Changes of Urban Environment in Surrounding Areas of Rail Transit Stations

庄, 馨雨

https://doi.org/10.15017/1455995

出版情報：九州大学, 2014, 博士（工学）, 課程博士
バージョン：

Changes of Urban Environment in Surrounding Areas of Rail Transit Stations

Xinyu Zhuang

April 2014

To

My beloved parents

Only parents but you give your all.

Your love & emotional support of my education

Have been a constant

For as long as I can remember.

Only parents but the best of all.

ACKNOWLEDGEMENTS

I would like to express my gratitude to all whose help and support have contributed to this dissertation. Without many people who gave their support to me in various ways, I could not complete this dissertation. To these people I would like to convey my heartfelt gratitude and sincere appreciation.

First and foremost, I am deeply grateful to my supervisor, Associate Professor Shichen Zhao, who has given me the guidance for the period of my research, I wish to express my sincere thanks for his great support, guidance and kind advice throughout my Ph.D. research studies. During the period that I studied in his laboratory, he has walked me through all the stages of the writing for this dissertation and made it a very rewarding and enjoyable experience. From problem solving to moral support, his help has been continued and invaluable. It was a real privilege and an honor for me to share of his exceptional scientific knowledge but also of his extraordinary human qualities. His devotion to the science encouraged me a lot, which has indeed facilitated me to work harder and harder in these years.

I also want to show my sincere gratitude to my other two co-supervisors, Professor Takeru Sakai and Associate Professor Satoshi Toi, who has taken much time to review my dissertation and advised me a lot in writing dissertation in a scientific way. And their constant support, availability and constructive suggestions, which were determinant for the accomplishment of the work presented in this thesis. Their insights in developing the research, especially from the perspective of an experimentalist, clarified a lot of my questions.

To all the members of Zhao Laboratory, with whom I shared my five and a half years, I have to express my thanks. It is a fortune for me to get to know and share my time with all the people here.

I would also like to acknowledge the China Scholarship Council (CSC) and Japan Student Services Organization (JASSO) as the scholarship sponsors for me.

To my dearest friends, I also wish to express my sincere thanks. Without the support and companionship of them, I would not complete this dissertation.

In particular, I would like to thank my boyfriend Dr. Xiangxiang Gao for making the periods of my staying in Japan an enjoyable and interesting time, whose endless encouragement and help were of immense help to me.

Lastly, enormous thanks go to my beloved parents whose emotional support of my education and endeavors has been a constant for as long as I can remember.

Xinyu Zhuang
Jan. 1, 2014
Fukuoka, Japan

PUBLICATIONS ARISING

Xinyu Zhuang. A Discussion on the Uptown Environment in the 21st Century. Journal of Sichuan College of Architectural Technology, 2008, Vol.18. (in Chinese)

Xinyu Zhuang. A Study on Traditional Fengshui and Architectural Esthetics. Sichuan Architecture, 2009, Vol.39 (4). (in Chinese)

Xinyu Zhuang, Shichen Zhao. Research on Influence of Railway Station Development and Changes of Land Use in Japanese Cities. Proceedings of the 7th International Symposium on City Planning and Environmental Management in Asian Countries, Fukuoka, Japan, 2010.

Xinyu Zhuang, Shichen Zhao. A Case Study on Trend of Changes of Building Usages on Surrounding Areas of Fukuoka Railway Stations and Subways. Proceedings of the 9th International Symposium on Architectural Interchanges in Asia, Gwang-ju, Korea, 2012.

Xinyu Zhuang, Shichen Zhao. A Study on Annual Changes of Urban Environment in Surrounding Regions of Railway Stations. Journal of Architecture and Urban Design, Kyushu University, 2013, Vol.23.

Xinyu Zhuang, Shichen Zhao. Impact Analysis of Land and Building Usage of Station Areas on Population, Land Price and Passengers: A case study in Fukuoka, Japan. Frontiers of Architectural Research, 2014, Vol.3.

ABSTRACT

The urban transportation is designed to help human participate in activities distributed over urban space. The urban planning and our interactions within it are rapidly changing due to forces like suburbanization, economic development and transportation technology. Research on development of integration station with urban area has being carried out. However, at the same time, with the rapid speed up of urban development, city development is being diffusion anywhere disorderly. In order to promote the integration of all kinds of urban functions in an intensive linking with the public transportation network, restructuring the urban structure and compacting the city has become an urgent task. On the other hand, as the development of land use around railway stations and subways, especially in recent years, the background problem has become serious in many parts, not only sparsely populated regions, but also central regions around stations. Generally, the developing situation of land use around railway stations can represent the developing situation of commerce, industry, business, entertainment, etc. It is said that the development of society is forming around a circle of stations, which can make an influence on people's life. Thus, for the better formation of the zones of railway stations, a further improvement of the convenience of railway stations and subway stations is sought constantly.

As the development of surrounding areas of railway stations and stations themselves in Fukuoka, Japan, the relationship among those stations, environment improvement and urban renaissance project is becoming more and more important. Thus, by selecting small-scale railway stations in Fukuoka City as research objects, the paper focuses on the distribution situation, annual changes of land use, as well as their relationship with population and number of users, in order to analyze the situations of exploiting surrounding areas of railway stations. On one hand, focusing on land use around railway stations can catch the distribution and characteristics of community facilities, including educational facilities, the public and government facilities, etc. to clarify the actual conditions and secular changes of them.

This dissertation is consisted of five parts as follows,

Chapter 1 - This chapter is focused on the general introduction including the research background, previous studies, research objectives, research aims and questions in process;

Chapter 2 - This chapter briefly discuss the current state and problems of land use and building usage in Fukuoka by the approach of GIS and quantitive analysis, furthermore, by reviewing the relevant knowledge and studies including the basic definitions and some important changing situation on stations, the context is formed with the research objects, that is, the selection of the target stations, an overview of data in hand and changes on stations;

Chapter 3 - This chapter is consisted by making categories on stations by the cluster method in order to get the state of stations being embodied and targeted; secondly, analyzing the developing status and annual changes on population, land price and passengers around target stations which have been clustered into several groups;

Chapter 4 - This chapter introduces the regression methodology and the theories used for this approach with examples to interpret several important changes on stations' developing process and also presents the influence degree for the population, the passengers and the land price in detail. Four cases on influenced areas are shown in this chapter;

Chapter 5 - This chapter includes general conclusions and tips on how the problems solved, which shows the analysis results, points out solution ways for problems and the next step in future and hope to provide a reference for other research later.

CONTENTS

Chapter One

General Introduction

Chapter 1
General Introduction

Recently, as the development of urbanization process, the potential value of railway and subway stations is becoming more and more important in many cities. The railway station is a necessary link for a city, the city planning and policies for the land use have been held by centering on the railway and subway stations. Railway and subway stations are also very important for the municipality, thus, each municipality also makes efforts to the development around stations. Moreover, the streets which have made of shopping streets with branch shops of large scale retailers and specialty stores become a serious problem in a local city, and the land readjustment project around the stations under the guidance of local governments. For instance, it has added the land readjustment project in Fukuoka city. The areas around stations are developed by making roads elevated and founding more and more buildings around stations, etc. Station buildings are actively built, and the situation around the railway and subway station is changing at a rapid speed. In order to promote the formation of intensive urban areas, the convenience of stations is always being enhanced further. Furthermore, because of the viewpoint of environmental problems, the importance of public transportation is also considered. It is thought that peripheral urban development that centers on the train station becomes more and more important to the city planning that centers on public traffic in an environmental society in the future.

The urban transportation is designed to help human participate in activities distributed over urban space. The urban planning and our interactions within it are rapidly changing due to forces like suburbanization, economic development and transportation technology. Research on development of integration station with urban

area has being carried out. However, at the same time, with the rapid speed up of urban development, city development is being diffusion anywhere disorderly. In order to promote the integration of all kinds of urban functions in an intensive linking with the public transportation network, restructuring the urban structure and compacting the city has become an urgent task. On the other hand, as the development of land use around railway stations and subways, especially in recent years, the background problem has become serious in many parts, not only sparsely populated regions, but also central regions around stations. Generally, the developing situation of land use around railway stations can represent the developing situation of commerce, industry, business, entertainment, etc. It is said that the development of society is forming around a circle of stations, which can make an influence on people's life. Thus, for the better formation of the zones of railway stations, a further improvement of the convenience of railway stations and subway stations is sought constantly.

Over the years, researchers have introduced a large number of development situations of railway and subway stations and analyze the relationship between the urban land and stations and the varying importance of the stations in a city according to one criterion or another. These following studies have proved of great value in the analysis and understanding of the roles played by railway and subway stations in a city's development, such as the theory of the rail transit and its development, impacts on land market, the influence and analysis on house price and land price, the developing situation of the land use and building usage, etc. which are as follows,

Sustainable development and livable communities represent the big visionary ideas of contemporary urban planning. But attempts to implement these popular visions can encounter a host of conflicts. The planning on land use may well depend on how it copes with these conflicts. (Godschalk, 2004). The influence of transit-oriented development (TOD) on the San Diego, CA, condominium market has been measured and indicates that TOD has a synergistic value greater than the sum of its parts. It also implies a healthy demand for more TOD housing in San Diego (Duncan, 2010). Kim (2010) examines how land use planning and regulation may affect regional economic prosperity by reviewing relevant literature. Golub, Guhathakurta and Sollapuram (2012) has shown that proximity to light rail transit (LRT) stations positively affects property values. Yano's Research by GIS on changes of enterprise location among stations in Kyoto", which used GIS to investigate the

number of enterprises and offices in Kyoto in order to indicate an economic activity in Kyoto and changes on their location, especially that around stations. Iwatani's "A GIS fundamental study on location tendency of condominium development and TOD promotion plan", which mainly focused on exploration of condominium around railway and subway stations by GIS and statistical investigation.

The relationship between land-use, building usage, transportation and people's activities can be summarized that assuming a positive change in the transportation infrastructure or services leads to certain land use in the urban system. These land uses will be experiencing a premium that will eventually lead to a change in the land use patterns and activity. Since the old activity won't be the ideal usage of land, a change in activity pattern will be present (see Fig. 1.1).

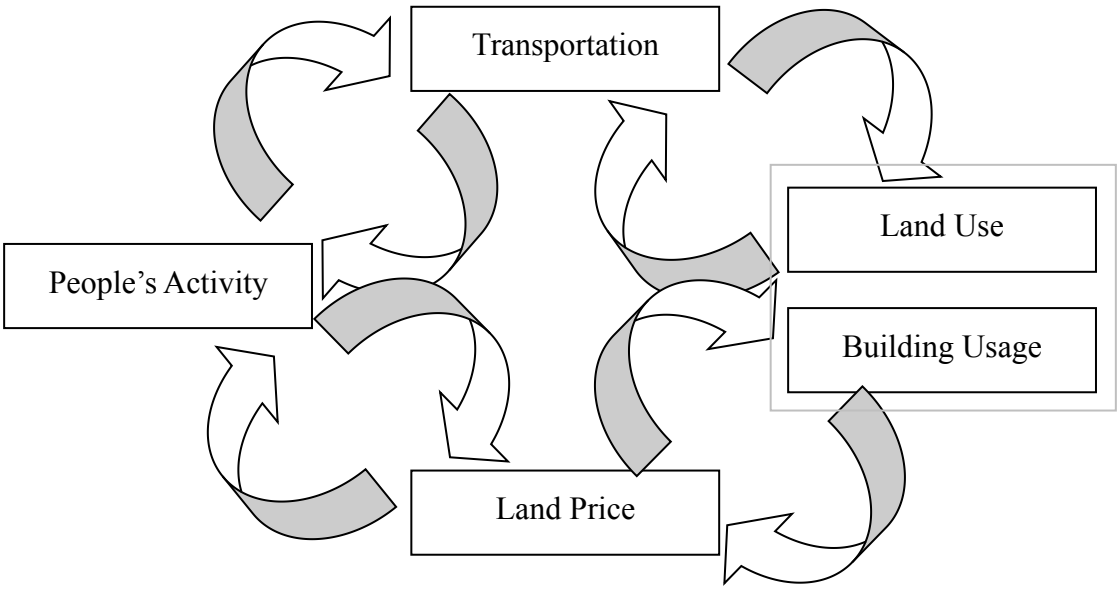


Fig. 1.1 The Urban System

It is illustrated that the high power and reliability of metabonomic data analysis using NMR spectroscopy together with chemometric techniques for the exploration and prediction of toxic effects in the rat (Beckonert et al, 2003). Timm et al (2004) have explored an approach to possibilistic fuzzy clustering that avoids a severe drawback of the conventional approach, namely that the objective function is truly minimized only if all cluster centers are identical. Kaufman and Rousseeuw (2009) introduce the method of cluster analysis to us and provide some ways to find groups in data. Maechler et al (2012) introduce the cluster analysis for us. Li and Yeh (2004) analyzed urban expansion and spatial restructuring of land use patterns in the Pearl

River Delta of south China by using remote sensing and GIS.

