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## Study on the Characteristics of Japanese Transit Oriented Development as Seen from Long-term Land-use Changes

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### Abstract

Many railway line development in Japan is occasionally compared to TOD advocated in the US in the 1980s, yet no clear difference has been specified. The purpose of this research is to grasp the history of the plan of Tama Garden City and its long-term land use changes, compare to TOD, and clarify the characteristics of Japanese TOD. Firstly, the development plan of Tama Garden City, was confirmed which was to develop urban functions in stages, not to keep everything under plan, but to coexist with natural change. Analysis of the change of land use actually revealed the gradual development from natural land use to housing, commercial and business land use gradually advanced from the beginning of development. Next, the comparison of the land use at 600 m around the station with mixed land use complexity rate recommended by TOD was conducted which confirmed a similar value to that of TOD. From the above, we found that Tama Garden City was developed by the development method coexisting both spontaneously and planned with the lapse of time. In this research, we define this urban structure which develops gradually and takes time to satisfy the application designation as "Induction type TOD". And we confirmed that there are many induction type TODs around the railway station in Tama Garden city. In the future, to realize or sustain this induction type TOD, it is important to introduce a highly regulated land use system by limiting tax measures and development permits to specific areas.

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*Keywords:* "Transit Oriented Development ; Tama Garden City ; Land use Change ; Mixed land use complexity rate ; Induction type TOD"

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## 1. Introduction

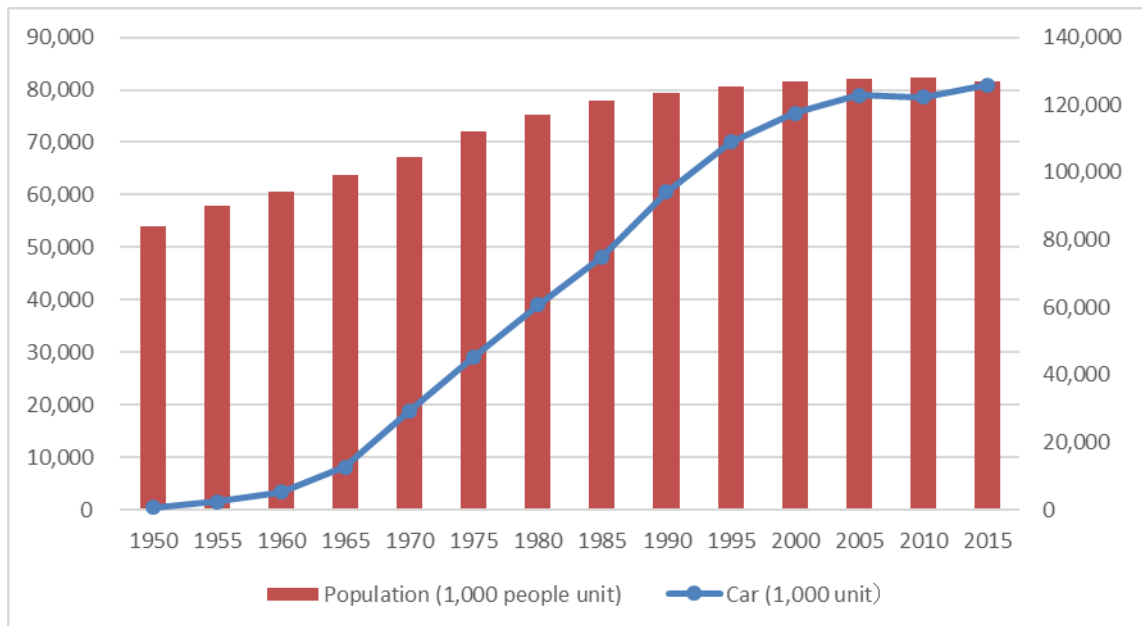
### 1.1. Background

In Japan, motorization and the development of suburban shopping centers promoted automobile dependent society and urban suburbanization, and had various adverse effects on urban structure. In this way, cities and transportation are closely related to each other and influence each other. Therefore, it is important to pay attention to traffic in order to improve various problems the city has. For example, in the United States, where reaching a car dependence society faster than Japan, Transit Oriented Development (TOD), aimed at making a society independent of cars but based on public transportation was developed in the 1980 's. This development method is aimed at creating a compact city with high density mixing purposes by placing public land, commercial and business areas, residential areas, etc., mainly at public transportation stations and stops. And now, many cities around the world are developing the city with the concept of TOD.

It is proposed that TOD has the effect of suppressing suburbanization of cities that are accompanied with motorization (Cervero et al., 2008). Therefore, especially in cities where sprawl of urban areas became a problem due to rapid motorization in recent years in the Asian region, studies on the effectiveness of TOD and survey on actual condition after the implementation are carried out (Lyu et al., 2016; Kitajima et al., 2015; Nakamura et al., 2013).

On the other hand, Japan began extending abruptly car ownership from around the 1960s, motorization has been progress. At the same time, the population has also increased, but the population growth has stopped growing around 2005, and now the population has begun to decline(Fig. 1.).

However, in Japan, before the progress of motorization, there is a history that private railroad companies have realized population consolidation along the railroad along with urban planning. As a typical example, Tokyu Corporation and there is "Tama Garden City", which was developed in the first half of the 20th century. In previous studies, it has been clarified that Tama Garden City has shifted from low - density development to gentle high - density development due to business profit and soaring land prices (Ishibashi et al., 2005). In addition, it has been pointed out that the improvement of living-related facilities utilizing own-owned land and the gradual change of use area contributed to commercial accumulation around the station (Ishibashi et al., 2009). Such railway development of private railway companies in Japan is sometimes regarded as the same type as TOD from the viewpoint of the integral



Data Source: Ministry of Land, Infrastructure, Transport and Tourism, "Number of retained motor vehicles" (2018)  
 Statistics Bureau, Ministry of Internal Affairs and Communications, "Population census in Japan" (2015)

Fig. 1. Changes in the population of Japan and the number of car owners

development of stations. For example, there is a research to evaluate and classify the area around the railway station located in the city centre of 30 km from the viewpoint of TOD (Song et al., 2013). However, these studies mainly focus on the evaluation of the function of the city, there are few mention of the comparison between TOD and railway development in Japan, and the clear positioning with TOD. In addition, the development of Tama Garden City is before the TOD was proposed in the 1980s. Therefore, "Japanese TOD" is thought to be different from TOD advocated in the US with development history and characteristics.

In this research, we investigated the development history and development method around the railway station in Tama Garden City and analysed the land use aging change in the target area. Especially, from the 1970 's when motorization advanced, we targeted until the 2000' s when the population increase of Japan stopped growing. The reason is that town planning based on Japanese public transportation is to clarify what type of land use change over time in the development of motorization and the increase of population. Finally, we compare it with TOD proposed by Peter Calthorpe (1993) and summarized the features on characteristics of Japanese TOD.

## 1.2. Research framework

This research proceeds with the following three steps.

