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The Role of Zoning in Cross-Border Industrial Land Transition: Lessons from Tokyo Metropolitan Area

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1 ABSTRACT

Tokyo Metropolitan Area (TMA) is one of the most developed urban regions in the world. It consists of about 200 municipalities across Tokyo prefecture and the adjacent prefectures of Kanagawa, Saitama and Chiba in the Kanto Plain. The region has witnessed drastic socio-economic transformation during the last half century. As the growth of TMA and deepening of globalization, secondary industrial sectors in the inner city have kept decreasing while moving to the metropolitan suburbs and the suburban municipalities have benefited from inflow of industries for local jobs and revenue. Meanwhile, the cross-border industrial development has caused massive land use change, however some of the constructions were unplanned in terms of zoning. So, the questions arise on how it could happen in a developed country like Japan which has a mature land use planning system, what were the driving forces under the surface, and what was the impact has caused in the sense of sustainable development.

As a common policy instrument in urbanisation and land use management, zoning plays a key role in regulating the socio-environmental impact of land use change, especially cross-border industrial land transition. However, implementation and the effects of zoning may extensively depend on supply and demand in land market as well as from stakeholders' collaboration. It is also difficult to manage a zoning system at different scales initiated for different policy goals. Hence, this study aims to investigate the industrial land transition and the adequacy of industrial land location in the suburb of TMA by using temporal-spatial analysis of industrial and demographic statistics to clarify the gaps and driving forces between zoning and land use.

Keywords: Temporal-spatial analysis; Industrial land transition; Zoning; Spatial pattern; Adequacy

2 INTRODUCTION

2.1 Regional Governance in TMA and the Position of Zoning

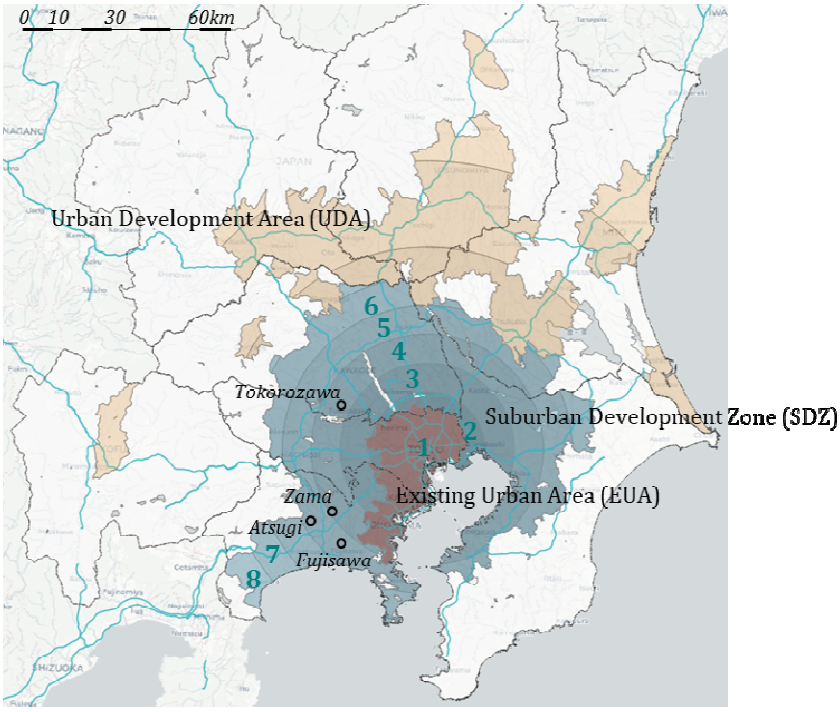

Figure 1: Governance area based on Tokyo Metropolitan Area Development Law.

In the 1950s, the deterioration of the environment in the existing urban areas and the problem of overcrowding became a serious issue in The Tokyo Metropolitan Area (further TMA), due to the

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concentration of industries and the accompanying rapid population influx from rural areas during the post-war period of high economic miracle. For this reason, the Tokyo Metropolitan Area Development Law was enacted in 1956 in order to prevent excessive concentration of industries and population in the existing urban areas of TMA, to prevent disordered sprawl and promote planned infrastructure development. According to the Law, the areas that have already been urbanised are considered as Existing Urban Area (further EUA, area #1 in Figure 1). It is an area that maintains or promotes the infrastructure necessary for the capital while suppressing the extreme concentration of industry and population. The areas that surround the EUA targeted in this study are the Suburban Development Zone (further SDZ, area #2-8 in Figure 1). It is an area in the suburbs of the EUA where green spaces are preserved and planned urban development is promoted. The areas outside SDZ are partially planned for future development as Urban Development Area (further UDA, area coloured beige in Figure 1). It is designated as an area that eases the concentration of industry and population and promotes development for the purpose of proper allocation of industry and population throughout TMA. Since the UDA is almost 60km and more away from the centre of the TMA and it is identified as a destination of industrial transfer from national perspective, in this study, we survey only the secondary industrial land in the SDZ and in the EUA (Figure 1). The SDZ was to preserve the environment of the urban area and to function as a buffer zone between the existing urban areas and the natural environment (Akita, 2017).

