A CONCEPT ON REGIONAL PLANNING
IN AREAS WITH NEW RAILWAY PROJECTS

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Abstract: In the Tokyo Metropolitan Area (hereinafter TMA), the conventional method of regional planning has obliged a lot of green spaces to change hastily to residential areas in last half a century. It is hard that the method makes the residential amenity high. This study (1) focuses on residential amenity in areas with new railway projects, (2) describes the relation between the level of accessibility and the other spatial data (e.g., land use, nighttime population etc.) that have a great impact on the quality of amenity with the help of Geographic Information System (hereinafter GIS) and (3) proposes new concept on regional planning intending to the sustainable development from the viewpoint of residential amenity.

Key Words: Regional Planning, Railway Planning, Sustainable Development, Residential Amenity, GIS

1. INTRODUCTION

While the population in the TMA was increased at the high economic growth periods, the networks of railway and those of road were hastily developed. The TMA has had one of the densest networks of transportation in the world. These are shown in Figure-1, Figure-2 and Table-1. Most offices have concentrated in the CBD and workers' residential areas have been located in suburbs. The green spaces as agricultural lands and forests have been obliged to change to residential areas. The quality of the residential amenity from surroundings (e.g., clear atmosphere, approachability to waterfront, clearness of water itself, richness of green etc.) has been disregarded to be low. Besides, such structure of residential location has caused traffic congestion at the peak commuting hour. Even though the trend of the concentration of population to the TMA has been shown to end, high quality of amenity as well as high level of accessibility in residential areas shall be desired. In other words, the residential amenity should be regarded as importance for the establishment of sustainable society.

On the other hand, it is well known that the railway mode has several distinct advantages vis-à-vis the other modes especially with respect to schedule, efficiency of transportation, energy consumption, pollution to the environment and so on. The railway mode is indispensable especially in the TMA that has the traffic congestion, the environmental problems and lots of elderly people. Therefore, it is necessary to continue to set up new railway projects even in

the depressed economy. In addition, the new railway projects may play the role of not only improvement in the level of the accessibility but also creation of the attractive areas along the railway lines. That is to say, the effective and strategic developments on the occasion of the regional planning are very important in the new railway planning, in order to create residential areas with both high level of accessibility and high quality of amenity.
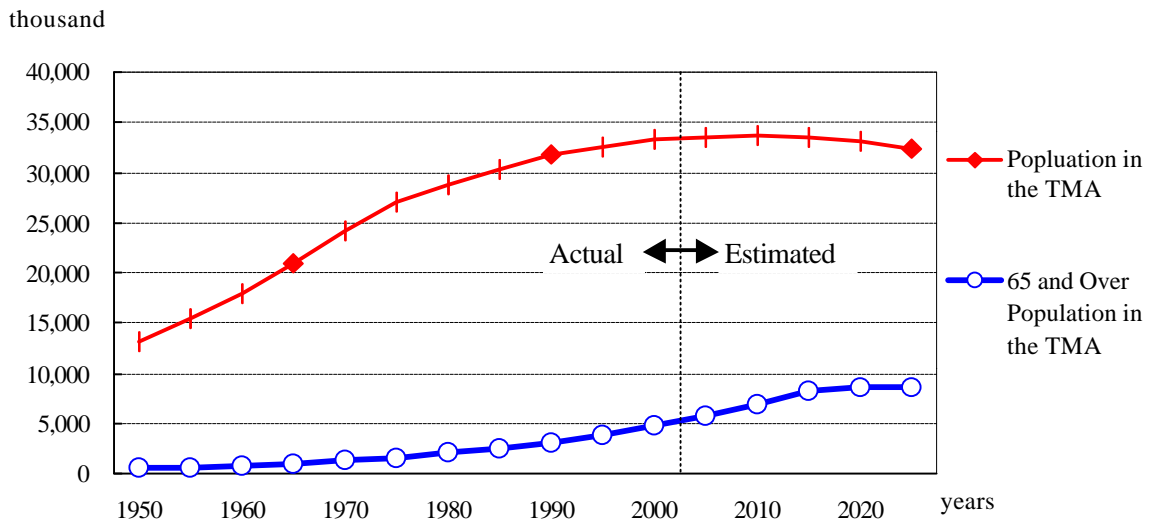

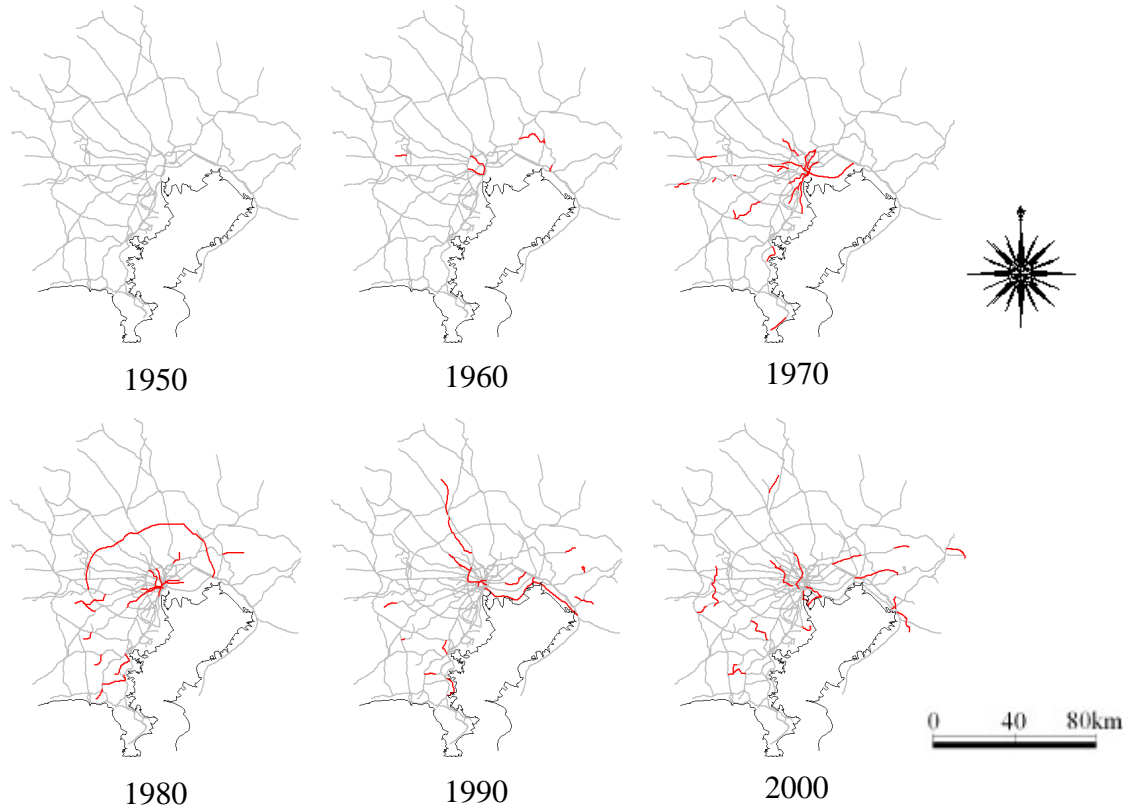**Figure-1 Trend of Total and Aged Population in the TMA**