### Step 1. Survey on the development of the target area:

We organized the development history and development method along the railroad track in the target area.

### Step 2. Analysis of land use data in the target area:

We analyzed the land use data around each railway station in the target area and clarified the secular change of land use, the land use for fulfillment rate, and mixed land use complexity rate.

### Step 3. Comparison of target area with TOD:

We compared the target area with TOD, and examined the characteristics and problems of the development along the Japanese railway lines.

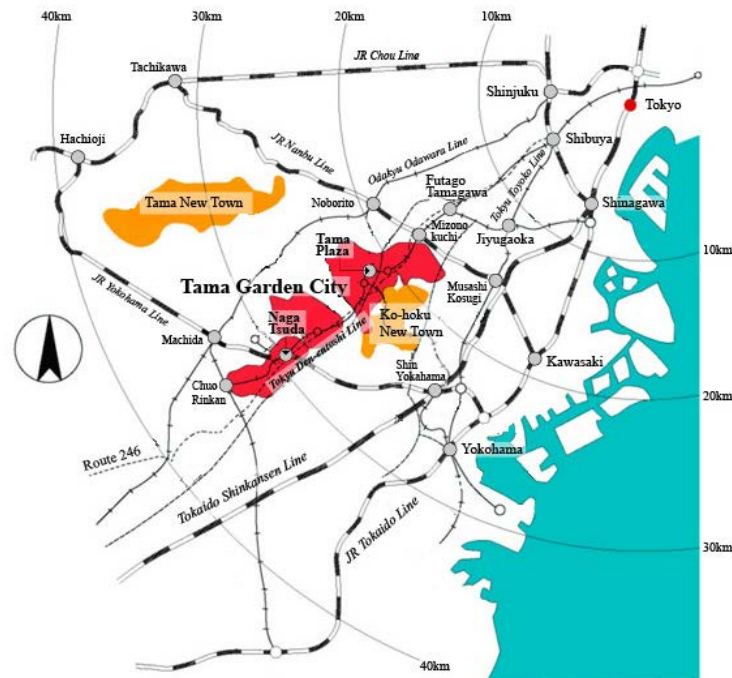
## 1.3. Organization of basic terms

- **Railway station sphere**  
The railway station sphere is a range of areas where the demand for transportation of passengers and cargo handled at the station is expected when looking at the station which is the sales base of the railway. Peter Calthorpe defined this station as a radius of 600 meter at TOD. As the basis of the definition, "comfortable walking distance" (about 10 minutes) is cited for most people. In this study, to compare with TOD defined by Peter Calthorpe, we defined 600 m as the station area.
- **Land use for fulfilment rate**  
The sufficiency rate is defined as the ratio representing how much the target element is filled within a certain range. In this research, we define the term " Land use for fulfilment rate" as the proportion representing the extent of target land use within the designated area.
- **Mixed land use complexity rate**  
In this study, in the specified area, as a percentage that indicates the location to the application it is present at a density of how much each define a word "Mixed land use complexity rate." In addition, road land at the time of the calculation does not include.

## 2. Development History of Tama Garden City

### 2.1. Summary of Tama Garden City

Tokyu Corporation is one of the private railway companies in Japan, which was involved with development of housings and had been the core business of the town development. Tokyu Corporation has focused on the symbolic and representative development of Tama Garden City for more than half a century. Tama Garden City is located in a partial area of Tama hills in southwestern part of Tokyo spanning 4 cities of Kawasaki, Yokohama, Machida, Yamato. This area is located 15 to 35 km from the center of Tokyo, the total development area is about 5000 ha, the population



Source: Tokyu Corporation, The history of the Tokyu Tama Garden City development 50 year (Revised)  
 Fig. 2. Location of Tama Garden City

is approximately 620 thousand people (as of March 31, 2017), which is the largest private-sector town development in the country. (Fig.2.).

## 2.2. Development method in Tama Garden City

### (1) Land Readjustment Project by collective agency method

Tokyu Corporation was also a developer and landowner. Therefore, business funds were provided to the collective acquisition of the reserved areas generated by the landowner association. In addition, they have created and practiced a method called "collective acting method" that acts on behalf of all the partnership involved with the project. This method was one of the major reasons why it promoted the land parcel organizing project of Tama Garden City. Ultimately, it was made possible for this region to grow rapidly. As Tokyu Corporation led the development of the whole area of Tama Garden City, it was decided that an urban planning covering a wide area, in such a way that the construction of a main road and a pedestrian road was lead as Tokyu Corporation led the development of the whole area of Tama Garden City, it was decided that an urban planning covering a wide area in such a way that the construction of a main road and a pedestrian road was lead to the station by the administrative division. With this flow, Tama Garden City started the business of the Nogawa Daiichi district in 1959, then consequently the compartment of reorganization projects in 58 districts.

### (2) Pair City Plan

In 1965, Tokyu Corporation repeatedly discussed with Kikutake Construction Design Office and proposed the development of Tama Garden City by base development method. Development was called "Pair City Plan." The content was called "channel development method" by creating three kinds of bases (plaza, village, cross point) and networks (transportation, shopping, green) (Fig.3.). This development method was a stepwise urban development method that adds necessary urban functions to each site according to the time. They had the idea of allowing

coexistence between plan and natural occurrence, in other words, not to plan everything and also to leave everything to naturally occur.

