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Does Regional Urbanization Promote Balanced Land Development? Evidence from Long Time Series Satellite Imagery

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Abstract: The urban megaregion has been promoted as among the major urbanization forms in New-Type Urbanization in China, which aims to promote more balanced development among cities and between the urban and rural areas in a region. While numerous studies have examined developed land expansion in cities worldwide using remotely sensed imagery, fewer have investigated its dynamic process in a rural area and the differences in the growth magnitude and expansion morphology between urban and rural areas. Using Landsat imagery from 1986 to 2020, we examined the spatiotemporal patterns of developed land in both the urban and rural areas in the Changsha–Zhuzhou–Xiangtan urban megaregion, China, using morphological analysis. We found that (1) the differences in the growth magnitude between the urban and rural areas varied between the different-sized cities, with increases in the largest city of Changsha, but decreases in the smaller ones of Zhuzhou and Xiangtan, although there was a slight increase at the megaregional scale. (2) The dynamic process of developed land in rural areas was similar to that in urban areas but showed a clear time-lag effect, where the dominant expansion types in urban areas shifted from edge to infilling expansion and to another edge expansion in 1986–2000, 2000–2010, and 2010–2020, whereas that in rural areas changed from outlying to edge expansion in 1986–2000 and 2000–2020. (3) The positive relationships between the growth speed and outlying and edge expansion suggested that the CZT urban megaregion was in the rapid outward expansion stage. Such a pattern may cause similar ecological effects, such as habitat fragmentation and urban heat archipelagos, to that in the eastern megaregions. Understanding such differences and their changes in the urban and rural areas will help optimize the strategies of urban megaregion sustainability.

Keywords: urban megaregion; coordinated regional development; urban morphology; urban expansion; rural development; urban ecology

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1. Introduction

The dynamic process described by the growth magnitude and the geometric characteristic of the built-up environment has long been a focus in geographical science [1–4] because it has significant social and ecological impacts, especially in the rapid urbanization era [5,6]. Previous studies have demonstrated that urbanization promotes the expansion of developed land not only in the urban area but also in the rural areas from the conceptual framework of the urban land teleconnection and the continuum of urbanity [7–9]. The changes in livelihood and lifestyle driven by global and regional teleconnections changed the magnitude and spatial configuration of developed land, resulting in different dynamic processes. Particularly in the complexity of processes in contemporary global urbanization, the organization of cities becomes diverse and so the metropolis model, the megalopolis model, and the megaregion model are coexisting and all these models integrate the contrasting urban and rural land cover types [8,10,11]. As a result, a question is involuntarily presented: How do rural areas change over time under the background of regional development? Does regional urbanization promote balanced land development between urban and rural areas?

In recent decades, the urban megaregion has been promoted as among the major urbanization forms in China. Among the aims is to promote balanced development among cities and between urban and rural areas via resource allocation, such as industrial cooperation, education and medical treatment optimization, and infrastructure extension [12,13]. Some studies argued that resource allocation is closely related to the population size and indirectly impacts the developed land scale, which may narrow the differences among cities and between urban and rural areas [14,15]. Further analysis of the balanced land development in the urban megaregion showed that the changes in the differences in developed land scale varied among different regions [16,17] but ignored an urban and rural comparison. Studies interested in the urban and rural differences mostly focused on the social dimension, such as the equity of income, infrastructure, and health [18–20]. Compared to the previous research, few focused on the dynamic process of developed land in rural areas, including the growth magnitude and the geometric characteristic, and differences between urban and rural areas.

With the free use of satellite imagery, such as time series Landsat and Sentinel data, considerable studies have been conducted to characterize the dynamic process of developed land in a long-term period because of the advantages in spatial details and temporal frequency [21–25]. Based on the historical imagery, the multi-temporal maps of developed land (can also be the settlement/urban land) were generated and then used to quantify the spatiotemporal patterns of urban change in every five- or ten-year intervals by the landscape analysis [26–28] and the morphology analysis [22–24,29]. The characteristics, involving the magnitude determined by growth extent and speed, the space trajectory depicted by the gravity center, and compactness/sprawl described by the patches' geometric location, were frequently examined.

Specifically, the morphology analysis, focusing on the geometric relationships between the existing developed land patches and newly developed land patches, was widely used because it explicitly displays the sequence of the spatial evolution of an urban area [30]. Basically, there are three types of expansion—outlying (leapfrogging/spontaneous), edge, and infilling expansion [1]. According to the composition of these three types, a two-step process of diffusion and coalescence of cities can be described. In the starting process, the urban core grows, leading to the outward expansion of the existing urban core and accompanied by dispersing of new cores of developed land. As the diffusion process continues, the outward expansion of cores makes the developed land patches touch each other, leading to the infilling of gaps within them, and the beginning of coalescence [30–32]. Many studies have performed the morphological analysis to investigate the spatial evolution in a single city [21,33], to analyze the changes over time among multiple cities with different sizes [24,34], and to compare the similarities and differences among the variedly geographical and economic regions [23,35,36]. The concerns of these studies were either the urban area change determined by dynamic boundaries detected from the satellite images [22] or the changes occurring within a fixed circle, square, and administration boundary. These studies demonstrated that outward expansion was dominant during rapid urbanization, represented by the positive relationships between the growth speed and the edge-expansion type [23,36,37]. However, under the regional development strategy, if the developed land in rural areas was promoted to increase rapidly, whether the geometric characteristics in rural areas have a similar process?

