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The smart growth of Chinese cities: Opportunities offered by vacant land

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Abstract

Despite the publicly accepted concept of 'smart growth' of urban areas and its wide implications in developed countries, there is less concern about this in a newly emerging economy like China. Yet, due to the unprecedented urbanization rates in many developing countries, how to control unordered urban sprawl is becoming a severe challenge to multiple levels of governments. This study is the first to comprehensively evaluate the spatial and temporal change of vacant land within the built-up area of a large city in China. We used the core city of Shanghai as a case-study to systematically investigate the spatial–temporal distribution of vacant land at the fine scale. The boundaries of vacant land patches and of other urban land use types were delineated using visual interpretation, based on 0.3-m resolution aerial photos collected in 2000, 2005, and 2010. We find that (a) vacant land plays a very important role in the composition of the urban landscape of central Shanghai, accounting for 9.3%, 11.3%, and 10.4% of the core city area in 2000, 2005, and 2010, respectively; (b) there exists obvious spatial–temporal change of transformation between vacant land and other land use types during the 10 years studied; and (c) the considerable amounts of vacant land and its change dynamic have important policy implications for smart growth of cities in China. Making the best planning and management decisions about these vacant lands might be one promising smart growth principle for China's cities.

KEYWORDS

compact city, developing country, land use, vacant land

1 | INTRODUCTION

Rapid global urbanization is increasingly accompanied by urban sprawl. This trend results in a more rapid increase of urban built-up area than of urban population, and this phenomenon occurs both in developed and in developing countries. For instance, from the 1980s to the 2000s, the amount of developed land in the United States grew at nearly twice the rate of the population (US Environmental Protection Agency, 2016). In Europe, the average developed land grew by over two times the rate of urban population growth since the mid-1950s (European Environment Agency, 2006; Nilsson & Nielsen, 2013). Comparatively, being the large emerging economy such as China, the urban built-up area has increased by 78.5%, a rate notably faster than the 46% increase of urban population over the same period since the 1950s (Bai, Shi, & Liu, 2014). Such sprawling urban growth pattern, characterized by the dramatic increase of built-up area has been regarded as one of the most important factors affecting land degradation (Foley et al., 2005; Haase, Haase, Kabisch, Kabisch, & Rink, 2012; Hammad & Tumeizi, 2012; Turner, Lambin, & Reenberg, 2007; Zhang, Fu, Zeng, Geng, & Hassani, 2013). Urban expansion converted agricultural farmlands, forest, and other natural vegetation into built environment, leading to the fragmentation of landscape, loss of natural habitats, decrease of biodiversity, and so on, thereby causing negative environmental and ecological consequences, such as environmental pollution and ecosystem services degradation (Mundia & Aniya, 2006; Wang et al., 2018; Zhang et al., 2013). Thus, how to appropriately plan and manage urban sprawl and realize a sustainable urban development is a significant challenge for many countries.