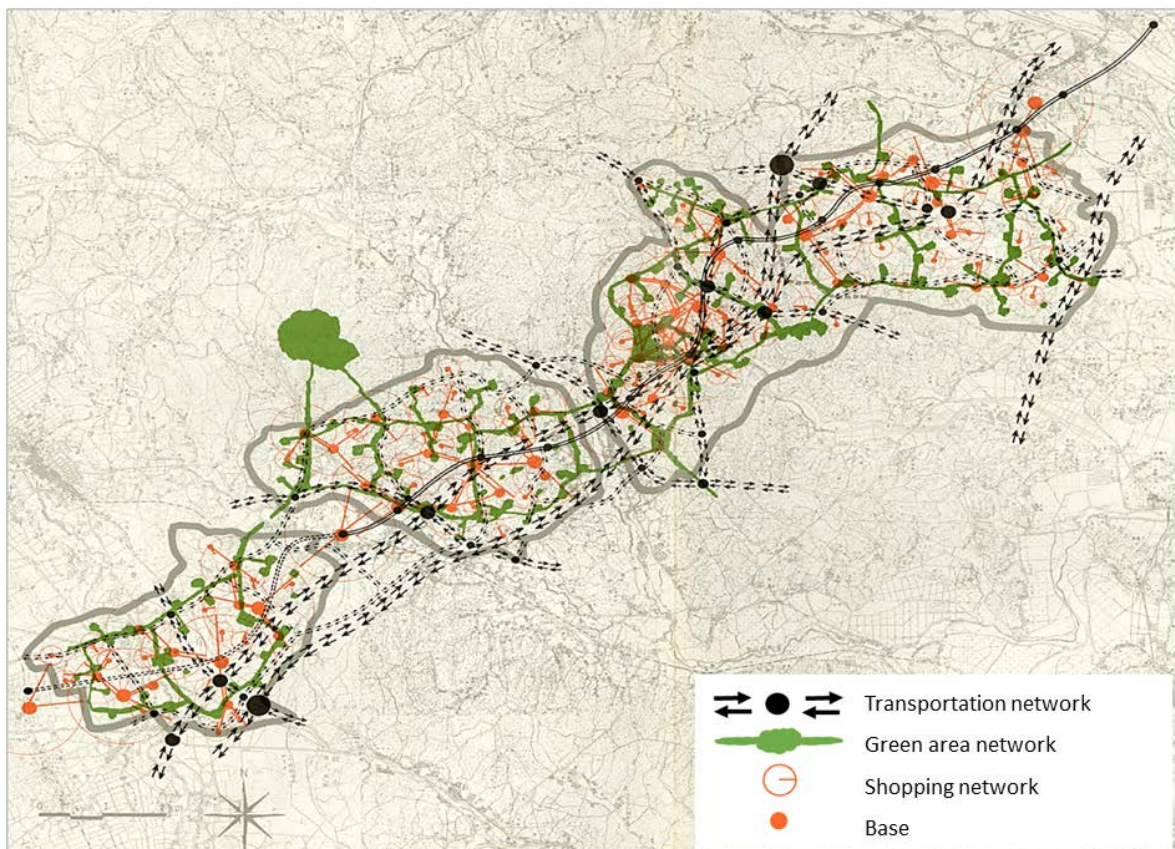
These bases and networks are not limited to static ones in terms of mutual relations with the region. The base changes the network, and the network establishes the base and develops it. Expansion and change of city functions in the region are understood as a dynamic progress and a change of mutual relations between the base and the network.

### (3) Amity Plan

The "Amity Plan" is a development plan based on an urban management perspective announced by Tokyu Corporation in 1973. Tokyu Corporation launched five plans to realize a comfortable urban space and development. Specifically, is an attraction of urban service facility, high schools, maintenance of bus lines, housing planning, greening plan. Among them, Saginuma Station, Tama Plaza Station, and Aobadai Station were positioned as important centres. With this plan, construction of the community centre and improvement of the bus transportation network were mentioned, and clarification of city plan centring the station.

### (4) Other city planning plans

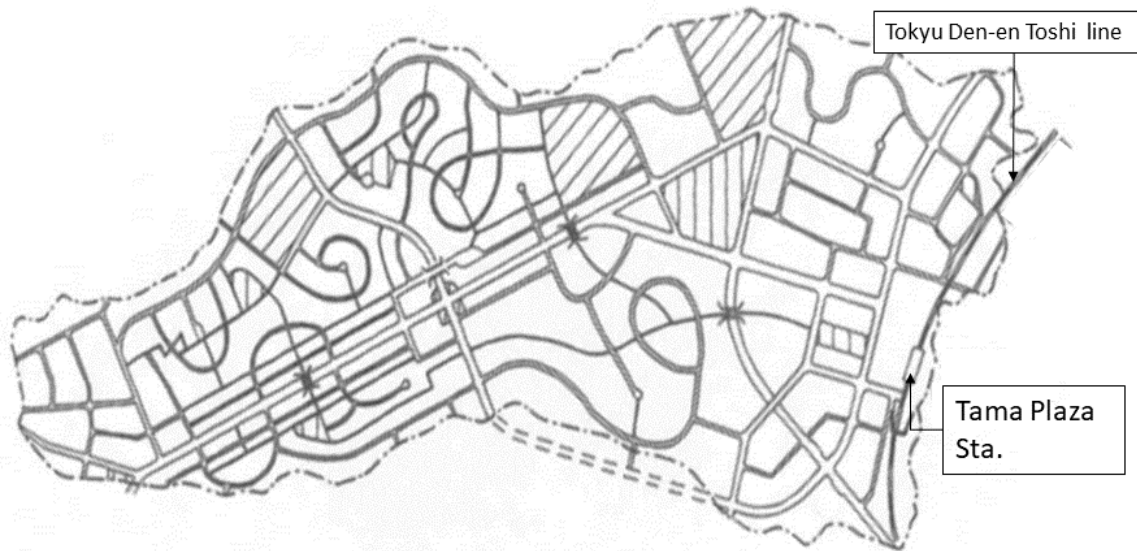
In addition, Tokyu Corporation had announced a variety of urban development in the following dates. Since the Amity Plan (1983), the "New Station Plan" (1987), "Tama Garden City 21 Plan" (1988), "Tokyu Action Plan" (1991), "Next Generation Suburban Street Design" (2013), which contributed to the growth of the city centering on the station.



Source: Shinkenchi-sha Co., Ltd, "Pair City Plan 1965"

Fig.3. Pair City Plan





### Readjustment view (Scale:1/20000)

Source: Shinkenchiku-sha Co., "Sustainability in the suburbs -Regional development and management of Tokyu Corporation-"

Fig.4. City blocks, street design of Motoishikawa Daiichi district.

### 2.3. Development method in Tama Garden City

Near the station of Denen-chofu station and Hiyoshi station where Tokyu Corporation developed before the war, they formed a block with radial roads and torus roads. In Tama Garden City, Radovan system and cul-de-sac method can be cited as a typical city block formation. As an example, in the Motoishikawa Daiichi district (present Tama Plaza), these street designs were complete separation of the walkway, which were adopted in the consideration of the responses to city development without traffic accidents (Fig 4).

## 3. Analysis method

The analysis of this research covers the station area in Tama Garden City along the Tokyu Den-en-toshi Line. Especially, the areas surrounding the 8 stations located in Yokohama city (Tama Plaza, Azamino, Eda, Ichigao, Fujigaoka, Aobadai, Tana, Nagatsuda) are the target areas to be analyzed.

The area around the station refers to area that is within 600 m of the station area where Peter Calthorpe defines the concept of TOD (for most people, a comfortable walking distance is "walking of 10 minutes").

In this research, in analyzing the change of land use, the land use data "detailed numerical geographical information (10 m mesh land use)" and "digital geographic map 5000 (land use)" created by the Geographical Survey Institute were used here. From the detailed numerical geographical information, five points of time in 1974, 1979, 1984, 1989, 1994 and from the digital geographic map 5000, two points of time in 2000 and 2005 was taken. Hereafter, the data for the above 7 years, total about 30 years, were managed and analyzed the secular change of land use. Equations and formulae should be typed in Math Type, and numbered consecutively with Arabic numerals in parentheses on the right hand side of the page (if referred to explicitly in the text). They should also be separated from the surrounding text by one space.

The detailed numerical geographical information (10 m mesh land use) is point data. On the other hand, digital geographic map 5000 (land use) is polygon data. Since here has data on the number of points and data on the area of polygons respectively, the proportion within the area was calculated and analyzed when analyzing.