Figure-2   Developmental Process of Railway Network in the TMA

Table-1 Outline of Urban Railways in Major Metropolitan Areas

Metropolitan Area	Area (km^2)	Population (10,000)	Population Density (people / km^2)	Total Route Kilometers of Railway (km)
Ile-de-France (France)	12,011	1,103	918	1,652
Berlin Metropolitan Area (Germany)	889	324	3,645	649
London Metropolitan Area (UK)	1,578	712	4,512	414
Rome Metropolitan Area (Italy)	17,208	524	305	676
Stockholm Metropolitan Area (Sweden)	6,490	180	278	454
New York Metropolitan Area (USA)	10,360	1,500	1,448	2,222
Tokyo Metropolitan Area (Japan)	**10,117**	**3,199**	**3,162**	**2,215**

The areas that would bring high level of accessibility by the new railway line, however, might be mainly developed without any consideration of residential amenity by the conventional method of regional planning. Actually, nighttime population has been densely located in the areas along the railway lines with losing green spaces in the TMA (e.g., Figure-3). The conventional method has not had the viewpoint of that green space plays a great role in residential environment. Therefore, it is necessary to propose a new concept of the regional planning.

This study focuses on residential amenity in areas with the new railway projects and derives it from the relation between the level of accessibility and the other spatial data (e.g., land use, nighttime population etc.) that have a great impact on the quality of amenity. As a case study, those relations are analyzed in a unit of 10-meter-grid geographical data and displayed in a unit of 100-meter meshes in the suburbs with the help of the Railway Planning Supporting System that has been proposed by the authors (1997, 1998 and 2000) on the basis of GIS. The purpose of the study is to propose a new concept on the method of the regional planning from the viewpoint of residential amenity.
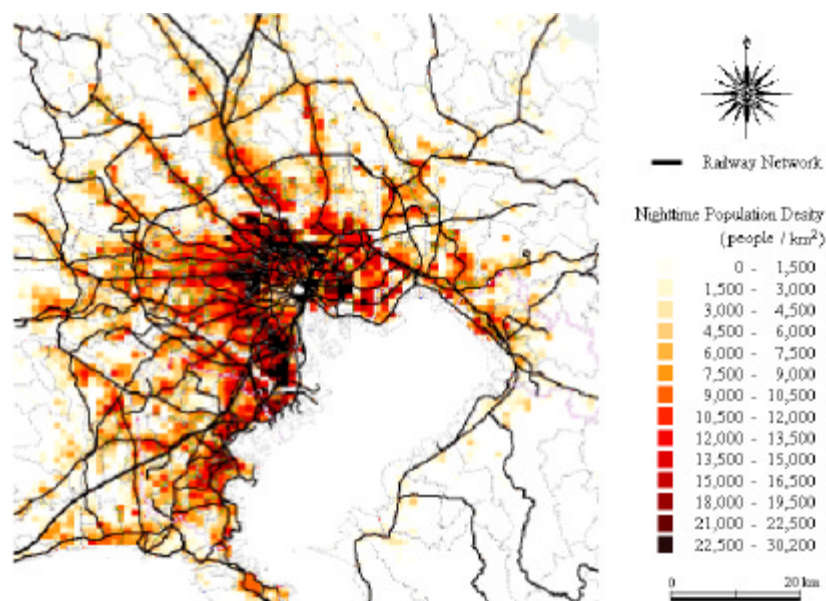

Figure-3 Distribution of Nighttime Population

2. REGIONAL PLANNING ON EXISTING PAPERS

The regional planning in the situation of increase in population has worked for the purpose to supply the large quantity of the residences for migrators in the TMA. The railway projects at that time have mainly aimed to increase the level of accessibility in the residential areas. A large number of studies on the planning have been implemented for these developments. NAKAMURA *et al.* (1981, 1983a and 1983b) proposed Computer Aided Land Use - Transport Analysis System (CALUTS) for evaluation of infrastructure planning on typical two assumptions mentioned below. First is that residential areas are surely changed from agricultural lands and green spaces. Second is that residential areas increase linearly with constructions of the infrastructure. FURUTA *et al.* (1992), EBINA *et al.* (1992), SHIBAGAKI (1992), KASHIMA *et al.* (1993) etc. also forecasted demands based on the above assumptions. The conventional methods of regional planning were established during the high-growth economy, which seemed mostly to reproduce the assumptions.

On the infrastructure planning in recent years, a cost benefit analysis has been imposed because of the economic depression in Japan. In the context, regional planning and railway planning cannot be avoided with each other. The detailed analysis with higher precision on the planning is required in order to measure the effectiveness. Consequently, the method of the demand forecast must be argued in detail in consideration of both the regional and railway developments. On the analysis, it is useful to apply the GIS that can process the spatial data and analyze them. HINO *et al.* (1999), YOSHIKAWA *et al.* (1999) and KAGAYA *et al.* (2001) proposed the method of evaluating the level of bus service such as an access mode to a station with the help of the GIS. KIKUCHI *et al.* (1999) calibrated the disaggregate models that were able to trace the individual trips spatially by using the GIS. The method of regional planning has been improved to be able to measure the level of transportation service much deeper.

