Case Study

Growth or Shrinkage: Discovering Development Patterns and Planning Strategies for Cross-Border Areas in China

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Abstract: Exponential growth and shrinkage of cities are two opposing trends in urban development. In this study, we analyze spatial growth and shrinkage at the regional level. We use the Guangzhou–Foshan region to identify the pattern and process of growth and shrinkage in the region with particular focus on cross-border areas. Specifically, we focus on how addressing shrinkage led to changes in urban planning with an in-depth discussion of its formation mechanism and the introduction of planning strategies. From the changes in light results during the period from 1985 to 2017 of the Guangzhou–Foshan region, stable areas are mainly concentrated in the old urban areas built before 2000, the largest urban area is of continuous growth type in line with the characteristics of urban expansion, and the area of shrinkage is small but concentrated in the cross-border areas. Particularly, since the 2008 financial crisis, extensive changes have been noted in the cross-border areas where such growing and shrinking areas coexist. Regional integration and the optimization of urban space would be effective methods to confront shrinkage. The findings may provide some reference for the urban shrinkage phenomenon that occurs in cross-border areas.
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Introduction

A nationwide slowdown in population growth, in addition to urban and rural transformation shifts from incremental planning to stock-based planning, has highlighted the concept of "shrinking city" among academia and governments (Martinez-Fernandez et al. 2012a). Cities in developed countries are faced with the problem of downsizing and China has ushered in a shrinking wave of cities (Liu 2013).

Current development scenarios for rapid urban population growth, slow growth, stability, and shrinkage may exist simultaneously or alternately. In this context, smart decline planning will become a necessary tool for maintaining the sustainable development of cities. "Smart Decline" advocates abandoning the inherent concept of "necessary growth" and suggests formulating planning policies for "adaptation decline" in population-declining areas that have lost growth momentum (Hollander and Németh 2011). It proposes the use of unique economic and spatial structural adjustment opportunities during the shrinkage period to explore the development of cities under slow or reverse economic growth in a targeted manner and to maintain (or improve) the inherent quality of urban life during population reduction. Therefore, the negative impact of the decline cycle is reduced as much as possible, and the foundation for the future growth cycle is laid (Oswalt and Rieniets 2006). However, most current planning methods and policy tools are only applicable to population growth scenarios. What remains an ongoing question is how urban development policies should be formulated to respond to the slow (inverse) growth of population/land scenarios.

Urban shrinkage and economic downside that occur in structurally weak areas (e.g., old industrialized "rust belts" or peripheral rural areas) are the most common symptoms of transformations observed in Europe and the United States (Pallagst et al. 2011; Wiechmann and Pallagst 2012; Großmann et al. 2012). As regional integration advances, the border effect will continue to decrease, further promoting spatial reconstruction and economic development (Wei et al. 2014). On one hand, transportation integration, rapid development of mobile communication infrastructure, and regional development policies have had a significant impact on regional socioeconomic space, transportation network space, and institutional spatial organization. In addition, industrial transfers and regional housing price differences have triggered development in cities. Changes in the flow of people, logistics, and information between regions enable dynamism in the border areas. On the other hand, in the era of global financial crisis, land use in China has witnessed a decline in export-oriented manufacturing, loss of demographic dividends, low-cost industrial advantages, tightening of land finance, and urban shrinkage (Lang et al. 2016). Typical urban shrinkage cases include those represented by the eastern export-oriented industrial and trade cities and small- and medium-sized towns outside the metropolis (Mykhnenko and Turok 2008).

Since 2000, Chinese academics have started to acknowledge the concept of a "shrinking city," and they have gradually begun to explore its application value under the "new normal" (*Xin Chang Tai*). In the past decade, domestic researchers have conducted extensive investigations and analyses on population reduction and economic recession in China's regions, towns, and villages using the perspective of "shrinking cities." The phenomenon of population shrinkage has been observed in many regions with various characteristics, such as the shrinkage of the old industrial zone in the northeast, outflow in the central region, exhausted resources, and administrative districts

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(Long and Wu 2016). At the same time, using the idea of "smart decline," scholars have explored operable planning methods to confront the shrinkage, such as "industrial-based transformation," "old city renewal," and "governance of hollow villages" (Hollander and Németh 2011; Li et al. 2015a; Long et al. 2012; Li et al. 2014). However, their research is on a national or city scale, yet there are still some urgent questions to be addressed on a city- or region-wide scale. For example, what could be the new spaces for creativity and productivity in the shrinking cities? How are urban growth and shrinkage perceived in a metropolitan region, particularly in the cross-border areas? Can shrinking cities, in the context of limited resources, be revitalized with opportunities for improved development modes or new modes of governance?

The influence of the previously mentioned theory on urban planning and design and urban management is still limited. In China, planning for growth is a unique model of contemporary urban planning, and proposing policy responses and planning methods for decline, poverty, and shrinking cities is also a general position of Western urban planning theory. In the future, staged, cyclical, and continuous shrinkage scenarios may occur frequently in the development of China's cities and towns, and it is necessary to explore rational and innovative planning strategies in response to this scenario. Planning can serve as a blueprint for urban development targeting prosperity and the search for sustainable paths in developing cities and towns while adapting to shrinkage, which are long-lasting tasks that provide opportunities for academic dialogue between China and the West (Pallagst 2008; Wiechmann and Pallagst 2012; Li et al. 2020a). Local perceptions and strategies of coping with shrinkage are comparable in developing countries, particularly whether the relative success in retaining the population and steady growth can be largely attributed to government intervention (Lang et al. 2020).

However, it is still not clear if and how planning paradigms, planning systems, planning strategies, and planning cultures change when shrinkage and decline take place. The current study investigated how planning is transformed in terms of shrinking cities. Using the Guangzhou–Foshan region, the study explored spatial characteristics, patterns, and processes of growth and shrinkage in the border area. The study focused on the questions of whether and how dealing with shrinkage led to changes in urban planning, followed by an in-depth discussion of its formation mechanism and, finally, introduced planning strategies. The findings may provide some reference for the urban shrinkage phenomenon that occurs in cross-border areas.

Literature Review

Defining Shrinking City

Scholars have varying views on the definition of a shrinking city. Shrinking cities are defined as "urban areas that have experienced population loss, economic downturn, employment decline, and social problems as symptoms of a structural crisis" (Martinez-Fernandez et al. 2012a, p. 213). Urban decline and the loss of employment opportunities are closely linked in a downward spiral, leading to an out-migration of the population (Pallagst 2008). Some researchers argue that a city is a multidimensional process containing, parts of cities, rural areas, and metropolitan areas that experienced a dramatic decline in their economic and social bases (Pallagst et al. 2017). Others consider shrinking cities as a worldwide multidimensional phenomenon that appear in many postindustrialized societies (Beauregard 2009; Cunningham and Fol 2008; Pallagst 2008). For many years, this phenomenon has been widely underrepresented in international comparative urban and regional research. Thus, from the year 2005 onward, "shrinking cities" were labeled as an emerging topic in spatial planning. The existing body of literature on shrinking cities has shown that the loss of urban population is not an entirely new phenomenon (Fol and Cunningham-Sabot 2010; Göb 1977; Häußermann and Siebel 1987; Oswalt 2004). What is new, however, is the extent to which shrinkage occurs on a global scale and the complexity of its causes (Pallagst et al. 2017).