Zoning is based upon the foundation of regional governance area. In Japan, zoning was a main part of the new city planning system introduced in 1968 by a new City Planning Act, and it is a key instrument in development and conservation of land resource in the metropolitan suburbs (Nakai, 1988). The representative task of the macro zoning, literally “Senbiki” in Japanese, means drawing the line or delineation. It divides City Planning Areas (further CPA) into mainly 2 parts (there are also small parts of CPA having not been divided, known as other zoned area or blank CPA, in the outer suburbs or rural area, but in tiny proportion): Urbanisation Promotion Area (further UPA) and Urbanisation Control Area (further UCA). The UPA includes both existing built-up area and the area where urban development is encouraged over the next 10 years, while the UCA includes both strictly conserved areas, such as agricultural land, forests and other natural landscapes which should not be developed at all, and the area where building is strictly limited for the time being (Sorensen, 2000). The benchmarks of UPA delineation are mainly: (1) population size and density, (2) ratio of built-up area, (3) plan for local infrastructure development, and (4) plan for middle and large-scale development. Meanwhile, the Land Use Zones, defined as micro zoning in this study, are the areas which are also regulated by the City Planning Law and designates the possible usage of land and properties in that area (MLIT, Japan). There are 13 zone categories in total: 8 residential zones including Quasi-Residential zone (QR), Neighbourhood Commercial zone (NC), Commercial zone (C), Quasi-Industrial zone (QI), Industrial zone (I), and Exclusively Industrial zone (EI). Land Use Zones are designated in the UPA but not in the UCA, and in the least number of situations, they are designated in other area of CPA (neither UPA nor UCA).

2.2 Industrial Land Use and its Policy Environment

First, there was a national comprehensive development plan based on the National Land Planning Law. In the early 1960s, when Japan was in the period of rapid growth, the goals of the national plan at that time were: to prevent the over-expansion of large cities, to avoid the over-concentration of industries and population, to narrow the development gap between cities and towns, and to achieve a balanced development. The Tokyo Metropolitan Area Development Law at that time was also one of the results of this national consideration. Theoretically, the allocation of industrial land was expected to be directed away from large cities to small towns, thereby increasing jobs in outer suburban or rural areas. The UDA, 60 km north of the TMA, was such a major regional industrial catchment area. It was expected that if there were enough jobs, the labour force did not have to settle in the big cities, and the development gap between the big cities and small towns or rural areas would not be too big as industries prospered. In special areas for industrial development, factories are encouraged and rewarded for moving in, while in the EUA, the core part of the TMA, factories that newly moved in are restricted. This is a top-down force that manages industrial land use, shaping the pattern of industrial land use throughout Japan and the TMA. However, with the overseas relocation of manufacturing industries that began in the late 1970s and the industrial upgrading of metropolitan areas, new domestic industrial land was drastically reduced. The policy framework for the domestic allocation of industrial land gradually receded from the stage of history, and in the 21st century, the

macro control of industrial land at the national level has practically ceased to exist (Aiba, 2021).
Second, urban planning controls and guides industrial land use. Specifically, the Quasi-Industrial zone (QI), Industrial zone (I) and Exclusively Industrial zone (EI) in the UPA are the main zones that were planned for the location of industrial land. By 2010, the area of the three zoning districts designated nationwide was growing at the annual rate of about 1% (calculation based on national land survey data from MLIT, Japan) and almost stagnated after 2010, which coincided with the population peak in Japan. This is reflected in the reduction of new factories and the conversion of factory brownfields into residential or commercial sites. The stock of industrial lands is unlikely to be growing significantly in the future, and will tend to decrease because of the ageing and low birth rate issues of Japan and the development of AI and ICT technologies.

Third, the basic principles for industrial construction and operation are determined by the Industrial Land Siting Law (1959). However, in the 1990s, because of the bursting of the bubble economy and the slowdown of industrial land growth, how to promote industrial development and how to encourage the metabolism of industrial land became an issue. Therefore, local governments with autonomy gradually eased these regulations and restrictions according to their own circumstances, which points to the unregulated industrial land location in the metropolitan suburbs to some extent.

2.3 Demographic and Land Use Change in the Metropolitan Suburbs

Japan has experienced a rapid change in socioeconomic conditions since 1960s and has undergone fast urbanisation. City planners and policy makers were not able to predict the frontier boundaries in advance (Usui, 2019). As a transition zone between urban and rural area, the suburbs of TMA, or the SDZ, has witnessed a serious issue with zoning due to changes in population and land use.

Now the TMA faces a saturation or terminal stage urbanisation (Mulligan, 2013) with an urbanisation level above 90% of the population. The population of the TMA is undergoing some subtle changes. The most densely populated areas are roughly distributed in a 0-20 km radius area. However, the latest statistics and forecasts show that the population is returning to the metropolitan centre. The residents who moved to the metropolitan suburbs during the period of rapid economic development gradually became old and rely on well-established urban services. On the other hand, the urban renewal projects in the metropolitan centre encourage the mixing of commercial and residential land use, which increases housing supply. Therefore, the elderly and high-income groups have replaced their real estate and moved back to the EUA from the SDZ.