The reasons for urban sprawl are mainly urban expansion and suburbanization (Daniels, 2001; Shen, Yuan, & Kong, 2013; Westerink, Haase, et al., 2013). The developed countries were the first to focus on controlling urban sprawl by putting forward theoretical concepts and new development policies. For instance, in the United States and Europe, smart growth has emerged as a widely accepted idea to curb uncontrolled urban sprawl since the 1970s (Daniels, 2001; Paulsen, 2013). In practice, many states officially enacted a number of smart growth principles, such as designating urban growth boundaries, encouraging mixed land use design, and conserving farm land and open space. In recent years, the smart growth policies in the United States focused on the redevelopment and infill of urban built-up areas by using compact forms for development (Ingram, Armando, Yu-Hung, & Flint, 2009). Many states such as Florida, Maryland, and New Jersey passed legislation to support the compact development of city centers (Ingram et al., 2009). Similarly, many European countries (e.g., UK, Netherlands, Germany, Norway, Poland, Spain, and Italy) also adopted various strategies to manage urban sprawl, such as better coordination between transport, land use and open space planning, urban containment by conservation and densification, development of a compact garden city with attractive inner-city areas, and preservation and development of blue and green infrastructure (Nilsson & Nielsen, 2013; Westerink, Haase, et al., 2013; Westerink, Lagendijk, Duhr, Jagt, & Kempenaar, 2013). Among these strategies, the most important and common policy is the densification of existing city centers by redeveloping the overabundance of vacant land caused by economic decline, population outmigration, or depopulation, especially in older industrial cities (Branas et al., 2011; Kremer, Hamstead, & McPhearson, 2013). By contrast, the most massive urban sprawl mainly due to the rapid growth of urban population now occurs in developing countries, resulting in growing tensions between urbanization and open land, natural resource management, and environmental quality. For instance, in China, as a newly emerging economy, the fast urbanization is reflected not only by the unordered outward expansion of urban area at the expanse of losing arable and natural land but also by the extensive urban renewal activities of the inner city (Bai et al., 2014; Shen et al., 2013; Zhou, Jiao, Yu, & Wang, 2017). Although the Chinese government has recognized the importance and emergence of promoting a smart growth strategy, there is still no concrete framework of sustainable urban growth management. Confronted with such a situation, the consensus is that it is imperative to find a way to improve the utilization efficiency in developed land. In March 2014, the Chinese Central Government released the China's National New-Type Urbanization Plan (2014–2020) (State Council of China [SCC], 2016). The target of optimizing urbanization by urban renewal is one of its goals.

In this study, we focused on two research questions that were currently overlooked in China: how much vacant land exists within the central core of a large city, and what is the spatial–temporal change of this kind of land? We purpose to examine these questions by assessing the extent of land reutilization potential of the central city at a fine scale. We used the administratively defined central core of Shanghai, the largest metropolis in China, as a case study. In addition, we used the term 'vacant land' to refer to the lands that are completely vacant without any developed use, the lands that are abandoned from previous industrial or other developed use, or the lands that are completely unbuilt, demolished, derelict, and underconstruction such as different types of urban construction land including public buildings, municipal facilities, transportation, and residentials within the urban built-up area. These lands provide a potential opportunity for urban development or redevelopment. First, we used aerial photos to accurately delineate all the vacant land polygons of the study area. Second, we assessed the spatial–temporal change of the vacant land during a period of 10 years from 2000 to 2010.

2 | DATA AND METHODS

2.1 | Study area

Shanghai is one of the largest and most important economic centers in China. It is located between latitudes 30°82′30″N and 31°82′70″N and longitudes 120°85′20″E and 121°84′50″E and is surrounded by the Yangtze River estuary to the north, the East Sea to the east, and Hangzhou Bay to the south. Shanghai has a subtropical monsoon climate. The average annual total precipitation is 1,067 mm, and average monthly temperature ranges from 2°C to 27°C. The total area of Shanghai is approximately 6,340.5 km^2, and the population is about 23.0 million (Shanghai Municipal Statistical Bureau, 2001). Shanghai has a long city development history, but the fast urbanization began since the implementation of the Reform and Open Policy in 1978. The proposed built-up area of the entire city of Shanghai, according to the City Master Plan (1999–2020; SCC, 2001), is 3,226 km^2 by 2020. However, the built-up area has already reached 2,900 km^2 at the end of 2011, implying there is only a very limited growing space in the coming years (Feng, 2013).

This study was conducted in the inner city of Shanghai within the outer-ring highway, an area officially designated as the central city core by the City Master Plan (Feng, 2013). It plays an important role in the city's development, aiming at high-end services, living, economy, trade and finance, science and technology, information, and culture. The study area totals 663.3 km^2 (Figure 1).

2.2 | Land use data

In this study, we employed land use categories to identify the different socioeconomic functions, such as residential, industrial, institutional, and commercial, in additional to a vacant land use type, as defined above. Land use classification was derived by a visual interpretation of 0.3-m resolution aerial photos, taken in 2000, 2005, and 2010. Although numerous studies have investigated urban land cover patterns using multiresolution remote sensing imagery, few studies have quantified urban land use distribution at fine scales (Ryznar & Wagner, 2001). Land use, different from land cover, refers to how people use the land in terms of social-economic functions and is difficult to be directly extracted from the remote sensed data automatically. Thus, in the study, each land use patch was manually delineated by referring to the local municipal cadastral data, which

FIGURE 1 Location of Shanghai City, and demarcation of the core or inner city area as defined by the Shanghai City Master Plan [Colour figure can be viewed at wileyonlinelibrary.com]

recorded the detailed social attributes of each land patch by the field investigation of land users. There were 13 main land use categories within the core of Shanghai City (Figures 2, 3; Table 1).