The contents of the land use data are shown in Table 1. In land use for residential purpose, "low-rise residential districts". "dense low-rise residential districts" and "middle-to-high-rise residential districts" are classified together as "residential districts".

Table.1. Data set

Name	Numerical Information (10m Mesh data)	Numerical Map 5000
Data from	1974,1979,1984,1989,1994	2000,2005
Image		
Data shape	Point Data	Polygon Data
How to obtain rate of land use	the rate of point number	the ratio of the area of a polygon

In this research, in order to calculate the land use proportion of target area, map analysis software "MapInfo" was used here. MapInfo is a type of software handling the Geographic Information System (GIS). It uses the geographical location to comprehensively manage and process data with information on position, then display it visually. As a result, advanced analysis and rapid judgment become possible in this software.

Files in text format of detailed numerical geographical information (10 m mesh land use) on MapInfo, and files in XML format of digital geographic map 5000 (land use) on ArcGIS (another GIS software) are converted to TAB format files. After conversion, analysis was conducted on MapInfo.

On MapInfo, create a buffer (circle) of 600 m around each station. When handling detailed numerical geographical information (10 m mesh land use) data, the number of points for each land use in the 600 [m] buffer was counted. When handling digital geographic map 5000 (land use) data, polygon was divided using circle of 600 [m] buffer as a boundary, and polygon area of each land use only within 600 m buffer was calculated. Hereafter, the number of points and the area taken out are divided by the number of points and the area of the land use of the whole area within 600 m of the station area, and the land use ratio was calculated.

Table.2. Summary of land use data (1)

Land classification	Summary	Minimum unit area [m <sup>2</sup> ]	Minimum narrow side length [m]
Forest and Waste, etc.	Forest, bamboo thicket, bamboo grass, wild grass (including abandoned farmland), waste land, golf course, etc.	400	20
Rice Field	Refers to paddy field that grows Asian rice, lotus, arrowhead (including short-term fallow fields), also contains seasonal cultivation of field crops.		
Field and Other agricultural land	Ordinary field, orchard, mulberry field, tea plantation, other tree gardens, nursery, livestock farm, grassland, grass pastures, cattle shed, greenhouse, and other agricultural lands.		
Developed land	The sites that are in progress of some man-made change for the purpose of residential land development, reclaimed, and so on.	200	15
A vacant site	Some man-made arrangement was done, but the sites is not yet utilized. The sites used for simple facilities are also included: for instance, outdoor parking lots, golf driving ranges, tennis court, materials storehouse, etc.		

Table.3. Summary of land use data (2)

Industrial site		The sites serve as manufacture factory, processing factory, repair factory, and so on. The facilities belonging to factories, such as storehouse, raw materials storehouse, products storehouse, and so on are also included.	400	20
Residential Land	low-rise residential districts	Refers to residential areas that consist of residential buildings lower than 3 floors, and the site area per occupant is larger than 100m <sup>2</sup> . In situations of farmer, the forest or grove of trees surrounding the house is also included.	200	15
	Dense low-rise residential districts	Refers to dense residential areas that consist of residential buildings lower than 3 floors, and the site area per occupant is smaller than 100m <sup>2</sup> .		
	medium-to-high-rise residential districts	Refers to residential areas that consist of mid-to-high-rise residential buildings higher than 4 floors.		
Commercial and Business site		The sites for service industry (shop, entertainment, lodging...) such as retail store, supermarket, department store, wholesale, restaurant, movie theatre, hotel, and so on. And the corporation office for bank, securities, insurance or trading company, Newspaper company, distribution facilities and sites for other similar functions are also included.	200	15
Road site		In principle, the road has effective width more than 1m <sup>2</sup> . (However, depending on the material to be used, and the case of drawing, this principle may not apply). Also, the squares before stations, the roads under construction and the cases that can be confirmed for road usages are also included.	-	1
Park and Open space, etc.		Facilities serve for public usages such as public park, zoo, botanical garden, cemetery, grounds of temples and shrines, amusement park. And facilities serve for usages of athletic sports such as gymnasium, arena, or baseball field.	200	15
Other public facilities*		Districts for public affairs (government office buildings for national or local authorities), education & culture facilities (schools, research institutes, libraries, art museums), supply & processing facilities (reservoir, sewage plant, transformer substation, crematory), social welfare facilities (hospital, sanatorium, senior citizens' home, nursery school), railroad sites (railway, railyard), bus landing centres, garages, sites for harbours facilities, airports, etc.	400*	20*
River and lakeside, etc.		In principle, the rivers (including flood plain, bank), lakes, marshes and fish-breeding ponds with width of water radical more than 1m <sup>2</sup> . Also, beachside area is included.	-	1
Others		Defence facilities, the US armed force institutions, manoeuvring ground, the facilities and resident places related to Imperial, and so on.	400	20
Sea		Refer to surface of sea.	-	-
Out of target area		The places where is outside the target area in the figure.	-	-

\* Railway route land has no minimum unit area standard. And minimum narrow side length is 2m.

#### 4. Land use analysis of Tama Garden City

##### 4.1. Analysis of secular change of land use

For the target 8 stations, we analyzed the secular change of land use within 600 m of the station area from 1974 to 2005. From the figure5,6, the natural land use such as forests, wastelands and other fields such as paddy fields, fields and other agricultural land has decreased year by year. This tendency occurred especially around Tama Plaza, Azamino, Eda station. In addition, although the open area increased from 1974 to 1979, it has kept constant after that, and it has been declining since 1994.