The activities and attractions, which aim to attract the people, are usually connected by the road network and can be easily accessed by different transportation modes such as bus, cars, or railways etc., especially public transport. Therefore, the transportation system has a significant function to form the distribution of activities and attractions patterns. The spatial distribution of tourist attractions in turn affects tourists' daily activities. Consequently, attractiveness of tourist attractions verifies from the viewpoint of land-use (distribution of activities locations), and spatial activities of tourists needs spatial interaction (Tillema et al 2003).

Based on the methodology and results, Farber (2004) has compared the results of the application of a number of spatial multivariate models to two 'global' models in a hedonic house price context.Bitter, Mulligan and Dall (2007) have compared two approaches to examine spatial heterogeneity in housing attribute prices within the Tucson, Arizona housing market: the spatial expansion method and geographically weighted regression (GWR). Yan Zhuang has analyzed the impact of subway station on commercial land values and used the methods of linear regression, analysis of regression to indicate the subway stations' significant impacts on the commercial land price, and on this basis, the model of the spatial relations between land prices and distances was established (Zhuang, 2007). An innovative LUR method implemented in a GIS environment that reflects both temporal and spatial variability and considers the role of meteorology is presented by Su, Brauer, Ainslie, et al. (2008). Handy (2005) said there is a connection between transportation and land use. Kestens et al (2006) introduce the household-level data into hedonic models in order to measure the heterogeneity of implicit prices regarding household type, age, educational attainment, income, and the previous tenure status of the buyers. Hess evaluated the influence on the housing price by the distance from Buffalo, NewYork, to the light railway stations. By using the price models and assessing the housing price of 14 light rail spots, he obtained the conclusion that each 1 foot away from the light rail station, the average value of the house will add $2.31 or $0.99 (according to the linear distance calculations (Hess, 2007). Cohen and Paul (2007) evaluated the impacts of enhanced transportation systems on property values. Ryan reviews the relationship between transportation facilities—highways, heavy rail, and light rail transit systems—and property values.

1.1 RESEARCH OBJECTIVES

As the development of surrounding areas of railway stations and stations themselves in Fukuoka, Japan, the relationship among those stations, environment improvement and urban renaissance project is becoming more and more important. Thus, by selecting small-scale railway stations in Fukuoka City as research objects, the paper focuses on the distribution situation, annual changes of land use, as well as their relationship with population and number of users, in order to analyze the situations of exploiting surrounding areas of railway stations. On one hand, focusing on land use around railway stations can catch the distribution and characteristics of community facilities, including educational facilities, the public and government facilities, etc. to clarify the actual conditions and secular changes of them.

Fukuoka City, which has become the object of this research, has eight lines and 68 stations in total, that is, the JR Kagoshima Line, the JR Kashii Line, the JR Chikuhi Line, the Nishitetsu Omuta Line, the Nishitetsu Kaizuka Line, and three lines of the Fukuoka municipal subway. The annual development on 68 stations in eight lines that exist in Fukuoka will be analyzed.

Data which are used in this research are shown in the table below, that is, the data of land use and building usage, which use the POSMAP (from data of land use and building use) in the four periods of (1985, 1993, 1998, 2003, 2008) at each station and the GIS (Geographic Information System) to extract each land use and building use. The data of population and number of households, which are from the census of population of Fukuoka city and in units of chome (the chome is a very special street unit in Japan, actually, the "cho" in Japanese is a kind of unit for streets; and the "me" in Japanese presents the No., so, the 1 Chome means the first Avenue) at the time of1985, 1990, 1995, 2000, 2005, 2010. The numbers of passengers, which are referred to the statistical books of Fukuoka and data of all routes of JR and Japanese western railways totaling for 36 years are collected from 1975 to 2011.The data of the

Fukuoka city subway were collected up from the opening year 1981 to 2011 totaling for 30 years. The data of survey for prefectural land price and public reviewing land prices, which are from National Land Numeric Information Download Service of the homepage of the Ministry of Land, Infrastructure, Transport and Tourism, are collected up to point data of 28 years from 1983 to 2011 in all. The data of architectural confirmation are ones of building confirmation of Fukuoka city from the year 1992 to the year 2004, totaling for 13 years. These data are all available and integrated by GIS.

1.2 RESEARCH METHODS AND AIMS

This research, which is based on the results of previous studies, is focused on surrounding areas of train stations and further improvement in future. Solution ways are needed to promote compact urban development and provide basic information about the design and distribution of the surrounding areas for the railway stations. The approach aims to develop a novel methodology, several analysis principles and techniques for holding the change on land use and building usage around stations and the relationship with the population, the land price and the passengers per day.

This research focuses on the railway stations and subways of Fukuoka city in order to clarify the trend of changes and development on them. With the survey of the land use around railway stations and subways of Fukuoka, the research selects 68 stations as the research targets, which are compared and analyzed on the distribution of land use, such as the commerce, the house, the government and education, the park and green land, etc., by extracting the POSMAP data on land use with the GIS. Furthermore, for each station, the data are analyzed by 5 years, separated with two steps, that is, 0-400m radius (Step. 1) and 400-800m radius (Step. 2), in addition, five-age points multiply 2 distance categories (Step.1, 2) that makes 10 series of data (each series of data corresponding to 68 stations), and are categorized into groups according to the cluster analysis by using the Ward method so that the spatial characteristics of stations can be hold and the research can indicate the changing tend and relationship among the population, the passengers and land use around railway stations and subways in the past five years. After that, the influence degree can be got by using the quantitive analysis method and the regression analysis.

Moreover, according to the second-time on cluster analysis, the research analyzes 52 stations without the stations of Nanakuma Line. As the stations of Nanakuma Line are founded in 2005 and annal changes and their characteristics can not be shown, thus, the research has got rid of them and paid attention on 52 remaining stations.

Furthermore, basing on the results of second-time cluster analysis, the research has made a predictive analysis which aims to find the characteristics and conditions on changes of stations in those annual years, thus, one station has changed from A type into B type and finally it has changed into C type, etc. can be found out.

The specific research aims of this thesis are:

- to propose an available methodology for analyzing the development on land use and building usage around railway and subway stations;
- to give a valuable research material on the development on stations and their surrounding areas;
- to find a useful way for studying on the relationship among people's activity, the transportation, the land use and building usage, the land price;
- to show a new angle point of analysis on influence degree on the passenger, the population and the land price;
- to find a special way to evaluate the annual changes on stations' type;
- to provide a well-founded reference on improving the current situation on urban transportation

1.3 FRAMEWORK

According to the background, the previous studies, the research objects and methods described above, by using relevant data on development status of land use and building usages, a series of analysis is launched. After that, changes on the land use within and outside station zones and annual developing trend have been interpreted, thus, the developing trends of Fukuoka station zones have been definite. Basing on the data of land use and building usages around railway stations and subways in Fukuoka, this research selects 68 stations and 8 lines as the research targets, which are compared and analyzed basing on the distribution of land use by extracting the POSMAP data on land use with the GIS. In addition, the data are separated with two steps of five years, that is, 0-400m radius (Step. 1) and 400-800m radius (Step. 2), which are categorized into groups according to the cluster analysis so that the characteristics of the stations can be interpreted.

This dissertation is consisted of six parts as follows,

Chapter 1 - This chapter is focused on the general introduction including the research background, previous studies, research objectives, research aims and questions in process;

Chapter 2 - This chapter briefly discuss the current state and problems of land use and building usage in Fukuoka by the approach of GIS and quantitive analysis, furthermore, by reviewing the relevant knowledge and studies including the basic definitions and some important changing situation on stations, the context is formed with the research objects, that is, the selection of the target stations, an overview of data in hand and changes on stations;

Chapter 3 - This chapter is consisted by making categories on stations by the cluster method in order to get the state of stations being embodied and targeted; secondly, analyzing the developing status and annual changes on population, land price and

passengers around target stations which have been clustered into several groups; this chapter aims to investigate stations which can find out the changing types of them in process and compares the differences types and characteristics among stations. For further understanding, this chapter also contains two examples on stations of 2008 after being clustered, and then a calculation and a forecast are going on for getting the changing condition of stations in future;

Chapter 4 - This chapter introduces the regression methodology and the theories used for this approach with examples to interpret several important changes on stations' developing process and also presents the influence degree for the population, the passengers and the land price in detail. Four cases on influenced areas are shown in this chapter;

Chapter 5 - This chapter includes general conclusions and tips on how the problems solved, which shows the analysis results, points out solution ways for problems and the next step in future and hope to provide a reference for other research later.

REFERENCES

A Research Report Concerning on Urban Structure of Fukuoka City. Fukuoka Asian Urban Research Laboratory, 2005, Japan.

Babalik-Sutcliffe E. Urban rail systems: Analysis of the factors behind success. Transport Reviews, 2002, 22(4): 415-447.

Beckonert O, E Bollard M, Ebbels T, Keun H C, Antti, H, Holmes E, Nicholson J K. NMR-based metabonomic toxicity classification: hierarchical cluster analysis and k-nearest-neighbour approaches. Analytica Chimica Acta, 2003, 490(1): 3-15.

Bafna S. An Introduction of Space Syntax, Environment and Behavior, 2003,35:17-29.

Bitter C, Mulligan G F, Dall’ erba S. Incorporating spatial variation in housing attribute prices: a comparison of geographically weighted regression and the spatial expansion method. Journal of Geographical Systems, 2007, 9(1): 7-27.

Capozza D R, Helsley R W. The fundamentals of land prices and urban growth. Journal of Urban Economics x, 1987, 295-306.

Cohen J P, Paul C M. The impacts of transportation infrastructure on property values: A higher-order spatial econometrics approach. Journal of Regional Science, 2007, 47(3): 457-478.

Damm D, Lerman S, Lerner-Lamm E, et a1. Response of urban real estate values in anticipation of Washington Metro. Journal of Transport Economics and Policy, 2007, 14:315-336.

Davis M A, Heathcote J. The price and quantity of residential land in the United States[J]. Journal of Monetary Economics, 2007, 54(8): 2595-2620.

Dowall D E, Leaf M. The price of land for housing in Jakarta[J]. Urban Studies, 1991, 28(5): 707-722.

Duncan M. The impact of transit-oriented development on housing prices in San Diego, CA. Urban Studies, 2011, 48 (1): 101-127.

Farber S, Yeates M. A comparison of localized regression models in a hedonic house price context. Canadian Journal of Regional Science, 2006, 29(3): 405-420.

Fukuoka City Statistics Book, Fukuoka City, Japan, 2000.

Ghebreegziabiher D, Eric P, Piet R. The impact of railway stations on residential and commercial property value: a meta-analysis. J Real Estate Finan Econ, 2007, 35:161−180.

Godschalk D R. Land use planning challenges: coping with conflicts in visions of sustainable development and livable communities. Journal of the American Planning Association, 2004, 70(1): 5-13.

Golub A, Guhathakurta S, Sollapuram B. Spatial and temporal capitalization effects of light rail in phoenix from conception, planning, and construction to operation. Journal of Planning Education and Research, 2012, 32 (4): 415-429.

Handy S. Smart growth and the transportation-land use connection: What does the research tell us? International Regional Science Review, 2005, 28 (2): 146-167.

Handy, S.L. and Niemeier, D. A.: Measuring Accessibility: an Exploration of Issues and Alternatives, Environment and Planning A, 29(7) pp.1175-1194, 1997

Hess D P. Impact of proximity to light rail rapid transit on station-area property values in Buffalo, New York. Urban Studies,2007, 44(5): 1041-1068.

Hillier, B. and Penn, A. (2004). Rejoinder to Carlo Ratti, Environment and Planning, B: Planning and Design, vol.31, pp.501-511.

Homepage of City Office in Fukuoka City, http://www.city.fukuoka.lg.jpHonda M, Shimada Im. Multivariate Statistical Technique for Management. Japan: Publishing Department of Sanno and Management University, 1977.

