

A STUDY ON URBAN DEVELOPMENT TREND AND THE SUBURBANIZATION USING THE GEOGRAPHICAL INFORMATION SYSTEM IN A LOCAL CITY

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Abstract: In a local city area in Japan, suburbanization has caused the low dense diffusion of the city functions, and also the decline of the public transportation. Moreover at the background of nationwide aging, the rapid increase of transportation poor in the suburb residence is apprehended. Although originally suburbanization should be controlled by administration, various developments and construction acts are executed in the Urbanization Control Area. This study intends to elucidate the relevance between urban development tendency and suburbanization. Temporal and spatial distribution characteristics of the Development Permission, the Existing Building Site, and the housing complex development on public sector initiative in the Urbanization Control Area are analyzed in Maebashi City based on the Geographic Information System (GIS). In addition, a demographic fluctuation is analyzed with a multivariate regression model in order to observe relevance between the suburb residence and the urban development trend quantitatively.

Key Words: suburbanization, Urbanization Control Area, Development Permission, Existing Building Site, housing complex development

1. INTRODUCTION

In a local city area in Japan, suburb residence with motorization is progressing suburbanization of city functions. The urban problems such as the low dense diffusion of the city functions and the decline of the city center are occurred by this vicious circle. Simultaneously, it has the big influence also on traffic, for instance, it causes the decline of public transportation. Further more, the outbreak of serious urban problems such as the rapid increase of transportation poor on the suburb residence, in which service level of public transportation is generally low, is apprehended against the background of nationwide aging. Therefore, it is evident that a local city is in the stage that the reconstruction of structure is required.

Originally, suburbanization should be controlled by administration with the Area Division System and the Development Permission System in the Urban Planning Area. However under the current development control, various developments and the construction acts are executed in the Urbanization Control Area where urbanization should be restrained, though there is some difference in degree by the city. Moreover the sprawl in the Urbanization Control Area is advancing owing to a deregulation measure such as the Existing Building Site Check System. In addition development of the housing complex on public sector initiative

is one of the factors which promoted suburbanization.

For the problems mentioned above, this study intends to elucidate the relevance between urban development tendency and suburbanization by temporal and spatial analysis in order to suggest for future development control and relaxation and the housing supply policy. Maebashi City in Gunma Prefecture is picked up as a case study area, since it is a local city where suburbanization and progress of the motorization are remarkable. Concretely, temporal and spatial distribution characteristics of the urban development in the Urbanization Control Area are grasped by using detailed database on the Development Permission Register, the Existing Building Site Register, and development year and scale of the housing complex on public sector initiative. Then, the population dynamic model is developed and verified using the vital statistic of the town zone in order to quantitatively analyze the effect of urban development tendency to residence. As a future deployment, we have an intention to develop the urban policy support system considering the effect that these policies give to urban structure. This model analysis is positioned at a first step of system development. The Geographic Information System (GIS) is applied to these analysis as a platform for the purpose of managing large quantity data and realizing visible result output of temporal and spatial analysis. Also we are gazing at development of the analysis system based on GIS.

There are many empirical studies about the sprawl in the Urbanization Control Area. For example, Hatano et al. (1984) and Seguchi et al. (1998) pointed out the problems that the Existing Building Check System exerted on the Urbanization Control Area from a viewpoint of its characteristics and application. Morio et al. (1995) and Kitani et al. (1996, 1998) considered both the Development Permission System and the Existing Building Check System, and evaluated the system application through an elucidation of the advance process of sprawl. In these study, the urban development characteristics were microscopically clarified by each urban development case at the limited study district. Li et al. (2000) analyzed the urban development location tendency peculiar to a local city and its factor in the Urbanization Control Area, and elucidated the spatial pattern of urban development. This research macroscopically clarified the factor and the spatial characteristic of the urban development. But the subject was limited to development permission. Since all of the existing researches above mentioned were concerned with tendency and characteristics of urban development itself, it is necessary to explicitly analyze the effect on suburbanization and dynamics of population. Although this study is in the macroscopic viewpoint, differs from the existing research in the respect that its subject is not only urban development characteristics but also its influence on suburbanization. In addition, the analysis is executed also in consideration of the housing complex development, which is a large factor of suburban residence.

2. OUTLINE OF THE URBAN DEVELOPMENT SYSTEM

2.1 Outline of the Development Permission System

In Japan, industry and population were dramatically concentrated on the city center with the advanced economic growth that began in the latter half of 1950's, and the urbanization phenomenon extensively arose. Therefore the demand for factory and housing lots increased at the fringe of the city center, and the town area was expanded to the suburban part. It causes the small-scale and one-shot development in the unsuitable area, and became cause for the urban district disorderly diffuses, what is called sprawl. Since it brought various evils in

A Study on Urban Development Trend and the Suburbanization Using the Geographical Information System in a Local City

the city, it was needed to establish the comprehensive land use and to control based on it.