In TMA, the further away from metropolitan centre or local central station, the faster the population are decreasing. According to the estimates of the National Institute of Population and Social Security Research (NIPSSR, 2018), population of the TMA will decline approximately by 6% until 2045 compared to the 16.3% decline for Japan nationwide. Since the EUA of the TMA is expected to increase by nearly 4.6%, the SDZ and other periphery areas of TMA can be expected to decrease by 10% to 15% or more. And within the SDZ, the degree of population decline would be severe in some areas and insignificant in the others. It may bring many new challenges to urban planning and management. First there is the dilution of urban area. Although residents of some areas decrease, the built-up environment including housing cannot change easily back to non-urban land use, responding to the population decrease in the SDZ. Second, urban public services have to be re-allocated. The issue of vacant facilities and community centre relocation are expected to be more serious and because of these two issues, the maintenance cost of public infrastructure might increase. Moreover, population decrease will also reduce the revenue source of the suburban municipalities.

2.4 Research objective

The urban land use in suburbs of metropolitan increases and decreases in number and typologies, which makes their planning a challenge for sustainable development (Geneletti et al., 2017). In the case of the TMA, the manufacturing shipping value and employees keep decreasing after 1980s, while the industrial land stocks remain unchanged in some places and increase at lower pace in others (Aiba, 2021). Additionally, the population growth in the metropolitan suburbs slowed by 2010, after which the population gradually declined and will decrease more until the 2050s according to population projections (MLIT, 2018). How zoning could adapt to such demographic and land use changes is questioned. Recent zoning enactments are mainly densifying into compact city areas around local rail hubs with guidance for residential and commercial land but not for industrial land, and the relationship between zoning and demographic-industrial changes is not well understood. Therefore, this study aims to investigate the land use changes and the

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adequacy of industrial land location in the suburbs of the TMA through temporal-spatial analysis. The results are expected to reveal the importance of industrial land planning for the urban peripheries within a decremental planning system under compact city and population decrease circumstance.

3 METHOD OF TEMPORAL-SPATIAL ANALYSIS

This study combines quantitative and descriptive research methods to interpret industrial land transition and the features and reasons for zoning in the outer area of one of the biggest metropolitan areas in the world. The study used land use data from 1980 to 2010 every 10 years, Densely Inhabited District (further DID) data from 1980 to 2010 every 10 years as secondary data. The study area is the region located about 60 km away from the centre of the TMA, which consists of 198 municipalities, sharing about 85% population, 80% industrial sector employees and 75% industrial shipping value of the whole TMA. The land use data is from 1980 (after two oil shocks), 1990, 2000 and 2010 (after the peak of average land price in the metropolitan and the peak of national population). Spatial statistical analysis of the industrial land transition was conducted across the study area at different distances to the centre of Tokyo. Eight spatial patterns of industrial land in the SDZ are observed based on land size and form of coalescence. By using macro zoning delineation data of 2010, the adequacy of industrial land location was interpreted in the 3 dimensions: (1) built-environment, (2) work-live proximity, and (3) land use zones.

City planners and practitioners usually rely on top-down approaches to deal with the urban area, which depends on predetermined basic spatial units (DID as one of them) provided by census or statistical bureaus (Jiang & Liu, 2012). Both the area size and population percentage of Densely Inhabited District (DID) are considered as factors of land use transition in the metropolitan suburbs (Hoshino, 1997). Distance from DID and population size were exerted opposite developed land during the phase od? rapid growth and population decline respectively (Kobayashi et al., 2020). Even though there are deficits in zoning when relying only on DID, because of the gap between it and the built-up area (Usui, 2019), it is used in this study as an important indicator for description of population distribution and density.

4 RESULTS

4.1 Industrial Land Transition Trend at Metropolitan Level

Industrial land inside the 20 km radius of the metropolitan centre decreased and that outside a 20 km distance from the metropolitan centre increased during all three ten-year periods from 1980 to 2010. In most radial directions, the critical point of industrial land use decrease in the inner city is in the region at around 20 to 30 km distance, while, in the southwest part of the TMA it is in the region at around 40 km distance while in the west part no increment is observed. The region at 30-50 km to the metropolitan centre is the largest receptacle of cross-border industrial development with a 56% increase of industrial land use of the whole study area from 1980 to 2010. Especially the industrial land use density in the 30-40 km distance region went to 6.8ha/km2 of buildable area (with a slope below 11 degree). The inner-city area of 0-10 km and 10-20 km from the centre face both absolute and proportional decrease in industrial land use (Table 1 and Figure 1). The most noticeable industrial land transition happened in the 30-40 km and 40-50 km distance in the SDZ by either increments or overall increased rate.

Serial number and Area			1980	1990	2000	2010	1980-2010		2010	
							Changes	Rate	Proportion	to Buildable land
1	Existing Urban Area (EUA)		6009	5594	6075	5139	-870	-14.5%	16.5%	5.8/100
2	Suburban Development Zone (SDZ)	10-20km	1680	1749	1596	1884	204	12.1%	6.1%	6.9/100
3		20-30km	2256	2613	2664	3198	942	41.8%	10.3%	3.3/100
4		30-40km	8685	9506	9579	11221	2536	29.2%	36.1%	6.8/100
5		40-50km	4648	5316	5992	6222	1574	33.9%	20.0%	3.9/100
6		50-60km	1541	1925	2202	2627	1086	70.5%	8.5%	3.8/100
7		60-70km	445	469	532	536	91	20.5%	1.7%	5.5/100
8		>70km	216	215	226	243	27	12.5%	0.8%	7.8/100
Total			25480	27387	28865	31070	5590	21.9%	100%	5.0/100