Iwatani M. A GIS Fundamental Study on Location Tendency of Condominium and TOD Promotion Plan, Architectonics Research, Graduation Thesis Outline Collections, 2002.

Jiang, B. and Claramunt, C. (2002). Integration of Space Syntax in GIS: New perspective for Urban Morphology, Transaction in GIS, 6-3, PP. 295-309.

Lynch, K. (1960). The Image of the City, MIT Press, Cambridge, Mass.

Kaufman L, Rousseeuw P J. Finding groups in data: an introduction to cluster analysis, 2009, 344, Wiley-Interscience.

Kestens Y, Thériault M, Des Rosiers F. Heterogeneity in hedonic modeling of house prices: looking at buyers' household profiles. Journal of Geographical Systems,

2006, 8(1): 61-96.

Kim C W, Phipps T T, Anselin L. Measuring the benefits of air quality improvement: a spatial hedonic approach. Journal of Environmental Economics and Management, 2003, 45(1): 24-39.

Luca Bertolini: Nodes and places: complexities of railway station redevelopment: European Planning Studies, 4(3), pp.331-345, 1996.

Luca Bertolini, Tejo Spit: Cities on rails: the redevelopment of railway station areas, Routledge, New York, 2001.

Makrí, M. and Folkesson, C.: Accessibility Measures for Analyses of Land Use and Traveling with Geographi-cal Information Systems, Proceedings of 2nd KFB-Research Conference, Institute of Technology, Lund, 1999.

Masahisa Honda, Kazuaki Shimada. (1977) Multivariate Statistical Technique for Management, Publishing Department of Sanno and Management University, Japan.

Porta, S., Crucitti, P. and Latora, V.: The Network Analysis of Urban Streets: A Primal Approach, Environment and Planning B: Planning and Design, 33(5), pp.705 − 725, 2005.Penn, A. (2003). Space Syntax and Spatial Cognition, or Why the Axial Line? Environment and Behavior, vol.35, pp.30-65.

Ratti, C. (2004). Space Syntax: Some Inconsistencies, Environment and Planning, B: Planning and Design, vol.31, 487-499.

Ratti, C.: Environment and Planning B: Planning and Design, Vol.31, pp.487 - 499, 2004.

Yang, S. J. (2005). Exploring Complex Networks by Walking on them, Physical Review E, vol. 71, 016107

Yano Keiji. (2006) Research by GIS on Changes of Enterprise Location among Stations in Kyoto, Ritsumeikan University Literature, Japan

Yasuhiko Yuize. (2000) Introduction to Econometrics by Excel, Toyo Economic Press Office, Japan.

Zhuang X Y. A Discussion on the Uptown Environment in the 21st Century. Journal of Sichuan College of Architectural Technology, 2008:18.

Zhu, Q. and Wang. J.: Optimization Research of Urban Space Configuration Based on Space Syntax, Geosci-ence and Remote Sensing Symposium, 2005.

Chapter Two

Transition of Influence Sphere of Stations in Fukuoka

Chapter 2
Transition of Influence Sphere of Stations in Fukuoka

2.1 INTRODUCTION

Basing on the interpretation of Chapter 1, it described the background of the research, the previous studies, the research methods and the research purpose. In Chapter 2, it describes the target city and the stations, and proposes the necessary data. Based on the description, "station circle", which will be focused on in this dissertation, is defined. In addition, it describes the changes of land use and the trend of development in the inner and outer places of "station circles" in recent years by referring the data of land uses and building usages of these circles.

2.1.1 Overview of Contents

Over the years, researchers have introduced a large number of development situations of railway and subway stations and analyze the relationship between the urban land

and stations and the varying importance of the stations in a city according to one criterion or another. These following studies have proved of great value in the analysis and understanding of the roles played by railway and subway stations in a city's development, such as the theory of the rail transit and its development, impacts on land market.

Bertolini et al. (2012) has come up with their ideas that the redevelopment of railway stations and their surroundings has been high on the agenda of European cities for more than two decades. An evolving set of factors has fuelled these initiatives. Driving forces include the expansion and upgrading of rail infrastructure, the reduced demand for industrial space in central urban locations, the privatization of railways, efforts to increase the attractiveness of cities, the quest for sustainable development and the spatial dynamics of contemporary society. Ishida et al. (2013) made a research on Jr Osaka Station area which has collected data fundamental to devising a method for inducting evacuation. Pan et al. (2012) made a Commuting Mode Choice of Residents in a New Suburban Metro Station Area in Shanghai. Alexander (2012) presented the results of a developed, and implemented a Fuzzy rule based model to determine the probability of precipitation in the Marion Illinois area. Bodnár et al. (2011) used the database to deal with the geologic sections and geomathematical methods to obtain a better correlation of the strata in the area and a reconstruction of the geologic evolution of the area. Then the samples were divided into five groups based on physical properties which allowed the use of multivariate statistical methods as cluster and discriminant analysis. According to the two attributes of HST station, which are the function of traffic and the function of city, product the node effect and the space effect on the surrounding area. Hou et al. (2012) make the example of Beijing south station to conduct a research. Then the authors find it belong the second type, which is the effect of node too strong to support the effect of space. In the future, the surrounding area of HST station needs government's supports and coordination to play a maximum effect on the surrounding regional development of the high-speed rail station. Land in the vicinity of railway stations in the Seoul metropolitan area has been spotlighted as a target for redevelopment in accordance with the principles of transit-oriented development (TOD). In order to understand the nature of station areas as a whole, it is required to identify their current status with respect to their built environments, demographic characteristics, socioeconomic status, and transport

aspects. Many researchers have used either supervised classifiers requiring a pre-classified dataset for training, or K-means-like unsupervised classifiers demanding a predetermined number of clusters. The present study focused on the fact that it was hard to find such a clear separation in station areas in Seoul. (Sohn, 2013). On the basis of analyzing the situation of domestic and foreign researches, evaluating the traffic state of Fengtai Station, the article, aiming at the existing questions and the constraint conditions of the railway net, does the design of traffic strategy, brings forward plans and measures of improving the traffic, uses traffic simulation software to do simulation evaluation and sensitivity analysis for the plans. Then the suggested plan and the relative traffic management and measures are proposed. (Zhao, et al. 2011). Jiang (2012) wrote a paper which examined the BRT station walk access patterns in rapidly urbanizing China and the relationship between bus rapid transit (BRT) station context and corridor type and the distance people will walk to access the system (i.e., catchment area). Arnold (2010) developed power models for macro and micro base stations relying on data sheets of several GSM and UMTS base stations with focus on component level, e.g., power amplifier and cooling equipment. In a first application of the model a traditional macro cell deployment and a heterogeneous deployment are compared.

The development of rail transit and the construction above subway station will (CASS) have profound influence on city. Jin Q L et al. (2012) tries to take Tianjin's practical situation into consideration, and after analyzing the theories and CASS in and abroad, attempts to find objective law between rail transit and urban development in Tianjin from the interaction of M1 (Metro 1 of Tianjin subway system) construction and urban development. Base on the existing problems and experience, the research puts forward the methods of exploitation above subway station and the qualitative indicators. Then take an under construction station's exploitation as an example, raising qualitative principles and quantitative indicators to the site construction nearby. By doing this, aim at leading the future CASS and realizing the harmonious interaction between the development of urban rail transit and land use above it. Li and Yeh (2004) analyzed urban expansion and spatial restructuring of land use patterns in the Pearl River Delta of south China by using remote sensing and GIS. The activities and attractions, which aim to attract the people, are usually connected by the road network and can be easily accessed by different transportation modes such as bus, cars,

or railways etc., especially public transport. Therefore, the transportation system has a significant function to form the distribution of activities and attractions patterns. The spatial distribution of tourist attractions in turn affects tourists' daily activities. Consequently, attractiveness of tourist attractions verifies from the viewpoint of land-use (distribution of activities locations), and spatial activities of tourists needs spatial interaction (Tillema et al 2003). An innovative LUR method implemented in a GIS environment that reflects both temporal and spatial variability and considers the role of meteorology is presented by Su, Brauer, Ainslie, et al. (2008). Widanapathiranage, Bunker and Bhaskar (2013) made a research by using micro simulation to treat the Bus Rapid Transit station operation and to analyze the relationship between station limit state bus capacity and total bus capacity, which provided better understanding to the BRT line capacity and is useful for transit authorities for designing better BRT operation.

Moreover, in 2010, Yang and Chen studied the adaptability of Grey Land planning to rail transit construction, then proposed that this dynamic land-use planning mode can enhance the use value and use efficiency of the land as well as solve some investment and financing problems. Finally, combined with the analysis of the Suzhou rail line 2, a detailed study about the Grey Land area selection surrounding the urban railway station was explored. Valizadeh et al. (2012) have made a study on influence of spacing of central columns and their dimensions on the magnitude of settlement. Effect of ground improvement of Tehran soil by consolidation grouting on ground surface settlement and stress distribution in supporting system is modeled and analyzed. It can be concluded that in an urban area over a large underground spaces (e.g., underground metro stations) with relatively low overburden similar to northern Tehran, CBC structure can be very effective and reliable measure in controlling and reducing the surface settlement and the stress concentration on initial supporting system. Jia et al. (2011) made a monitoring system that can be applied to hydropower projects is developed on the basis of the powerful spatial visualization and analysis characteristics of GIS. Furthermore, the proposed system promotes the spatial aspect of hydropower monitoring analysis and is expected to be an efficient tool for improving and maintaining the safety standard for the construction of hydropower stations.

In 2012, Ma et al. made a research on the structural deformations of the existing

metro station caused by adjacent building construction which should be controlled strictly so as to keep the normal operation of the existing metro station and guarantee the safety of the station structure. Based on a foundation pit excavation and building project which is adjacent to an existing metro station in Beijing, a 3D finite element model of foundation pit, metro station and surrounding soil is established. Then, the structural deformations of the main body structure (rail area), the passageway and the firefighting passageway in different construction stages are obtained. The control values of the station structure deformation during building construction process are proposed according to the calculation results. In Yuan's research (2011), the development, working principle, information generation, etc. of the urban traffic flow guidance system which is based on VMS are introduced in detail. Meanwhile, the previous research on the traffic flow guidance at home and abroad is reviewed. With the analysis of the requirements of the VMS users and the factors influencing the site distribution of VMS, the location choice model of the VMS is improved by following the principle of the VMS location choices and analyzing the effect of the guiding information on route choices. The impact of the VMS applied for the roads near Beijing South Railway Station is analyzed. Kong and Fang (2011) made a research basing on the current development of both domestic and foreign information systems, the selecting principle for the structure of space station information system is discussed, two kinds of topological schemes for space station information system are put forward, and the selection of the network system of space station information system is analyzed. The service of the space station information system is summarized, and the necessity of establishing an integrated satellite-earth design is narrated. The main researching contents in developing China's space station information system are presented. Basing on the synergy theory, this paper discusses the demand of synergetic development of developing rail transit station area in current China, and proposes the functional synergy, spatial synergy, resource synergy and cultural synergy, with the aim to construct a compact, effective, and sustainable development pattern of developing rail transit station area. (Qiu and Yang, 2010). After that, Smith (2011) assessed new rail station demand forecasting best practice drawing on post scheme evaluation of the introduction of Ebbw Vale Line service in 2008. It will draw on the results of 4 phases of transport modelling which used different techniques and highlights the recommended approaches for the future. The paper will inform on the

methodology employed and draw on experience in the development and application of the models in South Wales.

2.1.2 Research Aims

This chapter aims to the following items, that is,

- to propose basic data on surrounding areas of stations and to set the scale of "influence circle of stations";
- to show the current situations of the development on land use and building usage around railway and subway stations in Fukuoka;
- to propose existing problems of the land use and building usage by the methods of GIS and quantitive analysis;
- to analyze the changes and trend of development in the inner and outer circles of stations by using the data of land uses and building usages of these circles

2.1.3 Research Framework

(1) Firstly, this chapter briefly discusses the current state and problems of land use and building usage in Fukuoka by the approach of GIS and quantitive analysis,

(2) Secondly, by reviewing the relevant knowledge and studies including the basic definitions and some important changing situation on stations, the context is formed with the research objects, that is, the selection of the target stations, an overview of data in hand and changes on stations.

(3) Thirdly, based on the description, "influence sphere of stations", which will be focused on in this dissertation, is defined. In addition, it describes the changes of land use and the trend of development in the inner and outer places of "influence sphere of stations" in recent years by referring the data of land use and building usage of these spheres.