There is little clarity on what shrinkage is and how shrinkage should be addressed through various strategies (Hollander et al. 2009; Olsen 2013; Bernt 2016). The industrialization era of the nineteenth century was characterized by urban growth, yet many of these cities started to shrink in the following century (Oswalt and Rieniets 2006). Shrinkage often reinforces itself, as a "downward spiral" or "vicious cycle," where characteristic features are out-migration, rising unemployment, a decrease in purchasing power, and a shortfall in public revenues. The decline in population and jobs is accentuated by reductions in economic investment and public infrastructure (Fritsche et al. 2007). Postindustrial transformations, the decline of the manufacturing industry, and other economic fluctuations have contributed to diminishing populations and economic stagnation in cities worldwide (Hollander and Németh 2011). Many of these cities have been experiencing the effects of a second demographic transition, characterized by accelerated population aging and decreasing fertility rates (Lang et al. 2021). The complexity of factors enhances the need to embed shrinkage-based policies into local planning instruments and regulations (Cunningham-Sabot et al. 2013; Martinez-Fernandez et al. 2012b). Hollander et al. (2009) found that "if there were more, better, and especially cross-national research on shrinkage, the on-the-ground truth might turn out to be more complex and interesting," expanding beyond the common growth paradigm in planning.

In China, urban shrinkage is a new spatial phenomenon caused by the flow of production factors, such as capital and labor on the spatial scale (Li et al. 2015b; Long and Gao 2019). Its characteristics and causes are different from those of typical cases in Western countries. Due to changes in certain conditions of the original development model during the process of rapid urbanization in China, global mobility of essential factors of production, such as capital, labor, and technology, caused the coexistence of growth and shrinkage (Lang et al. 2020). This phenomenon indicates a wide range of approaches to new questions and produces evidence from both quantitative and qualitative empirical research. For example, Lang et al. (2019) used data from the *Fifth National Population Census* and the *Sixth National Population Census* to analyze the scale of townships nationwide, which include landmark research results of China's urban shrinkage. Xu and Pang (2014) pointed out that growth and shrinkage are the objective laws of urban development, and the government should actively respond to urban shrinkage. Li et al. (2015b), using the case of the Pearl River Delta, discussed that continual economic decline and immigrant reduction are typical characteristics of shrinkage. Further, the mismatching of industrial structure and labor supply structure causes urban shrinkage.

Contemporary urbanization, deindustrialization, economic restructuring, and the dislocations brought about by neoliberal globalization have transformed into the emergence of so-called "ghost cities" which is captivated by the hollowness in the built environment and ruin in urban development (Morton 2013; Woodworth and Wallace 2017; Woodworth 2020). Zheng et al. (2017) identified that a large number of "ghost cities" exist in China and summarized their spatial characteristics. Less-urbanized regions, small- and medium-sized cities, and new development zones and counties have a greater chance of suffering from the

ghost city phenomenon (Jin et al. 2017), while capital cities and larger cities have a released effect for ambient regions (Zheng et al. 2017). In addition, Chi et al. (2015) and Leichtle et al. (2019) classified cities with large vacant housing areas as cities or tourism sites.

Shrinkage Perceptions and Strategies

Features of Shrinking Cities

Shrinking cities are characterized by the vacancy of urban spatial structure, which is caused by population reduction and economic development transformation (Long and Gao 2019; Rieniets 2009). With the accumulation of capital worldwide, the phenomenon of shrinking cities will become more intense on a global scale, forming four types of shrinking cities (Antonić et al. 2019; Guan et al. 2021). First, due to the dependence on regional core cities, capital and labor forces are concentrated extremely in urban core areas, causing shrinkage of towns or cities in marginal areas. Second, global manufacturing transfers have led to the shrinkage of resource-based, old industrial cities and emerging manufacturing bases. Third, the migration of industries and populations introduced by suburbanization has triggered urban centers. These shrinkages are characterized by vacancy and decay. Fourth, urban shrinkage is caused by a mismatch between local institutional responses to changes in the external environment and land use resources.

Large population loss is a key feature of shrinking cities (Rieniets 2009). Population loss is a comprehensive manifestation of the effects of various factors, such as the deterioration of the urban development environment, housing abandonment (Hollander 2010), reduction in income level (Bernt 2016), and the loss of urban attractiveness. For example, from 1975 to 2006, the population of Qianli New City in Tokyo fell from a peak of 130,000 to 94,000, and from 1975 to 2000, the population of Tama New Town in western Tokyo decreased by 1.5% (Philipp 2006).

The second feature is the disjointed industry succession (Martinez-Fernandez et al. 2012a). Due to the low degree of industrial structure correlation and insufficient support for industrial structure transformation, the urban industrial system gradually disintegrated during the transition from industrialization to "de-industrialization" in many developed cities. For example, industrial development in the city of Walbrzych, Poland, is highly dependent on the mining industry, which has led to difficulties in industrial transformation. In 1993, mining and its related industries provided a total of 24,000 jobs, accounting for more than 50% of total urban jobs. After the recession, its successor mining industry could not be formed (Martinez-Fernandez et al. 2012a).

The third significant feature is a deteriorated urban environment. The deterioration of the urban environment in Thuringia, Germany, is divided into two situations (Dieter and Ariane 2006). A large number of industrial sites with environmental degradation have appeared, primarily because the production efficiency of enterprises under the original planned economic system is not high, and the German government maintains a mandatory closure policy issued by the original West German labor market, which forced factories to suspend production and be abandoned (Wiechmann and Pallagst 2012). Second, waste sites are formed due to industrial abandonment. During the privatization reform process, mining areas with low output rates were arbitrarily abandoned, which caused environmental pollution and land subsidence problems.

The fourth feature is idle urban land. The typical case is the emergence of idle land in Thuringia, Germany (Dieter and Ariane 2006). First, the downturn in the real estate market caused housing vacancies and idle land (Radzimski 2016). To maintain market stability and reduce construction maintenance costs, a large number of high-rise buildings were demolished in the suburbs, causing land to be deserted (Weck and Beißwenger 2014). Second, wasteland was formed when a large number of railways and freight stations were abandoned, and the railroad track site restricted the redevelopment of the land. Third, the current urban development space is sufficient. Yet there is uncertainty surrounding returns on investment expectations. With an increase in uncertainty, the shrinkage space is marginalized in the investment.