Table 1: Industrial land transition in suburbs of TMA from 1980 to 2010 (unit: ha)

4.2 Industrial Land Transition in the area at 30-50km distance from the centre and Spatial Pattens

The agglomeration types of industrial land in the selected study samples of areas at 30-40 km and 40-50 km distance are divided into 8 spatial patterns of industrial land transition (Figure 2). The parameters are: (1) with mainly large-scale industrial lands or with mainly small and middle-scale ones, (2) areas with a planned concentrated industrial park, (3) areas with local big foundries in a leading position, and (4) clustered or dispersed type of industrial land transition based on multiple-distance spatial cluster analysis. This shows that regardless of size, industrial land tends to be distributed along the National Road and Prefectural Road. As seen in patterns III to VI, the distribution of industrial land is more concentrated in the sample with the industrial park and large regional enterprises, but not limited to a single agglomeration. As seen in patterns I and II, the distribution of industrial land is more dispersed in the sample of mainly small-scale industrial enterprises, which is not necessarily related to the existence of a centralised industrial park. As seen from pattern VII and VIII, the samples with more dispersed distribution of large enterprises, with or without an industrial park, have a more dispersed overall industrial land location. All of them have an oversized UPA designation range.

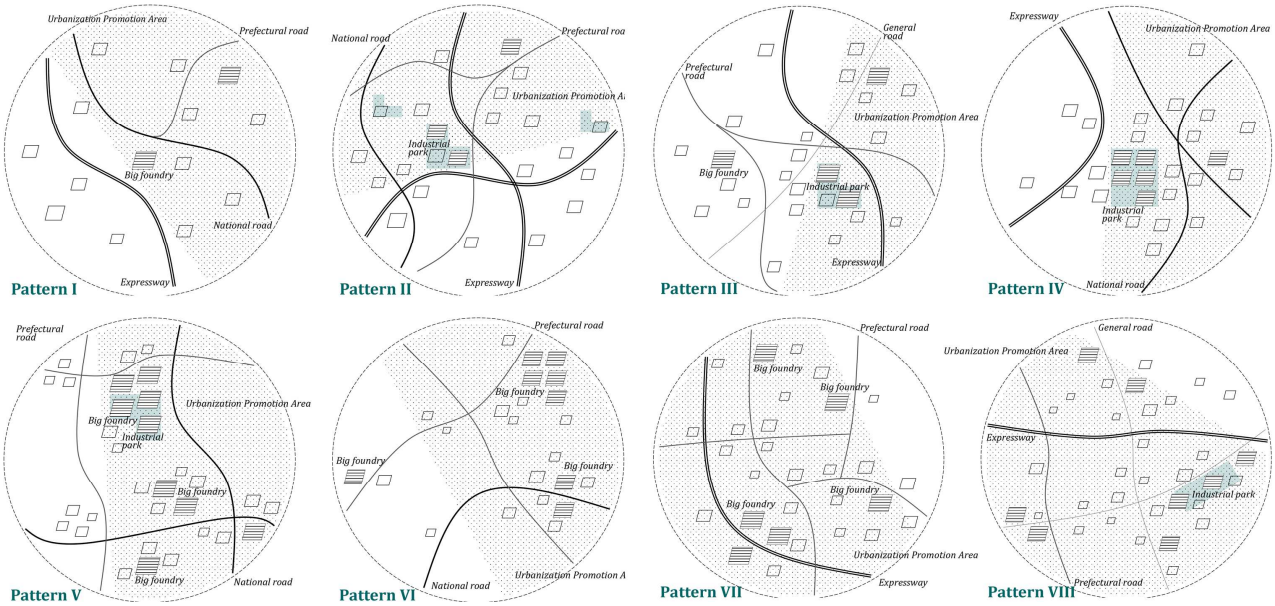

Figure 2: Spatial pattern of industrial land.

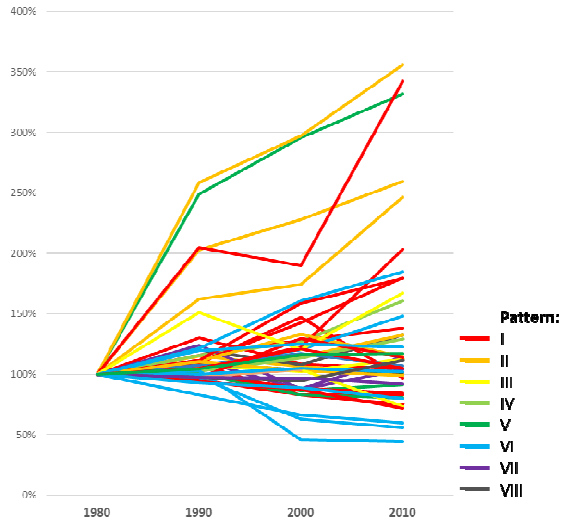

Figure 3: Samples in the 30-40 km area (1980 as 100%).