Based on the above, the objective of this study is to investigate the dynamic process of developed land in rural areas and examined the balanced land development under the developed strategy of an urban megaregion. We focused on three questions: (1) What are the trends in developed land growth across urban and rural areas? (2) How does the expansion morphology change in the urban and rural areas? (3) Does the growth speed also promote outward expansion in the rural area? We selected an urban megaregion located in south-central China, the Changsha—Zhuzhou–Xiangtan (CZT) urban megaregion, as the study area and first defined the urban and rural areas using the places-based method. Second, we compared the changes in developed land expansion between urban and rural areas at the megaregional and city levels. Finally, we investigated the spatial evolution in both urban and rural areas by quantifying the expansion types and their relations to the growth speed at the subdistrict level.

2. Materials and Methods

2.1. Study Area

The Changsha—Zhuzhou–Xiangtan (CZT) urban megaregion, located in south-central China, is among the important economic growth poles in the Yangtze River Economic zone. Since the period of the 10th Five-Year Plan for economic and social development, the CZT urban megaregion has been planned for constructing the Chinese urban system [38]. Since 2005, the Hunan Province has released several versions of the regional development plan and promoted urban–rural integration [39]. Therefore, the CZT urban megaregion is a typical study area to investigate whether regional urbanization promotes balanced land development between urban and rural areas. According to governmental planning, the extent of the CZT urban megaregion varies among different versions. The nucleus part of it, however, consistently contains three prefectural-level cities—Changsha, Zhuzhou, and Xiangtan (Figure 1). As a result, we only focus on these three cities in this study, with a total area of 28,000 km^2. With the rapid urbanization and economic development, its population increased from 10.82 million in 1986 to 16.68 million in 2020, with an annual growth rate of 1.6%, and the GDP dramatically grew from RMB 10.79 billion to 1759.20 billion from 1986 to 2020.

2.2. Data

The land cover thematic maps with a spatial resolution of 30 m used in this study have a 6-class legend based on the system determined from the project "Survey and Assessment of National Ecosystem Changes Between 2000 and 2010"—forest, grass, water, farmland, developed land and barren land. The type of developed land is consists of settlement and transportation land. We first collected the land cover maps in 2000, 2005, 2010, and 2015 from the Database for Ecosystem Assessment (https://www.ecosystem.csdb.cn/ecosys/index.jsp, accessed on 8 October 2021.). We then updated Map2020 based on Map2015 and backdated the maps in 1986, 1990, and 1995 based on Map2000 by using the same classification approach that integrates the updating/backdating method and an object-based image analysis [40].

Here, we briefly introduced this approach using the Map2020 generation as an example. All the available Landsat 5, 7, and 8 imagery in 2015 and 2020, covering the CZT urban megaregion, were collected on the Google Earth Engine platform and the cloud cover and cloud shadow pixels were removed, respectively. The image compositing method was then performed to obtain the imagery in 2015 and 2020, respectively [41]. The multi-resolution segmentation algorithm embraced in the eCognition software was performed to obtain the image objects, using the imagery in 2015 and 2020 as image layers and Map2015 as the thematic layer for maintaining consistent object boundaries. By the object-based change detection, the objects with change were detected and were then classified into 6 land cover types based on the spectrum and geometry features. The land cover types of those objects with no change were assigned the same as Map2015. The overall accuracies of all the land cover maps were over 85.0% (Figure 2).

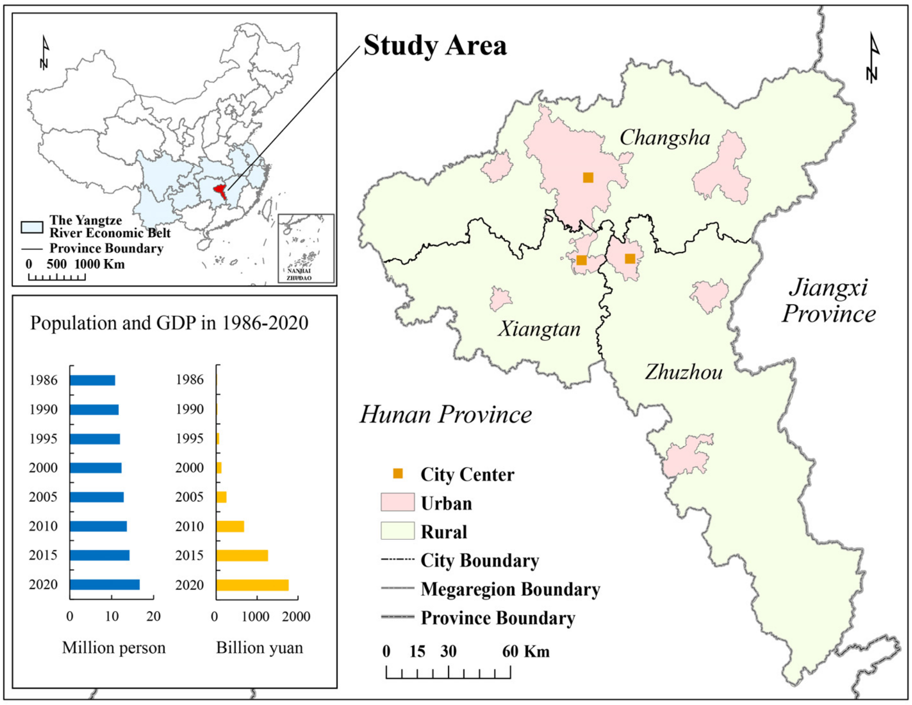

Figure 1. The geographic location of the Changsha—Zhuzhou–Xiangtan urban megaregion. The box at the bottom left is the population and GDP in the CZT urban megaregion and shows the hierarchical administrative boundary.