Patterns of Urban Shrinkage

One of the most typical regional marginalization cases is the area of eastern Germany (Philipp 2006). After the reunification of Germany, the original East German cities were far from the European decision-making center and missed the key investment of EU companies (Bartholomae et al. 2015). The cities' attractiveness was gradually lost. At the same time, the realization of economic integration within the EU has lifted the constraints of the free movement of the urban population. The population migrated westward to seek high-paying jobs. Thus, the original East German cities were gradually marginalized, both politically and economically.

The shrinking mode of small- and medium-sized cities is represented by small- and medium-sized cities in France (population size <50,000 people) (Cunningham and Fol 2008). Most of the declining small- and medium-sized cities are in the Ardennes, Central Plateau, and Pyrenees of France. Imperfect infrastructure and incomplete urban networks have prevented small- and medium-sized cities from fully participating in the international division of labor and information exchange; thus, these cities are at a disadvantage of being marginalized in economic globalization.

The shrinkage mode of large cities is represented by large cities or metropolitan areas in the UK (population size 150,000–450,000; 1 million–2.5 million, respectively), excluding London (Cunningham and Fol 2008). Affected by the industrial revolution, the development of big cities has long relied on industrial bases (mining industry), so "de-industrialization" is likely to cause shrinkage in big cities. In addition, the standardization of the labor market also has accelerated the shrinking urban population.

Current research in China and abroad has not yet formed a unified understanding of the definition criteria, evaluation indicators, and spatial scales for judging shrinking cities (Haase et al. 2014; Bernt 2016). How long is the time span and scope of space? Is there a unified framework for evaluating the shrinking city's economy, population, and other indicators? All these questions are of interest. In addition, the emergence of big data, such as points of interest (POI) data, night light data, and traffic travel data, can provide new evidence to assist in the identification of shrinking cities. And can this new data correct and supplement traditional statistical data? Future research should continue to focus on issues relevant to shrinking cities.

This paper extends the debate by adding a typology of the phases of shrinkage, which are based on the authors' observations of policy responses in the case of the Guangzhou–Foshan metropolitan area. The paper also reflects on these different phases by highlighting responses to the challenges of shrinkage at the municipal level and answers the question of how we can overcome the observed reluctance to integrate the postsocialist experience into general theory development. Research on shrinking postsocialist cities has strengthened the debate on determining factors and current and future forms of shrinking cities.

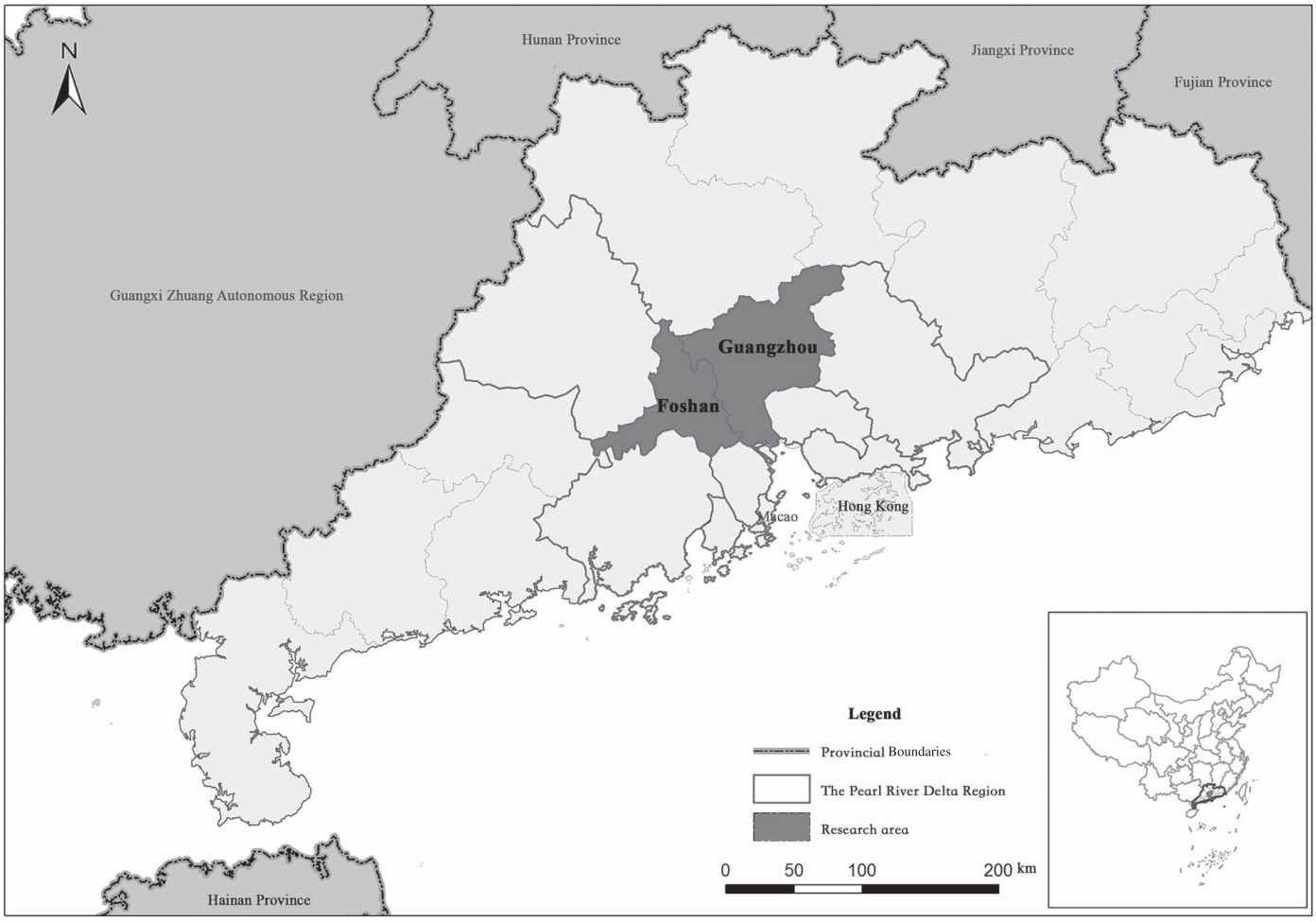


Fig. 1. The location of Guangzhou–Foshan region.

Research Methodology

Study Area

The Guangzhou–Foshan metropolitan area is located in a core subarea of the Pearl River Delta (PRD), the most developed and integrated area in China (Fig. 1). As the third largest city in China and the capital of Guangdong province, Guangzhou has a total area of 7,434 km^2 and a permanent population of 15.3 million as of 2019 (Guangzhou Statistic Bureau 2021). Foshan is one of the rapidly industrializing cities in China. Foshan is connected to Guangzhou in the west via highways and railways. Foshan has a total area of 3,797 km^2 and a permanent population of 8.15 million as of 2019 (Foshan Statistic Bureau 2020). The Guangzhou–Foshan metropolitan area chiefly refers to the towns bordering Guangzhou and Foshan, namely Guangzhou City (including 11 districts), Foshan City, Sanshui District, Nanhai District, Shunde District, and Gaoming District, whose border area is nearly 200 km long. The Guangzhou–Foshan region represents the crucial economic and cultural centers of Guangdong Province. The two cities of Guangzhou and Foshan have had close social, economic, and cultural connections throughout their development history.

