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Edge-Urbanization: Land Policy, Development Zones, and Urban Expansion in Tianjin

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Abstract: Fast-paced urban growth in China has produced a specific, transient form of urban periphery, which continuously shifts outwards as the city expands. Seeing this process as a distinctive type of (sub)urbanization, this paper encapsulates it under the notion of edge-urbanization. The paper argues that edge-urbanization in China is fueled by deliberate government policies, which seek to mobilize peripheral land for high-growth strategies. The relationships between urban expansions and spatial economic policy are analyzed more closely in the case of Tianjin. Geospatial analysis derived from satellite imagery for the period of 1980–2015 reveals the morphological and temporal dynamics of urban growth in the post-reform era. Built-up land in Tianjin has expanded 1.8 times during this period, with the dominant growth type being edge-expansion. This character of urban expansion is shown to be closely associated with government's "project fever"—setting up development zones and new economic activity on city edge. The results demonstrate a decisive role of the state in shaping (edge) urbanization in China's major cities.

Keywords: urban growth; land policy; state-market relations; development zones; Tianjin

1. Introduction

Cities have been center stage in China's dramatic transformation since the start of economic reforms in the late 1970s. An estimated 813 million people lived in China's urban areas in 2017, or 58% of national population, compared to 19% in 1980. It is particularly the largest cities that have experienced the most spectacular growth, economically and physically, while they also serve as the frontier of China's transition to an outward-looking market-oriented economy [1]. In 1990, only three cities—Beijing, Tianjin, and Shanghai—had a population over 5 million in the city proper; they hosted less than 2% of China's population and produced 6% of national GDP [2]. By 2017, the number of such megalopolises increased to 13; they hosted 11% of the population and produced 21% of the country's GDP [3].

A significant number of studies have been carried out to analyze the fast-paced urban growth of China. However, the literature is still narrowly divided between disciplinary lines and epistemologies, often preventing a full and fruitful dialogue between them. For instance, perspectives on urban governance, economic development, land use policy, and urban planning [4–6] are generally

disconnected from the advancements in urban morphological studies, including those based on remote sensing and other geospatial techniques that can provide high-resolution spatial data and compensate for inconsistencies in official statistical data [7–13]. Efforts to bridge the quantitative–qualitative divide can offer new and more nuanced understandings of the drivers, dynamics, and implications of the dramatic urban change in China.

This paper contributes to this ambition by analyzing the relationships between state economic policy and the morphologies of urban land expansions in Tianjin. As a major city in the Beijing-Tianjin-Hebei metropolitan region, Tianjin is representative of China's rapidly growing and globalizing cities, which are firmly placed at the forefront of reforms and economic development. Although each of the metropolises in China has its own contextual development, there are still many commonalities among them—both at the scale of the political economy underpinning urban growth and at the scale of physical change. Understanding these commonalities and specificities are important for understanding the nature of urbanism in contemporary China more generally. We will argue, in particular, that what very much defines the spatial character of China's urbanization is the rapid and continuous expansion of urban land at the edge of existing urban areas. This can be encapsulated in the notion of *edge-urbanization*—which we see as a process distinct from suburbanization, at least in its Western connotation. We will argue that edge-urbanization is not purely an "organic" and morphological category but a governance category too; an analysis of underlying spatial and economic development policies will help demonstrate that.

The paper is organized as follows. We begin with reviewing the landed political economies of urban development in China in general and the economic evolution of Tianjin in particular. We then present our data and methods for a longitudinal study of urban expansions in Tianjin in the 35-year period of 1980–2015. Based on multiple-sourced remote sensing data, we reveal three morphological types of urban growth in Tianjin—infilling, edge expansion, and leapfrogging—and demonstrate a rapid pace of edge expansion among them. We link these patterns of urban growth to the broader context of spatio-economic policies, highlighting, in particular, the role of mega-project "fever" and policies for setting up development zones in driving edge-urbanization. Thus, we document both the evolution of Tianjin's urban growth towards edge-urbanization and demonstrate the role of spatio-economic policies in this evolution.

2. The Land-Focused Politics of Economic Development

During the period of its economic transition, China has experienced a rapid physical expansion of urbanized territories. One of the spatial consequences of this expansion has been that the larger cities' previous monocentric and compact structure, with sparsely distributed small industrial satellite towns, has yielded to a more polycentric, if not sprawled, urban structure [14–16]. This may well be seen as an "organic" byproduct of industrialization, rural–urban migrations, absolute and relative growth in urban population, and the rise in national prosperity, akin to other rapidly urbanizing developing countries. However, the relationship between economic development and urbanization in China has been certainly more politically convoluted. What is distinctive about China's cities is their close reliance on the power of the state in providing land for other factors of production and in actively exploiting land for accumulation purposes [17,18]. We can derive several key observations from existing literature in this regard.

To begin with, contrary to many other developing countries, the state in China has retained considerable power over the distribution of land and other resources, which itself signifies the importance of political and administrative levers in managing urbanization. As well expressed by Rithmire [19]:

> At the beginning of the reform era […] many assumed that reforms would relax state control over urban life and urban landscapes, as if the freedom of the market would supplant state management of Chinese cities. With regard to urban land politics, these assumptions have taken the form of arguments that new features of urban landscapes in Chinese cities are

> somehow "organic" results of marketization, absent of the state engineering that marked the pre-reform era, or that greater degrees of market reforms would correlate with freer urban land markets and greater pluralities of landed interests [. . .] But, precisely by linking varying political economies of reform with the territorial strategies they produced [. . .] foreign opening and economic reform amplified local state power [. . .]. (p. 891)

However, in contrast to the pre-reform era, local state power has also taken a decisively entrepreneurial form. The deregulation and liberalization of fiscal policy and the downward shifts of fiscal and administrative powers since the start of economic transition pushed the local state to become growth-seeking and entrepreneurial, while GDP-based performance assessment systems of the government officials (so called GDPism) has further stimulated active competition between cities [20–22]. China's largest cities now compete between themselves as spearheads for both global capital to enter China and the Chinese economy to join the world [1]. Cities like Beijing, Guangzhou, Tianjin, and Hangzhou gear themselves towards 'world cities' (shijie chengshi) or 'global cities' (quanqiu chengshi) [23–27]. This involves the globally familiar arsenal of strategies underpinning 'world-city-entrepreneurialism' (a term coined by Golubchikov [28]), such as investing in world-class central business districts to accommodate regional headquarters of multinational corporations (MNCs), developing globally oriented and science-based industrial parks, cultural and leisure amenities, as well as various place promotion activities, including hosting mega-events.