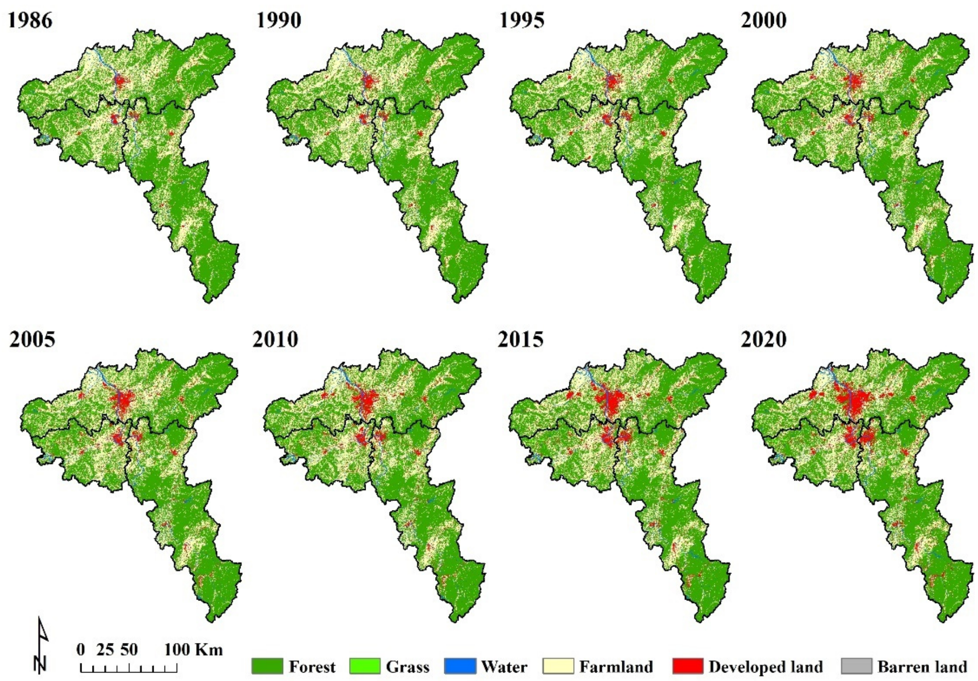

Figure 2. Land cover thematic maps of the Changsha—Zhuzhou–Xiangtan urban megaregion in 1986–2020.

2.3. Methods

Before we examined the dynamic process of developed land in the rural area and compared it with that in urban areas, the boundaries were defined to distinguish the urban and rural areas. Based on the multi-temporal land cover maps in 1986–2020, the spatiotemporal analysis was used to quantify the trends in developed land growth across urban and rural areas. Three indicators—the growth magnitude, the relative growth speed, and the area ratio of developed land between urban and rural areas—were calculated at the megaregional and city levels. The morphology analysis was then used to identify the expansion types and investigated the spatial evolution and the differences between urban and rural areas at the megaregional, city, and subdistrict levels. The workflows were displayed in Figure 3.

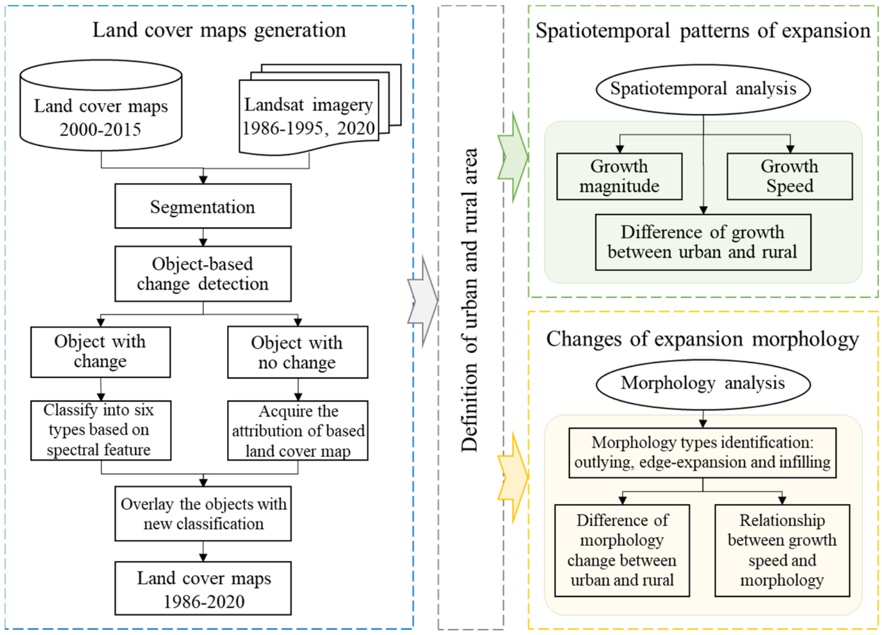

Figure 3. Flowchart for the dynamic process of developed land between urban and rural areas.

2.3.1. Definition of Urban and Rural Areas

Several methods have been presented to distinguish urban and rural areas and these methods can be roughly divided into two categories—the satellite imagery-driven boundary [42,43] and administration-driven boundary [44,45]. In this study, considering developed land expansion was significantly impacted by the governmental plan in China, we used administrative boundaries to define the extent of urban and rural areas. Limited by the acquisition of accurate historical data, the administrative boundaries in 2020 obtained from the Resource and Environment Science and Data Center (https://www.resdc.cn/, accessed on 26 March 2022.) were selected. We combined the boundaries with the codes released in 2020 by the National Bureau of Statistics of China (http://www.stats.gov.cn/tjsj/tjbz/tjyqhdmhcxhfdm/2020/index.html, accessed on 30 September 2022.) to define the urban area. According to the administrative division, the rankings were province, city, county/district, subdistrict/town/village, and neighborhood. In this study, the urban area includes the subdistrict and the rural area consists of the town and village (Figure 1). To easily state the analysis unit, we used the word 'subdistrict' to represent the administrative level of the subdistrict/town/village.