Since ancient times, Guangzhou and Foshan have been closely connected in terms of trade and population mobility due to their geographical proximity. Unlike Guangzhou, which had become an administrative center for regions or administrative divisions more than 2,000 years ago, Foshan had been established, withdrawn, and belonged to Nanhai County until the formation of the Republic of China and early liberation. After the approval of the Government Affairs Office on January 12, 1950, Foshan, Shaoguan, and Jiangmen were upgraded to prefecture-level cities, but within 6 months they were withdrawn from the city and changed to towns (Huang et al. 2016). On January 12, 1951, Foshan changed from a town and was established as a city. In the same year, the Zhujiang Special District Commissioner's Office was moved from Zhongshan County to Foshan City (Chen 2010). It was at this time that the regional foundation of the Guangzhou–Foshan region was formed. Although it later experienced multiple events, such as administrative division adjustments and regional downgrades, the regional institutional basis did not change. In the late 1980s, the administrative divisions in Guangzhou and Foshan gradually adjusted to the current scope. The economies of Guangzhou and Foshan have developed rapidly with the deepening of reform and opening-up of the city, including increases in the degree of urbanization, increases in the population and land density of towns, and blurring of the original urban geographical boundaries (Li and Wu 2014). The borders between Guangzhou and Foshan, including Huangqi Town, Lishui Town, Shunde District, Liwan, Baiyun District, and Panyu District, have been built into the eastern part of the South China Sea. Simultaneously, with the continuous economic development and strong social connection of the people from Guangzhou, Foshan, the ties of this metropolitan area have become strong (Lin and Wu 2019).

Data Sources

We used the generated global DMSP NTL time-series data from 1992 to 2018. The harmonized global nighttime light data set was provided by Li et al. (2020b). Nighttime light data are available at https://doi.org/10.6084/m9.figshare.9828827.v2. The stable light data contain lights from cities, towns, and other areas with continuous nighttime lighting, including gas flares (Zhang et al. 2016). The harmonized global NTL time-series data include stepwise calibrated stable DMSP NTL observations from 1992 to 2013: F10 (1992–1994), F12 (1995–1996), F14 (1997–2003), F16 (2004–2009), and F18 (2010–2013), and the simulated DMSP-like DNs from the VIIRS radiance data (2014–2018). The spatial resolution of this data set was 30 arcseconds. Its spatial resolution is a 1×1 km grid, and its brightness value is 0–63.

Research Methods

DMSP/OLS nighttime light data are used to reflect the economic level of the study area, and LandScan population grid data provided by ORNL were used to demonstrate the population distribution. Using corrected DMSP/OLS nighttime light remote sensing images and land use data extracted by Landsat, the light value, and built-up areas in Guangzhou and Foshan were quantitatively analyzed in 500×500 m grid units. A spatial grid matching of the light data was performed using ArcGIS. The light intensity was counted on the grid scale, and the following formulas were used to detect the rate of change (RC):

$$\mathrm{RC} = \frac{NTL_{t+1} - NTL_t}{NTL_t} \tag{1}$$

where RC = changes in light intensity value during a certain time; NTL_t = light intensity value at *time t*; and NTL_{t+1} = light intensity value at $t+1$ time. According to the RC value, we set ± 0.2 as the threshold, that is, $\mathrm{RC} < -0.2$ = shrinkage area, $\mathrm{RC} > 0.2$ = growth area, and $-0.2 < \mathrm{RC} < 0.2$ = stable areas. By calculating the RC index, the growth and shrinkage of the Guangzhou and Foshan metropolitan areas were divided into three different spatial types, according to the grid average value, as the measurement standard. The spatial pattern and development evolution of growth and shrinkage at the grid scale in Guangzhou and Foshan metropolitan areas from 1990 to 2018 were investigated.

Using reclassification detects time-series changes in light. Based on the RC value, we redefined the three types of areas: (1) shrinkage, (2) stable, and (3) growth. Then, the layers of the four cross sections are superimposed to form the following formulas to generate the time-series changes of lighting in the Guangzhou–Foshan area:

$$\mathrm{Change} = C_4 + 10 \times C_3 + 100 \times C_2 + 1{,}000 \times C_1 \tag{2}$$

where C_1, C_2, C_3, and C_4 = reclassified values of the corresponding pixels in 1992–1999, 2000–2007, 2008–2010, and 2011–2018, respectively. For example, "1-1-1-1" means the area has been shrinking, and "2-1-3-1" means the area has experienced "stability-shrinking-growth-shrinking." Further, 81 results (3 to the 4th power) can be obtained. Table 1 gives the statistical results of the time-series changes of night lighting in the Guangzhou–Foshan area from 1992 to 2018.

Table 1. Results of the time series changes of night lighting in Guangzhou–Foshan area from 1992 to 2018

Changes in night light value for the corresponding pixels in 1992–1999, 2000–2007, 2008–2010, and 2011–2018	Area (km^2)
3-3-3-3	7,845
2-2-2-2	1,798
3-3-3-1	450
3-3-1-3	384
2-2-1-2	134
3-3-1-1	60
2-2-2-1	59
3-1-3-3	36
1-2-2-2	34
1-2-1-2	18
2-2-1-1	14
2-1-2-2	8
3-1-1-3	6
2-1-1-2	5
3-1-3-1	5
1-1-2-2	4
1-2-1-1	2
1-2-2-1	2

Note: In terms of changes in night light value, 1 = shrinkage; 2 = stability; and 3 = growth.