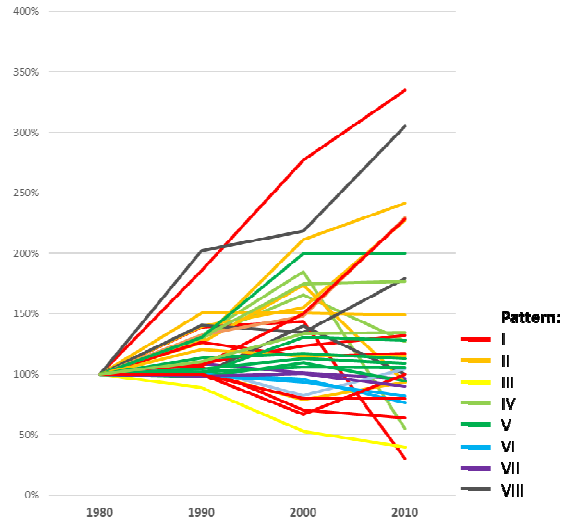

Figure 4: Samples in the 40-50 km area (1980 as 100%).

For seeing the industrial land transition in the 30-50 km distance area of SDZ from 1980 to 2010, we designated 83 3-km-radius study areas based on municipalities as standard samples. Figure 3 and Figure 4 show the rate of increase/decrease in industrial land every 10 years in 83 study areas with 1980 as 100%. We can see that areas of significant increase in industrial land outnumbered areas of decrease between 1980 and 2010. Among the 45 sample areas of the 30-40 km distance area, industrial land increased by 50% or more in

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12 areas, and decreased by 25% or more in 7 areas (Figure 3). Among the 38 sample areas of 40-50 km distance area, industrial land increased by 50% or more in 13 areas, and decreased by 25% or more in 4 areas (Figure 4). In terms of industrial land change in the different spatial patterns of the samples (Figure 2), Pattern II tends to have a large increase of industrial land. Pattern VII has a stable industrial land change within plus or minus 10%. Pattern IV and V samples mainly show an increase in the range of the 40-50 km distance area. The samples of Pattern I and VI do not show any significant tendency of industrial land increase or decrease.

4.3 Features and Reasons of Industrial Land Transition

4 typical examples from the 83 3 km-radius study areas of the 30-50 km distance area - 2 samples in the 30-40 km distance area and 2 samples in the 40-50 km distance area (location shown in Figure 1) are selected to show details of industrial land transition at a community level.

4.3.1 Industrial land transition in 4 samples of the 30-50 km radius area

In general, industrial land in all four samples increased from 1990 to 2000 and then decreased, with one sample being similar to the regional average and the other 3 samples being much lower or even opposite to the regional average (Table 2). By 2010, the end of the survey period, the industrial land in Tokorozawa and Zama at 30-40 km distance decreased, while the industrial land in Fujisawa and Atsugi at 40-50 km distance increased, and all of them belonged to pattern V mentioned above.