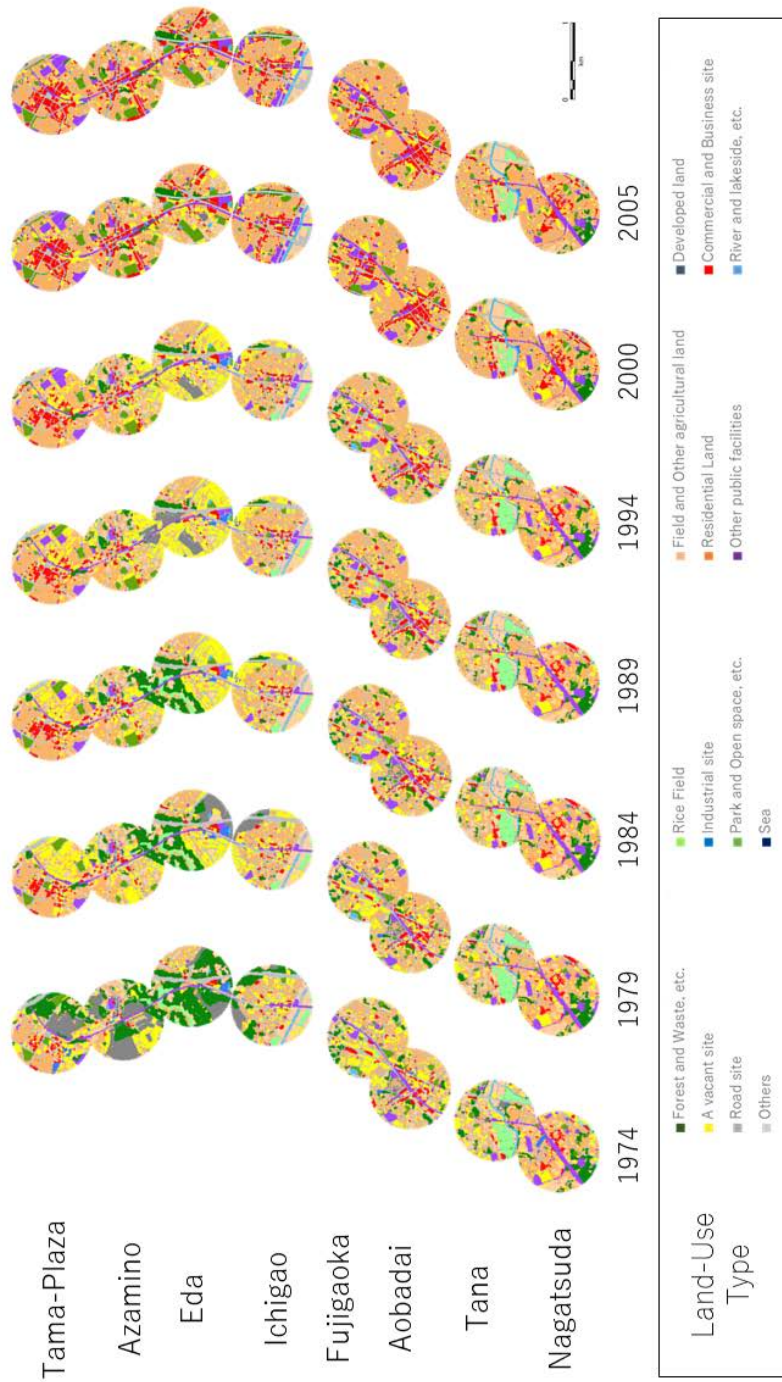


Fig. 5. Land use map of Tama Garden City (1974-2005)

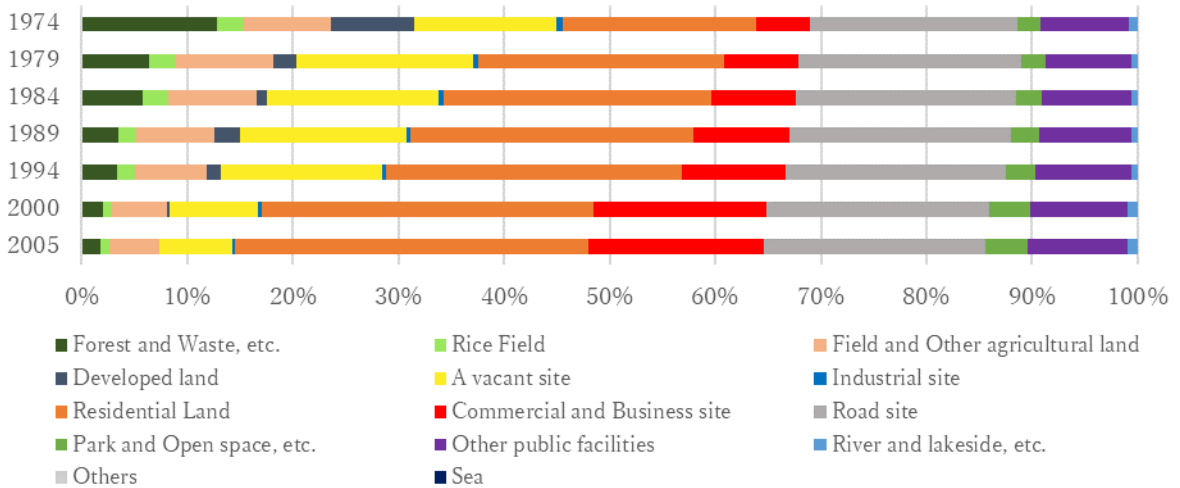
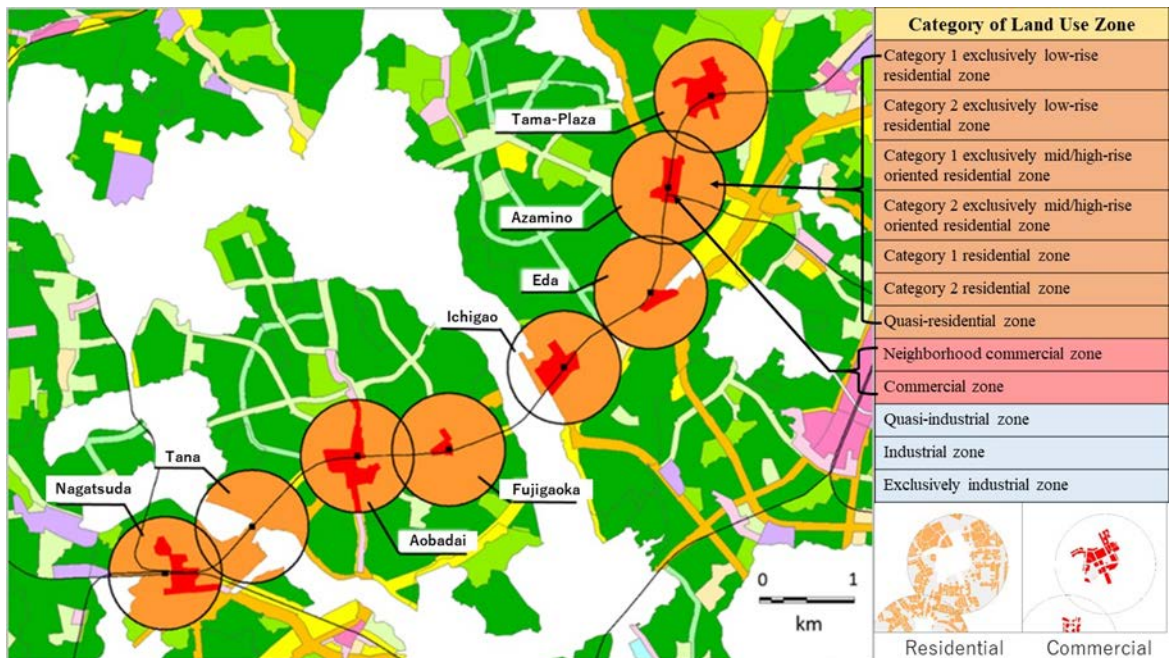


Fig. 6. Long-term change of land use of Tama Garden City (1974-2005)

On the other hand, residential areas and commercial and business sites continued to increase since 1974, indicating that from 1994 to 2000 the increase is large. From these facts, it can be seen from the 1974 to the 2005 year that natural land based use was developed, and instead residential areas and commercial and business sites increased gradually.