2.3.2. Spatiotemporal Analysis

For the spatiotemporal patterns of expansion, the newly developed land was extracted and two indicators—the area of newly developed land (A_{new}) and the annual growth rate of developed land (AGR)—in every five-year intervals—1986–1990, 1990–1995, 1995–2000, 2000–2005, 2005–2010, 2010–2015, and 2015–2020—were calculated for measuring the expansion magnitude and speed [46]. The indicator of the developed land ratio between urban and rural areas was calculated to quantify the differences and to investigate the changes.

$$A_{new} = A_{end} - A_{start} \quad (1)$$

$$\text{AGR} = \left(\left(\frac{A_{end}}{A_{start}} \right)^{\frac{1}{(t_{end} - t_{start})}} - 1 \right) \times 100\% \quad (2)$$

$$\text{Ratio} = \frac{DL_{urban}}{DL_{rural}} \quad (3)$$

where A_{start} and A_{end} represent the area of developed land at the time of t_{start} and t_{end} in the five-year interval, respectively.

2.3.3. Morphology Analysis

To examine the geometric characteristics of the dynamic processes of developed land, the morphology analysis presented by Xu et al. (2007) [21] was used. Based on the maps of developed land in 1986–2020, the patches of newly developed land were extracted in each five-year interval via spatial overlay analysis. The newly developed land patches were then classified into three types—outlying, edge, and infilling expansion—by considering the geometrical information. The identification for the three expansion types is shown below:

$$\text{S} = \text{Lc}/\text{P} \quad (4)$$

$$\begin{cases} \text{S} = 0 & Outlying \\ 0 < \text{S} \leq 0.5 & Edge - expansion \\ 0.5 < \text{S} \leq 1 & Infilling \end{cases} \quad (5)$$

where Lc represents the shared boundary between a patch of newly developed land and a patch of previously developed land, and P represents the perimeter of the parch of newly developed land. The types of expansion morphology are determined based on S.

The Pearson correlation analysis was performed to examine the relationships between the growth speed and the expansion types at the subdistrict level. In 2020, the CZT urban megaregion had 346 units at the subdistrict level. Before analyzing the statistical relationships, the area percentages of outlying, edge, and infilling expansion were calculated in each subdistrict and the ternary plots were used to display their changes in urban and rural areas in the past four decades.

3. Results

3.1. Spatiotemporal Patterns of Expansion

Results from the changes in the developed land area showed that the CZT urban megaregion experienced a dramatic expansion (Figure 4) The magnitude of developed land increased from 666.46 km^2 in 1986 to 2190.84 km^2 in 2020 at the megaregional level, which the size expended over three times. The growth speed represented by the AGR in 1986–2020 was 3.56%, with variations in different periods. The AGR sped up from 3.42% to 4.52% in the first three five-year intervals and then fell to 2.33% in 2005–2010. In the past decade, the AGR exhibited another increase, in which the value increased from 3.25% in 2010–2015 to 3.85% in 2015–2020, suggesting the CZT urban megaregion experienced another rapid expansion period (Figure 4b,c).

From the spatiotemporal patterns of expansion, the newly developed land mostly clustered in the city of Changsha, with an increased area of 836.88 km^2 in 1986–2020, followed by the city of Zhuzhou and Xiangtan, with increased areas of 412.54 and 246.74 km^2, respectively (Figure 4a, Table 1). From 1986 to 2005, the developed land expanded rapidly in all three cities. The trends in the past decade, however, showed differences. The AGR values were stable in Changsha but increased obviously in Zhuzhou and decreased in Xiangtan (Table 1). The comparisons between urban and rural areas showed that the changes in developed land varied between the different-sized cities although the ratio of developed land in urban areas to that in rural areas slightly increased from 0.85 in 1986 to 0.91 in 2020 at the megaregional level (Figure 4b, Table 1). In the city of Changsha, the ratio increased from 1.4 to 1.63 in the period of 1986–2020, while that in the city of Zhuzhou had a decreased trend in which the values decreased from 0.54 in 1986 to 0.42 in 2020. Similar trends in 1986–2010 can be found in the city of Xiangtan (Table 1).