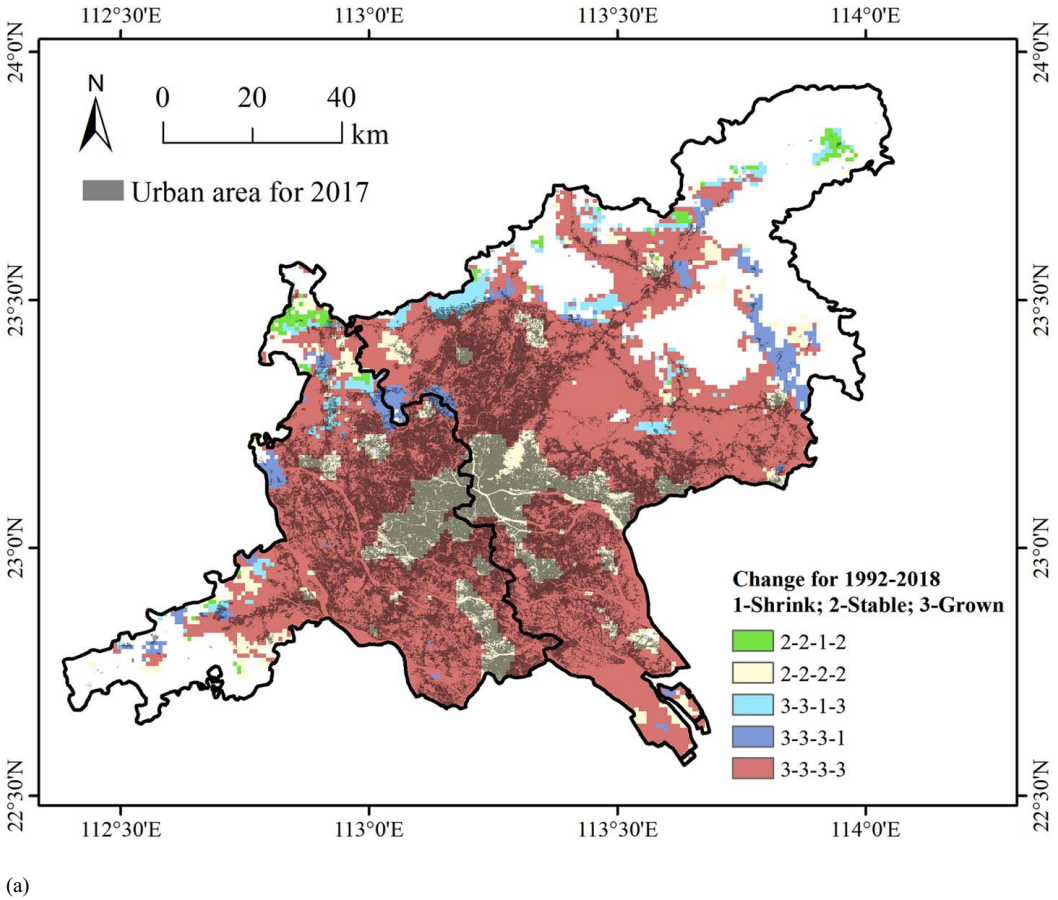
Results and Findings

Trajectories of Regional Development

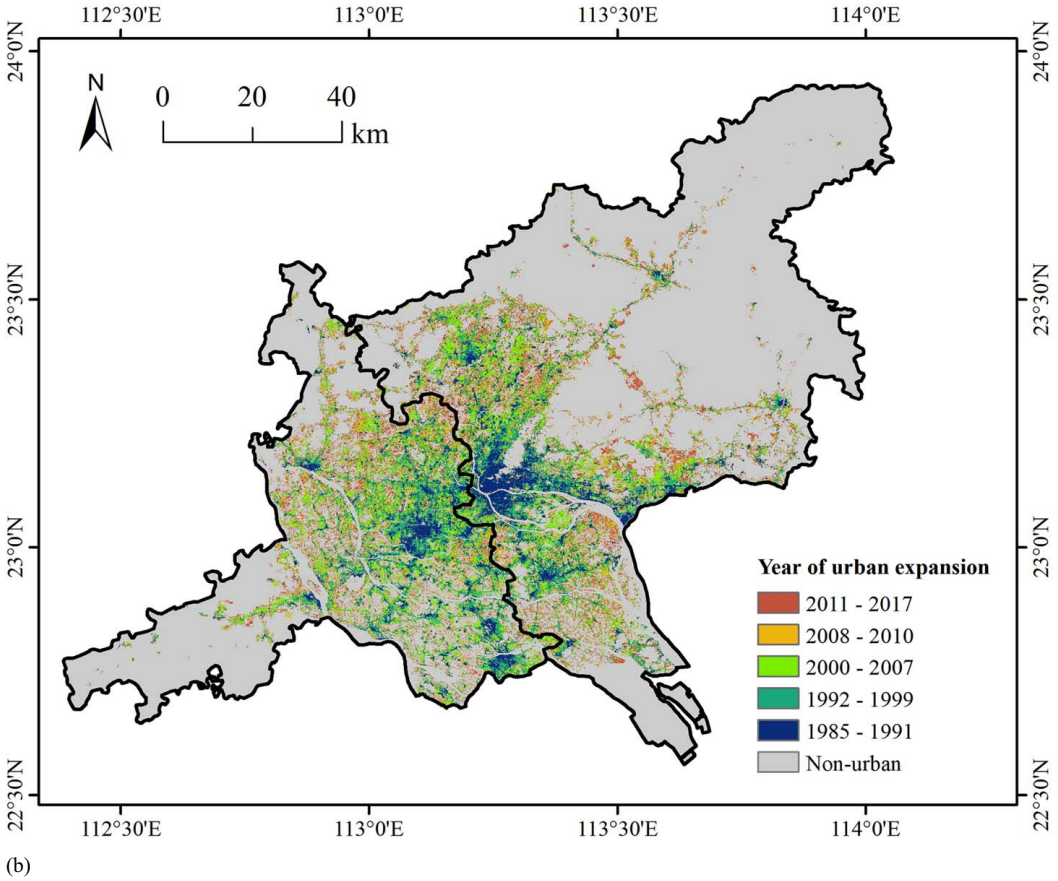
The integration process of Guangzhou–Foshan started in 1990 with urbanization as one of the key reasons for the simultaneous occurrence of a few land-use changes (Ye et al. 2018). In 1993, after the construction of the Guangzhou Metro Line 1, Guangzhou citizens began to buy property in Huangqi, South China Sea, which set off real estate development and a sales boom in Huangqi (Wu and Li 2013). The land along the Pearl River and Guangzhou–Foshan Highway in Huangqi is a hot spot for real estate development, which is also called the "Zhongshan Nine Road" (Liang 2007). As early as the 1990s, the two cities of Guangzhou and Foshan began to explore the possibility of regional cooperation.

From 2000 to 2005, the Guangzhou–Foshan region began to advocate for the development of "Guangzhou–Foshan integration." The construction land in Liwan District, Guangzhou, Nanhai District, and Foshan City has been connected, and the boundary has gradually become unclear [Fig. 2(a)]. The expansion of construction land in Guangzhou City is mainly distributed in Huadu and Panyu Districts and is also distributed in the northeast of Sanshui District in Foshan. In July and November 2003, Guangzhou and Foshan jointly held a seminar on "Guangzhou–Foshan Regional Cooperation and Coordinated Development" (Li 2003). In December 2005, the first "Guangzhou–Foshan Regional Cooperation and Development Forum," cohosted by the Guangzhou Municipal People's Government and Foshan Municipal People's Government, was held in Guangzhou, where ideas and intentions were introduced on the prospects and specific areas of regional cooperation between Guangzhou and Foshan (Li et al. 2019). The idea of promoting Guangzhou–Foshan regional cooperation as a common wish and requirement for Guangzhou and Foshan was also put forward. Clearly, the expansion of construction land in Guangzhou and Foshan clearly has been affected by the Guangdong–Foshan regional cooperation policies (Lin and Wu 2019).