4.2. Analysis of land use for fulfilment rate

To examine the land use plan and current situation, we look at zoning of the target area and the change of land use within zoning. We will classify zoning into commercial use areas and residential zoning, and consider the secular change of commercial land use and residential land use within each zoning (Fig.7.).



Data Source: Ministry of Land, Infrastructure, Transport and Tourism, “Digital national land information, Zoning Data” (2011) (Revised)

Fig. 7. Category of Land Use Zone in Tama Garden City (2011)

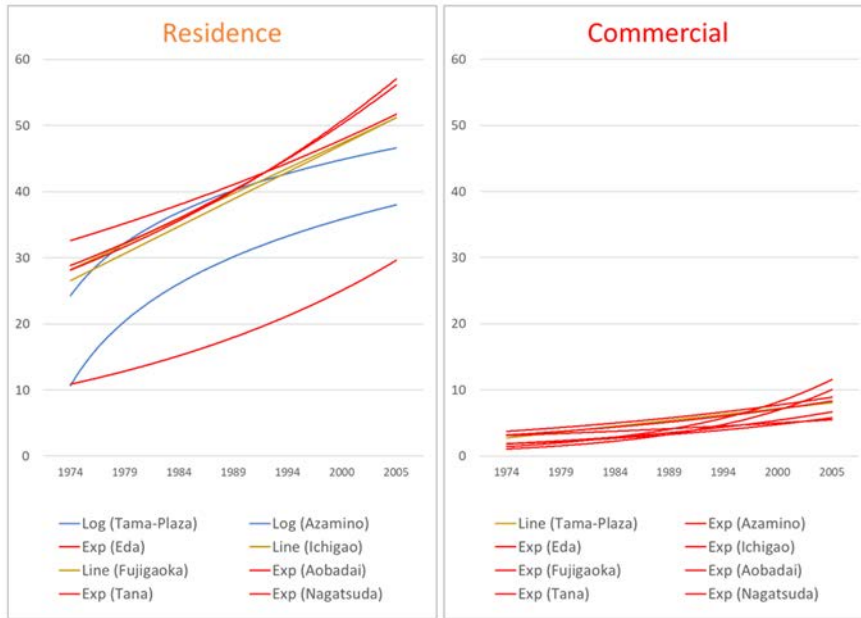


Fig. 8. The proportion of residential / commercial land use in the commercial zoning

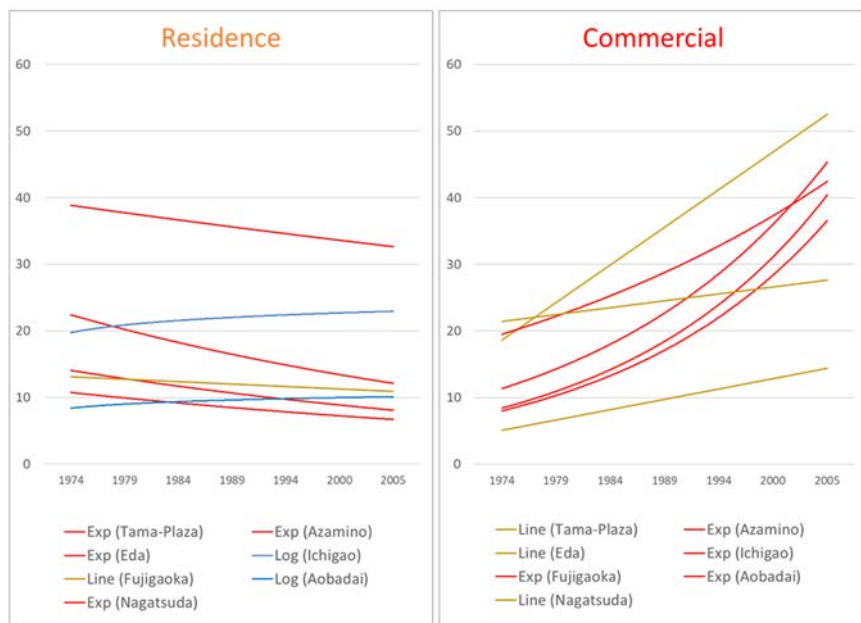


Fig. 9. The proportion of residential / commercial land use in the residential zoning

First, in the figure 8, the change in the proportion of residential / commercial land use within the commercial or residential zoning is represented by an approximate curve. Residential land use within the residential zoning tends to increase generally, but at Tama Plaza station and Azamino station it tended to converge at around 50%. In addition, commercial land use tends to increase with a small amount, and the amount of increase has also increased in recent years. On the other hand, residential land use within the commercial zoning was generally on a downward trend, except for a trace increase in Ichigao station and Aobadai station. Commercial land use continues to increase, and there are areas where there has been a rapid increase in recent years. However, the satisfaction rate remained only about 10% to 50%.

Results showed that residential areas increased in residential zoning and commercial areas tended to increase in commercial zoning as well. However, while residential areas are generally decreasing in commercial zoning, commercial areas tend to slightly increase in residential zoning. Therefore, within the zoning of the housing system, although it is effective by certain application regulations, it can be said that the possibility that the control of land use was not sufficient.

#### 4.3. Analysis of mixed land use complexity rate

Next, we compare the mixed land uses of TOD defined by Peter Calthorpe (Table.4) with the land use combination rate of the target site and look at the balance of the land use of the target area. When it falls within the value range of mixed land use complexity rate recommended by Peter Calthorpe, a white circle is given for Neighborhood TOD and a black circle is given for Urban TOD (Table.5).

Table.4 Mixed land use complexity rate recommended by Peter Calthorpe

Function	Neighborhood TOD	Urban TOD
Public Space	10% - 15%	5% - 15%
Employment/ Core	10% - 40%	30% - 70%
Residential use	50% - 80%	20% - 60%

Table.5 Mixed land use complexity rate in Tama Garden City

Name	Function (%)		
	Public Space	Employment/ Core	Residential use
Tama Plaza	22.2	19.4 ○	47.0 ●
Azamino	17.6	16.7 ○	46.3 ●
Eda	20.5	15.5 ○	40.1 ●
Ichigao	16.3	13.7 ○	50.9 ○ ●
Fujigaoka	18.2	10.3 ○	61.7 ○ ●
Aobadai	11.0 ○ ●	19.4 ○	59.4 ○ ●
Tana	6.7 ●	5.8	49.9 ●
Nagatsuda	16.9	9.9	53.8 ○ ●
Average	16.2	13.8 ○	51.1 ○ ●

○ : Neighborhood TOD ● : Urban TOD

From the results, it can be seen that there is a higher proportion of public use in the target site than mixed land use complexity rate of TOD presented by Peter Calthorpe. This is thought to be due to the fact that the educational facilities such as high schools were attracted around the station by the amenity plan of Tokyu Corporation.