2.3 | Analytical methods

First, we used descriptive statistics to analyze the amount and proportion of the vacant land in 2000, 2005, and 2010, respectively. Second, we calculated the land use transition characteristics between vacant land and other land use types for two 5-year periods, from 2000 to 2005 and from 2005 to 2010. All the analysis calculations were conducted using ArcGIS™ software.

3 | RESULTS

3.1 | Change of vacant land

For the period of 2000–2005, vacant land consistently accounted for approximately 10% of the study area, but its spatial distribution varied markedly from year to year (Table 2; Figure 2). The proportion of

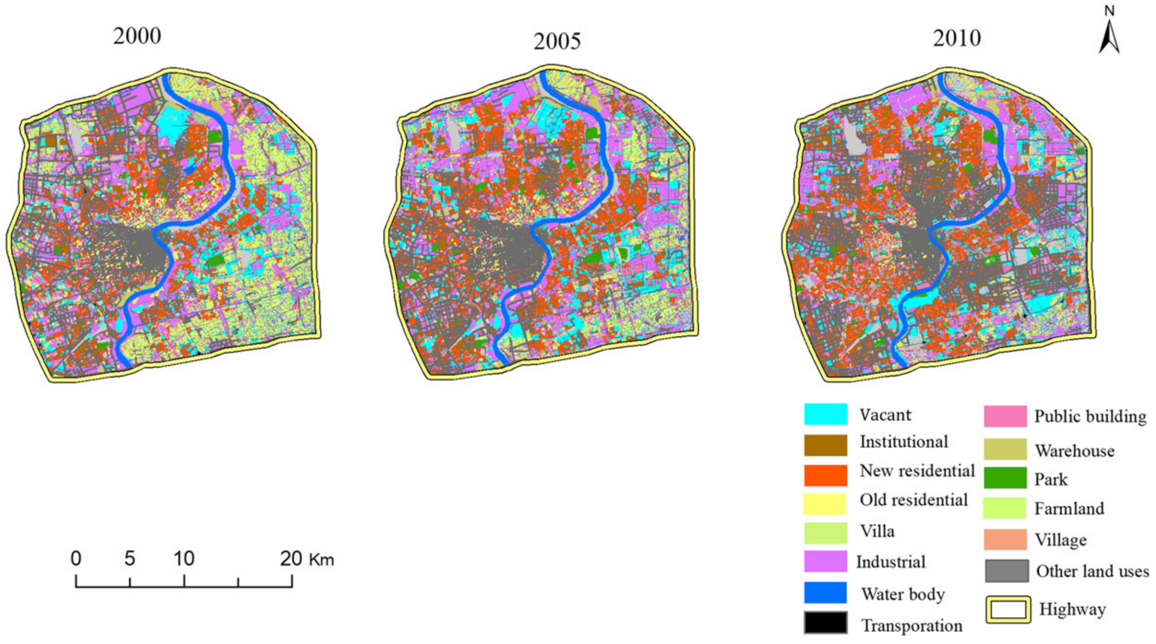

FIGURE 2 Spatial distribution of the land use types within the study site in 2000, 2005, and 2010 [Colour figure can be viewed at wileyonlinelibrary.com]

FIGURE 3 (a) Aerial photography showing the characteristics of vacant land in the core of Shanghai City—unbuilt (bare without construction structure). (b) Aerial photography showing the characteristics of vacant land in the core of Shanghai City—unbuilt (empty with some weeds). (c) Aerial photography showing the characteristics of vacant land in the core of Shanghai City—derelict (paved by demolished construction structure). (d) Aerial photography showing the characteristics of vacant land in the core of Shanghai City—underutilized (paved by building structure under construction) [Colour figure can be viewed at wileyonlinelibrary.com]

vacant land in the study area ranked fifth (9.3%) and fourth (11.3%) among all land use types in 2000 and 2005, respectively. The size of vacant land varied, ranging from several hundred square meters to hundreds of hectares.