2.2 OVERVIEW OF TARGET CITY

2.2.1 Overview of Fukuoka City

Fukuoka railway consists of 6 JR lines, JR Kyushu Kagoshima main line, Kashii Line, Sasaguri Line, Chikuhi Line and JR West Japan Hakata, Sanyo Shinkansen Line, 2 private lines which are Nishitetsu Tenjin Omuta Line and Nishitetsu Kaizuka Line, and three public lines which are public subway Airport line, Hakozaki Line, and Nanakuma Line. JR Kyushu Kagoshima main line connects northeast and south of city group with Hakata, Nishitetsu Tenjin Omuta Line connects south of city group with gods. These two lines undertake the main transportation tasks among city groups. Public subway airport line and Hakozaki Line connects Meinohama ~ Tenjin ~ Fukuoka Airport with Kaizuka, which links up the city center from east to west, and connect with JR Kyushu Kagoshima main line in Hakata, with Nishitetsu Tenjin Omuta Line. These lines undertake the main transportation tasks of the city, while the Nanakuma Line connects the southwest of the city with the city center. On Mar,1994, Subway airport line had been extended to Fukuoka airport, and dual track laying was completed on Jan,2001. Electrification transformation of JR Sasaguri Line was completed on Oct,2002 , and Sasaguri Line was renamed North Fukuoka Yutaka Line.On Feb, 2007, Nanakuma Line was opened and so on. All these projects have been implemented in order to enhance wide traffic network and improve capability of transportation (see Fig. 2.1& 2.2).

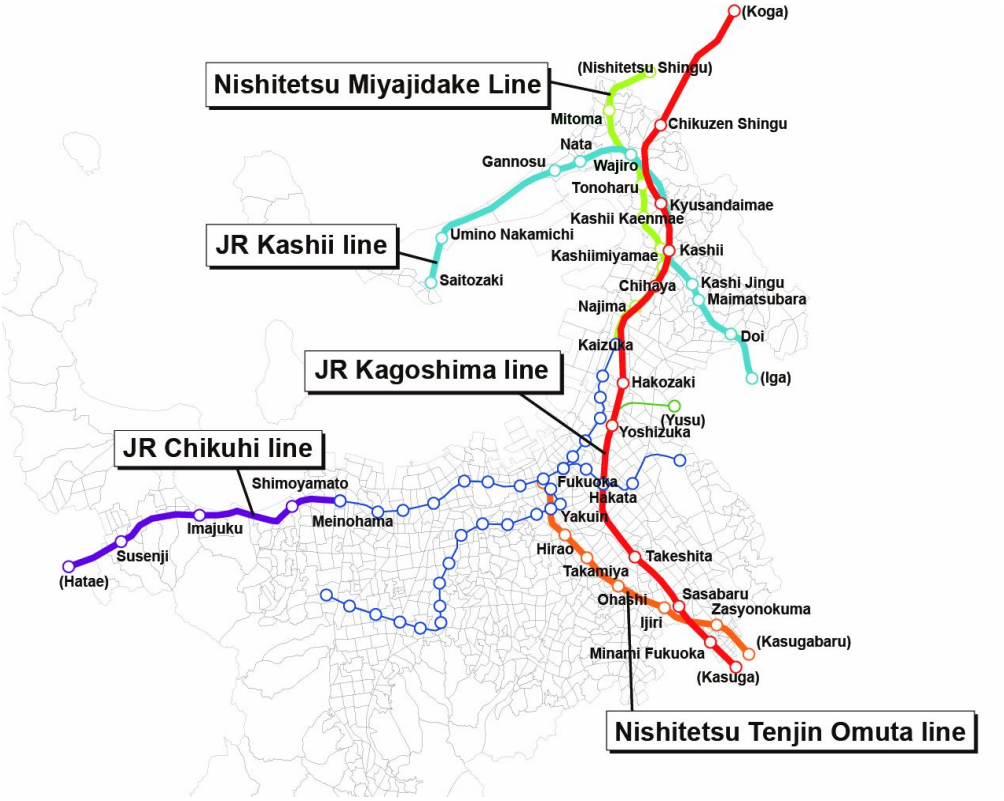


Figure 2.1 Outline of Railway Stations

Figure 2.2 Outline of Subway Stations

2.2.2 Overview of Target Lines and Stations

The objective is neither Shinkansen nor North Fukuoka Yutaka Line, but surrounding areas of 75 stations of railways (JRS line, West Japan railway) run through in Fukuoka. In addition, due to reduplicate with subway Nakasu Kawabata Station and JR Kashii Station, figures in the bracket are the number of extended station. Meanwhile, as the data of land and building usage, count of the objective station is 68 besides subway and the repeated station on the ground.

As for objective roadmap, refer to below table (see Table 2.1)

Table 2.1 Outline of Object Lines and Object Stations

Categories	Lines	Range	km	Numbers of Stations
JR Kyushu	Kagoshima Main Line*	Chikuzen Shingu-Minami Fukuoka	19.8	10
	Kashii Line*	Saitozaki-Doi	16.4	8(9)
	Chikuhi Line	Susenji-Meinohama	8.1	5
	Total		44.3	23
Nishi-Nippon Railroad	Tenjin Omuta Line	Nishitetsu Fukuoka (Tenjin)-Zassyonokuma	8	7
	Kaizuka Line	Kaizuka-Mitoma	9	9
	Total		17	16
Fukuoka City Subway	Line 1 (Kuko Line)	Meinohama-Fukuoka Kuko	13.1	13
	Line 2 (Hakozaki Line)	Nakasu Kawabata-Kaizuka	4.7	6(7)
	Line 3 (Nanakuma Line)	Hashimoto-Tenjin Minami	12	16
	Total		29.8	35
Total			91.1	74

*Kashii Station is on Kagoshima Main Line and Kashii Line.

This table shows the details target lines, and the total length of all the lines is 91.1 kilometres. JR Kyushu includes three lines, which is the Kagoshima main line, Kashii line, Chikuhi line, including 23 stations; Nishi-Nippon Railroad includes two lines, that is the Tenjin Omuta line and Kaizuka line, including 16 stations; And Fukuoka subway includes three lines, which is Kuko line, hakozaki line and Nanakuma line, including 35 stations. Those above are totally 74 stations in 8 lines.

There are 6 stations which are counted in two lines. For example: Kaizuka is on both the Nishi-Nippon Railroad Kaizuka Line and Fukuoka City Subway Hakozaki Line. So 6 lines are deleted in the research which are as follows,

JR Kashii Station and Hakata Station in JR Kakoshima Line;
Meinohama Station in JR Chikuhi Line;
Wajiro and Yakuin Station in JR Kashii Line;
Kaizuka Station in Nishitetsu Kaizuka Line.

Here, the introduction of JR Kyushu, Nishi-Nippon Railroad and Fukuoka City Subways are described as follows,

(1) Kyushu Railway Co. Ltd. (JR Kyushu)

From January 2009 to now, it is an overview of stations of JR Kyushu in Fukuoka City, which is shown in the table below (see Table 2.2). The JR Kyushu has three lines running in Fukuoka, which support the transportation between cities and within the Fukuoka City.

Table 2.2 Outline of JR Kyushu Stations

Route		Station	Address	Lim. Exp.	Exp.	Opening Year	Building Type	Home Type	Distance (km)
Kyushu Railway	Kagoshima Main Line	Fukudaimae	Wajirogaoka 1-chome, Higashi-ku, Fukuoka City	×	○	1-Oct-1920	Ground*	Island 2 surface	3.0
		Kyusandaimae	Tonoharu 1-chome, Higashi-ku, Fukuoka City	×	×	11-Mar-1989	Ground *	Relative 2 surface	1.7
		Kashii	Kashiiekimae 1-chome, Higashi-ku, Fukuoka City	△	○	28-Sep-1990	Ground	Island 2 surface, Relative 1 surface	1.7
		Chihaya	Mizutani 2-chome, Higashi-ku, Fukuoka City	×	○	7-Jul-2003	Elevated	Island 2 surface	4.0
		Hakozaki	Hakomatsu 2-chome, Higashi-ku, Fukuoka City	×	×	28-Sep-1990	Elevated	Island 1 surface, Relative 1 surface	1.4
		Yoshizuka	Yoshizukahon Town, Higashi-ku, Fukuoka City	○	○	19-Jun-1904	Elevated	Island 2 surface, Relative 1 surface	1.8
		Hakata	Hakataekichuogai, Hakata-ku, Fukuoka City	○	○	11-Dec-1989	Elevated	Island 4 surface	2.7
		Takeshita	Takeshita 4-chome, Hakata-ku, Fukuoka City	×	×	21-Sep-1913	Ground*	Island 1 surface	2.4
		Sasaharu	Ijiri 3-chome, Minami-ku, Fukuoka City	×	×	9-Mar-1987	Ground	Relative 2 surface	1.6
		Minami-Fukuoka	Kotobuki-cho, 2-chome, Hakata-ku, Fukuoka City	×	○	20-Jan-1989	Ground	Island 2 surface, Relative 1 surface	1.2
	Chikuhi Line	Meinohama	Meinohama 4-chome, Nishi-ku, Fukuoka City	×	○	15-Apr-1925	Elevated	Island 2 surface	1.6
		Shimoyamato	Shimoyamato 4-chome, Nishi-ku, Fukuoka City	×	○	20-Jul-1986	Ground	Relative 2 surface	3.6
		Imajuku	Imajukuekimae 1-chome, Nishi-ku, Fukuoka City	×	○	15-Apr-1925	Ground	Island 1 surface	1.6
		Kyudaigakkentoshi	Oaza Tokunaga, Nishi-ku, Fukuoka City	×	×	23-Sep-2005	Elevated	Island 1 surface	1.3
		Susenji	Susenji 1-chome, Nishi-ku, Fukuoka City	×	○	15-Apr-1925	Ground	Island 1 surface	2.0
	Kashii Line	Saitozaki	Saitozaki 1-chome, Higashi-ku, Fukuoka City	-	-	1-Jan-1904	Ground	Relative 2 surface	2.1
		Uminonakamichi	Saitozaki, Higashi-ku, Fukuoka City	-	-	10-Jul-1935	Ground	Single 1 surface	4.4
		Gan'nosu	Gan'nosu 2-chome, Higashi-ku, Fukuoka City	-	-	1-Jan-1904	Ground	Relative 2 surface	0.9
		Nata	Nata 3-chome, Higashi-ku, Fukuoka City	-	-	1-Aug-1960	Ground	Single 1 surface	1.8
		Wajiro	Wajiro 3-chome, Higashi-ku, Fukuoka City	-	-	24-Jan-1905	Ground	Relative 2 surface	3.7
		Kashii	Kashiiekimae 1-chome, Higashi-ku, Fukuoka City	-	-	28-Sep-1990	Ground	Island 2 surface, Relative 1 surface	1.3
		Kashiijingu	Kashii 6-chome, Higashi-ku, Fukuoka City	-	-	13-Mar-1988	Ground	Single 1 surface	0.6
		Maimatsubara	Maimatsubara 5-chome, Higashi-ku, Fukuoka City	-	-	1-Mar-1994	Ground	Single 1 surface	1.6
		Doi	Doi 4-chome, Higashi-ku, Fukuoka City	-	-	1-Jan-1904	Ground	Relative 2 surface	1.8

The Kagoshima Main Line plays an important role in linking the Fukuoka City and Fukuoka metropolitan area, and stations, which belong to this line generally have relatively large patterns, including many elevated platforms and land readjustment projects around stations.

The Chikuhi Line, which was started as a mutual directed operation after the subway was opened in 1981, has a soaring passengers. At the same time, there has been an increasing development in the vicinity of the Chikuhi Line. In 2005, as the transfer of Kyushu University, the Kyudai Gakken Station had been established, and the SC was opened in front of the station which has progressed the development around the station.

Hakata Bay Station is the predecessor as a railway of Kashii Line, its remnants are almostly disappeared, especially recently, the Saitozaki transport towards tourism, transportation and delivery towards Umi are the same routine.

- **JR Kagoshima Main Line**

1) Kagoshima Main Line of JR Kyushu

Kagoshima Main Line of JR Kyushu (Kaizuka solid crossing - Myoken solid crossing, 3490m) which transferred to Higashi park of the prefecture government office in 1981 as well as the roads improvement around Yoshizuka Station, is always promoting the development of urban facilities corresponding to the future development of this district.