What is more, while industrialization is known historically to intensify urbanization, China's state has sought to reverse this equation: it actively leverages urbanization in pursuit of industrialization and economic growth [17]. More specifically, for the local entrepreneurial state executing its power over land and other resources, a continuous provision of cheap land and industrial facilities on urban peripheries has been important for the attraction and development of new industries and the retention of old industries relocating from the urban core. Thus, while the market-oriented reforms and relaxations in the household registration system (hukou) triggered massive migrations into cities, the local state on its part channeled urbanization into industrial development. To this end, local and regional governments widely use development zones to attract external capital and to introduce preferential policies for investors, known as "zone fever" or "project fever" [29,30]. Lured by the original success of Shenzhen, China's first special economic zone, other cities had already launched various types of manufacturing-oriented development zones by the 1980s to attract foreign and domestic investment, including through a series of incentives—for example, cheap land rent and already-built factory buildings for lease. Again, new development zones are typically located on the city's periphery, where former farmlands are used as the source of a cheap land supply. Thus, periurban and rural lands have been transformed to massive-scale development projects.

Zone and project fever is intertwined with administrative rescaling. Many cities have reformed their administrative-territorial system to match urban advancements [31], typically by reclassifying rural land as urban or annexing adjacent districts in order to gain a large-scale supply of cheap land for urban development. For example, in Tianjin, three districts (Tanggu, Hangu, and Dagang) were merged in 2009 to form the Binhai New Area, while the two remaining rural counties (Ninghe and Jinghai) were converted into urban districts.

The location of development zones and industries on the periphery produces its own spin-off effects, including construction of new residential and commercial properties that complement the location of industrial activities proximal to development zones, or they even constitute a large share of development zones themselves. Further, with growing financialization of housing and tertiarization of the urban economy, the real estate market has become increasingly seen by the local state as a driver of economic growth in its own right. Even in the absence of industrialization, construction of real estate, especially in larger cities but in smaller cities too, can now generate profits and economic performance indicators [17]. Consequently, local and regional governments have mobilized rural and periurban land for large-scale real estate projects as well.

3. Urban Edge Expansion: Beyond Suburbanization?

These land-focused politics of development via urbanization have produced one of the most widespread, distinctive, and yet still under-theorized urban processes in China—*edge-urbanization*—a massive state-sponsored outward advancement of built-up areas on city edges, which appropriates large areas of peripheral (rural) land, produces new urbanity, and expands industrialization and economic development further and further from the historical core city.

We can see the relevance of the words of Phelps and Parson [32] who identify in the case of Europe "the formative contribution of edge urban populations and institutions to contemporary processes of urbanization" (p. 1736). Here, one can of course draw parallels between edge-urbanization in China and global processes of change on urban periphery, including suburbanization as well as so-called post-suburbanization. However, it is important not to overlook the problematic notions of these very processes, which, while appearing familiar, are vested with contextualized meanings that do not necessarily travel cross-contextually. China's edge-urbanization is arguably different from the 'traditional' notion of suburbanization, including urban forms and functions associated with it—in the sense that China still needs to host its growing urban population, while new urban areas are not necessarily low-density residential developments that lack workplaces and formal industrial activities (and often infrastructure), as characterizes suburban sprawl in many other parts of the world. In China, the state's strong grip on land, planning, and development ensures that new urban areas are functional centers of economic activity or, otherwise, high-density residential areas producing their own agglomerative demand for local services and economic activity.

China's edge-urbanization may then be rather more akin to urban processes exceeding suburbanization and related to the emergence of more mixed-use, economically functional centers of activity on urban peripheries, which are identified in the context of the US, Europe, and other regions as 'edge cities' [33], 'technoburbs' [34], or 'post-suburbia' [35]. However, what still distinguishes China from the latter is that all of these are defined in contrast to suburbanization experienced prior to the formation of these new functions. Alternatively, in other post-socialist contexts, edge-cities are also identified as a certain resurrection of the economic centrality of previous 'satellite cities' that more recently merged into the main city and lost their economic function [36]. However, China's edge-urbanization exceeds suburbanization, because of the new areas' high-urban, high-growth form and function, and obliterates post-suburbanization with an emphasis on the latter concept of 'post'—as either a chronological linearity (decline of central city—suburbanization—edge-city formation) or chronological circularity (satellite city—decline of its economic centrality—resurrection as an edge-city).

Furthermore, one should again recognize the leading role of the state and its deliberative development goals and planning in making new peripheries in China—which makes the distinction between (proper) urbanization and (post) suburbanization blurred, if not completely irrelevant for China. As Phelps and Wu [37] suggest, the "political economy of Chinese municipal entrepreneurialism has, on the whole, been altogether more complete in terms of the state's control of the land-development process, and strategic in terms of promotion, the supporting infra-structure, and, as a consequence, the location of that growth" (p. 427). In this regard, the notion of edge-urbanization is more suited to encompassing and understanding the morphological and governance changes on China's urban peripheries. It also needs to be recognized for what it is—a powerful spatio-economic process, which today much defines China's urbanization as a whole. In order to delve deeper into the patterns and causes of edge-urbanization, in what follows we discuss how it has played out in the specific context of Tianjin, including how its parameters are contingent on state development policy.