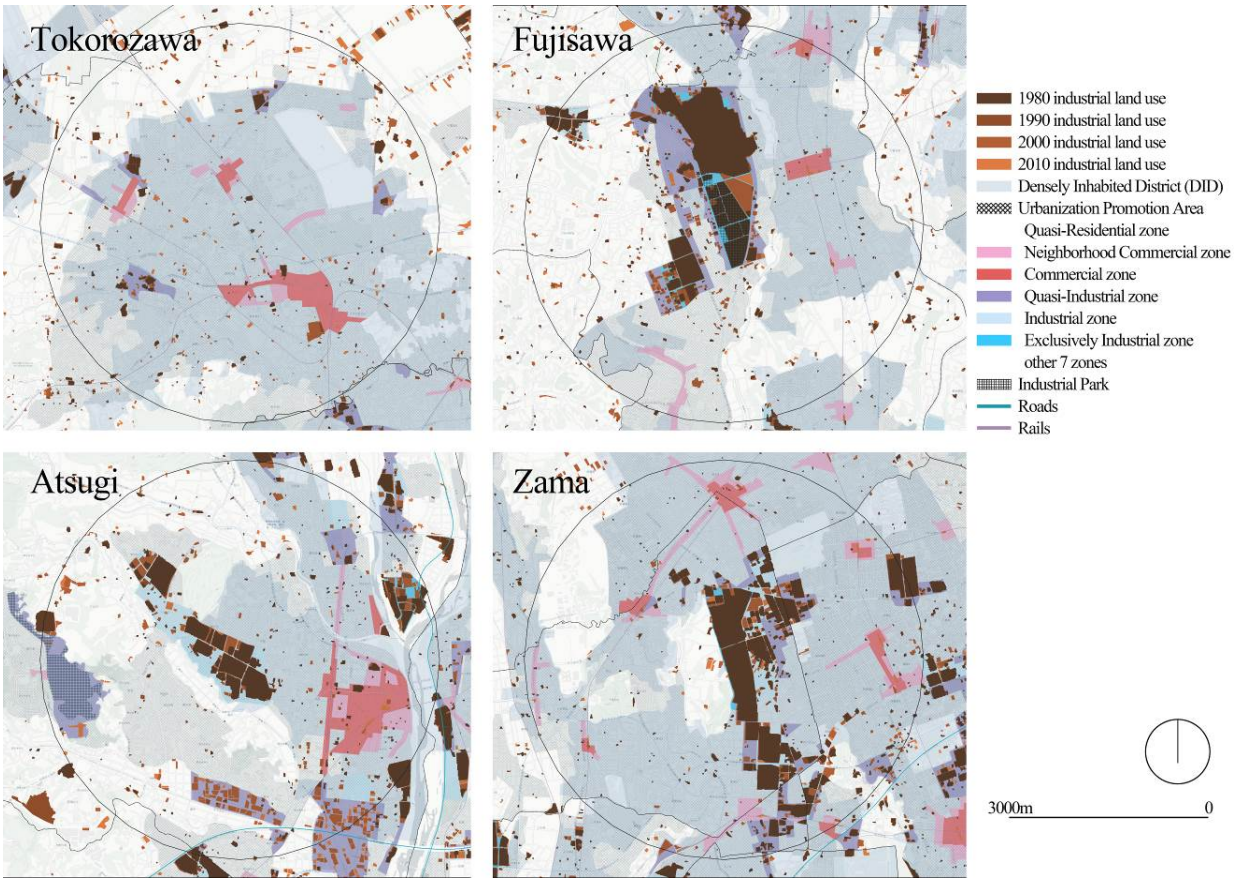

Figure 5: Industrial land location and zoning.

Region	3km-radius sample of City	Spatial pattern	1980	1990	2000	2010	1980-2010	
							Changes	Rate
30-40km	Tokorozawa	I	34	37	50	32	-2	-5.9%
40-50km	Fujisawa	V	233	243	264	255	22	9.4%
40-50km	Atsugi	V	140	142	185	181	41	29.3%
30-40km	Zama	VI	250	232	224	200	-50	-20.0%

Table 2: Industrial land transition (unit: ha).

In terms of overall land use structure, Tokorozawa has no large industrial enterprises and industrial park, and the industrial sites are scattered; Fujisawa has large industrial enterprises and an industrial park, and

industrial sites are relatively concentrated; Atsugi has both large industrial enterprises and an industrial park, and the industrial sites are scattered, but relatively concentrated in each industrial cluster area. Zama has large industrial enterprises but no industrial park, with a relatively concentrated industrial land cluster. In terms of the location of the industrial land transition, Tokorozawa has mainly sporadically increased in the border areas along the main roads. Fujisawa has mainly increased in the areas with good road conditions around the existing industrial clusters. Atsugi has mainly increased in the newly developed areas near the regional residential centre and away from the earlier developed industrial clusters. Zama is mainly partially metabolised within the existing industrial clusters. In terms of zoning context, Tokorozawa has only a Quasi-Industrial zone, and its industrial land changes mainly outside the planned zone. Fujisawa has all, a Quasi-Industrial zone, an Industrial zone and a designated Exclusively Industrial zone and its industrial land has increased mainly in the Exclusively Industrial zone. Industrial land changes in Atsugi and Zama mainly occur in the Quasi-Industrial zone (Figure 5).

4.3.2 Transportation convenience, built-up environment and the industrial park

In the total area of the TMA suburbs, 32% industrial land use was located in places at more than 5 km away from the interchange of the expressway in 2010 and before 2000 increasing speed of industrial land was higher in places far away than in places at 5 km to interchanges. The reason why the industrial land changes in the 4 cases are so varied can firstly be seen from the comparison of the difference in their freight traffic conditions and built environments (Table 3). In terms of the spatial relationship with the administrative centre of the municipality Tokorozawa and Zama, where industrial land use is decreasing, are within 1500 m distance to the city hall, while Fujisawa and Atsugi, where industrial land is increasing, are further away from the centre of the municipality. Fujisawa is located in the sub-centre of the municipality and Atsugi is at a distance of about 2000 m to the city hall. In terms of the spatial relationship with the central station of the municipality all 4 samples are within an approximately 1500-2000 meters range. In terms of the spatial relationship with the expressway interchange Tokorozawa, where industrial land has reduced and is dispersed, is 6600m away from the nearest station, while both Fujisawa and Atsugi, where industrial land is growing, are less than 5000 m from the expressway interchanges.

3 km radius samples in	Spatial pattern	Distance to (m)				Number of roads		
		City hall	Centre station	Expressway interchange	Industrial park	National	Prefectural main	Prefectural general
Tokorozawa	I	1000	1900	6600		1	2	
Fujisawa	V		1500	4600	0	1	2	1
Atsugi	V	1900	2100	3200	2200	2	2	1
Zama	VI	1400	1500	4700		1	2	

Table 3: Features of transportation convenience and built-up environment of the 4 samples.

In terms of road conditions within the sample regions, Atsugi with an increase in industrial land has one more national road than the other samples, but there is not much difference in the number of roads above the level of prefectural road.

4.3.3 Population changes and work-live proximity

In terms of the demographic context of the municipalities in which the 4 samples are located, we analysed the area, density and population share of the Densely Inhabited Districts of the 4 samples (Figure 6). During the observation period from 1980 to 2010, the DID area, DID population and DID population proportion of the four sample municipalities continued to increase. The largest proportion of DID population was 93.9% of Zama city in 2010, and the smallest was 50.8% of Atsugi city in 1980. The population density of DID is higher in Tokorozawa and Zama, where industrial land use has decreased, but the proportion of DID area in buildable land in Tokorozawa is less than 50%. while Fujisawa and Atsugi, where industrial land use has increased, both had a higher proportion of DID area in buildable land than Zama and Tokorozawa after the 1980-1990 period.

