indicating that the differences in the subjective quality of life across the different districts gradually decreased over time. However, residents' subjective quality of life in five of the eight districts with severe shrinkage showed an overall declining trend. Moreover, it was found that the more severe the degree of shrinkage, the more significantly residents' subjective life quality declined. For example, the shrinkage degrees of Dailing District and Wuyiling District were -1.82% and -2.04 , respectively, during the period of 2012–2016, and the corresponding change rates of residents' respective subjective quality of life were -44.72% and -58.04% , indicating that the degree of shrinkage exerts a certain influence on residents' subjective quality of life.

Relationships between Residents' Subjective and Objective Quality of Life

During the period of 2012–2016, while the change trends of residents' subjective and objective quality of life in some districts of

Yichun City were synchronous (including Yichun District, Youhao District, and Meixi District), these trends were not synchronous across most of the districts (Fig. 8). Most of the districts where residents' subjective and objective quality of life showed a rising trend (such as Xinqing District, Wumahe District, Tangwanghe District, and Hongxing District) were all among those with slight shrinkage, while those where residents' subjective and objective quality of life showed a declining trend (such as Youhao District, Meixi District,

Dailing District, and Wuyiling District) were all districts classified as having severe shrinkage.

The current study indicates that the urban shrinkage of Yichun City does not necessarily mean the decline of subjective and objective quality of life, but that the degree of shrinkage will have an influence on such quality. Residents' subjective and objective quality of life in the districts with slight shrinkage mostly showed a trend of increasing with fluctuation, while that in the districts with severe

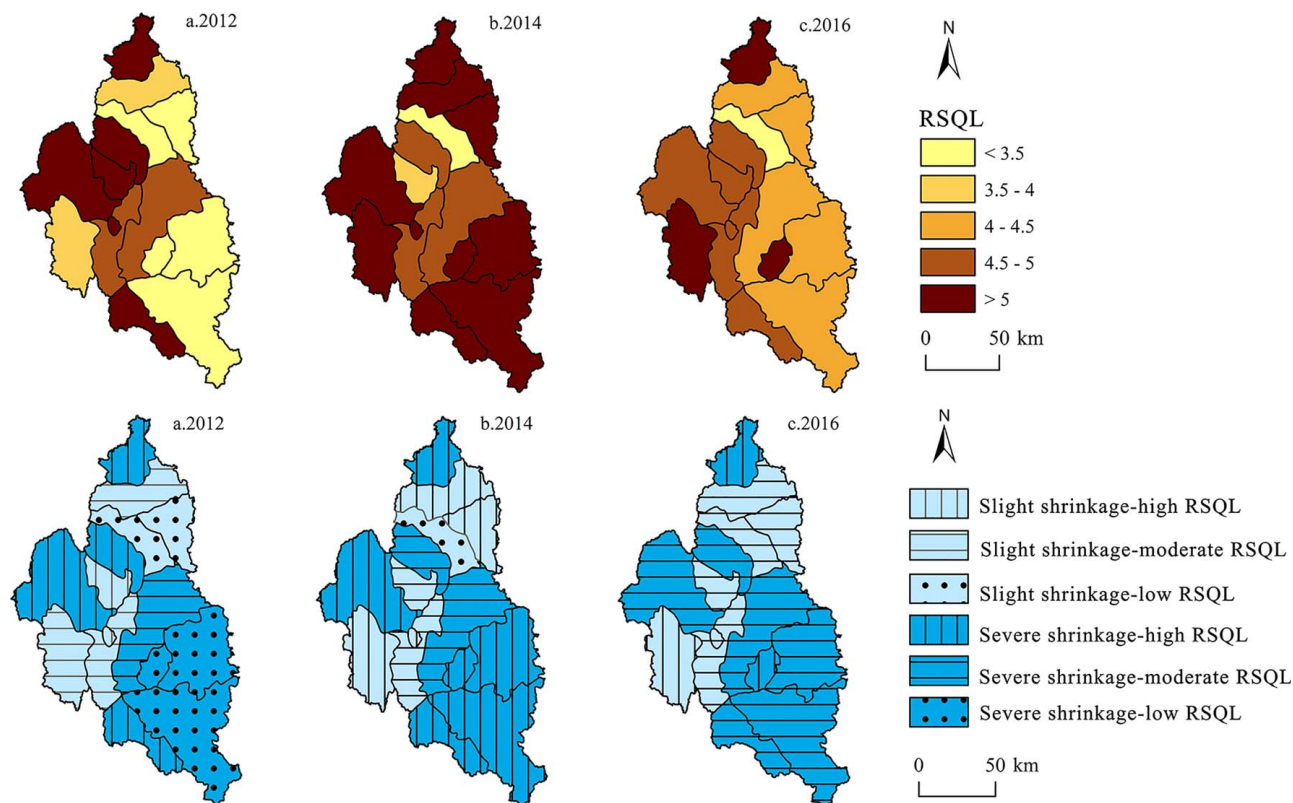


Fig. 7. Spatial-temporal differentiation and types of residents' subjective quality of life in Yichun City during 2012–2016.