4. The Study Area

The municipality of Tianjin is a subnational province and is one of four municipalities under the direct administration of central government. As one of the three core cities in the Beijing—Tianjin—Hebei metropolitan region, a super urban agglomeration, Tianjin represents a rapidly growing city, emerging out of the interplay of globalization forces, national reforms, and

bottom-up initiatives [27]. The inner city is located along the Sea River, formed by the confluence of five rivers flowing into the Bohai Bay. Tianjin is divided into 15 county-level districts and one subprovincial region (the Binhai New Area) (Figure 1). They occupy a total area of 11,917 km^2, including 173 km^2 in the six central city districts and 2270 km^2 in the coastal Binhai New Area. The Binhai New Area (or Binhai) is one of the so-called 'state-level new areas'—urban districts that are given special support by the central government. The spatial structure of the Tianjin metropolitan area is thus binuclear: the urban core is the concentration of business, higher education, commercial, and administrative activities, while Binhai is the location of traditional port activities and modern manufacturing areas [38].

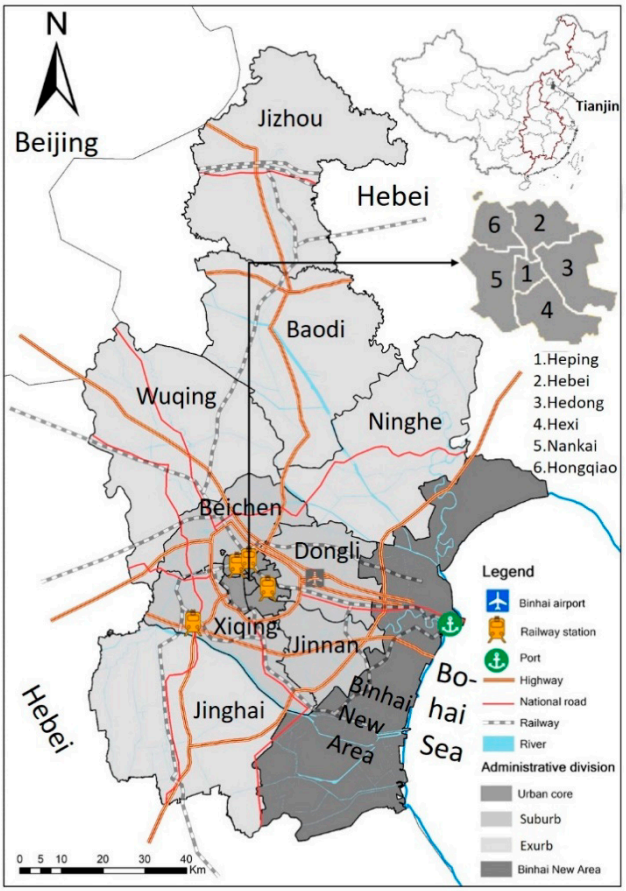

Figure 1. Location and administrative division of Tianjin.

In 2017, the population of Tianjin Municipality was 15.6 million, of which 5 million people (or 32.0%) were so-called "floating population", lacking hukou resident permits. The (official) urban population of Tianjin is 12.9 million or 83% of the total. In 2017, Tianjin's GDP was CNY1.86 trillion (USD275 billion), which ranks it sixth among Chinese cities. Its per capita GDP (CNY119 thousand or USD17,690) is ranked 20th among cities, slightly below Shanghai (CNY125 thousand) and Beijing (CNY129 thousand), but above Chongqing (CNY58 thousand). Table 1 provides a range of economic indicators for Tianjin in the post-war era, demonstrating its growing affluence and also a changing structure of its economy, including industrialization in the post-war decades followed by a gradual shift back to the tertiary sectors in more recent decades.

Table 1. Selected economic indicators for Tianjin, 1949–2017.

Year	GDP (Million Yuan)	GDP Per Capita (Yuan)	Total Population (Million)	Urbanization Rate (%)	FDI (USD Million)	Structure of GDP (%)		
						Primary	Secondary	Tertiary
1949	407	102	4.0	49.0	-	23.1	36.4	40.5
1952	1280	298	4.4	51.7	-	14.5	49.3	36.2
1978	8265	1133	7.2	49.8	-	6.1	69.6	24.3
1980	10,353	1357	7.6	52.4	3	6.3	70.1	23.6
1985	17,578	2169	8.2	58.2	44	7.4	65.4	27.2
1990	31,095	3487	8.8	55.0	83	8.8	58.3	32.9
1995	93,197	9769	9.4	56.8	1521	6.5	55.7	37.8
2000	170,188	17,993	10.0	72.0	2560	4.3	50.8	44.9
2005	390,564	37,796	10.4	75.1	3329	2.8	54.9	42.3
2010	922,446	72,994	13.0	79.6	10,849	1.5	52.8	45.7
2015	1,653,819	107,960	15.5	82.6	21,134	1.2	47	52.2

Source: Tianjin Statistical Bureau [39].

Historically, the city of Tianjin was one of the birthplaces of the industrial revolution and military industries established in the late 19th century; it began to develop modern industries such as machinery, chemical, metallurgy, textiles, and food processing [40]. These industries and the establishment of foreign powers' concessions contributed to the rapid expansion of Tianjin as one of the most important centers of manufacturing and commerce in northern China, as well as the second largest city of industry, finance, and trade behind Shanghai—it was often referred to as "Shanghai of the North" [27,41]. However, after establishment of the communist system, Tianjin's economic and political status eroded. Among the key projects supported by the Soviet Union, none were allocated to Tianjin as the focus shifted to industrialization in inland provinces [27]. Furthermore, Tianjin's status as a gateway to Beijing also diminished with a decline of inland waterways.