In terms of the industrial land transition in and outside the DID, 17% industrial land use was located at 1 km to DID and 17% located in places more than 1km to DID across the TMA suburbs. In the 4 samples industrial land outside DID increased even though total industrial land is decreasing in Tokorozawa and Zama. In Tokorozawa, where the industrial land is mainly small-scale and scattered, industrial land outside DID accounts for more than one-third of industrial land.

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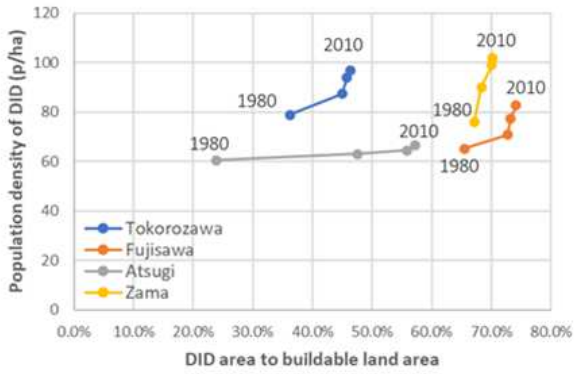

DID Pop.	1980	1990	2000	2010
Tokorozawa	81.7%	87.5%	88.0%	88.7%
Fujisawa	88.8%	91.8%	93.5%	93.5%
Atsugi	50.8%	77.3%	84.3%	86.3%
Zama	92.5%	93.3%	93.5%	93.9%

Figure 6: Demographic urban growth in the 4 municipalities of each sample and the DID population proportion

5 DISCUSSION

5.1 Industrial Transition and Features

Most industrial land was transferred from the inner city to the suburbs as a consequence of the downtown area shifting to the service sector. Meanwhile, the surplus of increment over decrement of industrial development in the suburban municipalities occurred when suppliers and subcontractors emerged after the industrial inflow. UCA shares 23% industrial land, and in all 3 time periods it contained more industrial land increment than UPA did in the 30-50 km distance regions. 5 out of 8 spatial patterns based on locational factors show fragmented small and medium-sized industrial development. The common piecemeal development in the controlled urbanisation area is affected by the transportation accessibility demands of different types of industry. The industrial transition relies more on transport accessibility after 2000 especially. In addition, industrial land use moved far away from where people lived. In the 30-50 km distance regions, increase of industrial land far away from inhabitants is greater than that near inhabitants in absolute value across all 3 time periods. And the 4 samples of the 30-50 km radius area revealed that 1) industrial park is not the necessary means of industrial land aggregation when there is large-scale factory, 2) in the absence of large-scale factory, industrial parks significantly cluster fragmented industrial land, and 3) it takes years or decades for the clustering process and it could be interrupted due to the economical enviroment.

In the TMA, industrial land is mainly located in the east, south, and north parts. It can be seen as an obvious spreading effect of industrial land in the surrounding areas in the past. The distribution of industries in the SDZ of TMA is not independent in each region, but interlinked on the balance of industrial land transition. So, a cross-border large-scale industrial cluster area covering the entire TMA is formed. In the 5th Tokyo Metropolitan Area Basic Plan of 1999, the government hoped that a multi-radius, multi-centre spatial framework of industrial land along the expressway network would be strengthened. However, uncertainty exists in the trends of industrial land transition. It comes from the location demands of each company or manufacturer. Some manufacturers focus on locations near rivers and oceans, while others focus on distribution hubs such as expressway interchanges. Some manufacturers emphasise the availability of workers, while others focus on the relationship with the parent manufacturers as subcontractor. The priorities and the way these conditions combine each other vary from manufacturer to manufacturer (Aiba, 2021).

5.2 Delineation and Implementation of Zoning for Suburban Industrial Development

In terms of micro zoning, industrial land transition shows different structures for the 4 samples (Figure 7). Almost all industrial land in the four samples is located in the Quasi-Industrial zone, Industrial zone, Exclusively Industrial zone, and Urbanisation Control Area, but only Tokorozawa has no designated Industrial zone and Exclusively Industrial zone. From the zoning perspective, firstly, the growth of industrial land in UCA is observed in all 4 samples; secondly, the decrease of industrial land in the Quasi-Industrial zone is present in Tokorozawa and Zama, which happen to be the samples with decrease of total industrial land; and in the other zoning with very little industrial land, industrial land is decreasing in all 4 samples. The increase in industrial land in Fujisawa is mainly in the Exclusively Industrial zone, which has the largest share of the zoning area, while the increase in industrial land in Atsugi is mainly in the Quasi-Industrial zone, which has a smaller share of the zoning area. In Tokorozawa where industrial land is mainly small-

scale and scattered, industrial land in the UCA accounts for more than one-third of industrial land. It reveals that the zoning that controls the expansion of urban land is not as effective as it should be, and its implementation needs to be improved, while the use of zoning that regulates the use of specific urban land use varies greatly in different municipalities. Besides, the increase or decrease of industrial land use is also commonly seen among different urban land uses, which indicates that unmissable leniency exists in the land use zoning.