In addition, there were no areas where mixed land use complexity rate for commercial and business use meets the criteria of urban TOD. Meanwhile, the six stations meet the criteria of neighborhood TOD. This is probably because the shopping network was emphasized by the Pair City Plan. In this plan, rather than completing the commercial function within each area around the station, it complements the commercial function between the stations. Therefore, it seems that it did not lead to a high degree of commercial concentration in the vicinity of one station.

Regarding residential areas, there are areas where circles are not attached when compared with neighboring area type TOD indicators, but there are many areas whose values are similar to indicators. As can be seen from the average value, it can be seen that there are many areas closely resembling the neighborhood type TOD in the target area of 8 stations. Mixed land use complexity rate of TOD is merely treated as one ideal form, mainly in America. However, through this analysis, we found that the target area is close to the degree of complexity that TOD is preferable.



## 5. Comparison of TOD development along Tama Garden City along the line

### 5.1. Integral type TOD / Induction type TOD

In order to organize the features of the Japanese railroad development, the TOD is systems classified into two types; " Integrated type TOD" and " Induction type TOD".

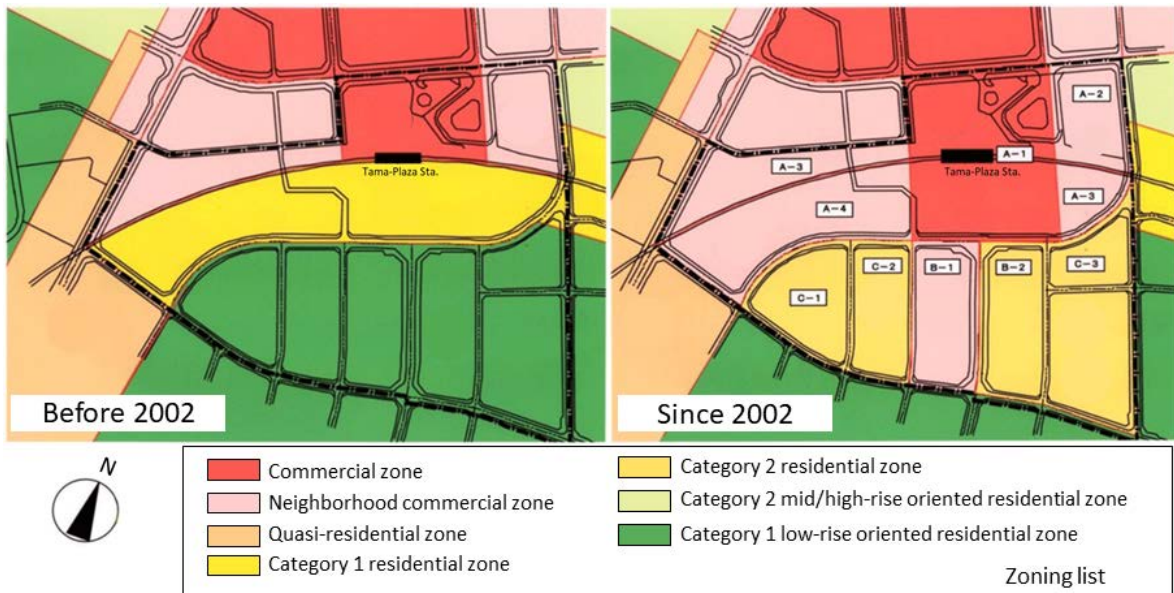
The integrated TOD is a type of TOD that develops around the station of public transportation such as railroads, LRT, and buses integrally. In this case, the design of streets and streets around the station emphasizes the promotion of the use of public transportation, and each block is developed with the clear land use and their arrangement are decided. For example, a redevelopment project around the station can be mentioned.

On the other hand, in the induction type TOD, land use around the station is determined by zoning, and development follows spontaneously with the passage of time, following the development rules to be determined for the block. Here, TOD will take place over a long period of time as development progresses to satisfy the application designation. As shown in Figure 10, this type of TOD is characterized by gradual development progress through gradual change of the zoning.

### 5.2. Urban Structure of Tama Garden City from the Viewpoint of TOD

From Chapter 2, it was found that a pedestrian friendly street design plan has been done. Since Tokyu Corporation is integrating railway construction and urban development, it is expected that Tokyu Corporation has designed to promote public transportation. Also, from Chapter 4, it can be said that aging in land use are generally in a direction to satisfy zoning designation. Values of land use complexity of the target area were found to approximate mixed land use complexity rate of TOD set by Peter Calthorpe.

From the beginning of the development of Tama Garden City, Pair City Plan that is rooted in as a concept hopes for the development of cities through the fusion of spontaneous development and planned development. Moreover, from Chapter 4, it was confirmed that the development from natural land use to residential areas and commercial / business land is being carried out gradually. From these factors, it can be said that there are many induction type TODs around the railway station in Tama Garden City.



Source: Tokyu Corporation, The history of the Tokyu Tama Garden City development 50 year (Revised)  
 Fig. 10. Change of zoning in 2002 (Tama Plaza)



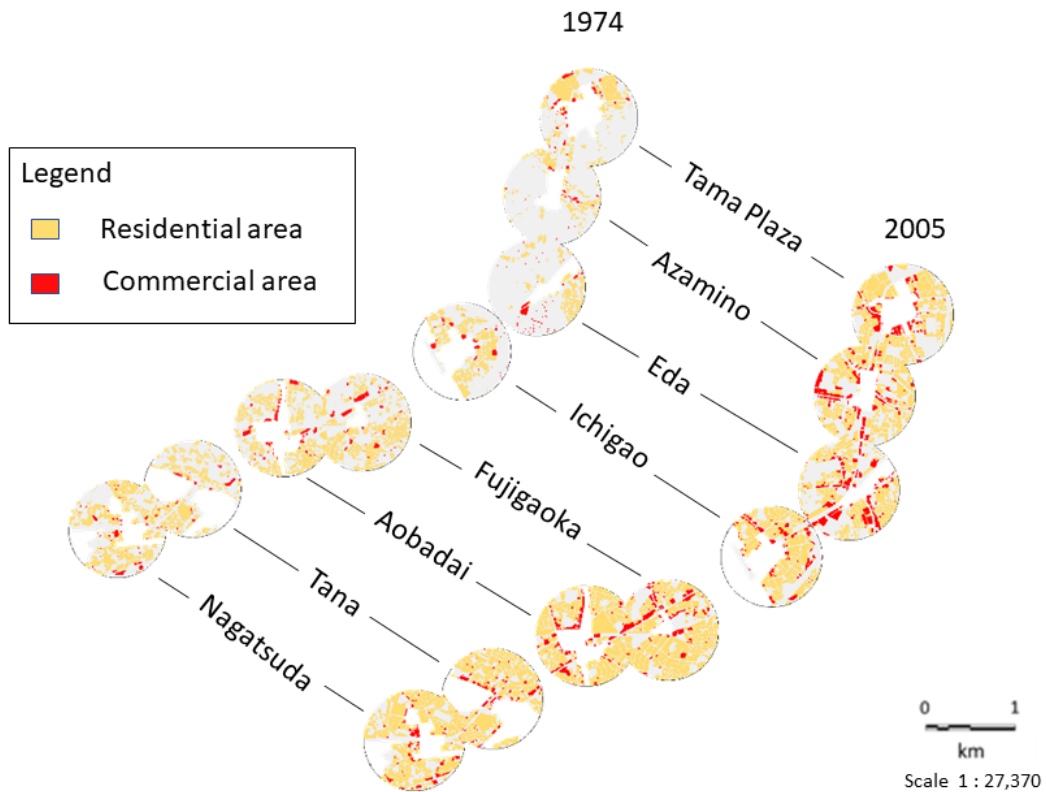


Fig. 11. Distribution of residential areas and commercial areas in residential use areas (1974 to 2005)