Accordingly, the Area Division System was instituted in the City Planning Act (1971) in order to attempt gradually and systematically urbanization. The City Planning Area was divided into the Urbanization Promotion Area and the Urbanization Control Area in the act. The former is a zone which has already formed urban area and should be promoted the urbanization within 10 years approximately, and the latter is controlled urbanization for the time being. In addition the Development Permission System that maintain a development to a certain extent and control it in the Urbanization Control Area was established in order to operate the Area Division System. The Development Permission System consists of three parts as follows.

- i) Permission of a development (Article 29 of City Planning Act)
 - ii) Standard of development permission (Article 34 of City Planning Act)
 - iii) Development permission and building restrictions (Article 43 of City Planning Act)
- i) prescribes the development without permission such as under 1,000m² in order to perform the systematic urban development in the Urbanization Promotion Area. ii) is the standard of the permission for all of the development acts in the Urbanization Control Area in order to control the development and to give efficacy to the Area Division System. iii) is the

Table 1. Contents and cases of the development in the representative clauses of Article 34

Article34, No.1	The development of a necessities store for neighbors. (A retail store, a barbershop etc.)
Article34, No.2	The development using a mine resources or a sightseeing resources. (A cement manufacturing, an observatory etc.)
Article 34, No.4	The development of a building required for disposition of agricultural products, and excepting defined in Article 29, No.2. (A stockbreeding, a food manufacturing etc.)
Article 34, No.4-2	The development of base facilities for agriculture and forestry activation on a designated agricultural a mountain village.
Article 34, No.5	The development of the building financed on the Act of Small Business Encourage Office.
Article 34, No.7	The development of a disposal plant or a storehouse of dangerous object. (A powder magazine etc.)
Article 34, No.8	The development that is difficult or unsuitable in the Urbanization Promotion Area and established at proper position. (A gas station, a drive-in, an institution of road maintenance etc.)
Article 34, No.8-2	The development of a building specified in the Village Area Consolidation Act.
Article 34, No.9	The development which is registered the existing right, and carried out within 5 years since the introduction of the Area Division System (A house in Existing Building Site, an inn, etc.)
Article 34, No.10-a	The development that is more than 5 ha, and doesn't disturb intentional urbanization. (A large-scale housing complex, an industrial park etc.)
Article 34, No.10-b	The development that doesn't promote the urbanization, and is difficult or unsuitable in the Urbanization Promotion Area. (A house for the second or the third son of a farming family, a small development in a large designated existing village, a charnel house, etc.)

restriction on the construction etc. in lands without the Development Permission. The Existing Building Site Check System later mentioned corresponds to it.

Because the subject of this study is the development in the Urbanization Control Area, the data on (ii), Article 34 of City Planning Act, is used as the development permission data. Contents and cases of the development are shown in Table 1 by representative clause of Article 34. Though only the developments which do not promote sprawl are ordinarily permitted, there are some clauses in which an ambiguous interpretation is possible, e.g. Article 34, No.10-b.

2.2 Outline of the Existing Building Site Check System

The Existing Building Site Check System is specified construction acts without permission by the prefecture governor concerning restriction on construction in the Urbanization Control Area, which is described in Article 43 Clause 1 No.6 of City Planning Act. This system is a deregulation measure based on the thought that it is not practical to control construction at the sites in a hamlet to a certain extent, which organize living environment similar to in the Urbanization Promotion Area and had been already housing site when Area Division System was introduced.

In the case of Gunma Prefecture, the Existing Building Site Check is acquired in case of meeting the following two requirements.

- 1) The site must be in the region, which organizes coherent living environment and is adjacent to the Urbanization Promotion Area.
- 2) The site must have been the housing site continuously since the Area Division System introduced.

“Adjacent” is defined as the region which is within 2 km in a direct distance or can arrive within about 15 minutes using a public transport from the Urbanization Promotion Area as a principle. The site is accepted as Existing Building Site only in the case where such a place exists in the Stretched District. Here, the Stretched District is the district where more than 50 buildings (lower limit is 20% decrease) are stretched within 50m on distance of each site in principle. As for the requirements 1), the distance conditions from the Urbanization Promotion Area is differ by prefecture. In the case of Gunma Prefecture, it is set as 2km, while it is less than 0.5 km or 1 km in neighboring prefectures. Therefore, quite large area may belong to the applicable district. The outline of these requirements is shown in Fig. 1.

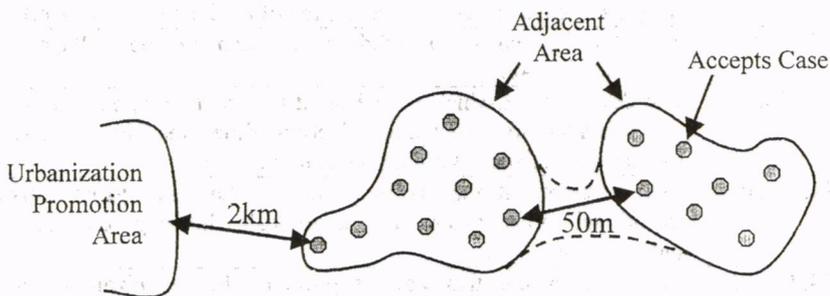


Fig. 1 Outline of the requirements in the Existing Building Site Check System

3. URBAN DEVELOPMENT TREND IN CASE STUDY AREA

3.1 Transition of the Area Division

In Maebashi City, the Urbanization Promotion Area was changed in 1977, 1985, 1991, and 1999 since the Area Division System was introduced in 1971. Its transition is shown in Fig. 2. At the beginning, the Urbanization Promotion Area was set up in relatively compact area around the city center. However, some part of northern area and southern area oozed out in the fringe of the Urbanization Promotion Area in 1977 and in 1985, respectively. Furthermore, the Urbanization Promotion Area was scattered into suburban area in 1991, and spread out still broadly in 1999. In view of these facts, it is thought that the Urbanization Promotion Area itself was suburbanized as years go by, and the scattering of it for last ten years affected the suburbanization of the city.