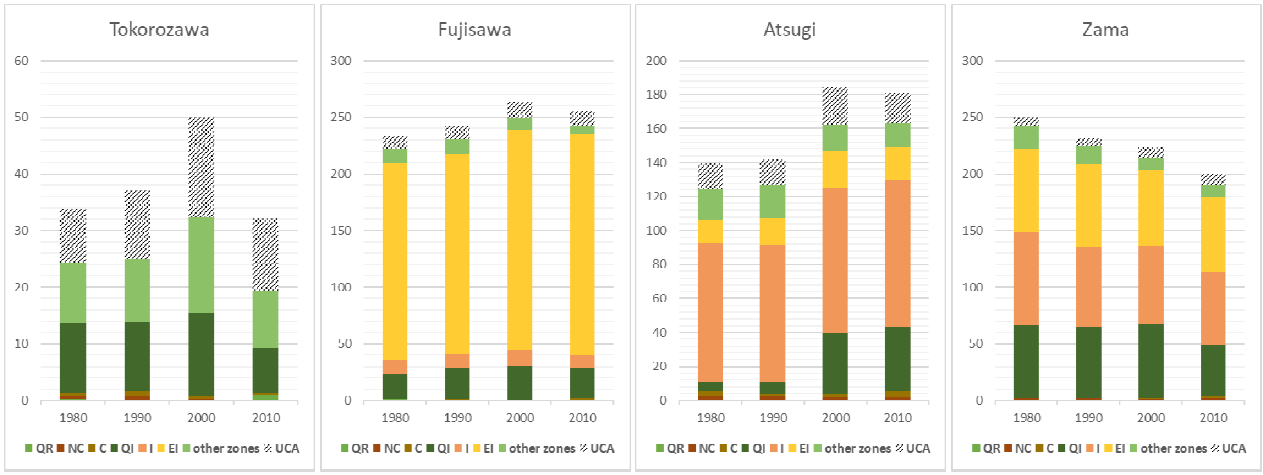

Figure 7: Industrial land transition in planned zones (2005 zoning as criteria).

Zoning should play a key role in land use transition. Among all policies regulating the relation between urban land and its hinterland, the most notable ones are regulatory and economic measures taken under the "zoning" law (Tsubota, 2006). However, conflict has occurred between two administrative ministers for identifying the priority between urbanisation promotion and natural environment protection in Japan (Moreno, 2011). Unregulated urbanisation due to flexible local implementation of zoning is a key cause for land use transition and commonly occurs in the area zoned as UCA (Saizen et al., 2006). Besides, there are requirements of supplying infrastructure or other municipal services in the UPA based on the law (Sorensen, 2001), but uncertainties about landowners' intention for land use transition, and therefore the delineation of zoning is challenged over time.

Conversely, because of the high traffic dependence of some industrial land, it will be laid out closer to regional transportation facilities such as expressway interchange, national highways and prefectural roads. And these areas are not necessarily the gathering place of nighttime population. In this case, the zoning, which is mainly based on population, does not include these industrial sites, thus presenting unplanned industrial land expansion outside of the planning control in the data. However, in order to intensify land use, improve land use efficiency, and protect suburban land resources, industrial land, as a kind of urban land, should be fully included in the control and guidance of urban land zoning. That is to say, zoning needs to consider industrial land use planning away from Densely Inhabited District based on built environment factors such as transportation facilities.

Because of the complex demographic and industrial land use changes in the area, both urban growth and shrinkage are witnessed in the suburbs of the TMA. And in the near future, underused and vacant urban land use would be seen more and more frequently in the urban peripheries because of the national depopulation and the concentration to the centre area of the TMA. In order to keep the vitality of the suburban municipalities, the government issued plan and policy based on the compact city concept. Base on the new policy, dwell and commerce activities are guided to some limited areas which are near the station. However, the new policy has not made the regulative and incentive measure clear outside of the plan area, and the existing suburban manufacturing land use, as receptor of local jobs and revenue, was not taken into consideration in the planning. For sustainable urbanisation, it is necessary to consider industrial land use changes and improve the planning approaches.

6 CONCLUSION

Depopulation of the metropolitan suburbs in the future gives opportunities to suburban land use in TMA. The lessons of industrial land use transition in TMA tell us that: 1) the industrial park could become the main

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carriers of the industrial transition to save the land resource; 2) the implementation of zoning needs to be improved for land resource conservation; 3) the delineation of zones needs to be based on not only population size and density but also on the built-up environment and transportation infrastructure.

The adequacy of industrial land location can be one of the perspectives to evaluate cross-border land use transition. Considering that many other factors, such as socio-economic factors exist during industrial land transition, the analysis of the industrial land location provides insights of the planning approach, together with the analysis of demographic urban growth and its built environment. A temporal-spatial analysis approach is used in this study to identify the effectiveness of zoning in suburban industrial land transition. Through the context-specific research in the TMA using a quantitative and descriptive method, this study revealed that the restriction of zoning on industrial land transition in the suburbs of TMA has been gradually mitigated since the economic bubble exploded in the early 1990s. In addition, the features of industrial land transition of each local municipality differ significantly. The effect of built-environment and work-live proximity in the outer metropolitan peripheries is significantly greater than that in the inner suburban area. This indicates that the existing zoning in different peripheral municipalities varies in terms of lineation and implementation. This method can be used for all other samples at municipality level in the metropolitan suburbs.

Several issues need further research for a way forward. First, this study focused only on secondary industrial land use, without specifying whether it is used for warehousing or small-scale workshops. There are also other driving forces of industrial land transition, such as shipping value and employment of manufacturing. Second, the future population projection in TMA needs to be simulated for providing zoning proposals in the future.

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