Although the advanced method has combined regional planning with railway planning and has been able to estimate the number of passengers in consideration of the level of accessibility, the method has not had the viewpoint of the quality of the residential amenity. On the other hand, HARASHINA *et al.* (1997) defined that the residential environment was classified into the amenity from surrounding environments and the accessibility to the outside. On the quality of residential environments, not only the level of accessibility but the residential amenity from surrounding environments has become important. There are a lot of studies on the residential amenity, in which SAWAKI *et al.* (1994), HARADA *et al.* (2000) and so on described the regional planning for raising the residential amenity from surroundings. Although the necessity for a green space or an open space has been a major focus of these studies, the relevance of transportation service such as the accessibility has not been discussed. Therefore, the concept of regional planning which considers both the accessibility and the amenity has not been established yet.

ASAMI *et al.* (1998) and HAYASHI (2001) proposed the system named GIS for Railway Project Evaluation (GRAPE) on the basis of the Railway Planning Supporting System mentioned above and forecasted travel demand in detail. The Railway Planning Supporting System has also aimed to measure the level of the railway service and to forecast the number of passengers. It is, however, important to measure the quality of amenity as well as the quantity which was requested to the regional planning and railway planning. In order to

discuss the method of the planning in consideration of amenity, it is necessary to analyze the relation of various spatial factors that influence the amenity. The Railway Planning Supporting System may offer the method of the analysis with some efforts. Hence, the study tries to propose the new method of regional planning by application of the system.

3. OUTLINE OF RAILWAY PLANNING SUPPORTING SYSTEM

The Railway Planning Supporting System is composed of various subsystems, such as geographic information subsystem, the transportation behavior analysis subsystem, the network assignment analysis subsystem and so on. The outline of the system is shown in Figure-4. The system is able to manage a lot of data, comprehensively analyze them and clearly display the results, because the subsystems are functionally related to each other. Many alternatives for the development plans are easily considered in the system. Furthermore, the changes of both the level of transportation services and spatial situations in areas are handled. This means that the system can process the various spatial factors that influence the amenity with the consideration of the level of accessibility. The system will be available to propose a new method of the regional planning.
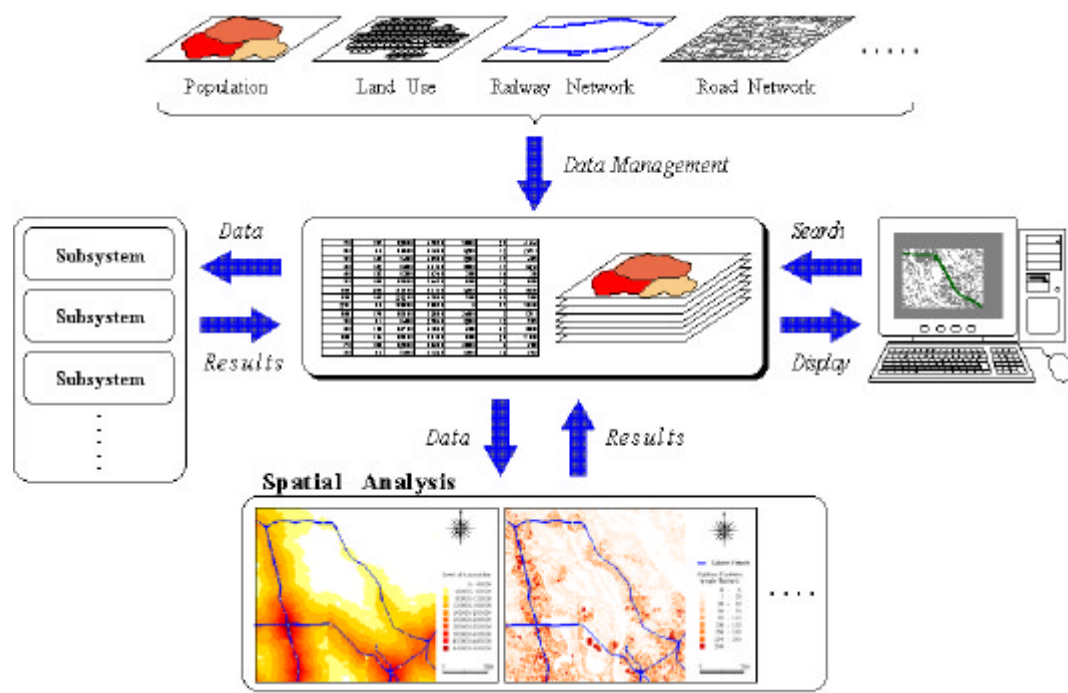
Figure-4 Outline of Railway Planning Supporting System

4. CASE STUDY

4.1 CASE STUDY AREA

Figure-5 displays the case study area which is located from 20 to 30 kilometers far from Tokyo station on the northeast in the TMA and goes on new railway project which is named the Tokyo Subway Line No.8. The line is planned to start the construction by 2015 in the