From 2005 to 2010, the Guangzhou–Foshan region further expanded the Guangzhou–Foshan integration and encouraged the rapid development of heavy and chemical industries, new



(a)



(b)

Fig. 2. (a) Urban expansion of Guangzhou–Foshan area from 1985 to 2017; and (b) spatial distribution of the five largest types of coverage (>100 km^2).

industrial products, and emerging industries. The Planning and Transportation Department in the two cities jointly prepared the "Guangdong–Foshan City Road System Connection Plan." In addition, other transportation routes, such as the Guangfo light rail and subway, have been gradually opened, and the construction of the university city, the development of the Panyu District, the holding of the Asian Games, for instance, have been greatly promoted (Li et al. 2014). This guided the expansion of construction land in Guangzhou. In 2007, several Guangzhou–Foshan intercity bus lines were opened. First, the Guangzhou–Foshan passenger transport bus was launched, and then the transportation network was constructed (Li and Wu 2014).

On March 19, 2009, the mayors of Guangzhou, Mr. Zhang Guangning, and Foshan, Mr. Chen Yunxian, signed the "Guangzhou Foshan City Urbanization Construction Cooperation Agreement" in the Nanhai District, at the junction of the two cities. Planning, transportation infrastructure, industrial cooperation, environmental protection, and four other aspects have established corresponding agreements, marking the official launch of the Guangzhou–Foshan integration. On November 3, 2010, taking advantage of the upcoming Asian Games in Guangzhou, the first line of the Guangzhou–Foshan Metro, which is equivalent to Foshan Metro Line 1 (also named Guangfo Line) was officially opened for operation. This is the first prefecture-level city on the mainland China Subway Line (Yang et al. 2015). This improvement to the transportation network increased the enthusiasm of Guangzhou residents to buy houses in Foshan (Li et al. 2020c). "Working in Guangzhou, living in Foshan" is no longer a dream, and the idea of rapidly promoting the Guangzhou–Foshan 1-hour living circle has become a reality (Ren et al. 2017).

From 2010 to 2018, the construction land of Guangzhou and Foshan expanded rapidly to the border and fringe areas of the Guangzhou–Foshan area (Huadu, Panyu, West Sanshui, and West Nanhai). The area of construction land in the Guangzhou–Foshan region has continued to increase and is currently in a stage of rapid expansion. The expansion of construction land in Guangzhou mainly occurs in the Huadu District and Panyu District, at the border of Foshan City. Foshan City is mainly oriented to the north, northwest, south, and southeast directions; that is, the construction land in the South China Sea, Sanshui, and Shunde is expanding rapidly. The areas under the jurisdiction of Guangzhou, Foshan, and Nanhai are rapidly developing, and the peripheral areas, such as Huadu, Panyu, Sanshui, Nanhai, and Shunde, are in the sporadic and spreading expansion stages. In addition, regular intercity buses operate between Guangzhou and Foshan and are mainly concentrated in the cross-border areas of Guangzhou and Foshan, which predominately cover the border areas of the two cities, with some lines extending to the central area of the two cities (Hui et al. 2020). Nanhai District has become a key area for the development of the Guangzhou–Foshan integration. A total of 22 bus routes were opened between Nanhai District and the neighboring Liwan District in 2018, which are mostly concentrated in the Fangcun Passenger Station and nearby passenger flow concentration points (Li et al. 2020c).

From the changes in light results shown in Fig. 2(b), we found that (1) stable areas (2-2-2-2) are mainly concentrated in the old urban areas built before 2000; (2) the area with the largest coverage area is of continuous growth type (3-3-3-3), and their spatial distribution is in line with the characteristics of urban expansion; and (3) the area of shrinkage (3-3-1-3 and 3-3-3-1) is small and concentrated at the edge of the city or where the two cities are connected to ground straps.

Urban Growth and Shrinkage in Cross-Border Areas

Clearly, urban development and economic development in cross-border areas have increasingly become one of the main driving forces for the regional integration of the two cities. Population aggregation and economic growth are internal sources of power that affect urban expansion. Regional development strategies, administrative divisions, transportation planning, and other government strategies are external mechanisms that affect urban expansion. As the urban integration process advanced, the urban land-use pattern became much denser and more compact. With the gradual completion of the Guangzhou–Foshan intercity rail transit line and the gradual implementation of the "Outline for the Reform and Development Plan of the Pearl River Delta," the expansion of construction land in the Guangzhou–Foshan area has further expanded toward the border between Guangzhou and Foshan [Fig. 3(a)].

Shrinkage is a feature of urban life cycle in which the city does not introduce interventions but rather relies on higher-level government support. The "expansive strategy" before 2000 aimed to retain population while expanding residential areas in the urbanization process. "Maintenance strategy" is characterized by the development of existing land to maintain attractiveness and spatial structure. "Planning for growth and adapting to shrinkage" (2008–2020) aimed to increase infrastructure and regenerate old factories while developing the unique qualities of the cross-border area. These initiatives are similar to those of Danielzyk et al. (2002).

With the reform and opening-up of the city, the economies and land use of Guangzhou and Foshan have rapidly developed, and the original urban geographical boundaries have been continuously blurred. The borders between Guangzhou and Foshan are mainly industrial development areas. After 2000, due to the increase in population, numerous developers constructed housing estates on their borders. The following cases are representative examples [Fig. 3(b)]. Baiyun District Jianggao Town–Hegang Village (3-3-3-1): This area is used as a factory and freight terminal. Ship traffic was very busy in 2006 and 2008; after 2008, the area was greatly affected by the global economic crisis. In 2013, most of the covered ground became bare soil. After 2017, the factory was demolished and turned into an open space. Zengcheng District–Xiaolou Town–Xiaolou Avenue (3-3-3-1): This location was used as a factory. Around 2013, the factory was demolished and changed to commercial land, which is now a home-building material store. Gaoming District–Mingcheng Town 1 (3-3-3-1): After the financial crisis, some factories were relocated, and some industrial land became residential land. Huadu District–Shiling Town–Dahuagang Reservoir (3-3-1-3): A residential area was built around the Dahuagang Reservoir. From 2008 to 2010, the community was under construction (or just completed), and the occupancy rate was low, so the light value was low. In 2018, after most of the residents moved in, popularity rose, and the lighting value increased. Gaoming District–Mingcheng Town 2 (3-3-1-3): The industrial area continued to shrink in the context of the financial crisis, and the land continued to expand during 2014–2017 (Fig. 4). However, due to the COVID-19 epidemic, factories in the industrial park have been severely affected by the suspension of work and production, and the light value has decreased, showing a repeated situation of shrinking.