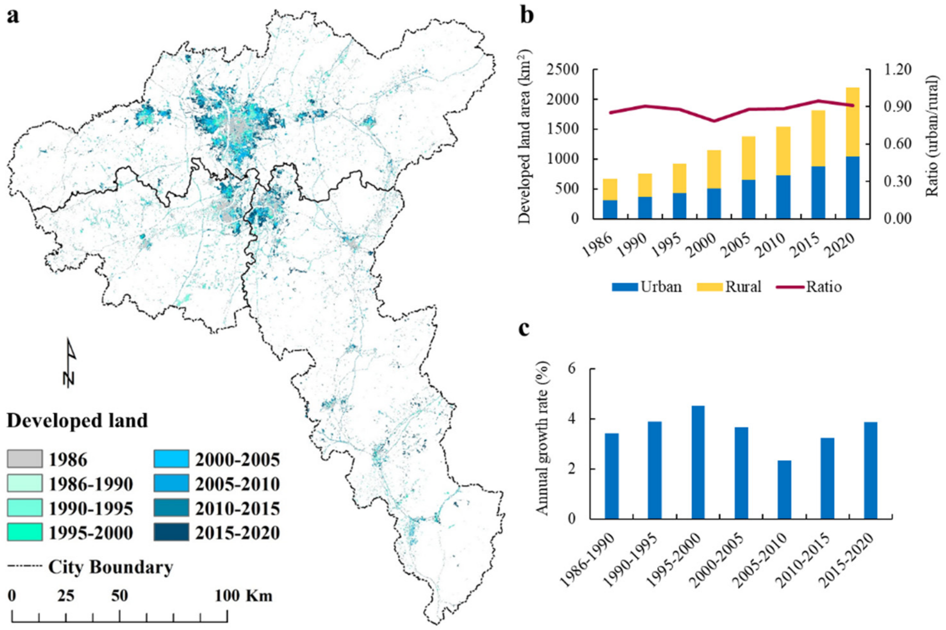

Figure 4. The growth of developed land in the CZT urban megaregion from 1986 to 2020: (**a**) the spatial patterns of the newly developed land, (**b**) the area and the differences in developed land between urban and rural areas, and (**c**) the annual growth rate of developed land.

Table 1. Urban and rural differences in developed land changes from 1986 to 2020.

Year	Changsha					Zhuzhou					Xiangtan				
	Total	**Urban**	**Rural**	**Ratio**	**AGR**	**Total**	**Urban**	**Rural**	**Ratio**	**AGR**	**Total**	**Urban**	**Rural**	**Ratio**	**AGR**
1986	286.98	167.17	119.81	1.40	/	225.54	79.00	146.53	0.54	/	153.95	60.91	93.04	0.65	/
1990	334.62	203.01	131.61	1.54	3.91	255.97	88.75	167.23	0.53	3.22	172.06	70.09	101.97	0.69	2.82
1995	408.11	253.79	154.32	1.64	4.05	283.37	99.59	183.78	0.54	2.05	231.68	77.90	153.78	0.51	6.13
2000	522.99	317.57	205.43	1.55	5.09	351.46	102.55	248.91	0.41	4.40	276.97	85.67	191.30	0.45	3.64
2005	660.17	421.71	238.46	1.77	4.77	411.05	121.88	289.17	0.42	3.18	306.07	100.52	205.55	0.49	2.02
2010	774.31	482.96	291.35	1.66	3.24	452.22	137.47	314.76	0.44	1.93	319.20	105.41	213.79	0.49	0.84
2015	924.38	581.95	342.43	1.70	3.61	510.88	160.53	350.35	0.46	2.47	378.16	140.15	238.01	0.59	3.45
2020	1123.96	697.17	426.80	1.63	3.99	648.33	191.21	457.11	0.42	4.88	418.55	154.43	264.12	0.58	2.05

3.2. Changes in Morphology between Urban and Rural Areas

Our results showed that the morphology in the CZT urban megaregion shifted from outward expansion to inward growth and then to another outward expansion, suggesting alternative processes of diffusion and coalescence in the past four decades (Figure 5). In 1986–2000, the total area percentages of outlying and edge-expansion patches were over 90%. In the later twenty years, the area percentage of edge and infilling expansion patches were over 86% (Figure 5h). Specifically, the area percentages of the infilling patch were 42.68% and 46.51% in 2000–2005 and 2005–2010, but that dropped to 23.84% in 2010–2015 and 21.45% in 2015–2020, respectively. The statistics at the city level showed a consistent process in the urban area within all the cities, in which the expansion types with area percentages over 50% were the same as that at the megaregional level. The process in rural areas exhibited a time lag that the dominant expansion type represented by over 50% of the area in Changsha and Zhuzhou changed from outlying in 1986–2000 to edge expansion in 2000–2020. Except for 1995–2005, the city of Xiangtan was dominated by the edge-expansion type (Figure 6).

According to the multi-temporal changes in morphology at the subdistrict level, we found that both the urban and rural areas had a lower proportion of infilling patches in 1986–2000; the dominant types, however, were varied. The proportions of subdistricts with an outlying area greater than 50% were 44.04% in 1986–1990, 34.43% in 1990–1995, and 68.35% in 1995–2000, respectively. Among them, the corresponding proportion of subdistricts belonging to the rural area were 61.17%, 93.61%, and 80.79% (Figure 7a–c). In the last twenty years, the urban areas were mostly of the infilling type and the proportion of subdistricts with an infilling area greater than 50% in each five-year interval was 60.69%, 48.28%, 55.86%, and 50.34%, respectively. The rural area, comparatively, showed a change from dominated edge expansion in 2000–2010, with subdistrict proportions of 50.75% and 49.75%, to outlying expansion in 2010–2015, with a proportion of 62.69%. In 2015–2020, the dominance changed to edge expansion again (Figure 7d–g).

The statistical results from the correlation analysis showed that the growth speed was the most significant factor relating to outlying and edge expansion. The relationships in the urban and rural areas showed similar trends in outlying expansion but variations in edge expansion (Table 2). The Pearson correlation coefficients between AGR and outlying expansion had downward trends, so the values decreased from 0.58 to 0.42 in urban areas and from 0.73 to 0.45 in rural areas. In the urban area, the AGR had a significantly positive effect on edge expansion, with a rising tendency of coefficients. In the rural area, the coefficients between AGR and edge expansion showed a fluctuation in 1986–2005 and a decreased trend in 2005–2020, although significant positive relationships can also be found. Additionally, we found that the AGR had positive relationships with infilling types in 2000–2020 in urban areas but the values dropped down from 0.53 to 0.26.