committee report No.18 of the Council for Transport Policy in January, 2000. Before opening the railway, it is required to perform this regional planning and to establish the direction of community development. Fast of all, the present state of the area should be grasped. The area is square of 20 kilometers on a side. It has the 40,000 pieces of 100 meter-meshes. 4 existing railway lines, JR Joban Line, JR Musashino Line, Tobu Isesaki Line and Tobu Noda Line surround the area. Besides, the new Tsukuba Express Line is scheduled to operate in 2005.
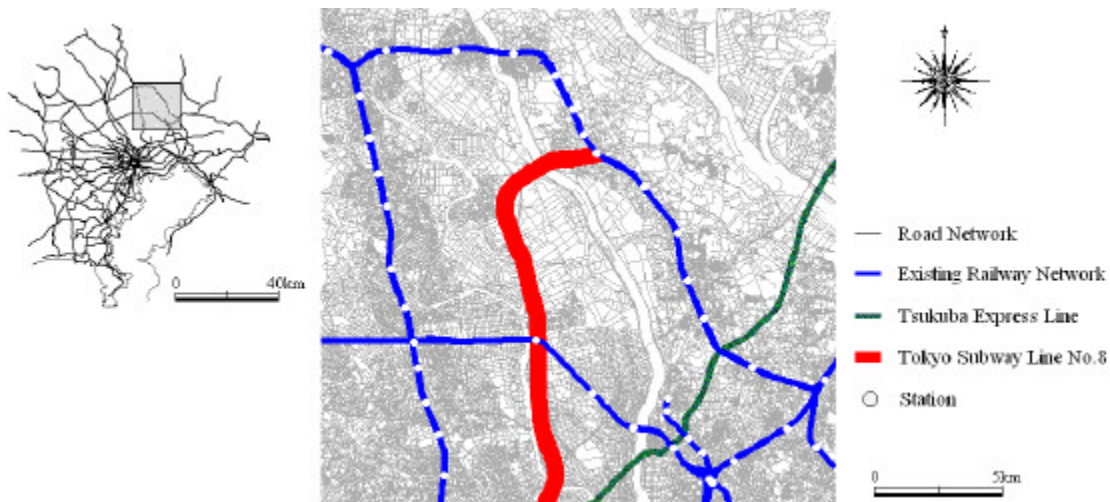

Figure-5 Case Study Area

4.2 DATA PROFILE

In the study, the accessibility to each business district by train and spatial data such as land use, nighttime population and the land use regulation as a great impact on the quality of amenity are compared. The relation between the said accessibility and each spatial data is analyzed simultaneously.

(1) Accessibility
The access time to the CBD such as Otemachi or Shinjuku has been considered as a major index of accessibility to the business districts. Many business districts, however, have been widely located in the TMA. In the study, the index of the accessibility should be calculated precisely on every 100-merter-meshes. Therefore, this study considers the accessibility to all the business districts in the TMA. The accessibility index in the study is based on gravity type model. The equation is as follows:

$$A_k = \sum_{j=1}^{N} \sum_{i=1}^{M} \left(\frac{W_i}{\exp(aT_{ij} + bL_{jk})} \right) \tag{1}$$

where A_k is the level of accessibility at mesh k, W_i is the number of workers in business district i, T_{ij} is the access time from the station j of the accessible station from the mesh k to the station which represents business district i, L_{ij} is the road distance between the mesh k and the station j, N is the number of accessible stations from the mesh k, M is the number of business districts in the TMA, and a and b are parameters. Figure-6 (above left) shows the distribution of the accessibility in the area.

(2) Land Use

In Japan, land use data of 10-merter-grid is released by the Geographical Survey Institute as the "Detailed Digital Information (10m Grid Land Use)". In this study, the category of land use data of the 10-merter-grids is counted and converted to the 100-merter-mesh, and it is considered as land use data belonging to the 100-merter-mesh. Figure-6 (above right) shows the distribution of the land use in the area. The bar chart under the land use distribution map indicates the rate of the category of land use in the area.

(3) Nighttime Population

Original statistics of nighttime population is obtained by Census Track Zone (minimum size of municipal zone) on the basis of Resident Register. In the study, the population in this zone is assigned for 100-merter-meshes composed of the zone. Figure-6 (below left) shows the distribution of nighttime population in the area.

(4)Land Use Regulation

The land use regulation is categorized into two different codes: urbanization promoted and urbanization controlled that the city-planning law regulates. The distribution map of the urbanization promoted zones and the urbanization controlled zones in the area is shown in Figure-6 (below right).
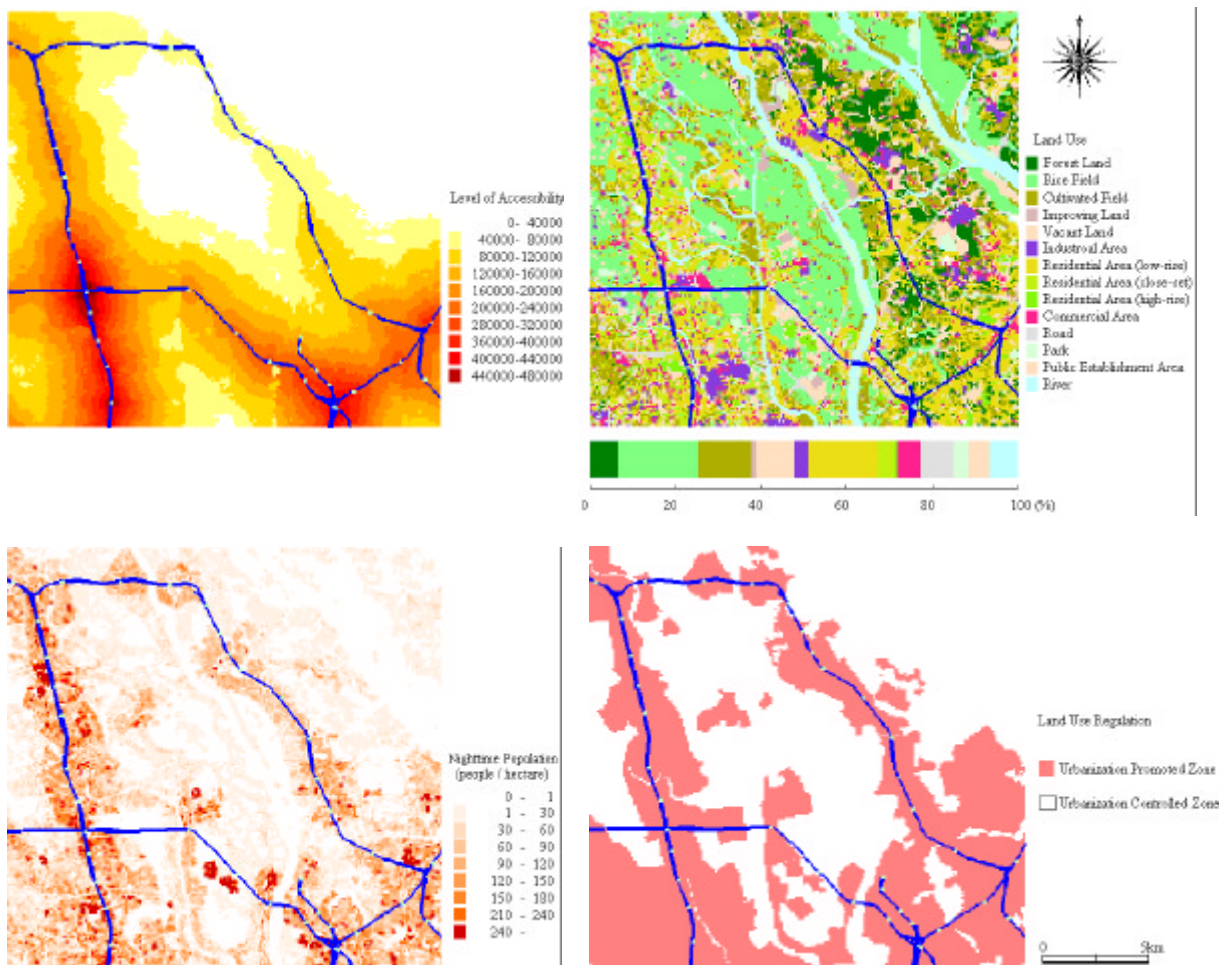