With the economy opening up from 1978, China's regional policy began re-emphasizing the coastal cities, which were supported through development zones. In 1984, Tianjin became one of the first coastal cities to open to the outside world. A national-level Tianjin Economic and Technological Development Area (TEDA) was established on the western side of the Bohai Bay to promote export-oriented industrialization [38]. Simultaneously, the emphasis of city development shifted to its coastal area (the Binghai New Area), partly due to a lack of developable land in the inner city [42]. In 1991, two new national-level development zones—Tianjin Binhai high-tech industrial development area (TBHIDA) and the Tianjin Port duty-free zone (TPDFZ)—were set up in the Binghai New Area. The economic position of Tianjin in northern China was emphasized as development of the Binhai New Area was upgraded in 2005 to the status of national strategy.

Today, Tianjin hosts 13 national-level zones, including six economic and technological development zones (ETDZs), one high-tech industrial development area (HTDA), one pilot free trade zone, and five special customs supervision zones (SCSZs, four bonded zones and one export-processing zone). The Sino-Singapore Tianjin eco-city, a collaborative project of China and Singapore to develop a socially harmonious, environmentally friendly, and resource-conserving city, is located in the south of TEDA. In addition, Tianjin government approved 21 provincial-level development zones or industrial parks.

Figure 2 demonstrates the spread and distribution of these various zones. Some of the development zones consist of two to three sub-zones, usually physically disconnected. For example, the Tianjin pilot free trade zone includes three subzones: a Tianjin Port area, a Tianjin Airport area, and a Binhai New Area central business area. The role of land conversion from rural to urban use has been key in the allocation of all those development zones and mega-projects.

But do all these development zones and associated policies matter for shaping the patterns of urban growth in Tianjin, as per our argument outlined at the beginning of this paper? If so, how exactly? Here, we need to move to our morphological analysis on the expansion of the built-up areas in Tianjin so that we can reveal it as the case of the co-production of state development policies, land conversions, and urban growth.

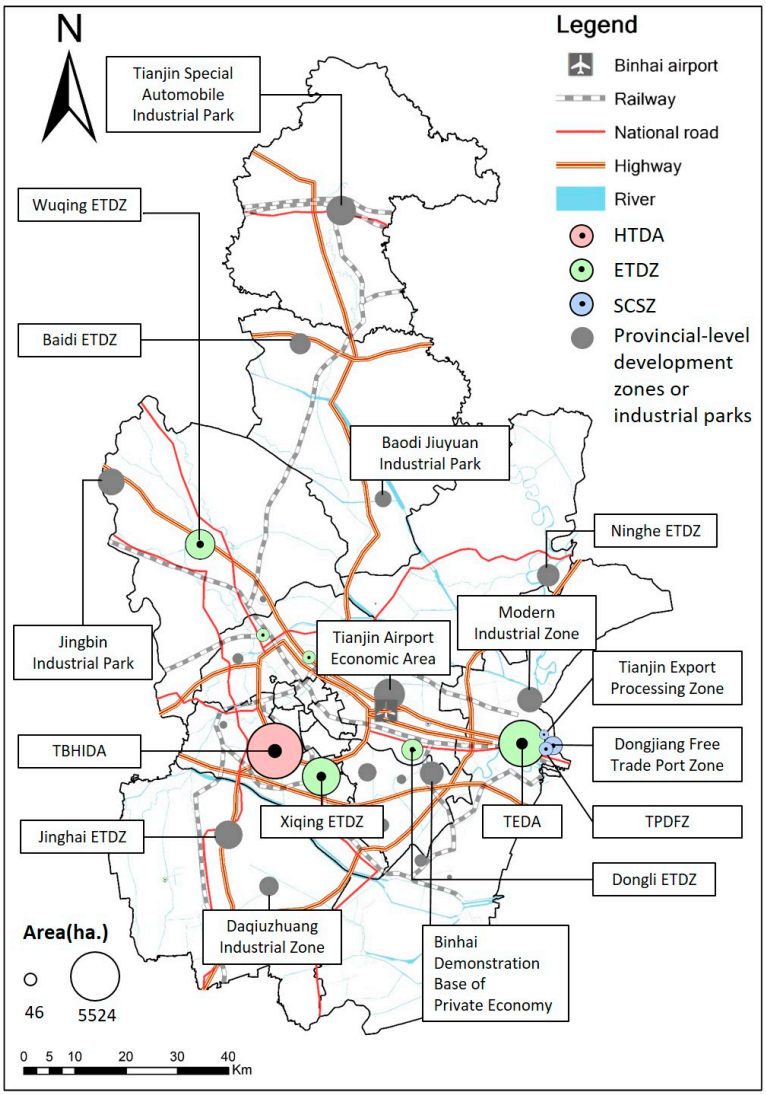

Figure 2. Development zones and special customs supervision zones in Tianjin.

5. Materials and Methods

Even if there are various official sources for data on urban built-up areas (e.g., the Urban Statistical Yearbook of China, the Statistical Yearbook for each city, and the National Land Survey), they are inconsistent between each other and are irregular in their reporting. Furthermore, they are unsuitable for analyzing spatial patterns. We have, therefore, used remote sensing data as a primary source to track landscape changes in Tianjin. Indeed, satellite imagery is increasingly employed to inform the process of urban development at both patch and landscape levels and also to quantify urban growth and land use change [43,44].

Land use data for our study were derived from remote sensing images downloaded from the Resource and Environment Data Cloud Platform, Chinese Academy of Sciences (http://www.resdc.cn/) with a 30 m spatial resolution. Four cloud-free Landsat images of Tianjin were acquired for April 1980 (MSS), May 1995 (TM), April 2010 (TM), and June 2015 (OLI). Our research design for geospatial data processing and analysis is summarized in Figure 3.