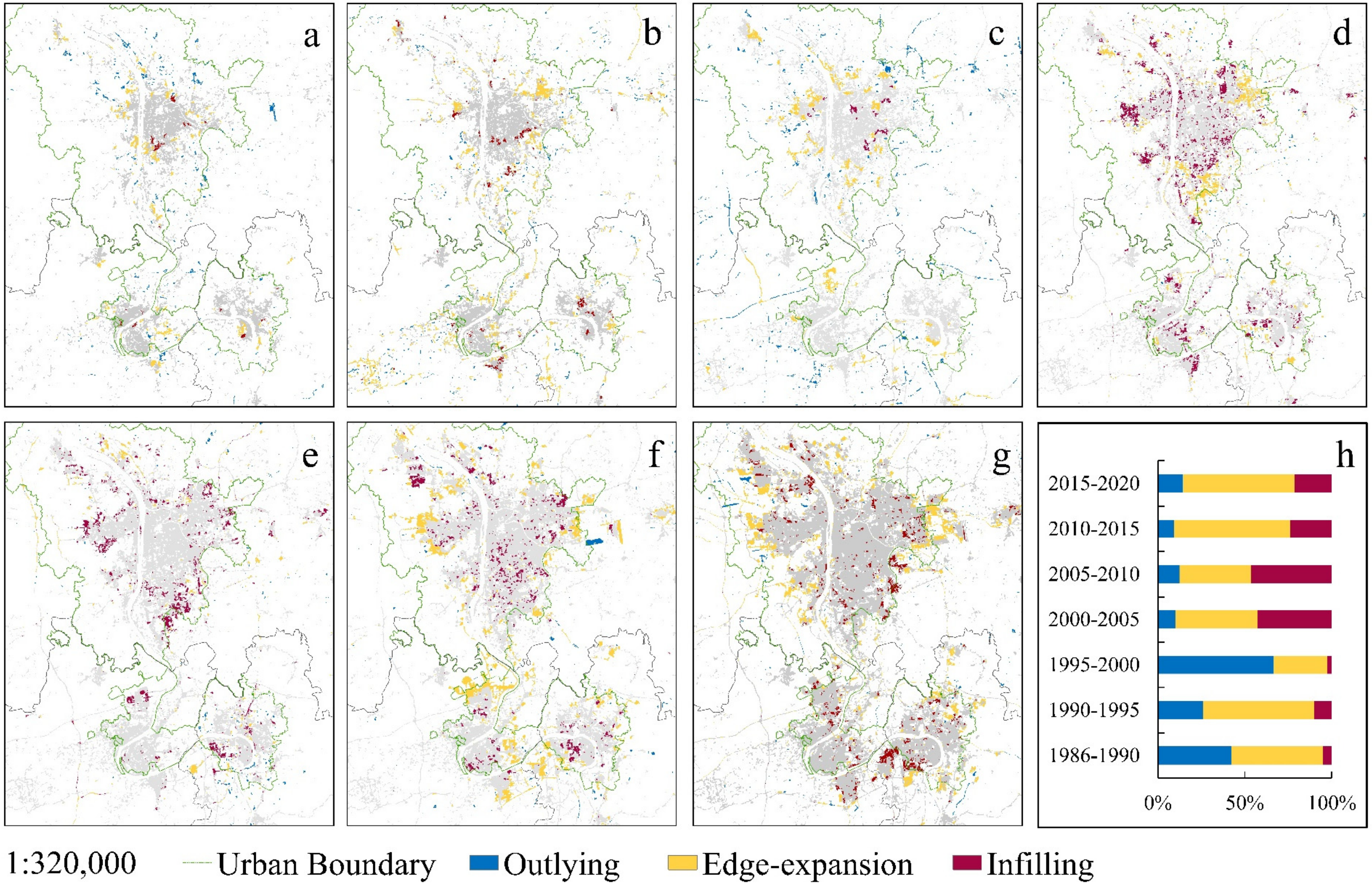

Figure 5. The expansion morphology in the CZT urban megaregion in 1986–2020: (**a**–**g**) the subsets for the spatial patterns of expansion morphology in the developed land clusters of Changsha, Zhuzhou, and Xiangtan, where the corresponding five-year intervals were 1986–1990, 1990–1995, 1995–2000, 2000–2005, 2005–2010, 2010–2015, and 2015–2020; (**h**) the area percentage of the three expansion types.

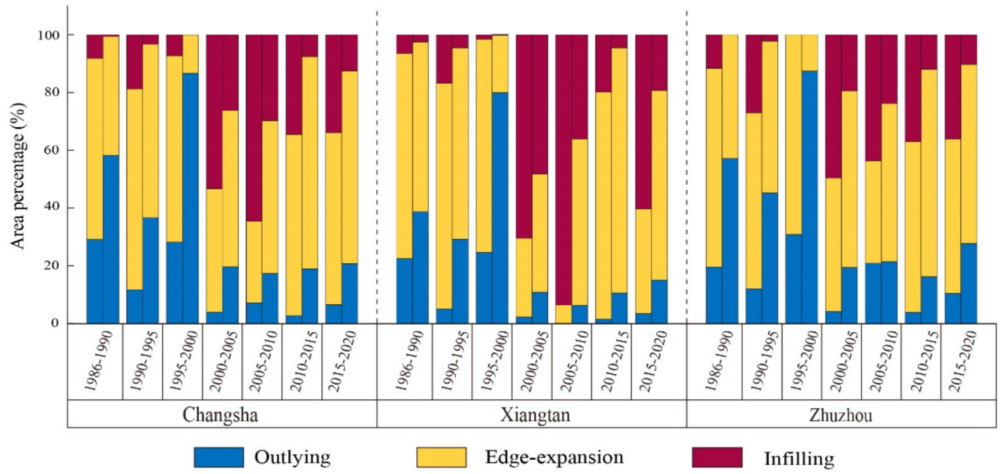

Figure 6. The differences in expansion morphology between urban and rural areas at the city level. In each city, the left and right columns are the results in urban and rural areas, respectively.