Figure-6 Distributions in Case Study Area

5. INITIAL FINDINGS

5.1 GENERAL TENDENCIES

(1) Relation between Accessibility and Land Use
The general relations between the accessibility and each land use category are shown in Figure-7 (above, middle and below). The figure (above) shows that the higher the level of the accessibility is, the higher the rates of the urbanized land use, such as commercial areas and road areas, are. That is, the level of accessibility and the rates of the urbanized land use have positive correlation. The figure (middle) shows that the higher the level of the accessibility is, the lower the rates of the non-urbanized land use, such as green spaces and agricultural areas, are. That is, the level of accessibility and the rates of non-urbanized land use have negative correlation. The figure (below) shows that many residential areas are located in the area where the accessibility is middle from low. Hence, the land use depends on the level of the accessibility in the area.

(2) Relation between Accessibility and Nighttime Population
The relation between the accessibility and the average of the nighttime population density among the same level of accessibility is shown in Figure-8. The higher the level of the accessibility is, the higher the population density is, except in the area with highest accessibility.

(3) Relation between Accessibility and Land Use Regulation
The relation between the accessibility and the land use regulation is shown in Figure-9. The percentage of urbanization promoted zones is increased in the same proportion as the level of the accessibility is high.

5.2 NOTED AREAS

There are several exceptions to the general trend in the area mentioned above. Here, focusing on the exceptional areas, the characteristics of these areas are compared with those areas that are occupied with general tendencies.

(1) Areas with Low Nighttime Population Density
If a new railway line were opened on the conventional occasion, would population be established along the rail line greatly? The area with lower population density is compared to the area with higher population density. Both areas have the same grade of the level of accessibility and the rate of residential areas (Table-2). The rate of land use of a couple of areas is shown in Figure-10. Various land uses are seen in the area with low population density in spite of the accessibility is high. The area with lower population density especially has more farmland.

(2) Urbanization Promoted and Controlled Zone
Local governments legally regulate land use. Although the level of accessibility, the rate of residential areas and nighttime population are of the same grade, the areas where land use regulation is different are compared (Table-3). In this way, the difference in the characteristic of the zone by law regulation is grasped. Figure-11 indicates that the difference in law

regulation affects all land use categories, and the land is used variously by in the urbanization controlled zone.
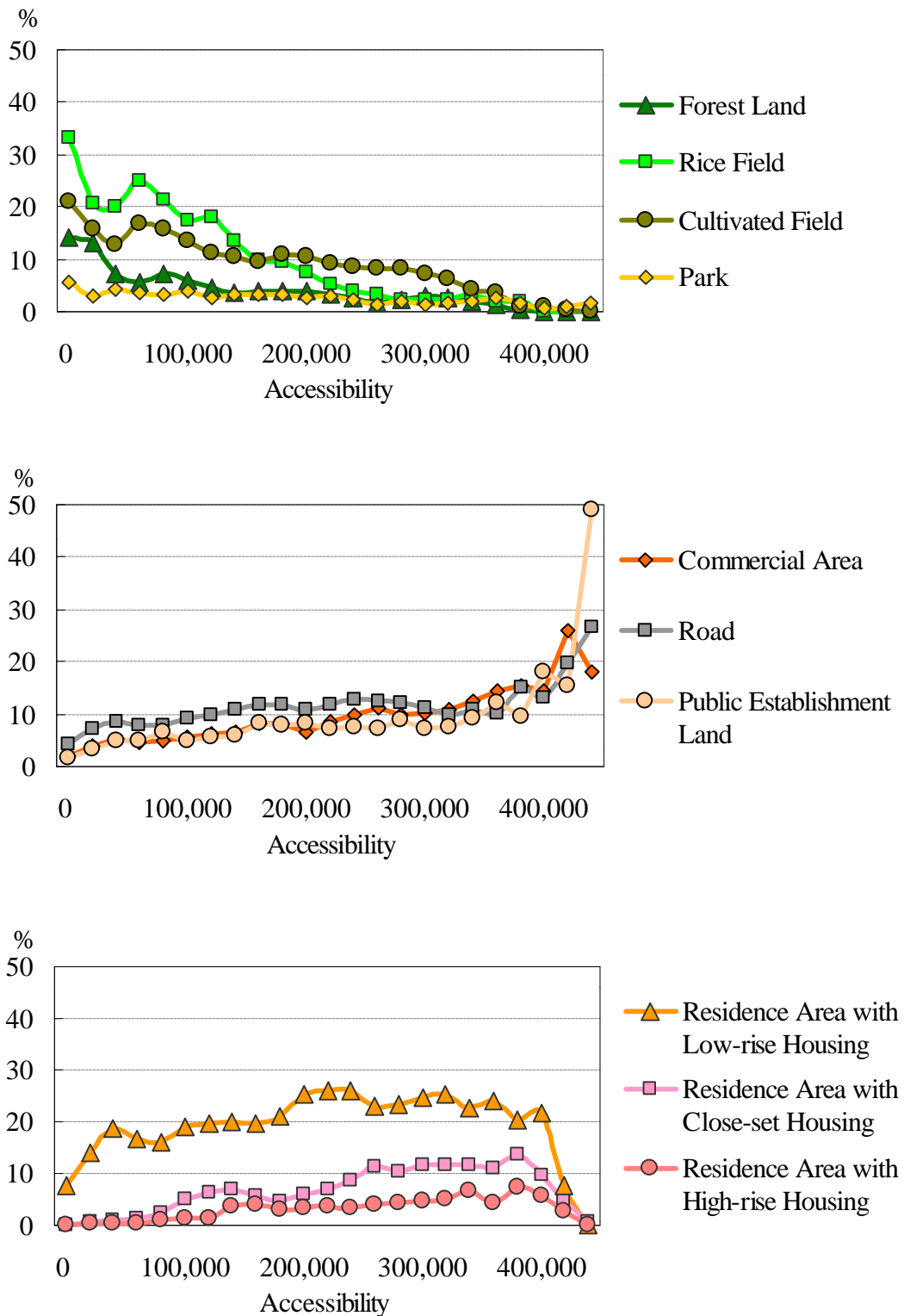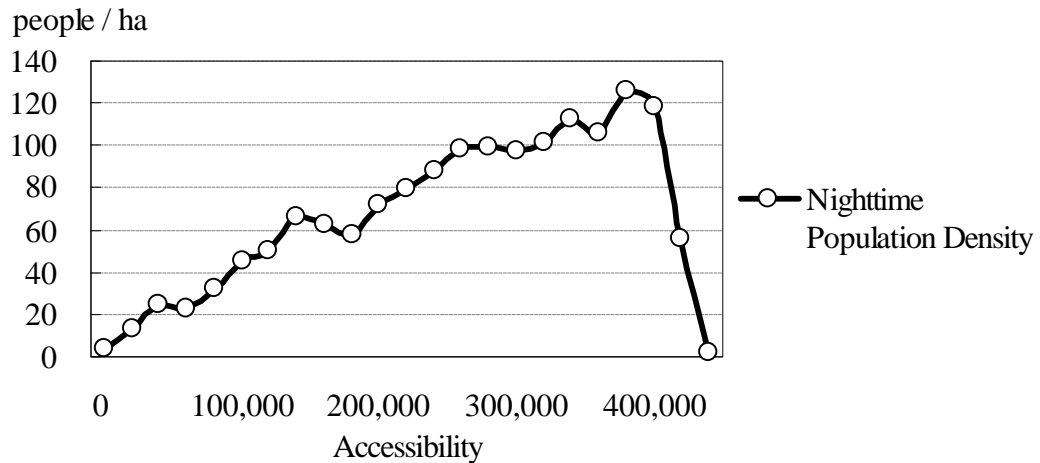