For the period of 2005–2010, it was similar to the first 5-year period. Vacant land still consistently accounted for a considerable proportion of the study area (Table 2), with a notable annual change (Figure 2). The proportion of vacant land of the total study area was 10.4% in 2010, lower than that of 2005 (11.3%), but higher than that of 2000 (9.3%). Vacant land was the fourth largest category in 2010.

3.2 | Vacant land transition between 2000 and 2010

During the period of 2000 to 2005, the change of vacant land use from and into other land use types was explicit. Totally, 69.8% of vacant (4,295.3 ha) land in 2000 was converted into other urban land use types, mainly including new residential (2,023.2 ha), industrial (733.0 ha), public buildings (520.6 ha), transport (394.8 ha), institutional (191.5 ha), and park (169.6 ha). About 30.2% (1,854.2 ha) of vacant land use remained undeveloped from 2000 to 2005 (Table 3; Figure 4). At the same time, 5,627.3 ha of other land uses (8.5% of the core of Shanghai City) were converted into vacant land (Table 4; Figure 4). Those land use conversions included 2,092.2 ha vacant land from agriculture and fisheries, 1,723.2 ha from industrial, 652.0 ha from village, and 426.6 ha from old residential, which constituted 65.4% of the total vacant land of 2005.

There was also notable land transition between vacant land and other land use types during 2005–2010 (Table 3; Figure 5). In all, 74.9% of vacant (5,602.8 ha) land in 2005 was converted into other urban land use types, mainly including new residential (2,292.7 ha), public buildings (806.2 ha), transport (755.1 ha), industrial (689.9 ha), and institutional (402.8 ha), whereas 25.1% (1878.0 ha) of vacant land of 2005 remained undeveloped. In comparison, during this 5-year period, 5,024.7 ha other land uses (7.6% of the total study area) were converted into vacant land (Table 4; Figure 5). Those transformations included 2,011.6 ha from industrial, 1,055.6 ha from agriculture and fisheries, 702.0 ha from village,

TABLE 1 Land cover and land use categories in the core of Shanghai City

Land use categorization	Description
1. Industrial (Ind)	Lands for industrial purposes, usually with multiple buildings for different industrial activities, such as workspaces, factories, warehouses, and associated infrastructure
2. Transport (T)	Lands for movement such as roads, railway lines, cycle tracks, public parking squares and transport terminals and interchanges, for example, airport, ship passenger terminal, railway station, bus station, and coach station
3. Institutional (Ins)	Institutional lands for schools, colleges, universities, research institutes, and associated infrastructure; commercial lands for business and services
4. New residential (NR)	Lands less than 15–20 years old, mixtures of high-rise apartment buildings and associated open space
5. Old residential (OR)	Lands older than 15–20 years, mixtures of dense low-rise apartment buildings and little open space
6. Villa (Villa)	Residential lands with single or multiple family houses, associated with open space in the form of gardens or yards
7. Village (Village)	Lands for housing rural residents
8. Parks (P)	Lands for public open space and specific use
9. Public buildings (PB)	Lands for various urban public services, such as indoor sports, hospital and commercial space, kindergarten
10. Municipal facilities (MF)	Lands for water storage, treatment purification facilities, refuse disposal facilities, postal service, power stations, and telecommunication facilities
11. Agriculture and fisheries (AF)	Agriculture includes crops, horticulture, fruit growing, the breeding and keeping of livestock; fisheries include fish hatchery and other fishing activities
12. Water body (WB)	Areas of open water and lands with water tables at or near the surface for prolonged periods of the year, such as river, lakes, canal, reservoir, and freshwater marsh
13. Vacant (Vacant)	Unbuilt, derelict, or underutilized lands within the urban built-up area

TABLE 2 Land use compositions of the study area from 2000 to 2010

Land use types	Land use composition in 2000 (%)	Land use composition in 2005 (%)	Land use composition in 2010 (%)
Industrial	20.9	20.0	16.0
Agriculture and fisheries	16.7	7.9	4.7
New residential	15.1	22.2	26.1
Transport	10.6	12.6	12.8
Vacant	9.3	11.3	10.4
Water body	6.8	6.2	6.1
Village	6.0	4.1	2.1
Public buildings	4.8	5.2	8.7
Old residential	4.2	2.9	1.9
Institutional	3.5	4.1	6.6
Park	1.2	2.1	2.6
Municipal facilities	0.4	0.4	0.6
Villa	0.4	1.0	1.3
Total	100	100	100

331.7 ha from old residential, and 283.1 ha from transport, which constituted 63.5% of the total vacant land use of 2010.