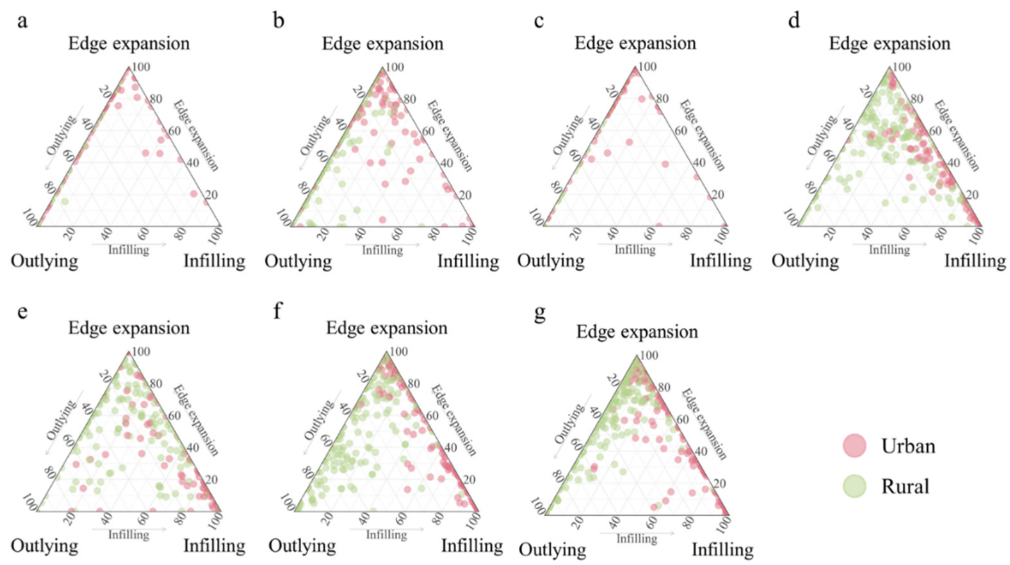

Figure 7. The changes in expansion morphology in the urban and rural areas at the subdistrict level in 1986–2020: (**a**–**g**) the results in the five-year intervals of 1986–1990, 1990–2000, 2000–2005, 2005–2010, 2010–2015, and 2015–2020.

Table 2. The relationship between the expansion speed and morphology (Pearson correlation analysis).

Year	CZT Megaregion			Urban			Rural		
	Outlying	Edge Expansion	Infilling	Outlying	Edge Expansion	Infilling	Outlying	Edge Expansion	Infilling
1986–1990	0.58 **	0.46 **	0.04	0.58 **	0.49 **	0.01	0.73 **	0.38 **	−0.02
1990–1995	0.41 *	0.71 **	0.08	0.43 **	0.68 **	0.12	0.44 **	0.73 **	0.07
1995–2000	0.34 **	0.20 **	−0.02	0.46 **	0.54 **	0.02	0.31 **	0.12	−0.05
2000–2005	0.34 **	0.67 **	0.46 **	0.51 **	0.67 **	0.53 **	0.45 **	0.68 **	0.19 *
2005–2010	0.43 **	0.56 **	0.36 **	033 **	0.53 **	0.53 **	0.47 **	0.58 **	0.32 **
2010–2015	0.37 **	0.52 **	0.24 **	0.46 **	0.55 **	0.32 **	0.44 **	0.52 **	0.12
2015–2020	0.46 **	0.55 **	0.10	0.42 **	0.77 **	0.26 **	0.45 **	0.45 **	0.09

* the coefficient is significant at the 0.05 level; ** the coefficient is significant at the 0.01 level.

4. Discussion

4.1. Policies for Differential Changes between Urban and Rural Areas

Many studies have examined the spatiotemporal patterns of the CZT urban megaregion and suggested that it was a multi-nucleated pattern led by the cities of Changsha, Zhuzhou, and Xiangtan [47]. Our comparative results based on the changes in developed land revealed more details that the urban and rural differences varied between the different-sized cities. The megacity Changsha, with an approximate population of 10 million in 2020, was more likely to give priority to developing the urban areas, especially the central built-up area in the urban region (municipal district of Changsha) (Figure 4a and Table 1). Comparatively, the large cities, Zhuzhou and Xiangtan, had narrowing trends in developed land growth in urban and rural areas (Table 1). Such changes in Changsha were similar to the cities within the urban megaregion led by single or double centers, such as the Beijing–Tianjin–Hebei urban megaregion [48]. The changes in Zhuzhou and Xiangtan showed similarities to those cities in the eastern regions, such as the Yangtze River Delta and the Pearl River Delta urban megaregions led by multiple nucleated patterns [49–51].