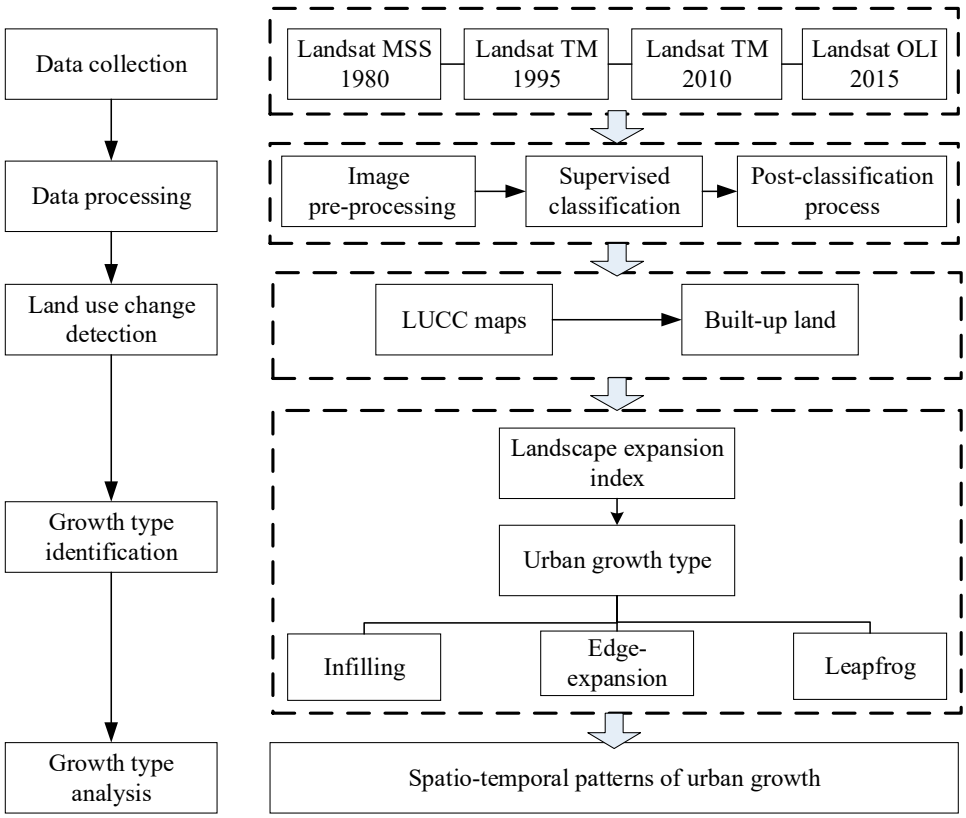

Figure 3. Flow chart of remote sensing data processing.

Using ENVI (Environment for Visualizing Images) 5.1 software, satellite images were converted into land use maps. Each scene was geo-referenced and preprocessed by radiometric correction, band combination, atmospheric correction, image sharpening, mosaicking, and image clipping. ENVI was used to combine image bands for better expressions of surface information and more accurate extractions. For atmospheric correction, we employed a FLAASH (Fast Line-of-sight Atmospheric Analysis of Spectral Hypercubes) module. The vector boundaries for the study area were extracted using ArcGIS 10.2 and ENVI 5.1 software. For land use classification, we adopted a hybrid of manual interpretation and supervised classification. The maximum likelihood method in supervised classification was employed to classify the images into six land use types (built-up land, cultivated land, woodland, grass, water, and unused land), and manual interpretation was used to modify and verify the supervised classification results. According to the Code for the Classification of Urban Land Use and Planning Standards of Development Land (GB 50137-2011), built-up land used in this study was synonymous with developed land and included residential as well as commercial and industrial lands [44]. These were key indicators for monitoring the spatial extent and intensity of urbanization [45]. The overall accuracies were 92.07%, 92.35%, 91.51%, and 90.03%, and the Kappa coefficients were 0.8674, 0.8412, 0.8317, and 0.8741 for 1980, 1995, 2010, and 2015, respectively.

These data were used to identify urban growth types following common typologies in the literature. For example, Camagni et al. [46] decomposed urban land expansion patterns into five types: filled, extended, extended along the line, sprawled, and satellite-cast. Marquez and Smith [47] proposed a more general classification of urban spatial expansion, namely: compact, edge or multi-node, and corridor type. Wilson et al. [48] distinguished five types: infilling, expansion, isolated, linear branch, and clustered branch. In our analysis, we adopted three main types of urban growth: infilling (or gap-filling), edge expansion, and leapfrog (spontaneous or outlying growth), since the other patterns can be seen as variants of these three basic forms [48]. Infill growth was characterized by development of new land patches mostly surrounded by existing built-up land (Figure 4a). Edge-expansion growth

represented an expansion of the existing urban built-up land patches as fringe development (Figure 4b). Leapfrog, also called enclave, spontaneous, or outlying growth, referred to developed patches that were converted from non-developed patches outside of, and disconnected from, the existing urban built-up land (Figure 4c) [44,46,49,50]. These three urban growth processes may, of course, concur, but the intensity of each type varied in different urbanization cycles and, thus, defined urban growth phases at each time point [51,52].

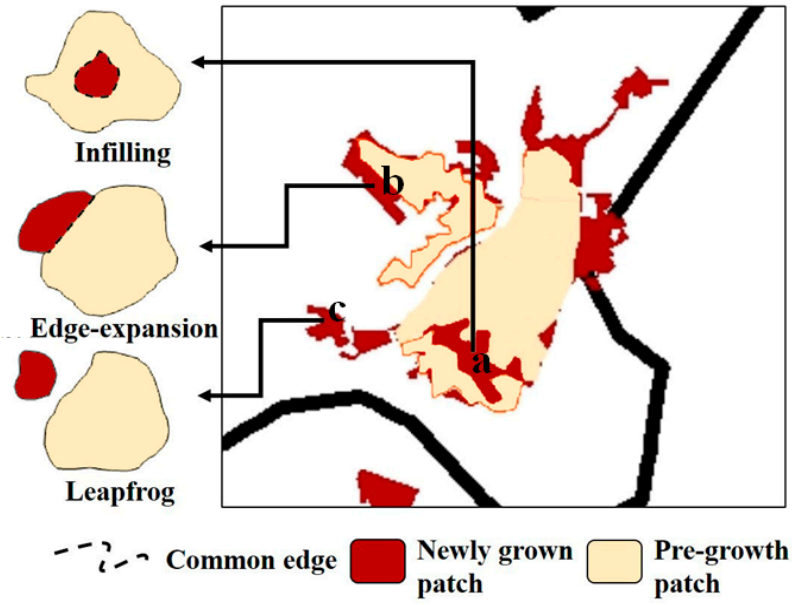

Figure 4. Urban growth models.