2) JR Chikuhi Line

JR Chikuhi Line (beside the Meinohama Station) is the west terminal station that connects the JR Kyushu Chikuhi Line and Fukuoka subway stations directly in the center of the Meinohama Station starting in 1978 and finishing in 1983. As the formation of this line, 11 locations were connected by railways including three new routes. The data has shown that there is an obvious growth of estates around the Meinohama Station and the ratio of population is also significantly higher. In order to ensure the distribution of commerce, government, etc. and a good living environment, the land readjustment is being underway in the south and west of Meinohama Station.

(2) Nishi-Nippon Railroad Co., Ltd.

From Jan. 2009, the railway stations in Nishi-Nippon Railroad of Fukuoka is listed in the table below (see Table 2.3) There are two Nishi-Nippon Railroad Lines in

Fukuoka. The Tenjin Omuta Line plays a subject role connecting the Kurume city and Omuta city. Another line is the Kaizuka Line which connects the eastern and northern suburbs and Shingu Street of Fukuoka. Since the year of 2007, stations behind the Nishitetsu Shingu Station, the line that connects the Fukuma Station and Tsuyazaki Station was stop to use because of less passengers and slower growth of passengers in 2007.

Table 2.3 Outline of Nishi-Nippon Railroad Co., Ltd

Route		Station	Address	Lim. Exp.	Exp.	Opening Year	Building Type	Home Type	Distance (km)
Nishi-Nippon Railroad Co., Ltd.	Tenjin-Omuta Line	Nishitetsu Fukuoka	Tenjin, Chuo-ku, Fukuoka 2-chome	○	○	12-Apr-1924	Elevated	Cephalic 4 surface	0.8
		Yakuin	Chuo-ku, Fukuoka Shirokane 1-chome,	○	○	1-Jun-1927	Elevated	Relative 2 surface	1.0
		Nishitetsu Hirao	Chuo-ku, Fukuoka Hirao 2-chome	×	×	12-Apr-1924	Elevated	Relative 2 surface	1.1
		Takamiya	Minami-ku, Fukuoka Okusu 3-chome	×	×	12-Apr-1924	Elevated	Relative 2 surface	1.4
		Ohashi	Minami-ku, Fukuoka Ohashi 1-chome	×	○	12-Apr-1924	Elevated	Island 2 surface	1.8
		Ijiri	Minami-ku, Fukuoka Ijiri 5-chome	×	×	12-Apr-1924	Ground	Relative 2 surface	2.1
		Zassyonokuma	Hakata-ku, Fukuoka Mugino 4-chome	×	×	12-Apr-1924	Ground	Relative 2 surface	1.5
	Kaizuka Line	Kaizuka	Higashi-ku, Fukuoka Hakozaki 7-chome	-	-	10-Apr-1950	Ground	Island 1 surface	1.4
		Najima	Higashi-ku, Fukuoka Najima 3-chome	-	-	23-May-1924	Ground	Island 1 surface	1.1
		Nishitetsu Chihaya	Higashi-ku, Fukuoka Chihaya 4-chome	-	-	15-Jun-1951	Elevated	Island 1 surface	0.5
		Kashiimiyamae	Higashi-ku, Fukuoka Chihaya 5-chome	-	-	1-Mar-1959	Elevated	Island 1 surface	0.6
		Nishitetsu Kashii	Higashi-ku, Fukuoka Kashiiekimae 2-chome	-	-	23-May-1924	Elevated	Island 1 surface	1.4
		Kashiikaenmae	Higashi-ku, Fukuoka Kashiikaenmael 6-chome	-	-	1-Jan-1939	Ground	Relative 2 surface	1.1
		Tonoharu	Higashi-ku, Fukuoka Wajiro 4-chome	-	-	1-Nov-1986	Ground	Island 1 surface	1.1
		Wajiro	Higashi-ku, Fukuoka Wajiro 3-chome	-	-	24-Jan-1905	Ground	Relative 2 surface	1.8
		Mitoma	Higashi-ku, Fukuoka Miwadai 4-chome	-	-	1-Jul-1925	Bridge	Relative 2 surface	2.0

The Tenjin Omuta Line was opened in 1924, after that, new stations in Fukuoka City are not set later. As the elevated between the districts of Tenjin and Ohashi and land readjustment projects in Ohashi Station and Takamiya Station, surrounding development is carried out actively so that the Ohashi station has been positioned as a sub-center of Fukuoka City.

In addition, as the elevated of Kashi area, the Nishitetsu Kashii Station, Kashiimiyamae Station and Nakano Station (today is Nishitetsu Chihaya Station) has become elevated stations and the Meinoshima Station has been reconstructed. The Chihaya area is gradually becoming a sub-center of east district due to large-scale land readjustment.

- **Railway-related business of Nishi-Nippon Railroad Co., Ltd.**

1) Regard to the elevated railways

(Between Hirao Station and Ohashi Station)

The elevated railway project was established in 1968, and completed in 1978. Totally 22 crossings, including 15 crossings from Hirao Station to Ohashi Station and 7 new highways were made three-dimensional by the project. Traffic chaos and accident in the crossing areas were solved because of the opening of the elevated railways. And the elevated railways also promoted the development of Takamiya, Noma and Shiobara districts, which are divided by the railway. Especially, because Shiobara district has promoted the land planning readjustment project, parts of fast trains stop at Ohashi Station, and meanwhile, this district has been developed vigorously as the sub-center of the north part of this city.

(Between Fukuoka Station and Hirao Station)

The elevated part of the railways is from Fukuoka Station to Hirao Station, the distance of which is 1700 m, and has been started from 1982 and completed in 1995. Thanks to this project, 9 crossings in the districts have been abolished, and crossing accidents were solved, and traffic congestions were softened at the same time. After the complement of the project, Continuous grade separation was realized in the 9.4 km distance from Fukuoka Station to Ohashi Station.

2) Regard to land readjustment project

(Land readjustment project of Shiobara district)

Overview of business

Sector decision date: Nov. 6th, 1968

Announcement date of business plan decision: Mar. 20th, 1972

Announcement date of allocated land disposal: Jan 5th, 1987

Area of the enforcement: 153.9ha

Period of the implementation: Mar., 1972 – Mar., 1993 (The settlement money collection affairs issued since Mar., 1987)

3) Regard to urban development projects

(Urban redevelopment project of Takamiya district)

Takamiya district locates 3 miles south of the city center – Tenjin area, west of Takamiya Station of Nishitetsu Omuta Line, and major arterial road - Nagahama-Dazaifu Line runs through this area, which is the life center locates in the south of hub area of transportation. The old lower-rise wood houses and the shops are mixed, which caused many problems in disaster prevention. In addition, because of the incompletion of public facilities and the characteristic of the traffic bottleneck of the district, the shopping centers are extended towards countryside with the business functions are more and more concentrated, and the streets in the city center are expanded, and the foundations in this area are not perfect due to its uncompleted industry constitution and store configuration.

Area of the enforcement: about 1.9ha

Enforcement business year: 1980--1988

Facility building: redevelopment building - Peer Takamiya

(3) Fukuoka City Subway

From Jan. 2009, the overview of subways of JR Kyushu in Fukuoka City is shown in the table below (see Table 2.4). There are totally three subway lines presented. The running trains on the road was discontinued and transferred into the subways. With the formation of subways, the capacity for transportation has been improved and the subways have become an important land vehicle for people's life. In addition, for a more convenient access to the city center, exploring the downtown is prevailing. The Airport Line has become a major route in the subway lines which includes two centers as the Hakata and Tenjin areas, thriving commerce and business areas around the Gion and Nakasu Kawabata Areas. The Airport Line is also stretching to the west suburban residential areas and has the most users. Due to the phenomenon of city center regression in recent years, it will become more and more important.

Table 2.4 Outline of Fukuoka City Subway

Route		Station	Address	Lim. Exp.	Exp.	Opening Year	Building Type	Home Type	Distance (km)
Fukuoka City Subway	Airport Line	Meinohama	Nishi-ku, Fukuoka Meinohama 4-chome	-	-	15-Apr-1925	Elevated	Island 2 surface	1.5
		Muromi	Sawara-ku , Fukuoka Muromi 5-chome	-	-	26-Jul-1981	Ground	Relative 2 surface	0.8
		Fujisaki	Sawara-ku , Fukuoka Momochi 2-chome	-	-	26-Jul-1981	Ground	Relative 2 surface	1.1
		Nishi	Fukuoka City , Sawara-ku, Nishi 2-chome	-	-	26-Jul-1981	Ground	Island 1 surface	1.2
		Tojinmachi	Chuo-ku, Fukuoka Kuromon	-	-	26-Jul-1981	Ground	Island 1 surface	0.8
		Ohorikoen	Chuo-ku, Fukuoka Otemon 3-chome	-	-	26-Jul-1981	Ground	Relative 2 surface	1.1
		Akasaka	Chuo-ku, Fukuoka Akasaka 1-chome	-	-	26-Jul-1981	Ground	Island 1 surface	0.8
		Tenjin	Tenjin, Chuo-ku, Fukuoka 1-chome,	-	-	26-Jul-1981	Ground	Island 1 surface	0.8
		Nakasu Kawabata	Hakata-ku, Fukuoka Kamikawabata	-	-	20-Apr-1982	Ground	Island 2 surface (Multilayer)	1.0
		Gion	Hakata-ku, Fukuoka Gion town	-	-	22-Mar-1983	Ground	Island 1 surface	0.7
		Hakata	Hakata-ku, Fukuoka Hakataekichuogai	-	-	22-Mar-1983	Ground	Island 1 surface	1.2
		Higashi-hie	Hakata-ku, Fukuoka Higashihie 2-chome	-	-	3-Mar-1993	Ground	Island 1 surface	2.1
		Fukuoka Airport	Hakata-ku, Fukuoka Oaza Shimousui	-	-	3-Mar-1993	Ground	Island 1 surface	-
	Hakozaki Line	Gofukumachi	Hakata-ku, Fukuoka Tsunaba town	-	-	20-Apr-1982	Ground	Island 1 surface	0.7
		Chiyo Kenchoguchi	Hakata-ku, Fukuoka Chiyo 4-chome	-	-	27-Apr-1984	Ground	Island 1 surface	0.9
		Maidashi Kyudaibyoinmae	Higashi-ku, Fukuoka Maidashi 2-chome	-	-	27-Apr-1984	Ground	Island 1 surface	0.8
		Hakozakimiyamae	Higashi-ku, Fukuoka Maidashi 4-chome	-	-	31-Jan-1986	Ground	Island 1 surface	0.8
		Hakozaki Kyudaimae	Higashi-ku, Fukuoka Hakozaki 3-chome	-	-	31-Jan-1986	Ground	Island 1 surface	1.0
		Kaizuka	Higashi-ku, Fukuoka Hakozaki 7 -chome	-	-	10-Apr-1950	Ground	Island 1 surface	-
	Nanakuma Line	Tenjinminami	Tenjin, Chuo-ku, Fukuoka 1-chome,	-	-	3-Feb-2005	Ground	Island 1 surface	0.7
		Watanabedori	Chuo-ku, Fukuoka Watanabedori 1-chome,	-	-	3-Feb-2005	Ground	Island 1 surface	0.5
		Yakuin	Chuo-ku, Fukuoka Shirokane 1-chome,	-	-	3-Feb-2005	Ground	Island 1 surface	0.6
		Yakuin Odori	Chuo-ku, Fukuoka Yakuin 4-chome	-	-	3-Feb-2005	Ground	Island 1 surface	1.0
		Sakurazaka	Chuo-ku, Fukuoka Sakurazaka 3-chome	-	-	3-Feb-2005	Ground	Island 1 surface	0.9
		Ropponmatsu	Chuo-ku, Fukuoka Ropponmatsu 4-chome	-	-	3-Feb-2005	Ground	Island 1 surface	0.8
		Befu	Jōnan-ku , Fukuoka Befu 2-chome	-	-	3-Feb-2005	Ground	Island 1 surface	1.0
		Chayama	Jōnan-ku , Fukuoka Chayama 1-chome	-	-	3-Feb-2005	Ground	Island 1 surface	0.8
		Kanayama	Jōnan-ku , Fukuoka Kanayamadanchi	-	-	3-Feb-2005	Ground	Island 1 surface	0.8
		Nanakuma	Jōnan-ku, Fukuoka Nanakuma 4-chome	-	-	3-Feb-2005	Ground	Island 1 surface	0.6
		Fukudai mae	Jōnan-ku , Fukuoka Nanakuma 8 -chome	-	-	3-Feb-2005	Ground	Island 1 surface	0.9
		Umebayashi	Jōnan-ku , Fukuoka Umebayashi 4-chome	-	-	3-Feb-2005	Ground	Island 1 surface	0.8
		Noke	Fukuoka City , Sawara-ku, 2-chome, vignetting	-	-	3-Feb-2005	Ground	Island 1 surface	0.9
		Kamo	Fukuoka City , Sawara-ku, Kamo 3-chome	-	-	3-Feb-2005	Ground	Island 1 surface	0.7
		Jiromaru	Sawara-ku , Fukuoka Jiromaru 4-chome	-	-	3-Feb-2005	Ground	Island 1 surface	1.0
		Hashimoto	Nishi-ku, Fukuoka Hashimoto 2-chome	-	-	3-Feb-2005	Ground	Island 1 surface, Single 1 surface	-

The Hakozaki Line mainly includes government agencies, education and welfare facilities and hospitals, such as the Kyushu Prefecture Hall, Hakozaki campus of Kyushu University. In addition, the Kaizuka station is the connection line of Nishitetsu Kaizuka presented a outstanding characteristic on working and studying.