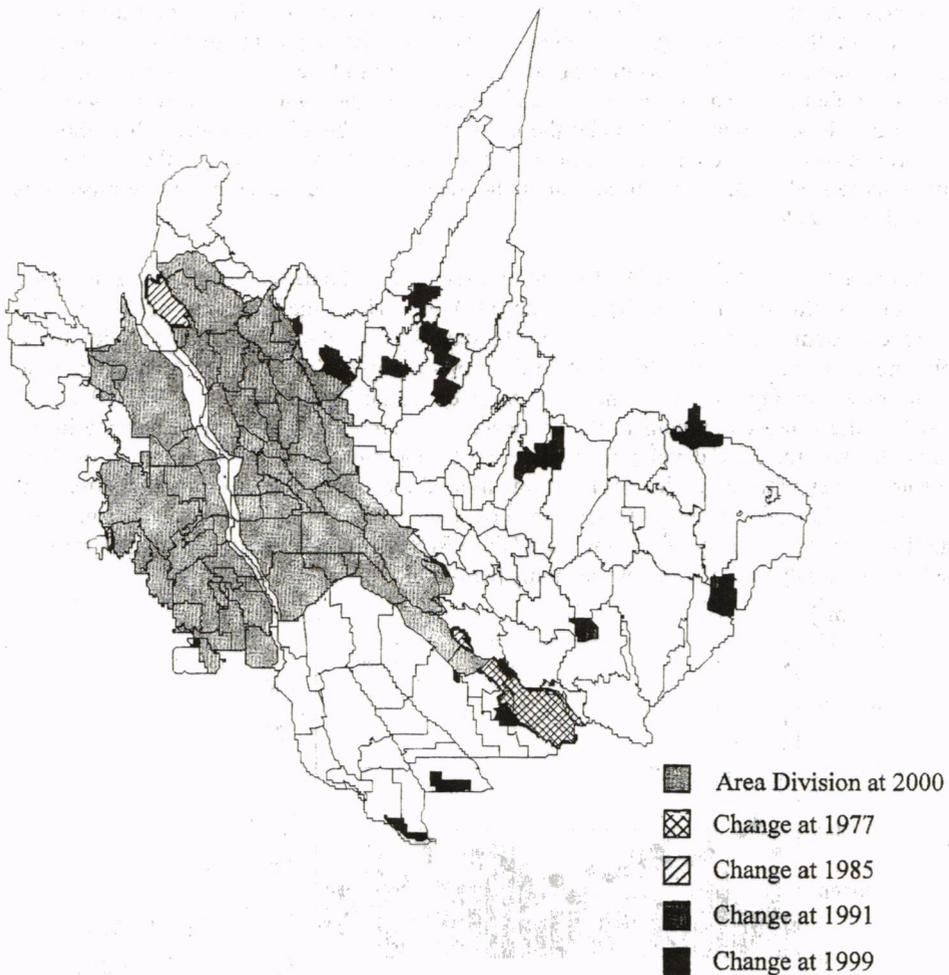


Fig.2 Transition of the Area Division in Maebashi City

3.2 The Development Permission

In this section, the characteristics of the Development Permission distribution are grasped by the temporal and spatial analysis using the data made an entry in the Development Permission Register from 1971 to 1999.

The transitions of total development permission number and area are shown in Fig.3. And the transitions of total number on representative clauses of Article 34 are shown in Fig. 4 in order to observe systematic characteristics in detail. Here, the data on Article 34 No.9 is not included in the total area because of lack of area data. In the period, total of the Development Permission is 6,420 cases, and total area is 1.7 million m^2 that corresponds to about 1.7% of the present Urbanization Control Area. In the point of transition of total application number, the registration of the existing right by Article 34 No.9 is remarkable in 5 years immediately after the Development Permission System introduced. Especially, it amounted to about 700 cases in the first year of system introduced. It can be said that the registration of the existing right increased the absolute development number, although it should be essentially relief measure against the system introduced. Afterward it gradually decreased to about 150 cases per year on an average over the 1980s. However, about 300 cases are developed around 1990 under the influence of the bubble economy. It is thought that a prosperous condition is the factor of sprawl acceleration. Although there are some fluctuations caused by the social background, the transition of the Development Permission is comparatively stable.