In order to quantify the distribution of these three urban expansion types for Tianjin, we employed a landscape expansion index (LEI), which was introduced by Xiaoping Liu [44], and ascribed newly added urban land patches to different growth types according to the following formula:

$$\text{LEI} = \frac{\text{L}_\text{c}}{\text{p}}, \quad (1)$$

where P is the perimeter of a newly grown patch and L_C is the length of the common boundary of the newly grown urban patch and pre-growth urban patch or patches. LEI values could range from zero to one. When LEI $\geq$ 0.5, it indicated that the new constructed lands tended to be filled in existing development, and the urban growth was of infilling type. When $S = 0$, which indicated no common edge between the newly added urban land and existing urban land, the urban growth could be identified as leapfrog. When $0 < S < 0.5$, the urban growth could be identified as edge-expansion.

One methodological problem with the distribution of built-up land into the three categories (infilling, edge-expansion, and leapfrog) related to a discrepancy between total built-up area changes identified prior to and after the classification. This was due to the specificities of imagery data analysis: to do growth type classification, the Erase function in ArcGIS was used, which produced many new land patches. As a result, the total change in built-up areas after the classification increased by about 1.5 times compared to the actual change in land use. However, we can safely assume that this error was consistent across the patterns and periods and did not interfere with the relative distribution of urban growth types—the key analysis that we performed. In the discussion of the urban growth types we, therefore, operated with ratios expressed as percentages rather than raw/absolute categories.

6. The Spatio-Temporal Patterns of Urban Expansions

Tianjin has undergone rapid expansion of built-up land, which has especially accelerated in recent years (Table 2). According to our analysis, from 1980 to 2010, the area classified as built-up land use in Tianjin increased from 1770 km^2 (15% of Tianjin's land area) to 2308 km^2 (20% of the land area), and then it jumped to 3145 km^2 by 2015 (26%). This was a significant increase—almost 1.8 times over the period. The annual rate of urban land expansion was highest (6.38%) in the latest analyzed period of 2010–2015. Table 3 reports the occurrence of the three types of urban growth discussed above. Overall, it can be seen that the edge type of urban growth was dominant, contributing to 75% of newly grown urban areas over the period of 35 years, and 85% in the latest two analyzed periods: 1995–2010 and 2010–2015. Leapfrog growth accounted for nearly 24% of urban expansion over the whole period, with a higher contribution (65%) in the first period analyzed (1980–1995). The contribution of the infill type to total urban expansion remained low: less than 1.5% over 1980–2015.

Table 2. Built-up land in Tianjin, 1980–2015.

Year	Built-Up Land, Total (km^2)	Share of Tianjin's Land Area (%)	Period	Change over the Specified Period	
				Annual Growth Rate (%)	Annual Expansion (km^2)
1980	1770	15	1980–1995	1.04%	19.78
1995	2067	18	1995–2010	0.74%	16.12
2010	2308	20	2010–2015	6.38%	167.24
2015	3145	26	1980–2015	0.05%	39.28

As per our discussion at the beginning of this paper, these patterns of growth demonstrated strong tendencies of using peripheral land for urban expansion and urbanization. Of course, some pre-existing urban land, especially in the urban core, also experienced structural intensification and redevelopment, which might not necessarily register as an infill growth. However, the presence of edge-urbanization as a dominant process of urban change appeared here quite prominently and, furthermore, strongly linked to the urban political economy. Indeed, the peripheral nature of growth is bound to the waves of mega-projects such as the establishment of development zones, university towns, commercial and residential spaces, and central business districts across Tianjin. This can be seen from the juxtaposition of different types of urban expansions and various key projects in Tianjin in different periods, as presented in Figure 5. As urban cores are rather densely developed in Chinese cities, new development zones are established on the edge of the city proper, on former rural or reclaimed lands, or along transportation corridors extending outward from the city center. The mega-project "fever" also included the construction of large-scale physical infrastructures such as the Binghai International Airport, highways, and railways, which require a large amount of land (also Figure 2).

Table 3 also presents spatiotemporal patterns of urban growth types divided according to their 'home' districts: urban core, suburbs, exurbs, and Binhai. The urban core generally showed a much less significant increase in new urban patches. In the pre-reform era, Tianjin was a compact city with a densely populated urban core, saturated with administrative and high education institutions and large manufacturing factories, and was surrounded by industrial satellite townships and rural communities. Since the late 1980s, Tianjin transformed itself into a more polycentric metropolis, extending gradually to the east, partly because of a new planning vision that considered a multinucleated city a good form to address the increasing social and environmental problems in the city core. The introduction of price-based land market mechanisms further forced many enterprises to seek cheaper places, usually in new development zones at the urban edges. Consequently, growth in the urban core has been relatively minor, with newly developed land increasing mostly outside the historic core.

Table 3. Area shares (%) of different urban growth types in Tianjin.