As a comparison between the two 5-year periods, the amount of land transition from vacant land to other land uses increased, from 4,295.3 to 5,602.8 ha (Table 3). In contrast, the amount of land transitions from other land use types into vacant land decreased, from 5,627.3 to 5,024.7 ha (Table 4). In addition, the amount of land transition from vacant land into new residential land increased from 2,023.2 to 2,292.7 ha, whereas the transition into industrial land use decreased from 733.0 to 689.9 ha (Table 3). By contrast, the amount of land transition from agriculture and fisheries into vacant land decreased from 2,092.2 to 1,055.6 ha due to the obviously reduced proportion of agricultural and fisheries from 2000 to 2010 within the study area (Table 2), whereas the transition from industrial into vacant land increased from 1,723.2 to 2,011.6 ha (Table 4).

TABLE 3 Land transition from vacant land into other land use types during 2000 to 2010

Land use types, converted from vacant land	Land use types in 2005, converted from vacant land in 2000		Land use types in 2010, converted from vacant land in 2005	
	Area (ha)	Percentage (%)	Area (ha)	Percentage (%)
Vacant	1,854.2	30.2	1,878.0	25.1
New residential	2,023.2	32.90	2,292.7	30.6
Industrial	733.0	11.92	689.9	9.2
Public buildings	520.6	8.47	806.2	10.8
Transport	394.8	6.42	755.1	10.1
Institutional	191.5	3.11	402.8	5.4
Park	169.6	2.76	153.5	2.1
Villa	109.3	1.78	165.2	2.2
Agriculture and fisheries	67.8	1.10	231.3	3.1
Water body	50.8	0.83	67.0	0.9
Municipal facilities	14.3	0.23	23.8	0.3
Old residential	11.0	0.18	7.3	0.1
Village	9.4	0.15	8.1	0.1
Total	6149.5	100.0	7480.8	100.0

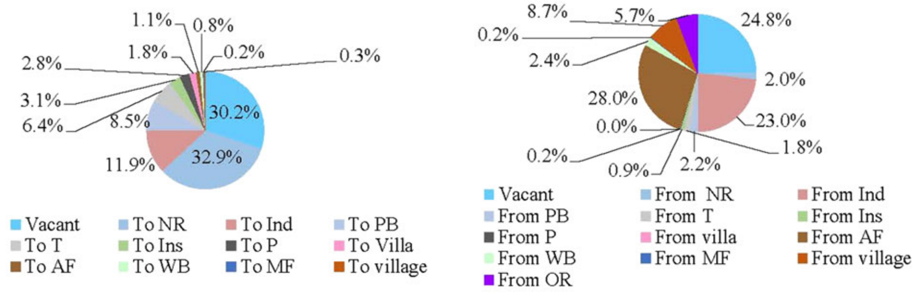

FIGURE 4 The composition patterns of all transitions from vacant to other land uses (left) and from other land uses to vacant during 2000 to 2005 (right), within the core of Shanghai City [Colour figure can be viewed at wileyonlinelibrary.com]

TABLE 4 Land transition from other land use types into vacant land during 2000 to 2010