Figure-7 Relation between Accessibility and Land Use

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Figure-8 Relation between Accessibility and Nighttime Population
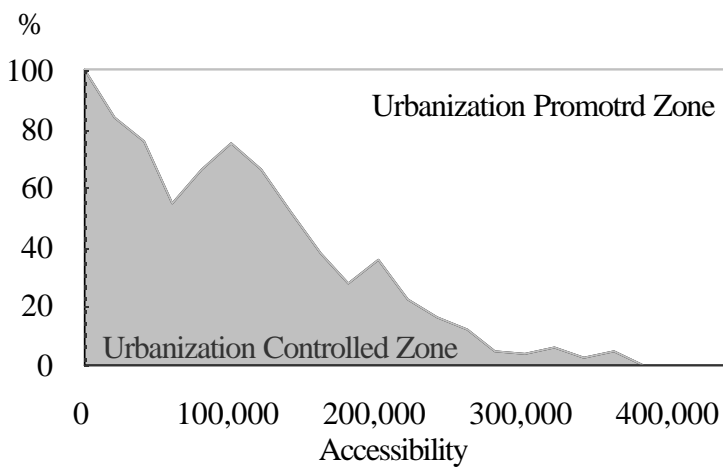

Figure-9 Relation between Accessibility and Land Use Regulation

Table-2 Comparison of a couple of different Areas

	Accessibility	Rate of Residential Area (%)	Population Density (people / hectare)
Area with High Population Density	2.7×10^5	31.2	74.6
Area with Low Population Density	2.7×10^5	38.2	32.2

Table-3 Comparison of a couple of different Areas

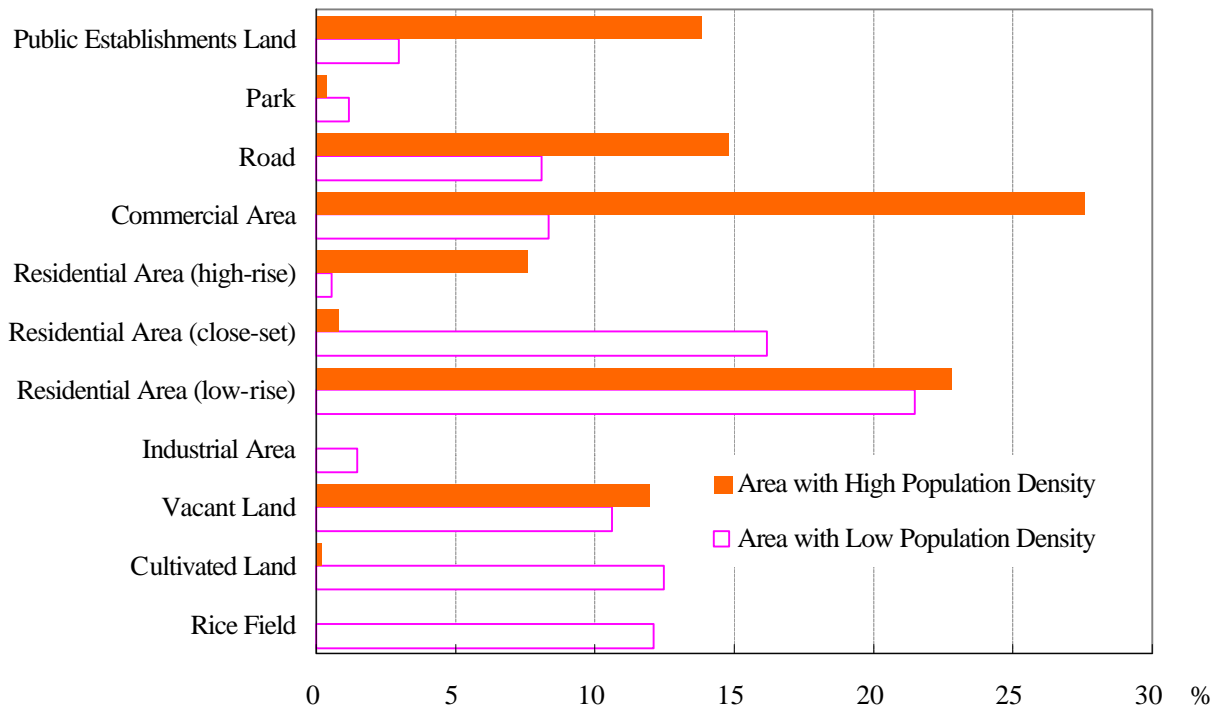|	Accessibility	Rate of Residential Area (%)	Population Density (people / hectare)
Urbanization Promoted Zone	2.4×10^5	19.1	24.0
Urbanization Controlled Zone	2.3×10^5	22.7	29.5