Next, in order to grasp the spatial distribution characteristic, the development rate is analyzed on the zones including the Urbanization Control Area. Here, the zones are defined as 133 town zones existing in Maebashi City, and the development rate is calculated dividing the development total area by the Urbanization Control Area in each town zone. The transition of it is shown in Fig. 5. In comparison with development situation in 1971-1980 and 1986-1995, the zones contiguous to the Urbanization Promotion Area were developed in the former. In the latter, the development advanced to one more suburb zone in spite of there were some zones with lower development rate around the Urbanization Promotion Area. It is proven that the development was performed on some zones contiguous to the Urbanization Promotion Area at the beginning of the Area Division System introduced, and it had spread to the suburb gradually until the bubble economy period.

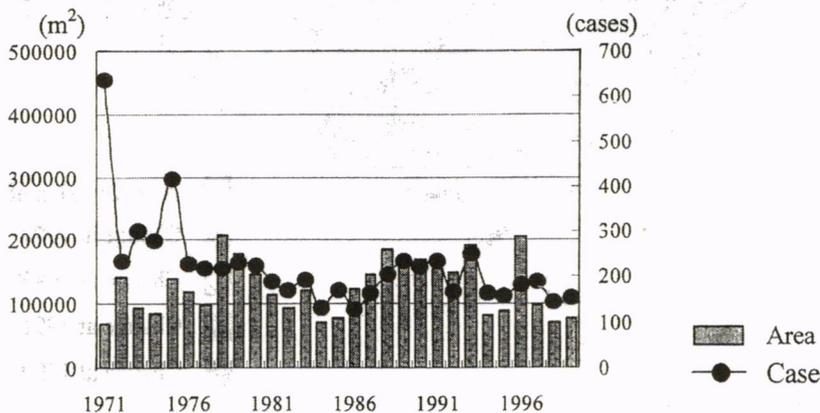


Fig.3 Transition of the Development Permission

A Study on Urban Development Trend and the Suburbanization Using the Geographical Information System in a Local City