	1980–1995	**1995–2010**	**2010–2015**	**1980–2015**
Total	100.0	100.0	100.0	100.0
infilling	3.2	0.4	1.3	1.4
edge expansion	31.7	85.9	85.4	74.7
leapfrog	65.1	13.8	13.2	23.8
Urban core	6.6	2.3	0.3	2.2
infilling	1.1	0.0	0.3	0.4
edge expansion	5.5	2.2	0.1	1.8
leapfrog	0.0	0.0	0.0	0.0
Suburbs	9.5	41.8	24.9	26.8
infilling	0.1	0.1	0.5	0.3
edge expansion	7.6	37.4	21.1	23.2
leapfrog	1.8	4.4	3.3	3.3
Exurbs	19.4	21.4	34.9	27.8
infilling	0.2	0.3	0.6	0.4
edge expansion	14.5	16.8	28.5	22.3
leapfrog	4.7	4.3	5.8	5.2
Binhai	64.6	34.6	39.9	43.3
infilling	1.9	0.0	0.0	0.4
edge expansion	4.2	29.4	35.7	27.5
leapfrog	58.6	5.1	4.2	15.4

The analysis of different periods further demonstrates the close association of urban expansion and state development policies. In our first analyzed period, from 1980 to 1995, leapfrog growth was dominant and occurred largely in the Binhai New Area. This was thanks to the construction of a Tianjin economic-technological development area (TEDA), which was approved by the central government back in 1984. Most of the edge-expansion growth in that era was concentrated in suburbs and exurbs. The 1986 Tianjin Master Plan used the multiple nuclei model to envisage a shift of manufacturing eastwards, along the Tianjin–Binhai Expressway to the Bohai Bay. The plan also initiated four industrial satellite towns: Yangliuqing, Dananhe in southwest of the city, Xianshuigu, and Junliangcheng in the east. Consequently, establishment of the Dongli development zone and the satellite towns of Junliangcheng and Xianshuigu promoted the eastward edge-expansion of urban land. The Xiqing development zone and the Xiqing university town produced further edge-expansion growth westwards. Moreover, development of industries and an increase in the population in previous rural counties led to massive edge-expansion growth combined with modest enclave growth in the outer suburbs.

In the next analyzed period, from 1995 to 2010, edge-expansion bypassed leapfrog as the dominant type. It occurred particularly in the inner suburbs and Binhai. With accelerated marketization and decentralization of responsibilities, especially after the 1994 fiscal reform, urban governments became more entrepreneurial, promoting economic growth and competitiveness. To boost its economic competitiveness, Tianjin managed to acquire four national-level economic and technological development zones, one export-processing zone, and three bonded zones, and established 17 provincial development zones—all located on the fringe of existing developed areas. It is through this period that Tianjin witnessed an unprecedented increase of foreign direct investment (FDI) (Table 1), from USD83 million in 1995 to USD10.85 billion in 2010. Importantly, since the Binhai New Area was upgraded to a national strategy in 2005 as the third national-level new area (the others being Shenzhen and Shanghai's Pudong), hundreds of global enterprises—including Motorola, IBM, Toyota Motor, Samsung Electronics, Rockefeller, Tishman Speyer, and Airbus—invested in Tianjin, largely in Binhai.