**Figure-10 Comparison of Rate of Land Use
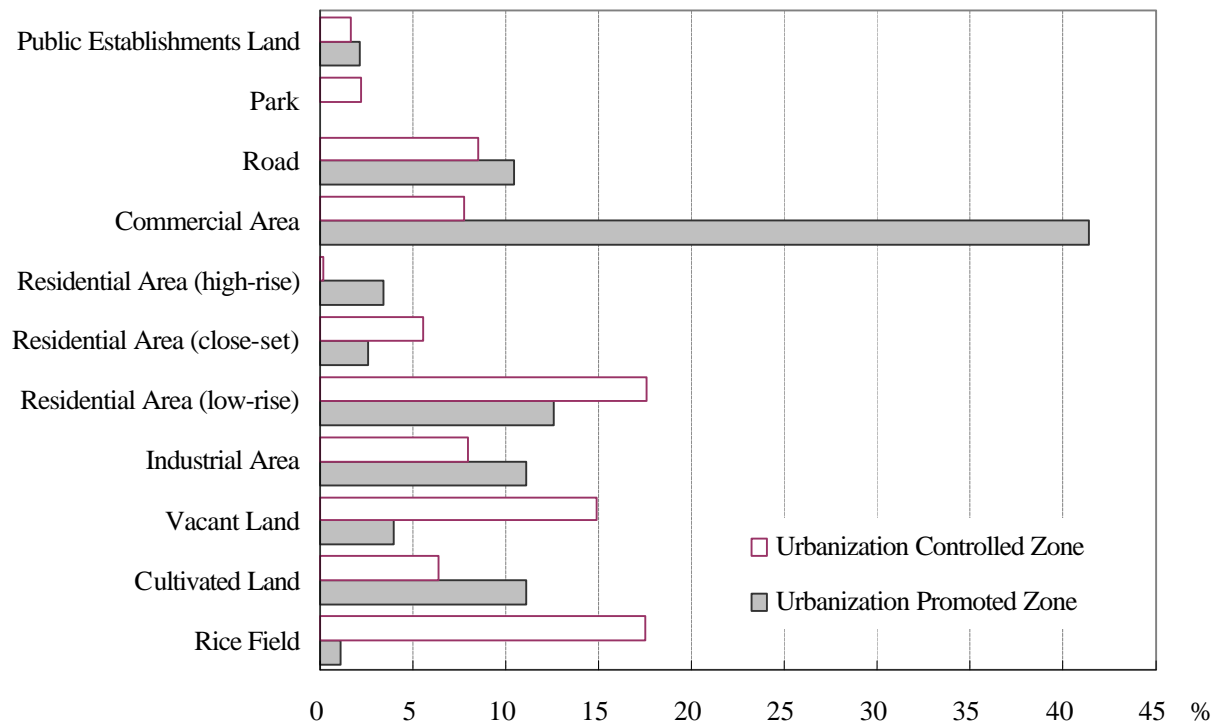between High and Low Population Density**

**Figure-11 Comparison of Rate of Land Use
between Urbanization Promoted and Controlled**

5.3 SUMMARY

The result of the case study shows as follows; (1) the level of the accessibility reacts land use, nighttime population and land use regulation, (2) the area with the high level of the accessibility is poor in green spaces in general, and (3) the particular areas, such as areas with the low density of population in spite of the high level of accessibility, exist.

6. FURTHER FINDINGS

The study illustrates an account of an important concept of the regional planning. The study focuses on the accessibility and the amenity in the suburbs with the new railway project in the TMA. It is important to create the area that has the high level of the accessibility with the high quality of amenity. Rich green spaces will be essential qualification for the high quality of amenity. The study finds that such areas exist actually on the GIS.

In concluding, the new concept on the regional planning is that the rich green spaces have to be regarded as the local peculiar property and be conserved in case of the development in those areas. Hence, the new concept on the regional planning is carefully considered from a viewpoint of amenity in order to create new attractive area to establish sustainable society.