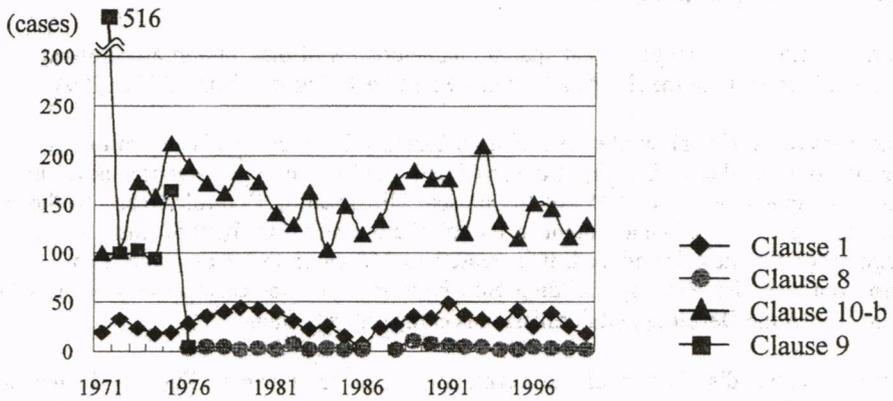


Fig.4 Transition on the Representative Clauses of Article 34

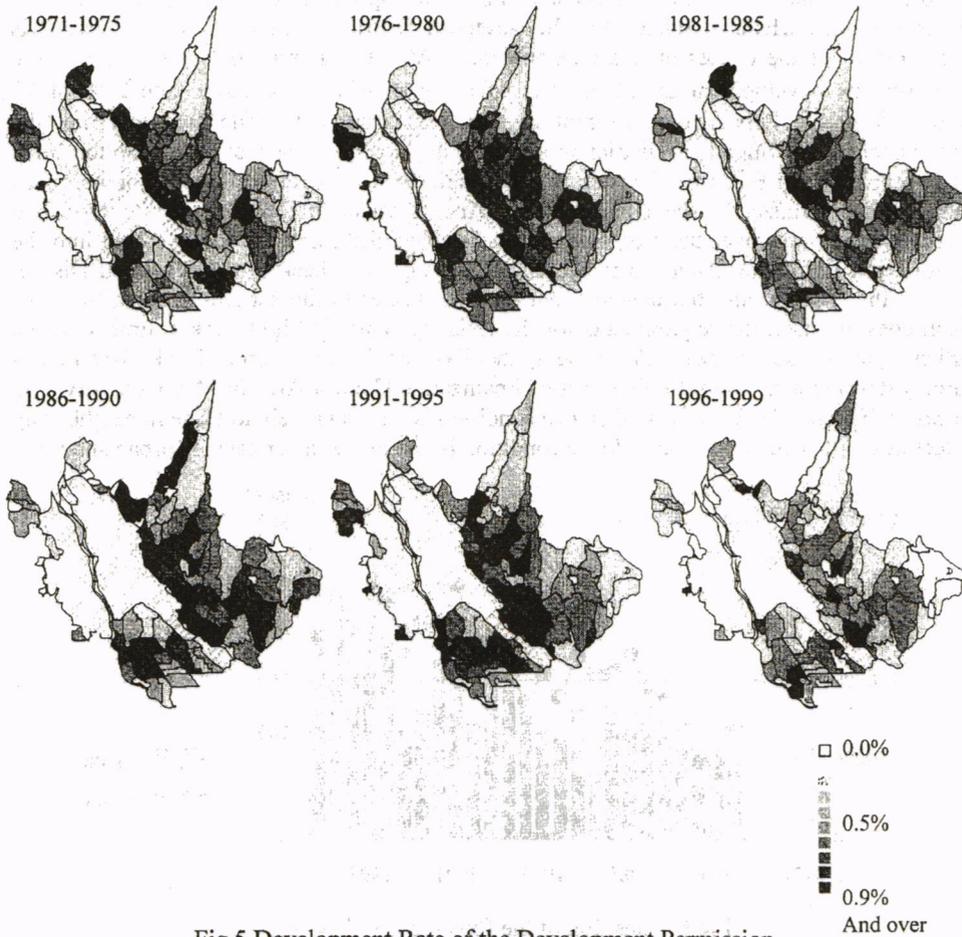


Fig.5 Development Rate of the Development Permission

3.3 The Existing Building Site

In this section, the temporal and spatial characteristics of distribution are grasped using the data made an entry in the Existing Building Site Check Register from 1975 to 1999.

The transitions of total number and area on Existing Building Site is shown in Fig.6. In the period, total number of Existing Building Site is 4,178 cases, and total area is 1.1 million m² that corresponds to about 1.1% of the present Urbanization Control Area. In the point of transition of total application number, though the number was about 50 cases per year at the beginning of system introduced, it increased to 150 cases that was about 4 to 5 times. It turns out that the Existing Building Site have gone on increasing every year, while the transition of the Development Permission is comparatively stable.

Next, a spatial distribution of the development rate is shown in Fig. 7. In the point of transition, there was no development in suburb, while the development rate was high in zones around the Urbanization Promotion Area in 1971-1980. However, the development in the suburb zone has gone on increasing as time gone by. Although suburbanization is observed in the Development Permission until the bubble economy period, the Existing Building Site has spread to suburban area even in recent years, and the upward tendency is more remarkable. The following mechanism related to "the Stretched District" mentioned in chapter 2-2 is considered to be the causes of this phenomenon. At the beginning of system introduced, there were no development in suburb, since the region which was more than 2 km or 15 minutes from the Urbanization Promotion Area was restricted. The area that met the requirement of the Stretched District was spread due to the Urbanization Promotion Area oozed by change of the Area Division in 1977 and 1985. Therefore the development was gradually suburbanized. The change of the Area Division in 1991 made the Stretched District spread to all over the city, since some detached districts were incorporated into the Urbanization Promotion Area. The Existing Building Site Check in the Stretched District cause further stretch, and the development spreads further to the suburbs. Now, the zone which does not meet the requirements for the Existing Building Site Check is limited to the northern part of study area. At present, the Existing Building Site Check System has scarcely development control effect to the Urbanization Control Area in Maebashi City. In the case of Gunma Prefecture, the distance condition is long relatively to these in neighboring prefectures. It is clear that such a loose condition is one of the factor causing urban sprawl.