The Nanakuma Line was opened in 2005 including residential areas of southwest of Fukuoka. However, the development around the station is not so active because of the low ratio of passengers. Furthermore, the transit from Tenjin station to Tenjin Minami Station is not so convenient. The future plan is stretching the subway lines and improving the exploitation of the Nanakuma Line.

- **Railway-related business in Fukuoka City Subway**

1) Urban redevelopment project of Chiyo district

Chiyo distric is about 2 miles away from the city center – Tenjin area, which is treated as the gateway of the city center for the traffic from Munakata, Kasuya and Chikuho direction since prewar time to the early 1950s. Meanwhile, it becomes prosperous, as it is the business and entertainment center of the east Fukuoka city. However, some years later, commercial and business center has transferred to Tenjin and Hakata areas, which made surrounding of Chiyo area begin to regress. In addition, the energy revolution of coal and petroleum fastened the regression of this area, which connected Kasuya and Chikuho areas.

In addition, this district survived in the war, so the layout of street stays in prewar style, which makes the old wood houses densely. And also, because the traffic is concentrated in this district, the problem such as the poor living environment and preventing from disasters often appears.

In this situation, the transferring plan, which was put forward in 1977, became the development opportunity of Chiyo district. This project aimed to begin from Nov. 1978 and end at autumn of 1981. In addition, renovation opportunity appears due to the configuration materialization of sites of subway line 2, so petition was presented to the city government.

With the consideration of the difficult of disaster prevention of the old street full of wood houses n this district, the beautification of the environment, and also there are relationship between construction of new prefectural government building, the government decided to build symmetrical street in the surrounding of the new prefectural government building. Therefore, since 1978, the government began to

redevelop the urban redevelopment project.

"Papillon 24"

The project was completed in July 1988, and in Aug 25th in the same year, the station opened in the name of "Papillon 24", which was conceived for 10 years. From location, the project "Papillon 24" is directly connected with Chiyo-kenchoguchi Station and connected the east Fukuoka with the city center, so that the number of passengers increased quickly, and it is believed that this district can play an important role in the development of Chiyo area.

Area of the enforcement: 1.3ha

Enforcement business year: 1982 – 1988

- **The railway-related business in Fukuoka**

In 1987, around the privatization of state-owned railway, new JR stations grow continually. In addition, due to the redevelopment after 1990, land planning readjustment projects carried out heavily. Until now, there are many places around the stations are redeveloping and carrying out the land planning readjustment projects.

In the reconstruction of the station, it involves with the project of the elevated railways and land readjustment. Station mansion are building in some bigger stations such as Kashii, Chikuzen Shingu, Minami-Fukuoka Station (see Table 2.5).

Table 2.5 The Development Project of Railway and Subway Stations in Fukuoka

Year	Projects on Railway and Subway Stations in Fukuoka	Foundation of New Stations	Reconstruction of Stations
1981			Meinohama
1982			
1983			
1984		Kashijingu	
1986		Sasabaru and Shimoyamato	Kaizuka
1988	the Determination of Planning Project on Meinohama District	Kyusandai mae	
1990	the Determination of Redevelopment Project on Urban Areas of Tenjin District		
1991	the Determination of Redevelopment Project on Urban Areas of Shimokawabata District		
1992	the Determination of Land Planning and Consolidation Project on Hakozaki District		
1992	the Determination of Land Planning and Consolidation		

	Project on Kashii Second-central District		
1993	the Starting of Extension Project on Kuko Line in Subway (Hakata to Fukuoka Airport)	Maimatsubara	
1994	the Determination of Redevelopment Project on Urban Areas of the East Shimokawabata		
1996	the Determination of Development Project on Urban Areas of the East Shimokawabata		Kashii and Yakurin
1997	the Determination of Land Planning and Consolidation Project on Areas around the Kashii Station		Sasabaru, Minami Fukuoka and Nishitetsu Fukuoka
2003	the Elevated Accomplishment of JR Kagoshima Main Line and Sasaguri Line (Chikuho to Yoshizuka area)	Chihaya	Chikuzen Shingu
2003	the Accomplishment of Land Planning and Consolidation Project on Meinohama District		Hakozaki, Yoshizuka, Najima and Nishitetsu Chihaya
2004	the Determination of Three-dimensional Urban Planning Project on Traffic Square of Hakata Station		
2004	the Elevated Accomplishment of JR Kagoshima Main Line (Kashii to Yoshizuka)		
2004	the Determination of Land Planning and Consolidation Project on North of the Watanabe Station		
2005	the Accomplishment of New Tenjin Underground Street	Kyudaigakkentoshi	
2005	the Opening of Nanakuma Line in Subway (Hashimoto to Tenjin Minami)		

Since late 1980s till now, large number of projects related to railway has been developing, such as public railway privatization, new station setting, subway Airport Line and Hakozaki Line opening, land readjustment project, urban street redevelopment, subway Nanakuma Line opening and so on. These projects are connected with railway network of Fukuoka, which made the construction of Fukuoka city changed.

2.2.3 Setting of the Influence Sphere of Stations

This research mainly focuses on changes of land use in the sphere of each station and comparison for changes on distance. The most convenient method for this study is to set station zones. There are about 1,100 chomes existed In Fukuoka. In recent years, that number is increasing as the addresses are also changing. The study uses the GIS to integrate data, a geographic information system (GIS) is a "computer-based system for the integration and analysis of geographic data." It is a part of a "larger constellation of computer technologies for processing geographical data." The GIS software stores locations of features on the earth's surface to allow identification of different features on the same location. However, integration of GIS data has been more difficult, and information from the Internet and various materials is limited, so errors have been avoided as much as possible. (see Fig. 2.3).

For the setting of stations, from January 2009, there are 74 stations in Fukuoka City (except the Shinkansen, bullet train). The goal of this study is to analyze changes of land use by urban development with a focus on the station, within walking distance of the station; the range of 800-metre (800m) radius (within a 10-minute walk) from the station is set as a station zone. In order to identify the station by using data from the railway station of GIS, the circle of 800m radius from the center point of the station is set, which is in relation to the spatial location of chome. The step is as follows, firstly, the chome is overlap with the buffer circle; secondly, the chome should be included in the full circle of the buffer; thirdly, the center of the buffer is the station.

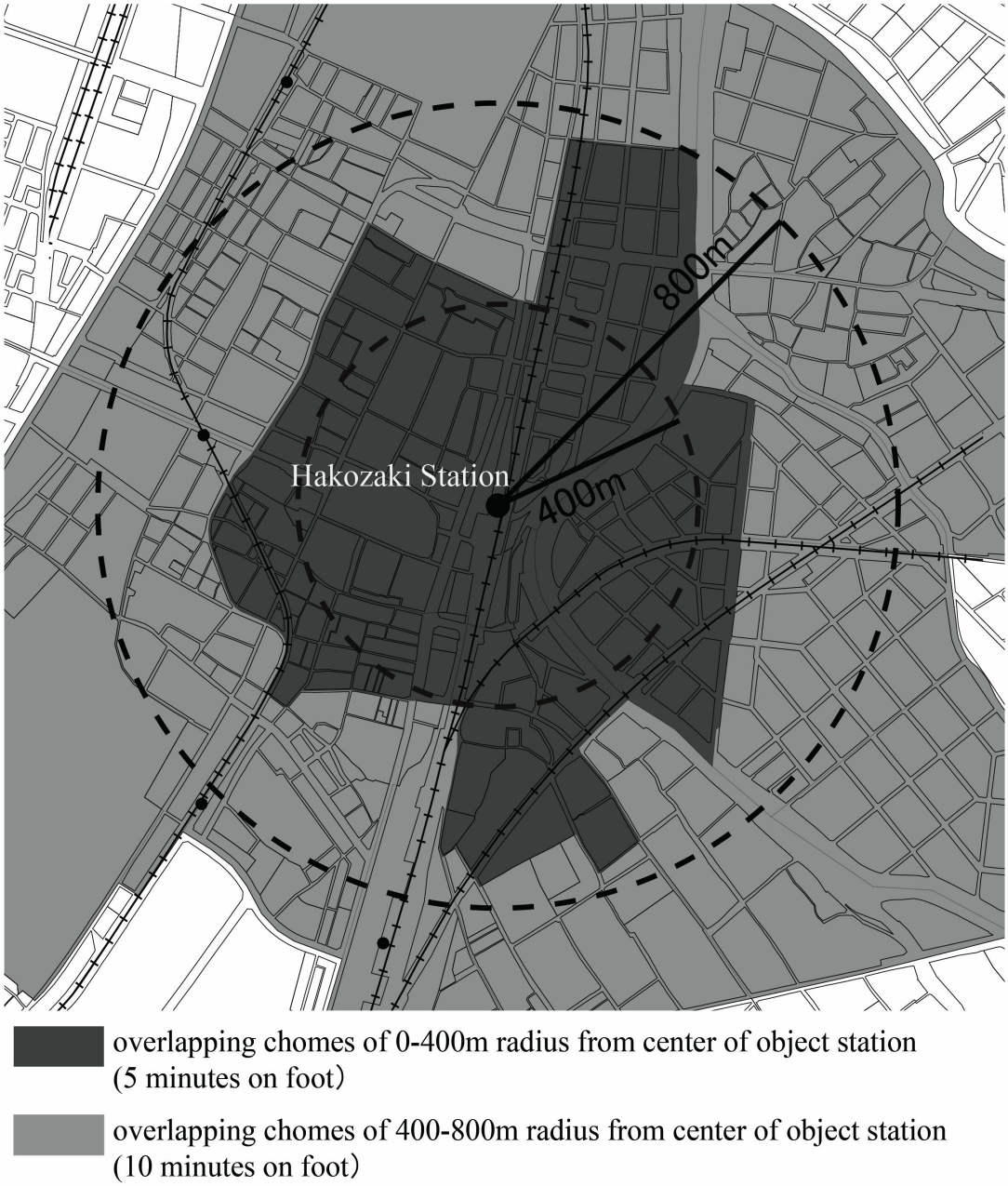


Fig. 2.3 Setting of influence sphere of stations

2.3 OVERVIEW OF DATA

Data that are used in this research are the data of land use and building usage, which use the POSMAP (from data of land use and building use) in the four periods of (1985, 1993, 1998, 2003,2008) at each station and the GIS (Geographic Information System) to extract each land use and building use. The data of population and number of households, which are from the census of population of Fukuoka city and in units of chome (the chome is a very special street unit in Japan, actually, the "cho" in Japanese is a kind of unit for streets; and the "me" in Japanese presents the No., so, the 1 Chome means the first Avenue) at the time of 1985, 1990, 1995, 2000, 2005, 2010. The numbers of passengers, which are referred to the statistical books of Fukuoka and data of all routes of JR and Japanese western railways totaling for 36 years are collected from 1975 to 2011.The data of the Fukuoka city subway were collected up from the opening year 1981 to 2011 totaling for 30 years. The data of survey for prefectural land price and public reviewing land prices, which are from National Land Numeric Information Download Service of the homepage of the Ministry of Land, Infrastructure, Transport and Tourism, are collected up to point data of 28 years from 1983 to 2011 in all. The data of architectural confirmation are ones of building confirmation of Fukuoka city from the year 1992 to the year 2004, totaling for 13 years. These data are all available and integrated by GIS. (see Table 2.6)

Table 2.6 Overview of Data

	Fukuoka Stations	Reference	Unit	Year
Number of Passengers	Kyushu Railway	Statistic Book	Stations	1975-2012
	Nishi-Nippon Railroad	Statistic Book	Stations	1975-2012
	Municipal Subway	Statistic Book	Stations	1981-2012
Generation and Population		Census	Towns & Chomes	1985, 1990, 1995, 2000, 2005, 2010
Land Use and Building Usages		POSMAP	Towns & Chomes	1985, 1993, 1998, 2003,2008
Official Land Price		Land Value Information	Point	1983-2010
Investigation of Land Price		Land Value Information	Point	1983-2010
Data of Architectural Confirmation Application		Fukuoka City	Point	1992-2008

The data of generation and population comes from the Population Report of Fukuoka; the source of data of land use and building usage is from POSMAP; the data of land price comes from the Land Value Information. Basic data are collected by towns and chomes, official land price, investigation of land price and data from the architectural confirmation application.