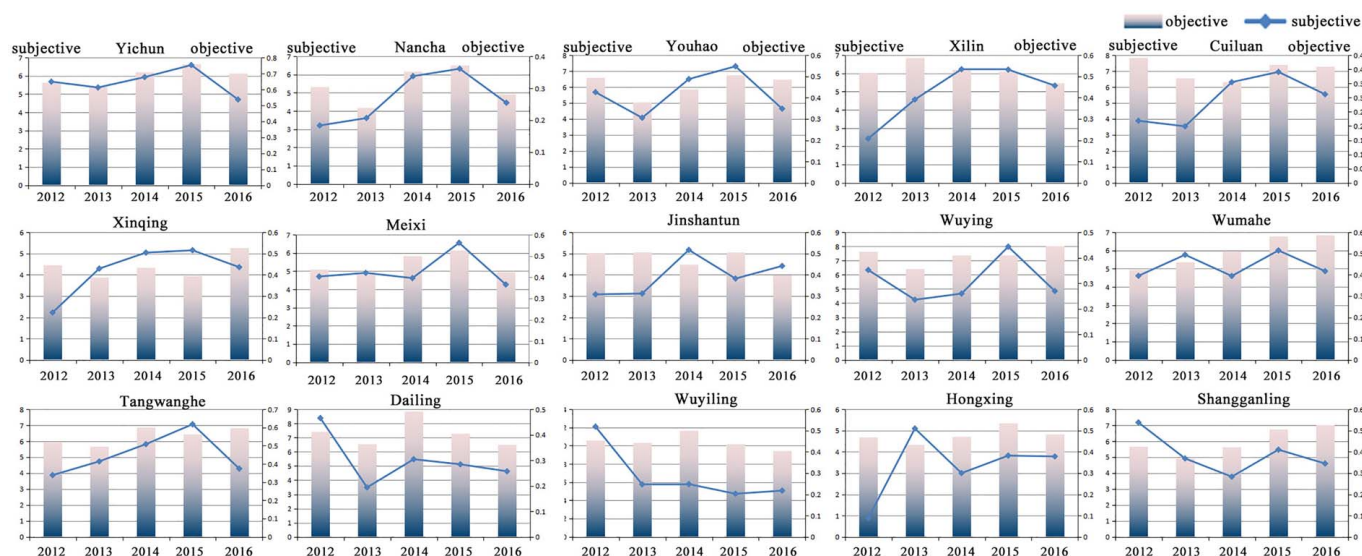
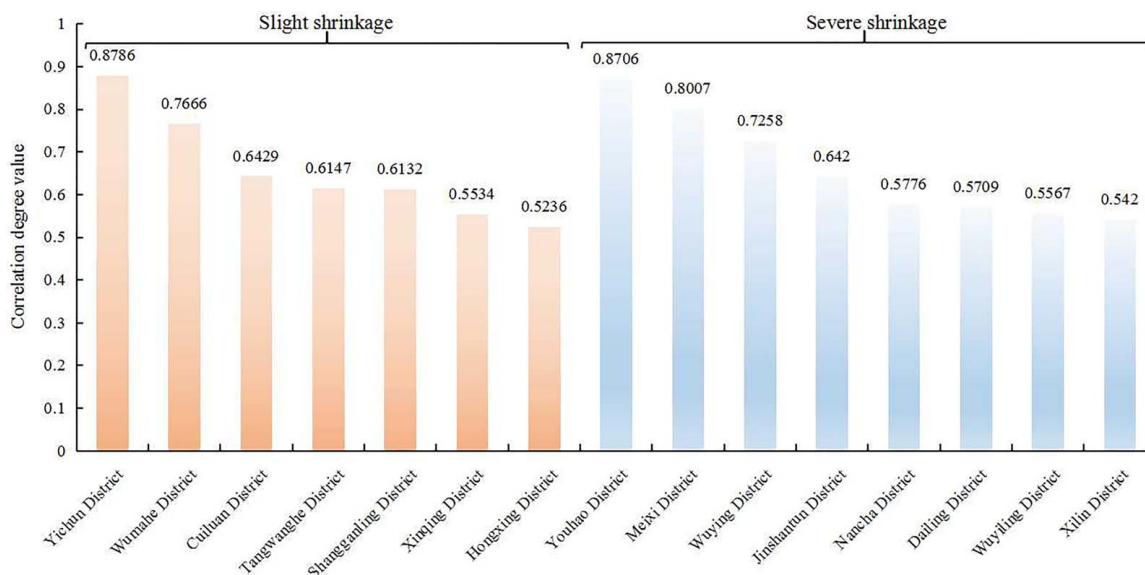


Fig. 8. Relationship between the evolution of subjective and objective quality of life in Yichun City during 2012–2016.