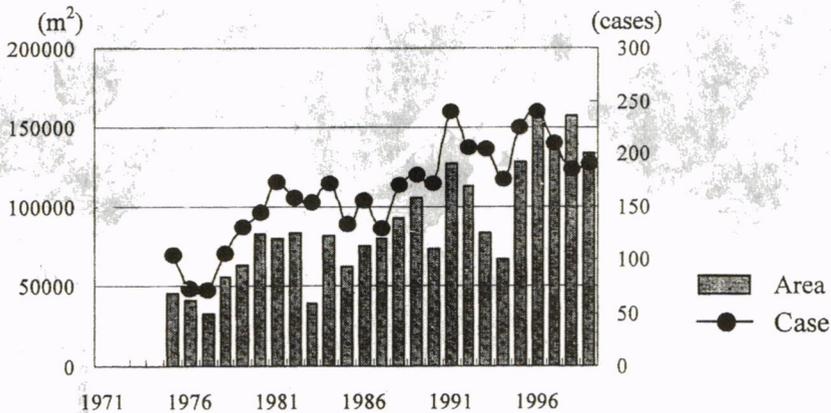


Fig.6 Transition of the Existing Building Site

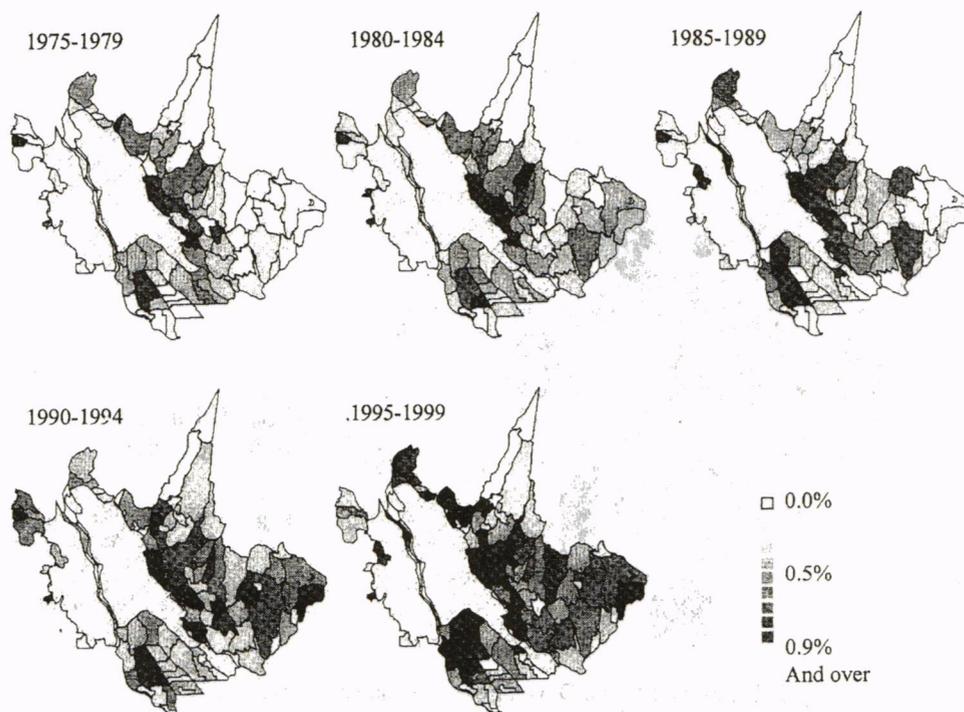


Fig.7 Development Rate of the Existing Building Site

3.4 Housing Complex Development by Public Sector Initiative

In this section, the temporal and spatial characteristics of housing complex development on the public sector initiative are grasped using the data from 1971 to 1999.

Total number of houses that are divided by the Area Division type and the transition of the housing complex development are shown in Fig. 7 and Fig. 8, respectively. In the period, total of public housing complex development is 9,757 houses. As shown in Fig. 8, the housing complex had extensively developed until 1990. However, recently it is decreasing and the main development is the apartment house included for old people. Although the development of the housing complex had been advanced mainly in the Urbanization Promotion Area, the large-scale one had been developed also in the Urbanization Control Area including the district that was incorporated into the Urbanization Promotion Area.

In terms of the Area Division type, some regions incorporated into the Urbanization Promotion Area in 1991 as detached district include the large-scale housing complex developed by the public sector. As mentioned above, the spread of the Urbanization Promotion Area to suburb has an effect on increase of the area that meet the requirement of the Stretched District in the Existing Building Site Check System. Consequently, it can be said that the development of the housing complex in the Urbanization Control Area have a double effect for the promotion of the suburbanization, owing to not only suburb housing itself but also increasing the Existing Building Site.