Discussion and Implications

Cyclical Growth and Shrinkage of Cities

Before and after the 2008 financial crisis, the coexistence of growth and shrinkage of cities and towns in Guangzhou and Foshan

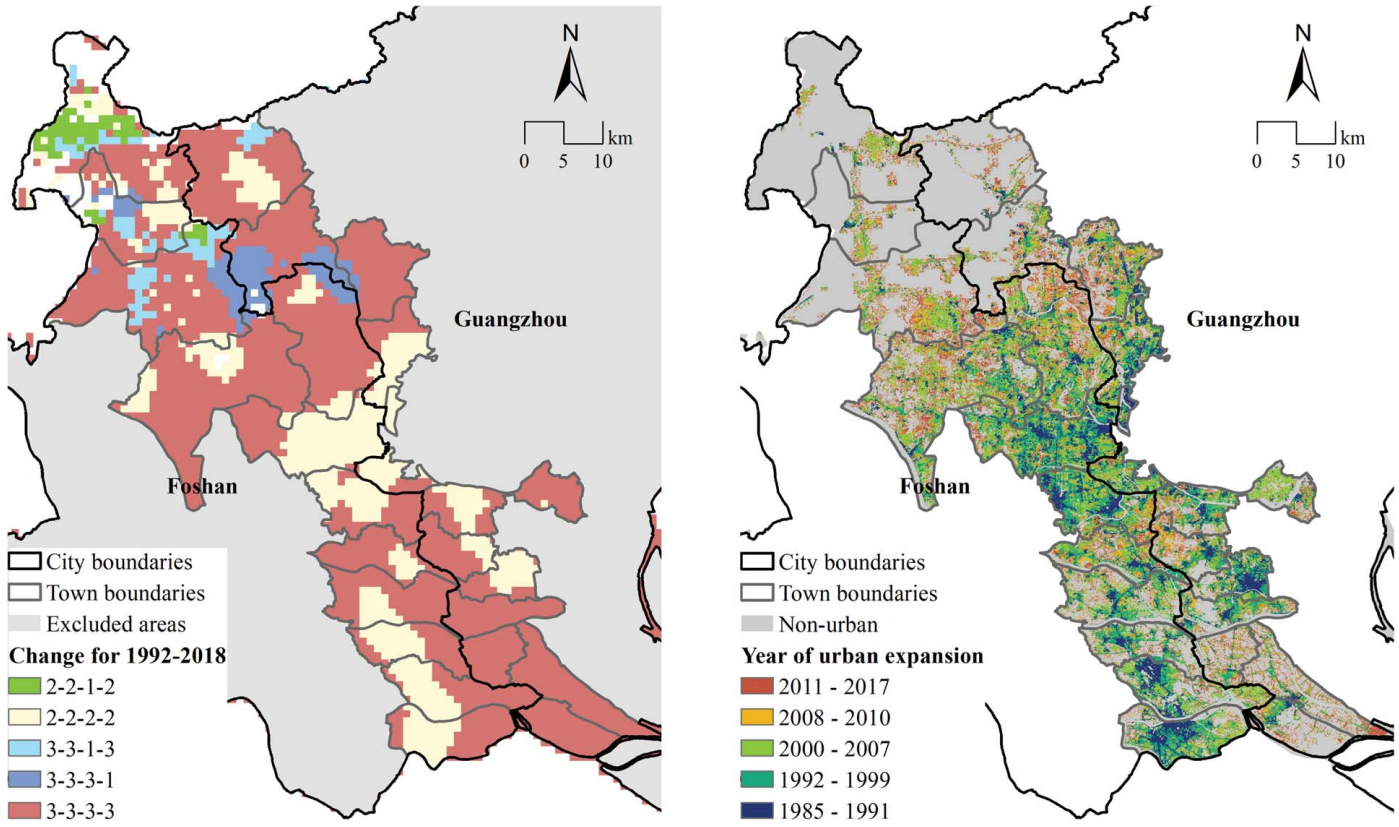


Fig. 3. (a) Urban expansion of the Guangzhou–Foshan cross-border area from 1985 to 2017; and (b) spatial distribution of the changes in Guangzhou–Foshan cross-border area.

became typical features of urban development. The spatial distribution of growth and shrinkage in cities and towns has a relatively high degree of concentration, demonstrating that urban growth is concentrated in central areas and urban shrinkage is scattered in the outer areas of cities. The overall characteristics of cross-border areas, such as Guangzhou and Foshan, show that the two cities' new growth poles are gradually changing their spatial development patterns. In growing cities and towns, the main driving forces are improvements in the economic scale and population size, and optimization of the economic and population structure in the direction of high-end automation, youth, and higher education (Ren et al. 2020). However, shrinking cities and towns have shown slower economic growth, increased corporate failures, and intensification of population outflow, accompanied by noteworthy phenomena, such as idle infrastructure and rising vacancy rates of rental houses (Lang et al. 2020). In rural urbanized areas, space shrinkage is characterized by vacant rental houses and miniaturization and sublease of factory buildings, which are mainly concentrated in old villages and old industrial areas. The transformation and upgrading of export-oriented processing and manufacturing industries and the loss of foreign industries are the primary reasons for shrinkage in the village (Long et al. 2012).

Regional Integration Promoting Growth and Shrinkage

Regarding regions with rapid development, necessary upgrades include the level of governance power structure, increasing the scale of various policies and activities, improving spatial position in the governance structure to obtain more resources, and investments to achieve leapfrog urban development. Observing the trend in population density of the east–west direction in the last 3 years, it can be seen that the high-density central area of Guangzhou has continuously expanded to the east (toward Foshan) over the past two decades (Chen 2010). However, population density is growing slowly. The population density in the central area of Foshan has increased. The population density growth in the border area to the east is affected by the border and has a slow population density growth. In other words, due to the existence of the administrative division boundary, before the integration development of Guangzhou and Foshan, a depression area with population density distribution was formed in the border area and the development of border towns and streets was limited (Chen 2010).

With the advancement of the integration, the Guangzhou and Foshan areas have become a new standard of regional governance. Through the joint meeting system and the annual plan for the key construction of the city, Guangzhou and Foshan have formed a different level of scale relationship based on the governance of social and economic affairs in the city. In response to the development of border towns, the two cities proposed focusing on the border areas and promoting a comprehensive experiment of urbanization. Specifically, it includes the boundary spaces of the two levels. The first is at the municipal level where the two cities proposed five key development zones for intracity development. The zones have comprehensive services, well-built infrastructure, livable living environment, and ecological cultivation, as well as important areas with clear development positioning, good foundation, and joint promotion of cooperation. The five junction areas, namely the Fangcun–Guicheng region, the Guangzhou South Railway Station region, the New Baiyun Airport region, the Jinshazhou

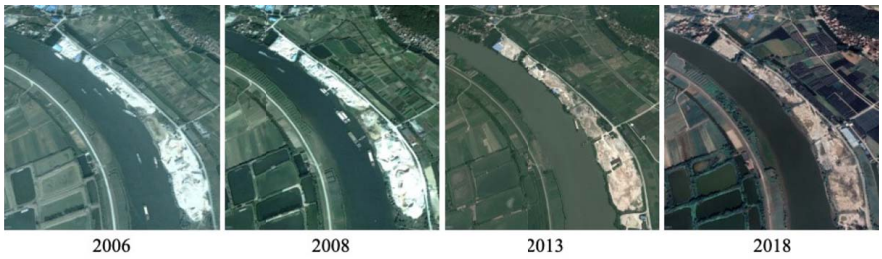
Type	Transformation process
Baiyun District Jianggao Town-Hegang Village (3-3-3-1)	
Zengcheng District-Xiaolou Town-Xiaolou Avenue (3-3-3-1)	
Gaoming District Mingcheng Town 1 (3-3-3-1)	
Huadu District-Shiling Town-Dahuagang Reservoir (3-3-1-3)	
Gaoming District-Mingcheng Town 2 (3-3-1-3)	

Fig. 4. Representative examples of rapid development in the cross-border areas. (Images © 2020 CNES/Airbus, Maxar Technologies, Map data © 2020.)

area, and the Wusha area, have carried out comprehensive experiments on the integration of Guangzhou and Foshan. After the five border areas were proposed, the two municipal governments and the joint meeting proposed specific planning guidance and development layouts for spatial planning coordination, infrastructure docking, industrial collaboration, and people's livelihood.