### 5.3. Urban Structure of Tama Garden City from the Viewpoint of TOD

#### (1) Interspersed with commercial development

In introducing "Induction type TOD" in Japan, the weakness of regulation force on the mix of land use can be pointed out (Suda et al., 2014). Japan's zoning regulations are extremely low to suppress mixing. Therefore, when induction type TOD is introduced, there are cases where land use or arrangement would not be as planned.

Even in the target area, there are parts where the concern is realized. Figure 11 shows the distribution of residential areas and commercial areas within the residential zoning within 600 m of target stations in 1974 and 2005. Compared to the year 1974, it is understood that the development is proceeding within the residential zoning as of 2005. On the other hand, it can be seen that the development of commercial areas has been scattered within the residential zoning. Such scattering of commercial development can lead to urban sprawl. In order to create a high-density and compact city within a range of comfortable walking distance from the public transportation station, it is considered that strong land use regulations are important.

#### (2) Expansion of residential areas

Within 600 m of the target area there was an accumulation of commercial land use within the commercial use area and an increase in housing within the residential zoning. Also, the scattering of commercial development is recognized, there is concern about sprawl in the target area. In this example, the inside of 600 m of the station area is further divided every 100 m and 6 areas are determined. And the proportion of commercial area and residential area in each area are calculated to verify the secular change of the ratio of each area.

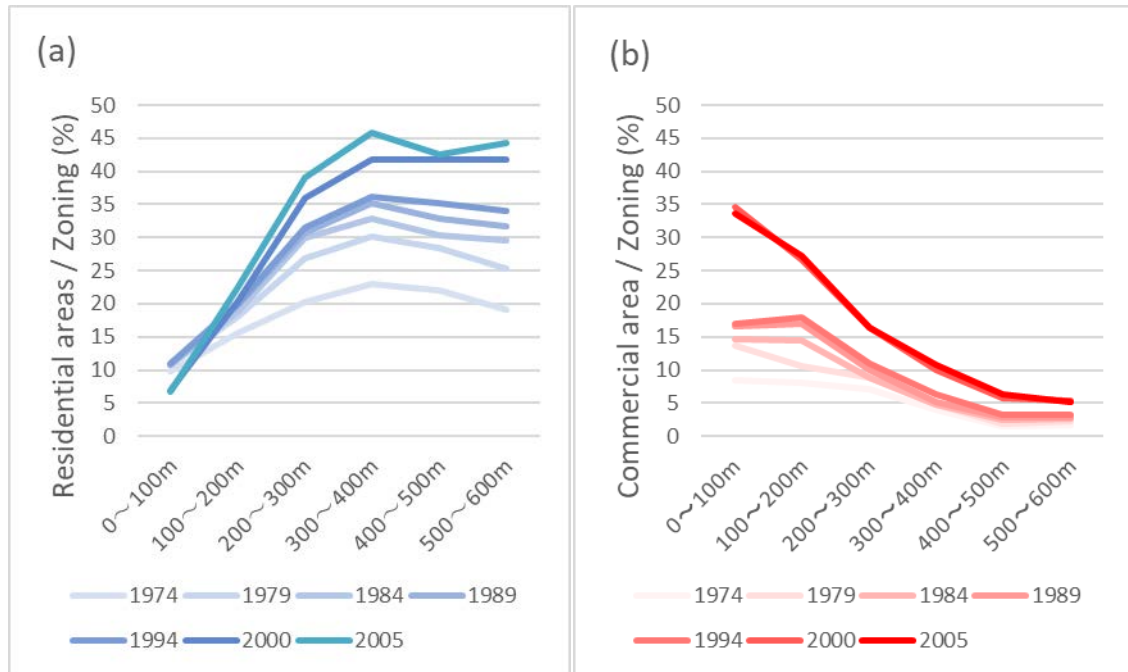


Fig. 12. Long-term change of land use within 600 m of station: (a) Residential areas; (b) Commercial areas

Figure 12(a) shows the secular change of the residential area as seen from the distance from the station, and the secular change of the commercial area is shown in Figure 12(b).

From the results, it can be seen that the proportion of the commercial area is greatly increasing in the area close to the station. Also, small-scale growth is observed in the regions far from the station. On the other hand, the proportion of residential areas is greatly increasing in areas far from the station. The growth rate of residential areas cannot be recognized in the area near the station. From the above, it can be seen that the land use aging change within the TOD zone of residential area and commercial area tends to be symmetrical. It is thought that this is due to the accumulation of commercial areas around the station hence, the residential area is pushed out to the suburbs.

## 6. Conclusion

This study investigated the history of the development of Tama Garden City, in analyzing the aging of the station around land use in comparison to TOD. In Tama Garden City, residential areas from the natural system of land use, the development of the commercial and business land are carried out gradually. Moreover, land use rose largely according to the specified use of the application area. In addition, mixed land use complexity rate of Tama Garden City was similar to that of neighborhood TOD defined by Peter Calthorpe. Therefore, it can be stated Tama Garden City retain its balance of land use recommended by TOD. In addition, when classifying TOD into "Integrated type TOD" and "Induced type TOD", it was found that "Induced type TOD" exists abundantly around the station of Tama Garden City. From the above, it is considered that induced TOD is one characteristic of Japanese TOD.

On the other hand, in the target area, the scattering of commercial area within the residential zoning and the tendency of gradual location of residential area far from the station were confirmed. As a cause of this, we pointed out that weak regulatory power of the application area hinders realization of induced type TOD in Japan. Under such circumstances, a part of the "Urban Renaissance Special Measure Law etc." was revised in 2014 in Japan. With this amendment, it became possible to limit tax measures and development permits to specific areas. Therefore, as to sustain and making induced type TOD in reality, application of a highly regulated land use system is significant.

This study has discussed the characteristics of the development along the railway lines in Japan based on the change of over the years of 1974 to 2005 in Tama Garden City. From now on, analysis using data from 2005 and beyond,

further expansion of the target area and analysis is a subject. We also examine the relationship between the application regional system and TOD that we pointed out as an issue and try to solve the problem of community development based on public transportation in Japan.

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