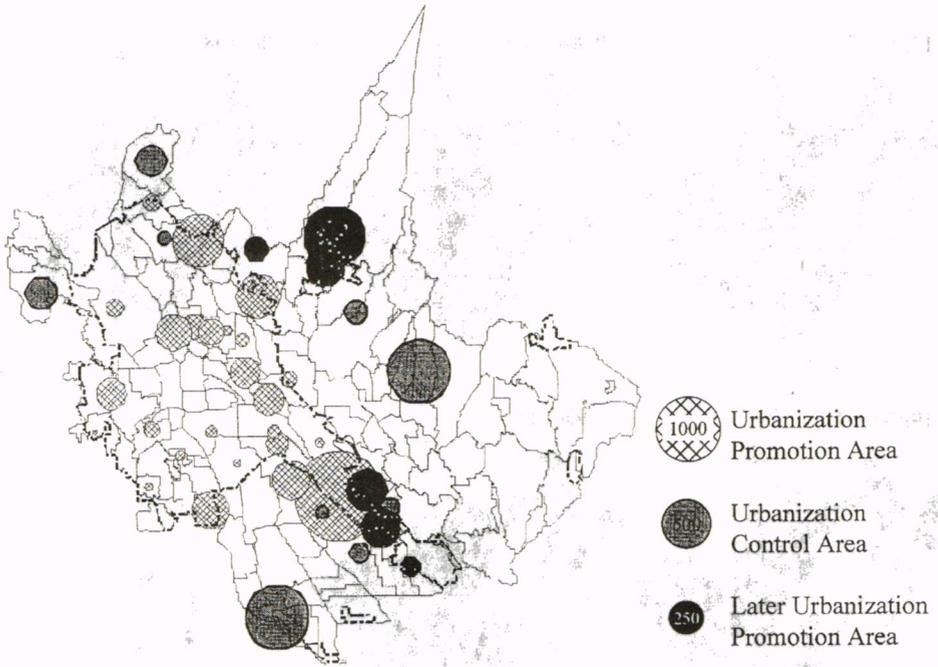


Fig.8 Housing Complex Development by the Area Division Type

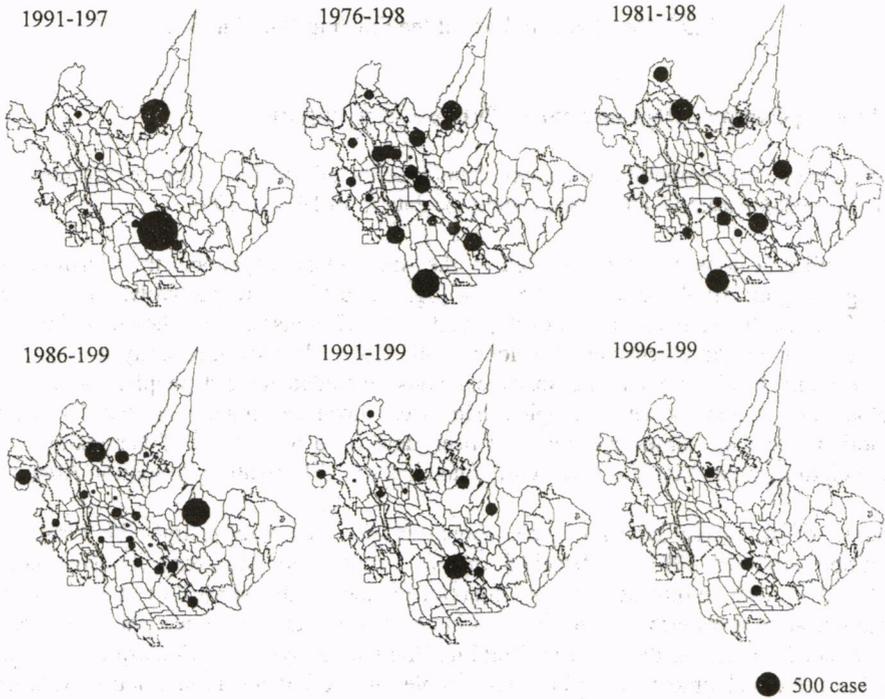


Fig.9 Transition of the Housing Complex Development

4. THE RELEVANT ANALYSIS BETWEEN SUBURBANIZATION AND URBAN DEVELOPMENT TREND

4.1 Population Growth Model

In this study, for the purpose of quantitatively observation on relevance between the suburb residence and the urban development trend, a demographic fluctuation is analyzed with a multivariate regression model. This model represents the fluctuation of population in each town zone based on a 5-years time scale. The object area is limited to 83 zones that consist of or include the Urbanization Control Area, since the data on the development in the Urbanization Promotion Area is not sufficient. The fluctuation of population for zone i in period t , ΔP_{it} , is represented by equation (1).

$$\Delta P_{it} = \alpha_1 DN_{it} + \alpha_2 EN_{it} + \alpha_3 H_{it} + \alpha_4 ASP_{it} + \alpha_5 LNUP_t + C \quad (1)$$

where,

α : Parameters

DN_{it} : Cases of the Development Permission of zone i in period t

EN_{it} : Cases of the Existing Building Site Check of zone i in period t

H_{it} : Houses of the housing complex development on the public sector initiative of zone i in period t

ASP_{it} : Ratio of the Urbanization Promotion Area of zone i in period t

$LNUP_t$: Log of the population growth rate of the whole study area in period t

C : Constant

Total cases of the Development Permission and the Existing Building Site, and total houses of housing complex development of each zone in period t are considered as development quantity variables. Since some zones include the Urbanization Promotion Area and they expand as time goes by, the ratio of them in each zone is considered. In addition, log of the population growth rate of the whole study area is introduced as a time scale term in order to express the difference in each period.

4.2 Parameter Estimation

We estimated the parameters of the model represented in equation (1) based on available data. An object term is from 1970 to 1999, and it was divided into 5-years time scale. The samples for parameter estimation consist of the fluctuation of population, the amount of development and so on, in each zone and period. The data concerning the fluctuation of population was made with the detailed population data in Maebashi City from 1970 to 1999. The data concerning the amount of development was totaled per five years in each zone. Ratio of the Urbanization Promotion Area was calculated using the overlay function and the area measurement function of GIS. The result of parameter estimation is shown in Table 2. Since there is no significant difference, the parameter of DN_{it} and EN_{it} were estimated in a lump. Although the determinant coefficient is low, t-statistics and positive and negative conditions of each parameter are relatively proper. The result is expressed that development causes the increase of population. Thereby, it was quantitatively clarified that the development of the Urbanization Control Area had big influence on suburbanization. Moreover, because both of the parameter value and t-statistics of the housing complex development are higher than these of the Development Permission and the Existing Building Site, it has more greatly effect on the population growth. It is expressing a synergy effect of the housing complex development that mentioned in chapter 3-4.

Table 2. Result of the Parameter Estimation

Variable	Coefficient	t-statistics
DN	1.39	1.50
EN		
H	2.26	6.42
ASP	333.53	4.43
LNUP	1255.30	2.14
C	-44.14	-1.20