Table 6. Classification of the relationships between residents' subjective and objective life quality in different districts of Yichun City under different shrinkage degrees

Shrinkage degree	Quality of life increasing with fluctuation	Quality of life declining with fluctuation
Slight shrinkage	Subjective: Cuiluan District, Xinqing District, Wumahe District, Tangwanghe District, and Hongxing District Objective: Yichun District, Xinqing District, Wumahe District, Tangwanghe District, Hongxing District and Shangganling District	Subjective: Yichun District and Shangganling District Objective: Cuiluan District
Severe shrinkage	Subjective: Nancha District, Xilin District, and Jinshantun District Objective: Wuying District	Subjective: Youhao District, Meixi District, Wuying District, Dailing District, and Wuyiling District Objective: Nancha District, Youhao District, Xilin District, Meixi District, Jinshantun District, Dailing District, and Wuyiling District

**Fig. 9.** Correlation between residents' subjective and objective quality of life.

shrinkage mostly showed a trend of declining with fluctuation (Table 6). The subjective and objective quality of life in the districts with slight shrinkage increased due to the increase of the possession of facilities per capita, the improvement of living conditions and other favorable factors contributing to the improvement of objective quality of life, and to residents' better subjective perception of their residence, to a certain extent. In the districts with severe shrinkage, urban spatial quality has been seriously affected given economic and social problems. As a result, both residents' objective and subjective quality of life there declined.

In order to further explore the scientificity of the stated conclusions, the relationship between the subjective and objective quality of life of residents in Yichun City under the background of urban shrinkage is tested by the gray correlation model (Fig. 9). The average correlation between the residents' subjective and objective quality of life is 0.66, which indicates that there is a certain connection between the residents' subjective and objective quality of life, but the strength of the connection is weak. In other words, the variation trend of the objective quality of life is not necessarily consistent with that of subjective quality of life. The value of the gray correlation of the 15 districts also illustrates this. The gray correlation degree of Yichun District, Youhao District, and Meixi District is greater than 0.8, indicating that the change trend of residents' subjective and objective quality of life in the three districts from 2012 to 2016 is consistent, while the other districts are inconsistent. In the

area of low and high gray correlation degree, the slight shrinkage areas and the severe shrinkage areas coexist. This fully illustrates that the changes in the residents' subjective and objective quality of life in the context of urban shrinkage are complex. Thus, different coping strategies should be adopted for regions with severe shrinkage and those with slight shrinkage, respectively.

Discussion and Conclusions

Based on statistical data and microblog data and using a typical shrinking city, Yichun, as a case study, this paper discussed the spatial-temporal evolution of residents' quality of life in the context of urban shrinkage. To measure the change in residents' quality of life comprehensively and accurately, subjective and objective data and methodology were used to evaluate residents' objective and subjective quality of life. The study indicated that urban shrinkage does not necessarily imply a decline in residents' quality of life, and that the variation trend of objective quality of life was not consistent with that of subjective life quality. In terms of objective quality of life, that in seven districts of Yichun City showed a rising trend, while that in eight districts showed a declining trend. In terms of subjective quality of life, that in three districts showed a rising trend, while that in 12 districts showed a declining trend. These findings make it clear that residents' quality of life did not

consistently show a declining trend in the context of urban shrinkage, but that residents' subjective feelings showed significantly negative changes. The variation trends of objective and subjective life quality in nine districts of Yichun City were consistent, while those in the other six emerged as inconsistent. It is here evident that, in the context of urban shrinkage, the variation trends of residents' objective and subjective quality of life were not necessarily consistent.

This study holds that the degree of urban shrinkage will have different impacts on residents' subjective and objective quality of life. Both of the latter in districts with slight shrinkage mostly showed a rising trend, while those in the districts with severe shrinkage mostly showed a declining trend. The degree of urban shrinkage can influence residents' subjective perception of environmental change by affecting the level of economic development and urban spatial quality. Regarding the districts with slight shrinkage, the partial population loss can effectively reduce population density, improve the per capita share of urban service facilities, and improve residents' happiness and satisfaction. In terms of the districts with severe shrinkage, due to excessive population loss, serious waste of urban service facilities and lack of maintenance, the urban spatial quality declines, and residents' subjective and objective quality of life mostly show a declining trend; in addition, the more severe the degree of shrinkage, the more significant the declining trend.