Land use types, converted into vacant land	Land use types in 2000, converted into vacant land in 2005		Land use types in 2005, converted into vacant land in 2010	
	Area (ha)	Percentage (%)	Area (ha)	Percentage (%)
Vacant	1,854.2	24.8	1,878.0	27.2
Agriculture and fisheries	2,092.2	28.0	1,055.6	15.3
Industrial	1,723.2	23.0	2,011.6	29.1
Village	652.0	8.7	702.0	10.2
Old residential	426.6	5.7	331.7	4.8
Water body	181.5	2.4	159.4	2.3
Public buildings	167.2	2.2	180.6	2.6
New residential	146.6	2.0	162.1	2.3
Transport	136.1	1.8	283.1	4.1
Institutional	66.2	0.9	2,011.6	29.1
Municipal facilities	17.9	0.2	12.2	0.2
Park	15.6	0.2	34.6	0.5
Villa	2.2	0.03	4.6	0.1
Total	7,481.5	100.0	6,902.7	100.0

It should be noted that during the 10-year period of 2000–2010, there was a small amount of temporary use of vacant land, which referred to a short-time land transition from vacant land use into other urban land use types, then in turn converted back into vacant land. A total of 254.3 ha of vacant land was temporarily developed between 2000 and 2010, and 43.3% of which was devoted to short-term industrial use.

4 | DISCUSSION

4.1 | The significance of vacant land

The considerable proportion of vacant land in the officially designated central core of Shanghai indicates that vacant land plays an important role in urban land use composition. Its marked spatial–temporal change reveals the specific urbanization mode and land use policy with Chinese characteristics, which are apparently different from the driving forces of developed countries. For example, many postindustrial cities, such as Philadelphia, Detroi, and Chicago in the United States, have very high persistent stocks of vacant land, reflecting loss of industrial and shipping enterprises, and the associated loss of jobs, population, and investment (Accordino & Johnson, 2000; Deng & Ma, 2015; Hoalst-Pullen, Patterson, & Gatrell, 2011; Johnson, Hollander, & Hallulli, 2014; McPhearson, Kremer, & Hamstead, 2013). Subsequent abandonment of buildings, sometimes followed by demolition, yielded high official vacancy rates. On average, US cities have 15% vacant land covers, with new, rapidly developing cities in the South and Southwest exhibiting vacancy as high as 43% (Pagano & Bowman, 2000). Similarly, some European cities, such as Taranto, Porto, Aberdeen, Frankfurt, and Tallinn, also experienced the decline of population associated with the increase of land vacancy in old

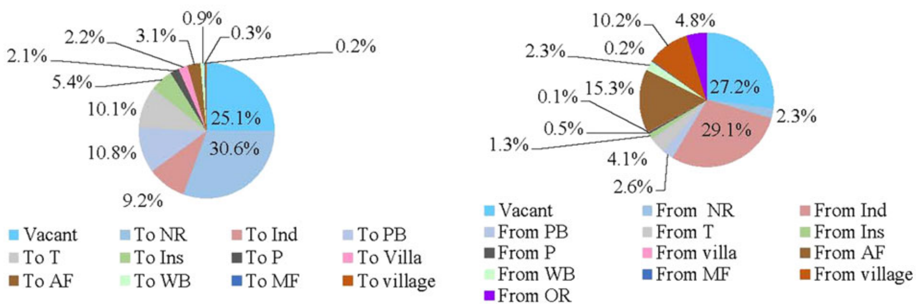

FIGURE 5 The composition patterns of all transitions from vacant to other land uses (left) and from other land uses to vacant during 2005 to 2010 (right), within the core of Shanghai City [Colour figure can be viewed at wileyonlinelibrary.com]

urban areas (Johnson et al., 2014). The comprehensive understanding of the status and reasons of vacant lots of China's cities is very important to promote the goal of 'smart growth.'

China's unprecedented sprawl might contribute to the existence of the considerable amount of vacant land in already built-up areas of Shanghai (Bai et al., 2014; Zhou, Jiao, Yu, & Wang, 2017). For example, from 2000 to 2010, the urban built-up area of Shanghai dramatically increased by 75%, from 1,600 to nearly 3,000 km^2 (National Bureau of Statistics of China, 2001). However, partly as a result of such a rapid urban expansion, much land within the built-up area was insufficiently used. Thus, with the continuous sprawl of the city, large amounts of urban built-up area increased outward from the city center. Such a pattern of urbanization ignored the fact that there still existed a certain amount of scattered farmland and rural residential land use in the city center of Shanghai, accounting for 22.0%, 11.1%, and 4.8% of the total study area in 2000, 2005, and 2010, respectively. As a result, some of the lands shifting from nonurban uses were temporarily converted into vacant land.