$R^2 = 0.12$

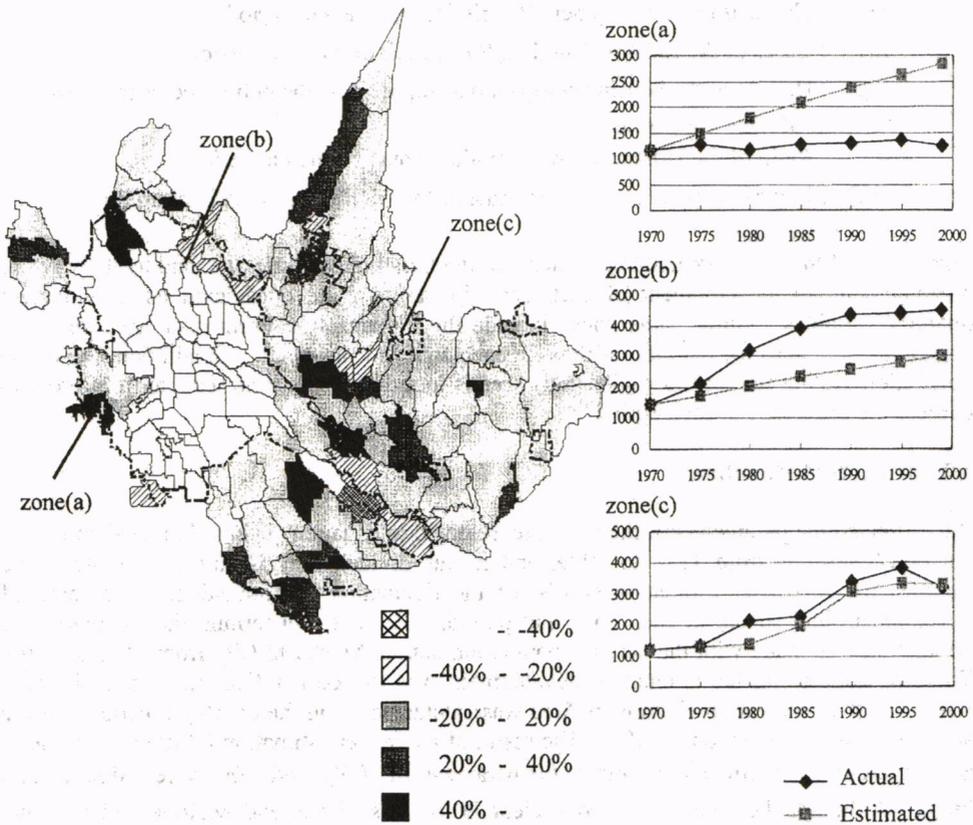


Fig.10 Result of Model Reproduction

4.3 Examination of Reproduction Possibility

Next, the estimated model is examined on reproduction possibility using population in 1970 as initial data. The average value of error ratio in each zone and transitional reproduction states of population in typical zones are shown in Fig. 10. Here, the average value was error ratio calculated from estimated and actual population and averaged on time.

As shown in Fig. 10, the zones that include the Urbanization Promotion Area have relatively large error. It is remarkable especially in the zones where ratio of the Urbanization Promotion Area are large. In this model, the area ratio of the Urbanization Promotion Area plays a role only as a constant, and it doesn't take the factor of population growth into consideration in the Urbanization Promotion Area. For this reason, the overestimation as shown in zone (a) or the underestimation in zone (b) have happened. And some zones in the suburb have large error, since most of them have the change of a town boundary within an object term. The population data in the zones with boundary change is generated with an area-division method based on the present town boundary. Therefore, it is considered that the errors are large in the zones where the local increase of population happened for instance by housing complex build. However, the population change situation is exactly reproduced in greater part of the zones, as shown in zone (c), and it shows the validity of the model.

Since this study intended to prove the effect of the development act to the population change, we developed the statistical model with the multivariate regression analysis. In future, we would like to improve the population-forecasting model. In order to this purpose, acquisition of the data concerning the development situation in the Urbanization Promotion Area and remaining undeveloped area, and reconsideration of modeling method are planned.

5. CONCLUDING REMARKS

In this study, several conclusions are summarized as follows.

- 1) Although the urban development in the Urbanization Control Area caused by the Development Permission System is comparatively stable, it by the Existing Building Site Check System is continuing increasing and the sprawl phenomenon continues.
- 2) The urban development has shifted to the suburban from around the Urbanization Promotion Area. It is remarkable especially in the Existing Building Site Check System.
- 3) The housing complex has been developed on administration initiative also in the Urbanization Control Area. When the size became large, the zone containing the housing complex was incorporated into the Urbanization Promotion Area. The suburbanization of the Existing Building Site is promoted by the spread of the Urbanization Promotion Area. Therefore, the housing complex development has large influence for the suburbanization.
- 4) In order to observe the effect of the urban development trend on the population fluctuation quantitatively, the population growth model is developed. In this model, though the improvement would be the necessity in future, the relevance of the urban development for the suburbanization was clarified to some extent.

From these results, it is proven that the Development Permission System and the Existing

Building Site Check System do not restrain the sprawl in the Urbanization Control Area sufficiently. For this reason, it needs to reexamine policy itself. And, there are some problems in the operation aspect of the Area Division, housing supply policy and the other urban development system, which are plurally and extensively applied. Therefore, it is indispensable to synthetically operate these.

Further study is planed to construct the database of all over the city and improve of the model. And, the detailed analysis of the development action will be also carried out noticing individual case. At that case, it wants to clarify the more detailed mechanism of the suburbanization relating with a land use model and a housing demand model. Furthermore in future, through these empirical studies and model analysis, we will aim at development of the urban policy support system based on GIS as a platform.

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