Compared with studies on residents' quality of life in shrinking cities, from the perspectives of residents' subjective and objective quality of life, the current paper attempts to describe spatial-temporal differentiation laws between urban shrinkage and residents' quality of life more comprehensively. In addition, the paper aims further to explore the correlations between urban shrinkage and residents' subjective quality of life, between urban shrinkage and residents' objective quality of life, and between subjective and objective life quality, thus providing a reference point for coping with urban shrinkage and improving residents' quality of life. In addition, current discussions on urban shrinkage in China are mostly focused on the description and interpretation of phenomena, with a lack of research on the social impact of urban shrinkage. In order to make up for this defect, this study comprehensively explores changes in residents' quality of life in the context of urban shrinkage and the relationships between urban shrinkage degree and such quality.

The research findings indicate that residents' quality of life quality does not necessarily decline in the context of urban shrinkage, echoing the research conclusions of some Western scholars (Delken 2008). Besides, the existing studies focus only on residents' subjective or objective quality of life, with it being difficult to comprehensively and accurately reflect the evolution of this quality in the context of urban shrinkage (Delken 2008; Schetke and Haase 2008). This research attempts to make up for this deficiency. The current research conducted comparative studies on residents' subjective and objective quality of life, finding that in the context of urban shrinkage, the change in residents' objective life quality was not consistent with their subjective life quality. This research conclusion reveals the complexity of changes to residents' quality of life in the context of urban shrinkage, making further, in-depth research worthwhile. The research results also show that the degree of urban shrinkage will have a significant impact on residents' quality of life. Such subjective and objective quality in most of the districts with slight shrinkage showed an overall increasing trend during the period of 2012–2016, while that in the districts with severe shrinkage showed an overall declining trend during the same period. Ultimately, these findings serve to deepen discussions on residents' quality of life in shrinking cities, as they have appeared in existing studies from the West, and expand the depth of

research on residents' life quality in the context of urban shrinkage. It is hoped that the research conclusions of this paper can provide certain reference points for improving the quality of life of residents in shrinking cities. Attention should be paid not only to residents' subjective quality of life, but also to the objective. In addition, different coping strategies should be adopted for districts with severe shrinkage versus those with slight shrinkage. The conclusions obtained in this work have important reference significance for planning adjustment and mode selection of shrinking cities. Moreover, it is further emphasized that *smart decline* is one of the feasible ways to achieve connotative development of shrinking cities.

In this paper, a multi-index comprehensive evaluation method and Sina microblog data were used to conduct a quantitative measurement and evaluation of residents' subjective and objective quality of life in 15 municipal districts of Yichun City. An in-depth analysis was carried out on the spatial-temporal differentiation laws of residents' subjective and objective quality of life and the correlations between them, with the following conclusions drawn:

1. Yichun City is a typical shrinking city. The variation trends of subjective and objective quality of life in each district mostly show greater fluctuations, with significant spatial differentiation. Significant differences were also found between the variation trends of subjective and objective quality of life in the districts with slight shrinkage versus those with severe shrinkage.
2. The current analysis based on Yichun City shows that urban shrinkage does not necessarily imply the decline of residents' subjective and objective quality of life, and that the effects of urban shrinkage on such quality are not wholly consistent.
3. The districts with differing degrees of shrinkage in Yichun City were found to have significantly different impacts on changes to residents' subjective and objective quality of life. The latter mostly showed a trend of rising with fluctuation in the districts with slight shrinkage, while those in the districts with severe shrinkage mostly showed a trend of declining with fluctuation. In the districts with severer shrinkage, the subjective and objective quality of life both showed a more obvious declining trend.

The study in this paper is mainly based on comprehensive indices and big Weibo data. Through the combination with big data and questionnaires in the future to confirm the existing conclusions, a more reasonable evaluation model for residents' subjective and objective life quality will be established, making the results more practically applicable and further discussing the spatial-temporal differentiation laws, mechanisms and effects of residents' subjective and objective quality of life in the context of urban shrinkage.

Data Availability Statement

Some or all data, models, or code generated or used during the study are available from the corresponding author by request (including demographic data and Sina Weibo data).

Acknowledgments

This research was supported by the National Natural Science Foundation of China (No. 41771172) and China Postdoctoral Science Foundation (2018M641760). The anonymous reviewers are also gratefully acknowledged.

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