In China, urban renewal is one of the important issues in the Urban Master Plan from the central to municipal governments, particularly for large cities such as Shanghai where land supply is quite limited relative to the demand (SCC, 2001). As a result, many land developers strive to redevelop the already developed lands in order to gain more profits by trading on the land use rights. Under such circumstance, all the designs of urban renewal projects are finally determined by various land contractors, who own the land use rights. Thus, such unplanned and decentralized urban redevelopment makes the planners and managers primarily concerned with more short-term interests, which lead to the frequent demolition and reconstruction according to the rapidly changing market demands. For instance, in both the 5-year periods from 2000 to 2005 and from 2005 to 2010, significant amounts of industrial and old residential buildings were demolished, resulting in vacant land, which accounted for 28.7% and 33.9% of the total vacant land in 2005 and 2010, respectively (Table 4). In addition, our finding of the temporary use of vacant land for a short-term industrial use during the 10-year period partly reflected the lack of long-term urban land use policy of China. In China, the practice of urban planning is often criticized for not keeping up with the fast development. Many buildings with housing age less than 20 or 30 years have been demolished just because of the change of the city planning, and it has to make way for the changes such as the short term of industrial use of vacant land in Shanghai and among some other cities (Shen et al., 2013).

4.2 | Potential effects and implications of vacant land in China

Like many cities in the developed countries, such a large amount of vacant land and its frequent changes have marked effects, which in turn has significant policy implications. For example, in some US cities such as Baltimore and Chicago, the influences of vacant lands on urban ecosystems were explored (Kremer et al., 2013; McPhearson et al., 2013). In Baltimore, New York City, Detroit, Cleveland, and others, some suggestions on how to utilize the vacant lands to improve urban development had been proposed (Kremer et al., 2013). Similarly, in Europe, some cities (e.g., Leipzig–Halle, German, Hague, Netherland, Manchester, and UK) emphasized on the reuse of vacant or brownfield land to encourage urban renewal or reurbanization by adopting the compact city strategy (Nilsson & Nielsen, 2013; Shetty & Reid, 2014; Westerink, Haase, et al., 2013). However, in China, little attention is given to the phenomenon of vacant land in the already built-up areas. Our finding highlighted that more attention should be paid to this specific land type in developing countries and emerging economies such as China, where the amount of land resource is very limited relative to the demand. We suggest that a regular survey of the conditions of land vacancy should be brought into the cities' land use planning and management departments. This survey can serve as a base for further quantitative analysis.

Vacant land in an urban area may have diverse and important impacts in the local systems and beyond. On one hand, the frequent spatial–temporal change of vacant land posed seriously negative impacts on urban ecosystem (Beniston, Lai, & Mercer, 2016). For instance, the large amounts of reconstruction of buildings consumed many resources, such as steel and cement, and much energy. China, as the largest cement and steel consumer in the world, generates tremendous construction waste. This accounts for 30–40% of the total urban waste stream and is an important carbon emission factor (Chen & Zhu, 2013). Therefore, it is necessary for urban carbon management to call attention to the impacts of the dynamics of vacant land. Additionally, the frequent construction and demolition process associated with vacant land resulted in many environmental problems, such as a huge amount of waste, the consumption of energy, noise, and dust (Fu, Pan, Ma, & Li, 2013; Shen et al., 2013).