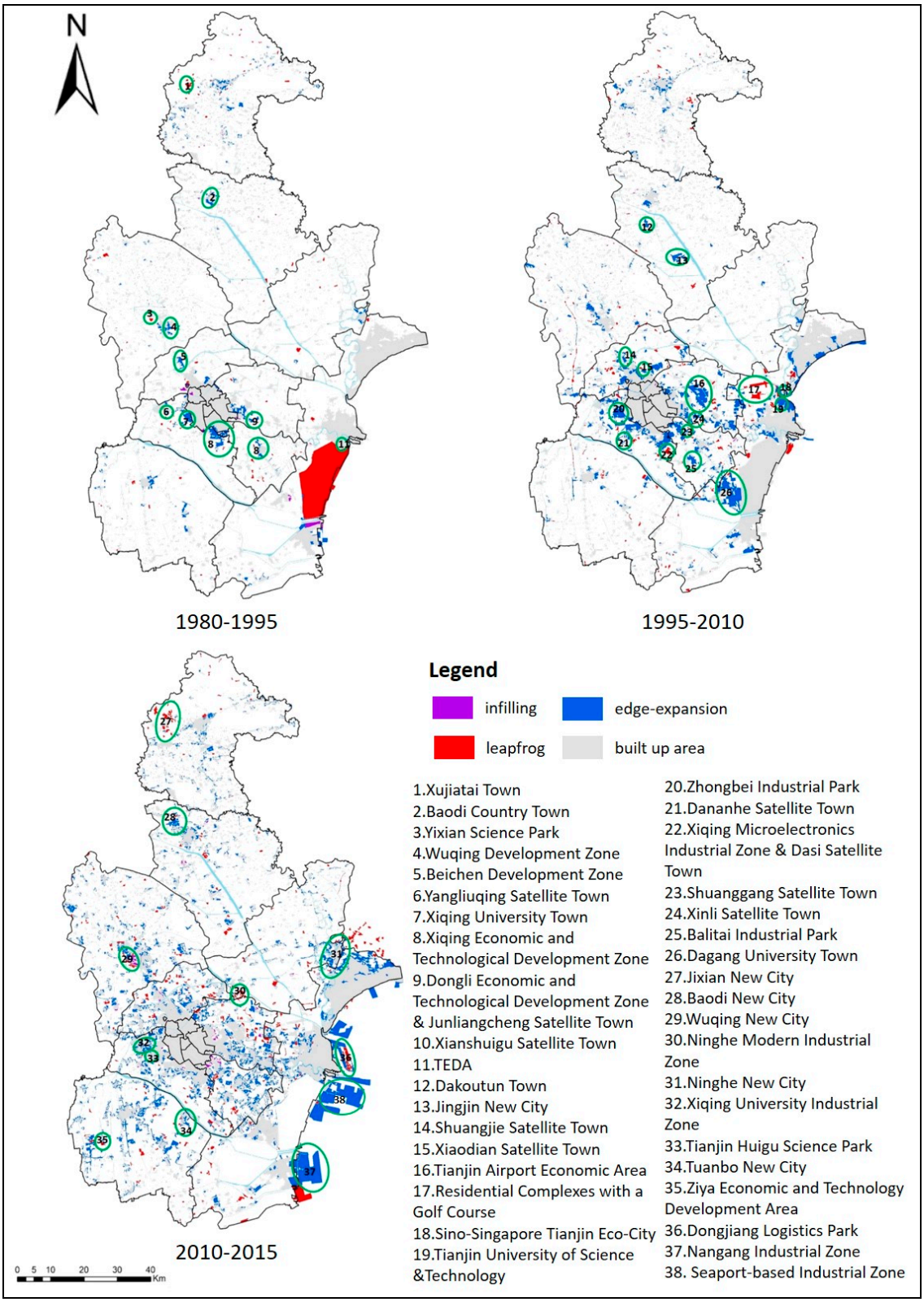

Figure 5. Spatial distribution of the growth types in Tianjin in different periods.

The 1996 Master Plan further encouraged urban development to shift eastwards, with a focus on the Binhai New Area, but also emphasized a southwards expansion strategy. Five new satellite towns (Xinli, Shuanggang, Dasi, Shuangjie, and Xiaodian) were set up around the edge of the city.

The plan also included a southern city in the Jinnan District as a new multifunctional development area of industrial and commercial zones, leading to a massive expansion southward. With the construction of satellite towns, mega-projects, and expansion of the previously established development zones (e.g., Xiqing development zone) and the university towns of Xiqing and Binhai, edge-expansion growth accelerated. New mega-projects included the Tianjin South railway station, Binghai International Airport, as well as an airport economic zone and the Zhongbei development zone.

In our third analyzed period, from 2010 to 2015, growth continued around the edges of the original built-up areas, including in the remote county towns, as well as the expansion of TEDA. Furthermore, infilling growth occurred in the east of the city proper because of the commercial and high-density residential areas around existing urban patches. Leapfrog growth was still witnessed in the Binhai New Area thanks to reclamation projects for the construction of a Nangang industrial zone, a Dongjiang logistics park, and a seaport-based industrial zone.

The 2005 version of the Master Plan employed the concept of a "new city" to promote a comprehensive development of suburban areas. In contrast to the satellite towns planned in the 1980s and 1990s, which focused on industrial and/or residential uses, 11 newly planned cities in suburbs and exurbs envisaged more comprehensive functions. They were largely the seats of former rural counties (Jixian, Baodi, Wuqing, Ninghe, Hangu, Xiqing, Jinnan, Jinghai, and Dagang) and two large rural towns (Jingjin and Tuanbo). With the improvement of physical infrastructures, the new cites attracted population and enterprises, facilitating the transformation of Tianjin into a more polycentric city, at least morphologically.

It was also clear that the development zones drew the construction of new commercial and residential spaces, thus, gradually creating their own waves of expansion with their own edge or leapfrog developments. The Sino-Singapore Tianjin eco-city was a case in point here [53]. It was a large, newly built, mixed-use development in Binhai, which was supposed to host 350,000 people. The development was originally located 10 km away from the core district of the Binhai New Area on reclaimed lands. The development was heavily promoted backed by 'green' marketing, but the difference from other remote developments was minor. Such remote developments are often dubbed 'ghost cities' in the Western world. However, as it became gradually better connected and populated, it emerged into a center of gravity of its own. Those 'chain' expansions dictated much of the built-up land use changes in Tianjin.

7. Discussion and Conclusions

China has experienced one of the highest rates of urbanization growth in the world; the large cities have increased greatly in built-up areas and urban populations. Here, we analyzed the relationships between urban growth and regional development policies in Tianjin, one of China's major globalizing cities. Tianjin was shown to have experienced large-scale edge-urbanization since the 1980s, which could also be seen in other large cities, although to varying degrees. This type of growth is not so much "organic" or spontaneous, but is rather clearly associated with the pursuits of state economic policies, through the construction of development zones and other large-scale mega-projects such as university towns and physical infrastructure. For example, the Binhai New Area has been one of the key areas where most of that new growth has taken place.

The case of Tianjin reveals interesting, generalizable categories for understanding contemporary urbanization in China. Indeed, edge urbanization, or the expansion of urban built-up areas and economic activities further and further outwards beyond existing urban areas, coupled with new 'leapfrogging' urban enclaves in previously rural areas, has been the dominant type of urbanization in much of China. It may be a byproduct of the continual urban–rural demographic shift, but it is generously lubricated by the pro-growth mentality and entrepreneurial development policies of the state, both national and local.

China's resultant edge-urbanization still appears different from the traditional notion of urban sprawl, since new areas are well-established residential areas (mostly high-density even if shaped

around low-density industrial zones), which either are production centers or provide their own agglomerative demand for services and economic activity. And yet, like in the case of sprawl, the edge patterns of development based on large-scale investment and mega-projects face challenges with respect to sustainability and livability—what the Chinese government has recently termed a "big city disease". The lack of coordination of intra—and inter-urban competition for attracting new investment has wasted economic and land resources and made many development zones economically inefficient and environmentally unsustainable.

Nowadays, the central government is promoting coordinated development of the Beijing–Tianjin–Hebei region, relocating economic functions from Beijing to neighboring provinces including Tianjin. The infusion of new populations and enterprises will definitely produce even more demand for land. In order to make Tianjin more sustainable, new projects need to be located in the existing development zones. However, this would require quite a reversal from the dominant edge-urbanization mindsets of the local state.

Overall, our analysis indicates that studies of the spatial and temporal patterns of urban land expansions can combine qualitative and quantitative methodologies and pay more attention to economic policies, local initiatives, and the interaction of forces operating at multiple geographical scales. Furthermore, additional studies could deepen the understanding of the processes, patterns, and mechanisms of edge-urbanization.

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