2.4 SECULAR CHANGE IN AND OUTSIDE THE STATIONS CIRCLES

2.4.1 Changes of the Stations Circles

(1) Stations circles in 1985

The figure below is the station zone of Fukuoka City in 1985, which overlaps with the Y-shaped structure of Fukuoka city, had spread very huge. Some parts of the station zone had fault areas in the suburbs. In addition, the southwestern part of Fukuoka City that had huge residential areas was removing outside the southwestern station zone of Fukuoka City. These areas would become the main direction of the bus or car movement (see Fig. 2.4).

(2) Station circles in 2005

The figure below is the station zone of Fukuoka City in 1985, which was based on the Y-shaped structure of Fukuoka City, had been always increasing since the opening of Nanakuma Line of Fukuoka Subway in 2005. Furthermore, the station zone had ever broken in 1985, but become integral again in 2003 (see Fig. 2.5).

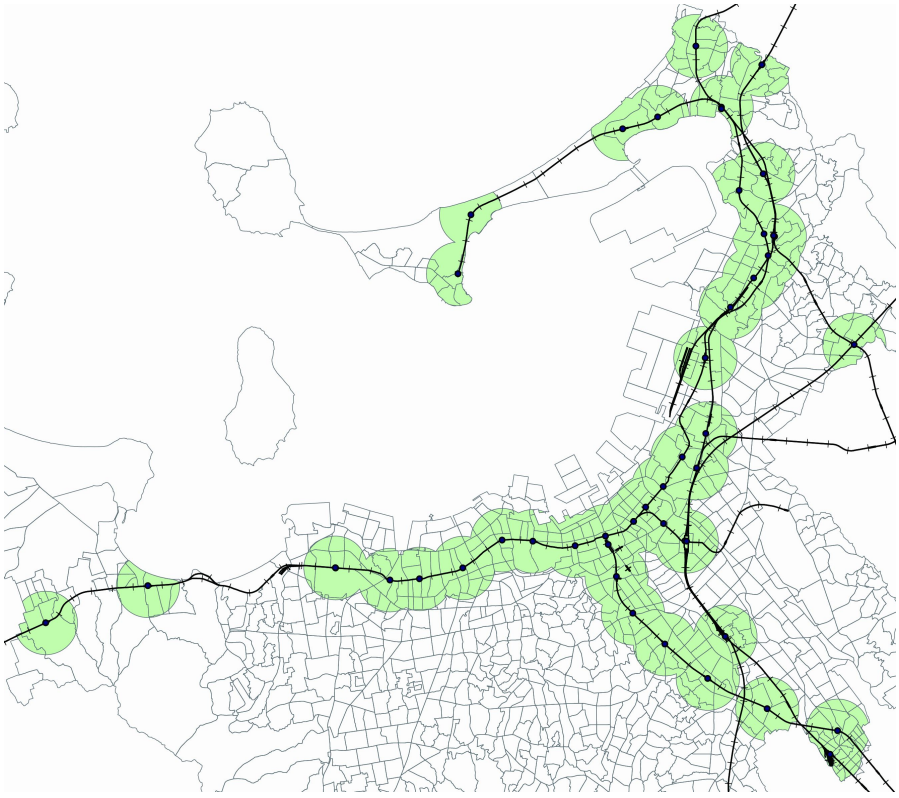


Fig. 2.4 Distributions of the station zones in the year 1985

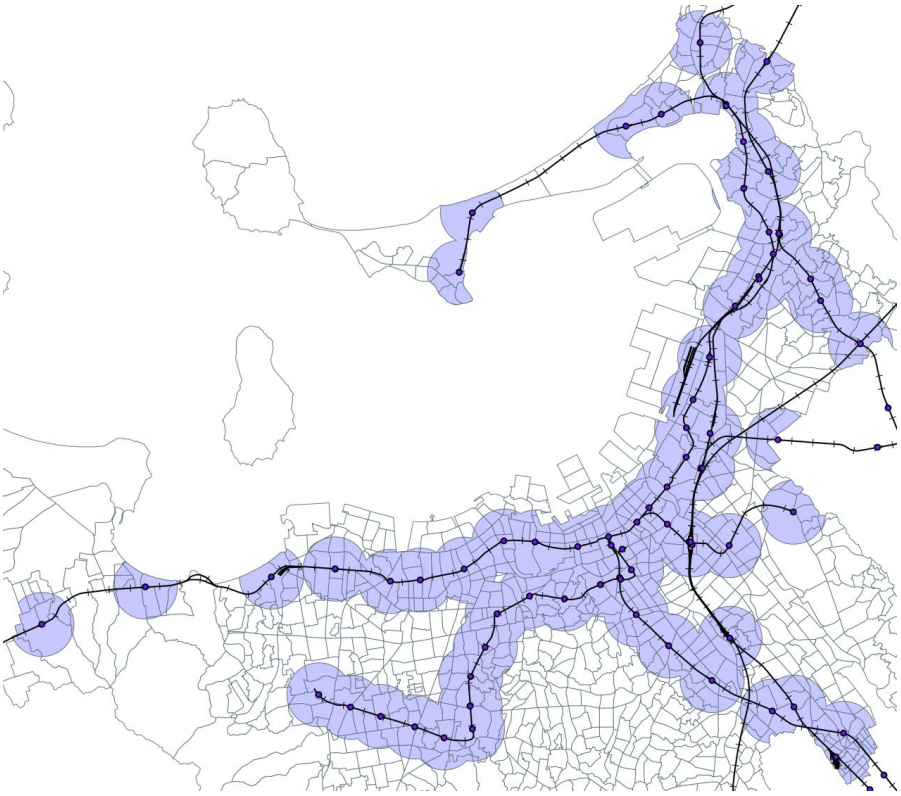


Fig. 2.5 Distributions of the station zones in the year 2005

(3) Changes on the population and area of the station circle

Areas extended quickly from 1985 to 1996. In 1996, about 30% of the total urban areas, which are also 70% of population concentrated areas, had become station business circles. In addition, due to the opening of the Nanakuma Line, houses in the southwest of the city which were not connected with railway had been added to this range, which made the areas of the station business circles achieved 40% of the total urban area, and 90% of population concentrated districts, and urban streets had been basically involved in the station business circles (see Table 2.7).

Table 2.7 Changes of the station circle

Change of Sphere of Stations	1985	1995	2000	2005
Population of Sphere of Stations (%)	552,526	710,932	745,002	966,883
Ratio of Population (%)	47.6	55.3	55.5	69.0
Sphere (km^2)	89.7	104.1	108.4	136.4
Ratio of Total Sphere (%)	26.6	30.8	31.9	40.1
Ratio of Densely Inhabited District (%)	67.2	70.5	72.7	90.7

2.4.2 Changes on Population in Fukuoka

The population of Fukuoka increased year by year, and appeared the trend of returning back to city center. In addition, the passengers began to decrease after achieving the peak in 1996. However, passengers increased as the Nanakuma Line opened.

From each line respectively, we can see that the passengers of JR line increased dramatically after 1985, but decreased after achieved the peak in 1996. The passengers of Nishitetsu Railway Line were surpassed by that of JR Line after achieved the peak in 1991, after that, the difference expanded gradually. In addition, passenger of Fukuoka City Subway opened in 1981, climbed to 350000 in 1985, which surpassed the other two lines and became the one with the most passengers. And passengers further increased after the Nanakuma Line opened in 2006. It can be seen that passengers of all companies began to decrease after achieved the peak in around 1996, and there appeared a trend that people were far away from the railway year by year. There appeared a trend that people are far away from the railway

because cars are more convenient due to the facility of urban highway and trunk roads in and outside the urban areas, and also the constructions of shopping mall are proceeding accordingly (see Fig. 2.6).

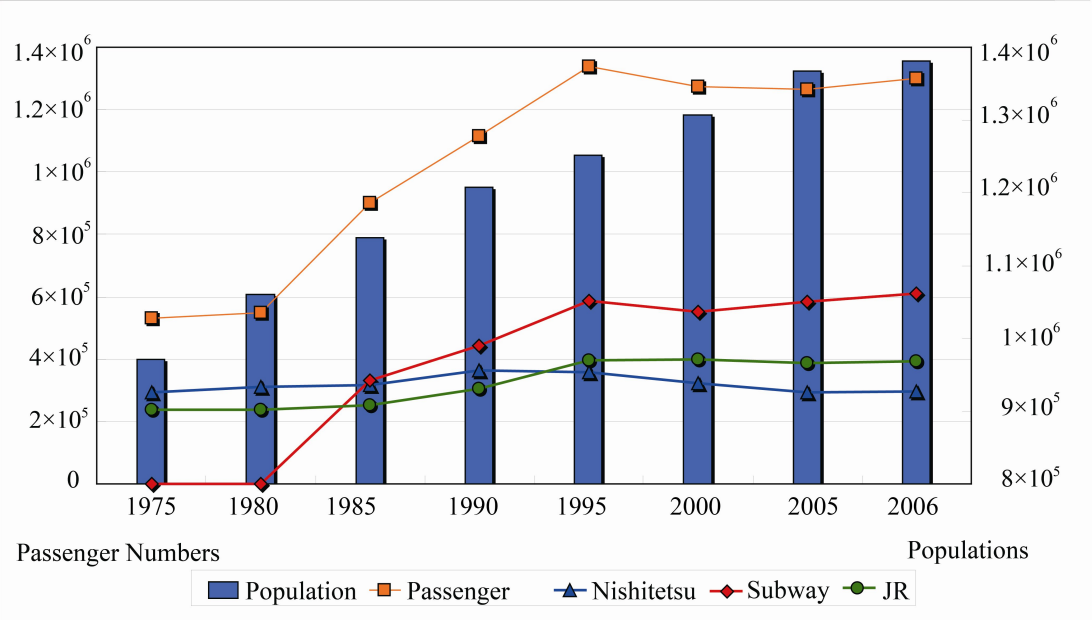


Fig. 2.6 Total population and passengers amount of each line of Fukuoka city

2.4.3 Development Trends and Changes in Land Use and Building Use in and outside the Station Circle

(1) Changes on land use

As for the ranges within radius of 400m of stations, from 1985 to 2004, the proportion of residential site increased dramatically, and there appeared a trend of developing land for residential use. Meanwhile, considering using land for residential and road site, the proportion of land use in agriculture and forest decreased (see Table 2.8).

Table 2.8 Changes of land use of the Station Zones

Category	Year	Commerce	House	Government & Education	Industry	Transportation	Park	Agriculture	Forest	Road
0~400m	**1985**	7.7	24.9	9.1	1.7	5.0	7.6	7.4	6.3	15.2
	1993	7.2	27.7	9.7	1.7	5.3	6.0	5.5	7.0	14.1
	1998	7.4	29.8	8.8	1.5	4.6	7.2	4.9	6.1	16.2
	2003	7.1	30.6	9.4	1.2	4.6	7.2	4.1	5.8	16.7
	2008	7.5	32.3	9.6	1.4	4.9	7.1	4.2	5.5	17.1
400~800m	**1985**	5.9	23.5	4.8	2.0	2.7	2.9	10.6	14.5	13.9
	1993	5.7	27.6	6.0	2.8	3.4	3.1	7.9	14.2	15.0
	1998	6.0	27.0	5.3	2.3	3.5	4.5	6.4	17.2	14.5
	2003	5.8	25.9	5.2	1.9	4.1	4.6	5.0	15.2	14.3
	2008	5.5	25.2	5.4	1.8	4.3	4.9	4.9	14.9	13.9
800m~	**1985**	1.9	8.6	1.8	0.7	0.8	3.1	15.3	51.1	7.8
	1993	2.0	10.5	2.2	0.9	0.8	2.4	13.6	52.2	6.3
	1998	2.4	11.8	2.2	0.8	1.4	3.2	13.2	49.4	6.8
	2003	2.3	11.6	2.2	0.7	1.6	3.3	11.8	50.9	6.8
	2008	2.2	12.3	2.2	0.8	1.5	3.5	11.9	49.9	6.4

Comparing the range of less than radius of 400m with the range between radius of 400m to 800m, the nearer the area apart from the station, the higher the proportion of commercial use land will be, the proportion of residential site increased dramatically, and land around the stations became residential obviously.