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ACKNOWLEDGEMENT

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REFERENCES

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ASAMI, H., TAKAKU, H. and KANAYAMA, Y. (1998) A New Method of Travel Demand Forecasting for Planning of Railway and Urban with Computer Aided Planning System, **Infrastructure Planning**, **No.21 (2)**, pp.309-312 (in Japanese)

EBINA, K., IWATA, O., NAKASHIMA, J. and KOIZUMI, H. (1992) Forecasting Travel Demands in Planning the Railway Network in the Nagoya Metropolitan Region, **Infrastructure Planning**, **No.15 (1)**, pp.541-548 (in Japanese)

FURUTA, M., TAKANO, K., SHUGIYAMA, S., ITO, M. and MORICHI, S. (1992) Traffic Demand Forecasting System and the Application of the System to Tokyo Subway Line No.12, **Infrastructure Planning**, **No.15 (1)**, pp.533-540 (in Japanese)

HARADA, K., TAKAMIZAWA, M. and MATSUMOTO, N. and NOZAWA, Y. (2000) The Study on Effective Open Space Rate as a Residential Environmental Index in High Density Areas, **Paper on City Planning**, **No.35**, pp.121-126 (in Japanese)

HARASHINA, Y. and NAKAGUCHI, T. (1993) Consideration on Residential Environmental Indicators Systems - Introducing Accessibility Concept -, **Journal of Environmental Information Science**, **Vol.19**, **No.1**, pp.130-139 (in Japanese)

HAYASHI, J., TAKAKU, H., YORITA, J. and TADENUMA, Y. (2001) Constructing a Traffic Planning Support System Using GIS, **Proceedings of 9th WCTR (CD-ROM)**, 16pages

HIBINO, N., UCHIYAMA, H. and HOSHI, K. (1999) A Study on GIS-Based Supporting System for Metropolitan Railway Planning, **Proceedings of Infrastructure Planning**, **No.22 (1)**, pp.427-430 (in Japanese)

HIBINO, N. and UCHIYAMA, H. (2001) An Application of Geographic Information System (GIS) to Transportation Planning, **Proceedings of Applied Survey Technology**, **Vol.12**, pp.59-65 (in Japanese)

HINO, S., HARAGUCHI, M. and SATOU, K. (1999) A Calculation of User's Average Travel Time by GIS and an Evaluation of Public Transportation Routes, **Paper on City Planning**, **No.34**, pp.973-978 (in Japanese)

HOSHI, K. and HIBINO, N. (1997) A GIS for Urban Railway Planning Process with Consideration of Accessibility to Station, **Proceedings of J-Rail Symposium**, pp.533-536 (in Japanese)

KAGAYA, S. and TAKANO, S. (2001) Evaluation of Bus Service in a Rural Town Using a Geographic Information System Constructing a Traffic Planning Support System Using GIS, **Proceedings of 9th WCTR (CD-ROM)**, 18pages

KASIMA, T., SAWAKI, S. and SAITO, K. (1993) New Railway Line and its Effects on Development, **Proceedings of Infrastructure Planning**, **No.16 (1),** pp.691-696 (in Japanese)

KIKUCHI, A., KOBATA, A., FUJII, S. and KITAMURA, R. (2000) A Mode and Destination Choice Model on GIS Database, **Proceedings of Infrastructure Planning**, **No.17**, pp.605-611 (in Japanese)

Ministry of Construction of Japanese (1993) The 5th Comprehensive National Development Plan Grand Design for the 21st Century - Promotion of Regional Independence and Creation of Beautiful National Land - (in Japanese)

NAKAMURA, H., HAYASI, Y. and MIYAMOTO, K. (1981) A Land Use Model for Suburban Area, **Journal of Infrastructure Planning and Management**, **No.308,** pp.103-112 (in Japanese)

NAKAMURA, H., HAYASI, Y. and MIYAMOTO, K. (1983a) A Land Use Land Use-Transport Analysis System for A Metropolitan Area, **Journal of Infrastructure Planning and Management**, **No.335,** pp.141-153 (in Japanese)

NAKAMURA, H., HAYASI, Y., MIYAMOTO, K. and NAKAMURA, H. (1983b) Computer Aided Land Use - Transport Analysis System (CALTAS) for Evaluation of Infrastructure Planning, **Selected Proceeding of the 3rd World Conference on Transport Research**, pp.620-632

NAKAMURA, H., KAWAGUCHI, Y., SHIMIZU, E., YAN, W. and SHIBASAKI, R. (1993) A GIS Integrated City Planning System Based on Systems Analysis, **Journal of Infrastructure Planning and Management**, **No.476 / 4-21**, pp.67-76 (in Japanese)

PAEZ, A. and SUZUKI, J. (2001) Transportation Impacts on Land Use Change: An Assessment Considering Neighborhood Effects, **Journal of the Eastern Asia Society for Transportation Studies**, **Vol.4**, **No.6**, pp.47-58

PAULLEY, N., SESSA, C. and VERROEN, E. (2001) TRANSLAND: a study on integrated land-use and transport planning, **Proceedings of 9th WCTR (CD-ROM)**, 19pages

SAWAKI, M. (1994) Study on the Improvement of Residential Environment with the Residents' Taste for Nature Life, **Paper on City Planning**, **No.29**, pp.367-372 (in Japanese)

SHIBAGAKI, H. (1992) A Study for An Effect of Commutation Time Shortening by Railroad Transportation on the Population in Satellite Cities, **Infrastructure Planning**, **No.15 (1)**, pp.425-430 (in Japanese)

UCHIYAMA, H. and HOSHI, K. (1998) A GIS-Based Metropolitan Railway Planning Process, **Proceedings of Infrastructure Planning**, **No.15**, pp.705-712 (in Japanese)

UCHIYAMA, H. and HIBINO, N. (2000) An Application of GIS to Railway Planning in Metropolitan Area in Consideration of Access to Station, **Transport Policy Study's Review**, **Vol.2**, **No.4**, pp.12-20 (in Japanese)

YAMANO, T., MATSUSHITA, N. and YOSHIKAWA, S. (1999) Planning Support System for Public Transportation Facilities, **Papers and Proceeding of the Geographic Information System Association**, **Vol.8**, pp.377-380 (in Japanese)

YAN, W., NAKAMURA, H. and SHIBASAKI, R. (1991) A Computer System for Evaluation the Quality of Residential Environment, **Proceedings of Infrastructure Planning**, **No.14 (1)**, pp.679-686 (in Japanese)

YOSHIKAWA, K., KOBAYASHI, K. and MUN, S. (1986) A System Analysis for Regional Planning in Suburban Area of Large City Using Land-Use Model, **Proceedings of Infrastructure Planning**, **No.3**, pp.129-136 (in Japanese)

YOSHIIKE, M. and YOSHIKAWA, S. (2001) Public Transportation Planning Assisted by GIS - Adjacency Analysis to Bus Route -, **Papers and Proceeding of the Geographic Information System Association**, **Vol.10**, pp.197-202 (in Japanese)