The proposal and implementation of the concept of the Guangzhou–Foshan integration coincided with two economic crises. The first was the Asian economic crisis of 1997. The country experienced a soft landing from an overheated economy. With the recovery of economic development and the transformation of capital, both Guangzhou and Foshan were facing challenges from peripheral cities, in addition to the weakening of the economic center status of Guangzhou's provincial capital. The status of the economy was shaken, coupled with the development of industrialization and urbanization of other cities, such as Dongguan, Shenzhen,

Zhongshan, and Zhuhai. Both Guangzhou and Foshan faced a crisis of slow capital accumulation. Therefore, around 2000, the concept of the Guangzhou–Foshan metropolitan area was proposed to establish a new governance structure and spatial structure to attract capital expansion (Wei et al. 2014). After the 2008 global financial crisis, the "Pearl River Delta Reform and Development Program" officially proposed a policy for urbanizing Guangzhou–Foshan, which gave the Guangzhou–Foshan metropolitan area an important historical mission and the task of revitalizing the economy of the PRD. The new governance structure and spatial structure appear in various government policies related to the process of infrastructure construction, especially in the cross-border areas (Chen 2010).

Regional Planning Strategies to Deal with a Shrinking City

Under the new normal, China's urban growth speed, urban structure, and development motivation have driven the transformation of urban planning. Stock planning and urban shrinkage have often been compared, yet they are two different subjects. Stock planning is the adjustment of urban planning methods, technical indicators, implementation management, and other aspects after the transformation of development momentum; under the new normal, it is a policy issue. Shrinking cities emphasize the development motivation of cities, highlighting the changes in the city's endogenous and exogenous power, and provide a new basis for urban planning (Chen et al. 2019).

To avoid the continuous shrinkage of urban areas, we should propose a combination of shrinking characteristics and mechanisms of rural urbanization areas and draw on the development strategy of "Smart Decline" adopted by European and American countries. Regarding different types of shrinkage cities, we would cultivate the formation of urban innovation space and improve the quality of urban space, focusing on old city and old industrial zone transformation, improving the human settlement environment, and promoting a comprehensive planning response according to the city planning of Guangzhou and Foshan.

Using the ideas of city resilience to solve the issues of city shrinkage is crucial. City resilience corresponds with city shrinkage (Chen et al. 2020). It is a core method for solving shrinkage, to build a city with dynamism, social mobility, government networks, well-built areas, and resilience. In addition, city resilience emphasizes that the idea of public participation is incorporated into the planning response of a shrinking city. The most important sign of city shrinkage is that there is no vitality. Public participation policies encourage more people to participate in shrinkage planning and make a vibrant city (Hui et al. 2021).

Adjusting urban spaces for long-term development is a good solution. European and American countries have two models for shrinking urban space adjustment (Cepl 2006). One is the urban island model, which centralizes the urban population and industrial development space and transforms the development depression space (mainly industrial land) into a green ecological land or revitalizing space, for example, a creative industrial park. The second is the de-densification model, which develops residential, commercial, and public facilities at many industrial waste sites to change the original high-density crowded urban space (Radzimski 2016). The combination of these two modes is more suitable for the transformation of large Chinese cities.

All of the resource-depleted cities in China should consider the best way to balance their infrastructure with decreased demand. While it is important for all developing countries to efficiently manage shrinking cities, a significant number of cities in these countries are witnessing depopulation and are finding that they have constructed more infrastructure than they need or can manage. The community perception of shrinkage plays a substantial role in the development of planning and economic strategies.

Conclusions

Shrinkage is considered a short-term stage in the urbanization process faced by most cities in China and abroad. We used the Guangzhou–Foshan region as an example to identify the pattern and process of growth and shrinkage in the region, particularly focusing on the cross-border areas. Specifically, we focused on how addressing shrinkage led to changes in urban planning with an in-depth discussion of its formation mechanism and the introduction of planning strategies.

The relationship between the rise and fall of cities shows that city shrinkage is regarded as a short-term periodic phenomenon that occurs in the city lifecycle during the transition process from maturity to decline or revival. Changes in light results during the period from 1985 to 2017 of the Guangzhou–Foshan region show that stable areas are mainly concentrated in the old urban areas built before 2000, the largest urban area is of continuous growth type in line with the characteristics of urban expansion because of urbanization and globalization, and the area of shrinkage is small and concentrated in the cross-border areas. Particularly, since the 2008 financial crisis, extensive changes have been noted in the cross-border areas, where such growing and shrinking areas coexist. With the wave of urbanization, improvements in the economic scale and population size are the main driving forces of city growth. Confronting with the financial crisis, the reform of state-owned enterprises and economic recession, which is resulting in vacancy of the physical space and population outflow, are the primary cause of urban shrinkage. That is different from western cities where have experienced shrinkage after the relocation of third-tier factories.

The Guangzhou–Foshan integration can be seen an effective method to confront shrinkage. The cultivation of urban space in old city and old industrial zones and using the idea of city resilience are the core methods for solving shrinkage to optimize resource allocation. Thus, whether a shrinking city is reviving, like Pittsburgh, or declining, like Detroit, can be better understood by this case. The research may provide planning strategies for the urban shrinkage phenomenon that occurs in cross-border areas.

Continuous monitoring is indispensable for city-regions in order to reach a final decision on the persistent presence of urban growth and shrinkage and their future development. Concerning the limitation of nighttime light imagery that is the presence of systematic biases and the light saturation problem, in future research, we would explore additional information especially on human activities that might be included for extensive understanding of the characteristics of urban shrinkage. The employed methodology also should be improved and new techniques and data for change detection as well as associated object-based features must be calculated and included. For broader investigation of urban growth and shrinkage and related processes, future research should incorporate more Chinese and global cities and larger spatial scales.

Data Availability Statement

Some or all data, models, or code used during the study were provided by a third party. The harmonized global nighttime light data set was provided by Li et al. (2020b). Nighttime light data are available at https://doi.org/10.6084/m9.figshare.9828827.v2. Direct requests for these materials may be made to the provider, as indicated in the Acknowledgments.

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