On the other hand, the vacant land can also potentially benefit urban environment. First, it offers a notable opportunity for the densification or infill development of cities. In China, the fast urbanization is mainly found on the increase of developed land, which means that the income from developing nonurban land into developed land accounts for an important proportion of a city's financial revenue (Bai, Chen, & Shi, 2012). For instance, the proposed amount of built-up area of Shanghai is 3,326 km^2 in 2020; however, the amount of built-up area was nearly 3,000 km^2 in 2010 almost reaching the extreme limit, suggesting the emergent need for changing the city's growth mode. Fortunately, the Chinese Government has begun to pursue some alternative pathways to ease the high dependency of urban growth on land input, without affecting the fast urbanization process. In recent years, the national government has issued a series of guidance or public notices to address the necessity of advocating the smart or compact development to push the sustainable urbanization, such as the guidance of promoting China's National New-Type Urbanization Plan, the notice of Implementing Controls to the Strictest Arable land Protection, the notice of Promoting the Economical and Intensive Use of Land, and the guidance of Promoting Sponge City Construction (Ministry of Land and Resources of the People's Republic of China, 2014; SCC, 2008, 2015, 2016). Locally, the municipal government of Shanghai City has also released some guidance of underscoring the importance of optimizing the old urban areas to promote urban development, such as the Shanghai City Master Plan and the Implementation Measures of Urban Renewal of Shanghai

(SCC, 2001; Shanghai Municipal Government, 2015). For example, the Shanghai City Master Plan (1999–2020) definitely proposed the rules of 'Two Increase versus Two Decrease Measures' for the central urban area plan and management (SCC, 2016). The Two-Increase Measures require both increasing green space and open space, whereas the Two-Decrease Measures mean the requirement of both decreasing the plot ration of construction land and total amount of constructed lands. Hence, developing the right strategy for the sustainable utilization of these vacant lands through the synchronous consideration of economic, social, and ecological benefits might offer an opportunity to support smart growth of China's cities. For example, proper green-blue infrastructure can be associated with the redevelopment and management of vacant land (Nilsson & Nielsen, 2013).

A second potential benefit of vacant land is that it can potentially serve as an important source to enhance ecological services (Beniston et al., 2016; Kremer et al., 2013). The vacant lots can be served as patches to support ecological services within the urban fabric, such as climate mitigation, stormwater management, biodiversity, and both passive and active recreation (Kremer et al., 2013). It shall be noted that vacant land as a resource of ecosystem services is not directly taken, and it normally requires some form of construction such as the development of different ecosystems on vacant lots. In some US cities such as Baltimore, Cleveland, St. Louis, and Flint, strategies to green vacant land for neighborhood improvement has been adopted, such as the development of new park, community and business gardens, and sport field (Branas et al., 2011; Drake & Lawson, 2014; Heckert & Mennis, 2012; Kremer et al., 2013). For instance, in the United Kingdom and some other west European states, utilizing vacant land has been fostered as a way to improve the quality of life and functioning of urban ecosystem services, such as integrating green structures in the forms of forested areas, open space, and agriculture into the renewal of vacant lots (Großmann, Bontje, Haase, & Mykhnenko, 2013; McPhearson et al., 2013). By contrast, the Chinese government's hope is to find efficient solutions to maintain the fast urbanization rate by balancing its conflict with land, resource, and environment. However, there is still lack of effective ways, which can be extrapolated to other cities of China. Our finding indicates that vacant land might have a chance to be a good smart growth principle for China's eco-friendly urban development. For example, the cities' planners and managers can guide the land users to make the best use of these vacant lands by improving the standards of construction and setting up incentives to promote urban renewal policy. For example, proper green-blue infrastructures need to be combined with the redevelopment of vacant lots, such as community gardens, green roofs and walls (vegetated), blue roofs and rain gardens, and white roof and walls (cooling with light or reflective material). As a result, including consideration of the value of vacant land for its contribution to urban ecosystem services becomes an important component of smart growth.

5 | CONCLUSION

This study is the first to comprehensively investigate the spatial–temporal change of vacant land within the central core of a large city in China. We found that vacant land accounted for an important share of urban land use—roughly 10% in the central core of Shanghai City from 2000 to 2010. Furthermore, we found that the spatial distribution of vacant land tended to change over the same period, reflecting the unmanaged urban sprawl and the unplanned, decentralized urban redevelopment pattern of China's cities. However, the existences of vacant land and their potential impacts have been ignored. Our results suggest that although the spatial–temporal change of vacant land has many negative impacts on environment, it may also provide promising opportunities for enhancing the urban functions of the old inner city, which has been issued as one important goal of China's city development. Similar comprehensive studies in other Chinese cities are necessary to determine whether our findings are generalizable to other cities and indeed whether the proportion of vacant land in Shanghai will change in the future.

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