These differential changes between urban and rural areas seem to be the result of two major factors—urban megaregion planning from the central government and the local orientation of economic function. In the early 2000s, the Chinese central government released a general plan to promote megaregion development [52]. As an economic center in south-central China, the tremendous potential of development attracts a large number of people to cluster in the CZT region, promoting the growth of developed land. Specifically, several plans, such as the 11th Five-Year plan for economic integration and the Chang–Zhu–Tan metropolitan development plan released by the Hunan provincial government, all emphasized narrowing the urban and rural differences [39,53]. These strategies suggest promoting township and village enterprise development, transportation network construction, and public infrastructure optimization in the rural area. Benefiting from urban and rural integration, the economy and function transformation in rural areas accelerated the developed land growth, resulting in a narrowing difference in magnitude [54]. However, we also found that not all the cities had narrowing trends, which is likely to be impacted by the city functions. As the capital city of the Hunan Province, Changsha has more social resources, such as employment, education, and medical care, which attract the people who live in town and village, even those who live somewhere far away from the Hunan Province move into the urban area, resulting in enlarged differences between urban and rural areas. Comparatively, the city of Zhuzhou is a transportation junction that connects the southern and central networks in China. The urban and rural differences in Zhuzhou can be reduced from by the convenience of road links that provide opportunities for the flow of people and materials, activating the rural economy.

4.2. Implications for Regional Development

Relatively few studies examined the land dynamics considering the changes in the rural areas with that in the urban areas under the background of urban megaregion development. In this study, the morphology comparisons showed that the spatial evolution of developed land in rural areas was similar to that in urban areas, only with a lag time, no matter what the differences in area growth exhibited between the urban and rural areas (Figures 6 and 7). We found that the CZT megaregion began with the diffusion process, which was indeed led by the edge expansion in urban areas and outlying expansion in rural areas (Figure 6). Similarities can be found in the later coalescence process that the infilling in urban areas and the edge expansion in rural areas dominate the megaregional expansion types. It suggested that the spatial evolution of an urban megaregion still follows the hypothesis of diffusion and coalescence processes. Based on the long-term observations, we also found that the expansion speed had significantly positive relationships with outlying and edge expansion. However, from the fluctuations and alterations of the coefficients for both the two types, the effects seem likely to be dependent on the expansion phases, which were often ignored from the short-term observation. These results suggested that the morphological change in an urban megaregion can be recognized as a scale-up city.

The finding that developed land changes in rural areas exhibit a similar process to that in urban areas has important implications for urban sustainability. First, in the past decade, the rural areas experienced a diffusion process dominated by outlying and edge expansion, suggesting a trend of habitat loss and fragmentation [47,55]. Some previous studies showed that the developed land sprawl may cause a regional ecological issue, such as urban heat islands becoming extended and connected, forming urban heat archipelagos [56]. From 1986 to 2020, the balanced land development between urban and rural areas in Zhuzhou suggested an appropriate control and an improvement of land use efficiency that may require attention. Second, the urban areas become more compact, with a high-level proportion of the infilling type, compared to the rural area. Such compactness of urban morphology has advantages in improving land use efficiency and preserving ecosystem services [57]. For example, the compact main urban areas in Changsha, Zhuzhou, and Xiangtan had advantages in protecting the "green core" that is located in the center of these three main urban areas and is considered the most important ecologically isolated zone in the CZT megaregion. Third, the finding that the dynamic process of developed land in rural areas helps prove the universality of the diffusion–coalescence hypothesis optimizes the strategies for urban–rural integration, such as a plan for when to promote and when to control. For example, the urban area in Changsha was still in the rapid outward expansion stage, although the size of it has been much larger than that of the other two cities. Controlling the development intensity and adjusting the non-provincial function to the rural area around the urban area or to the neighboring cities may promote regional integration. Fourth, the positive relationship between the growth speed and outlying and edge expansion suggests that the CZT megaregion is in the rapid outward expansion stage, which may have a low land use efficiency that was revealed in some eastern coastal urban megaregions. However, more analysis combined with population and resource utilization is needed.

4.3. Limitations and Future Work

In this study, we compared the differences in the land dynamics between urban and rural areas in the CZT urban megaregion based on the historical information derived from the remotely sensed imagery. Limited by the acquisition of historical data, we only used fixed administrative boundaries instead of dynamic boundaries to define the urban and rural areas. Indeed, such fixed boundaries partly enlarged the growth magnitude of developed land in the urban area. Collecting the accurate historical boundary and defining a transition area between urban and rural areas will help address this issue via the urban–rural gradient approach. Additionally, we did not examine the driving factors for the growth patterns. Many factors, such as typology, landform, economy, and lifestyle, may impact the growth magnitude and geometric characteristics of developed land. Understanding their impact may help with management. Therefore, examining the driving force and their changes will be the next focuses in future work.

5. Conclusions

A large number of studies have examined developed land expansion in cities, but few have investigated the dynamic process in rural areas under a megaregional development background. In this study, we investigated the dynamic process of rural areas and the differences in the growth magnitude and spatial morphology between urban and rural areas in the Changsha–Zhuzhou–Xiangtan urban megaregion by using the multi-temporal land cover maps derived from the Landsat imagery in 1986–2020. The results showed that the differences in developed land in the growth magnitude between urban and rural areas slightly increased at the megaregional scale but varied among the different-sized cities. The differences in the largest city of Changsha increased but decreased in the smaller ones, Zhuzhou and Xiangtan. The dynamic process of developed land in rural areas was similar to that in urban areas but showed a clear time-lag effect. The growth rate of developed land had positive relationships with outlying and edge expansion, suggesting the CZT urban megaregion was in the rapid outward expansion stage. Such patterns may cause similar regional ecological effects, such as habitat fragmentation and urban heat archipelagos, to that in the eastern megaregions.

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