Furthermore, in the respect of government and educational welfare, park and green space, it appears an atmosphere of high proportion within 400 m apart from stations, and configuration of facilities in this area should be more complete than that of 400 - 800 m apart from stations, that is to say facilities are configured for an area with an radius of 400m apart from the stations.

Considering urbanization control area out of station circles, land proportion of agricultural site and mountain forest site was relatively high, but land proportion related to agricultural site decreased. All of the agricultural land had been used for residential and commercial use after development.

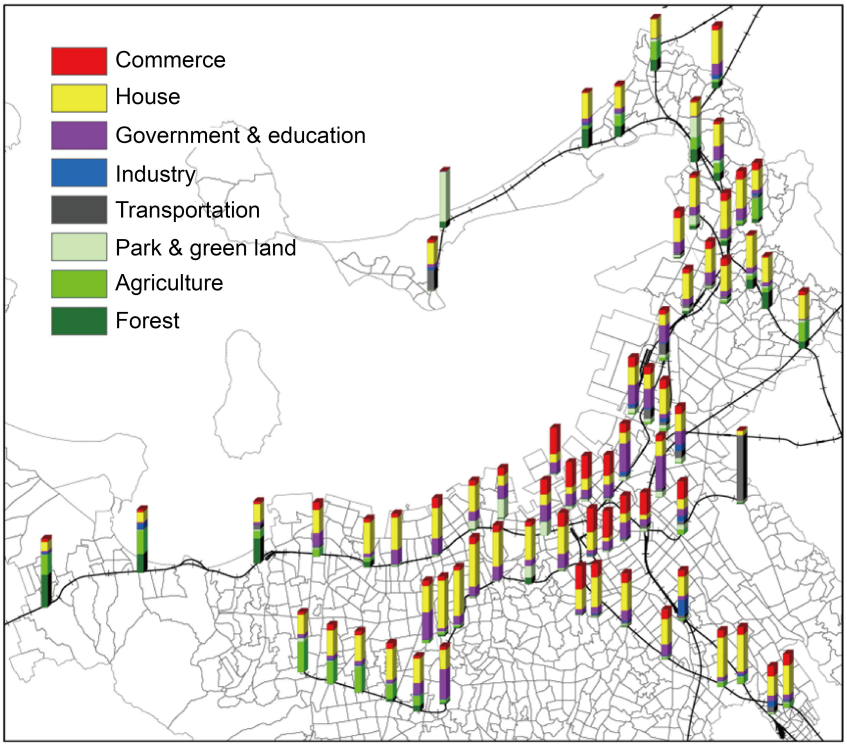


Fig. 2.7 Proportion of Land Use in 1985

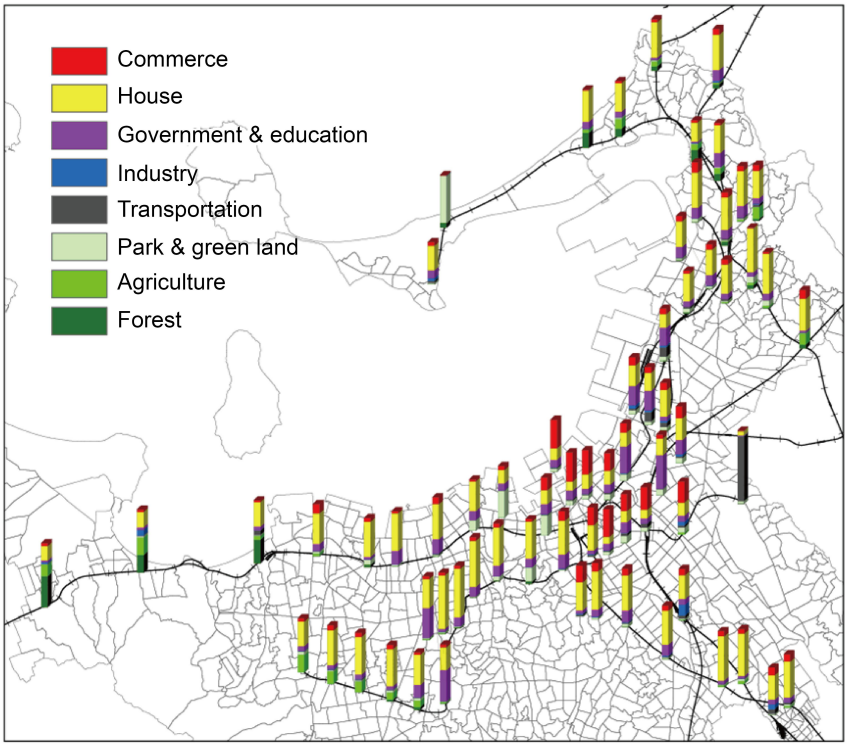


Fig. 2.8 Proportion of Land Use in 2003

These figures above show the proportion of Land Use within Influence Sphere of Stations in 1985 and 2003. (See Fig. 2.7 & 2.8)

The Fig. 2.7 shows the proportion of land use within influence sphere of stations in 1985.

The red bar shows the commerce

The yellow bar shows the house

The purple bar shows the government and education

The blue bar shows the industry

The grey bar shows the transportation

The light green bar shows the park and green land

The green bar shows the agriculture

The deep green bar shows the forest.

It can be seen from the Fig. 2.7 that there is an increment in "House" and reduction in "Commerce" in city center and areas along railway lines. And there is also an increment in "Park & green land" in city center and a reduction in "Agriculture" in suburbs.

And Fig. 2.8 shows the one in 2003. It can be seen from the comparison of these 2 years. The park and green land increased in city center, and agriculture reduced in suburbs. And we can conclude that the house increased and commerce reduced in city center and areas along railway lines.

(2) Changes on building usage

From the year 1985 to 2008, according to the proportion of detached houses and apartments, the detached houses are gradually reducing and apartments had a tendency of increasing which are seen in the distance of all segments. It is also noticeable that detached houses have reduced in double and apartments have increased in double from the center of the station to the range of 400m radius. However, in the range of 400m-800m radius and outside 800m radius, this situation is different from the frontier one. The changing trend of detached house and apartments in the range of 400m-800m and outside 800m has been slow. In the range of stations zones, there are short reverse bias in the proportion of detached houses and apartments. Whereas that, outside the station zone, there is still a characteristic that a high proportion of detached houses exist (see Table 2.9).

Table 2.9 Changes of Building Usages of the Station Zone

Category	Year	Business & Hotel	Entertainment	Detached House	Condominium	Government & Education	Transportation	Industry	Plot Ratio	Human Occupancy
		%								person/km^2
0~400m	**1985**	15.5	6.4	30.0	23.2	17.4	2.9	3.6	52.4	5240
	1993	15.7	8.1	19.2	35.5	16.8	2.4	2.2	56.0	5600
	1998	14.7	6.6	18.3	43.1	12.9	2.0	1.5	54.1	5410
	2003	14.9	7.2	16.7	43.6	12.8	2.4	1.4	58.3	5830
	2008	14.6	7.8	13.3	45.2	10.1	2.2	1.2	59.2	5920
400~800m	**1985**	10.1	3.1	33.9	25.5	11.5	9.1	5.5	37.0	3700
	1993	8.5	3.9	24.7	36.9	12.7	7.0	4.9	41.8	4180
	1998	9.6	4.1	23.6	43.2	8.7	5.9	3.5	38.6	3860
	2003	9.5	4.9	22.2	42.6	8.9	7.0	3.2	37.8	3780
	2008	9.8	4.7	20.0	48.5	7.9	7.8	2.9	26.5	2650
800m~	**1985**	7.4	3.7	43.3	20.0	11.9	6.9	4.3	9.1	910
	1993	6.3	4.1	38.8	26.4	12.9	4.7	4.0	11.3	1130
	1998	7.7	4.1	38.1	30.5	9.1	4.9	2.9	12.2	1220
	2003	7.2	5.0	36.6	30.9	9.3	4.7	2.9	11.9	1190
	2008	7.5	5.6	34.4	32.1	9.8	4.8	2.7	11.2	1120

The distributed tendency of commerce, business facilities, government agencies and education facilities are in a high degree in the center of stations, not only residential areas, but also other various buildings for different uses. The distributed tendency of transportation and warehousing facility are in a high degree in the 400m-800m radius and they are tended to be located slightly away from the center of stations. In addition, the trend of the plot ratio can be seen within 400m from the centre of stations and the development is in progress around stations. The trend of population density is increasing rapidly in the range within 400m radius from the center of the station, at the same time, it can also be seen that the proportion of mansions is in an increase.

(3) Changes on the development trend

It is shown that changes of development trend of the station zone in the table below (see Table 2.10). According to the development amounts of the station zone, there was a reducing trend from 1996. In addition, it can be seen that the proportion of the condominium is increasing year by year in building usages. As well as the reducing percentage change on the detached houses and the peaking of the condominium houses, the distance from the center of stations is spreading gradually and changes of percentage is becoming slower. With respect to the number of stores and restaurants, there are a certain slightly higher percentages from the center of stations to the distance of 400m and the difference in distance is smaller. Furthermore, the percentage of office amounts tends to increase from the center of station to the distance of 400m, although there has still been some slightly reduction, which is similar with the percentage of 2002 from 400m to 800m. It is shown that changes of development trend of the station zone in the table below (see Table 2.10).

Table 2.10 Changes of Development Amounts and Percentage of the Station Zone

Category	Building Usages	1994		1996		1998		2000		2002		2004	
		DA*	%	DA*	%	DA*	%	DA*	%	DA*	%	DA*	%
0~400m	Detached house	455	48.0	464	45.2	279	37.9	286	40.9	245	39.8	223	38.3
	Condominium	309	32.6	350	34.1	293	39.8	269	38.5	273	44.3	276	47.4
	Store	39	4.1	46	4.5	33	4.5	28	4.0	21	3.4	19	3.3
	Restaurant	11	1.2	20	1.9	15	2.0	14	2.0	7	1.1	6	1.0
	Office	89	9.4	75	7.3	69	9.4	60	8.6	36	5.8	22	3.8
	Total	948		1026		736		699		616		582	
400~800m	Detached house	774	57.5	765	56.1	574	54.5	599	53.4	427	46.4	382	47.4
	Condominium	407	30.2	437	32.1	348	33.0	401	35.7	353	38.4	320	39.7
	Store	19	1.4	30	2.2	29	2.8	22	2.0	28	3.0	26	3.2
	Restaurant	12	0.9	15	1.1	10	0.9	15	1.3	11	1.2	12	1.5
	Office	76	5.6	51	3.7	46	4.4	50	4.5	52	5.7	56	6.9
	Total	1346		1363		1054		1122		920		806	
800m~	Detached house	1820	69.4	1947	70.5	1251	61.5	1244	67.2	1107	66.9	1008	66.9
	Condominium	515	19.6	485	17.6	427	21.0	386	20.8	363	21.9	343	22.8
	Store	47	1.8	62	2.2	40	2.0	43	2.3	33	2.0	30	2.0
	Restaurant	12	0.5	26	0.9	13	0.6	24	1.3	17	1.0	13	0.9
	Office	112	4.3	104	3.8	77	3.8	70	3.8	53	3.2	49	3.3
	Total	2623		2763		2033		1852		1654		1506	

* DA: Abbreviation of "Development Amount"

According to the development amounts of the station zone, there was a reducing trend from 1996. In addition, it can be seen that the proportion of the condominium is increasing year by year in building usages. As well as the reducing percentage change on the detached houses and the peaking of the condominium houses, the distance from the center of stations is spreading gradually and changes of percentage is becoming slower.

With respect to the number of stores and restaurants, there are a certain slightly higher percentages from the center of stations to the distance of 400m and the difference in distance is smaller. Furthermore, the percentage of office amounts tends to increase from the center of station to the distance of 400m, although there has still been some slightly reduction, which is similar with the percentage of 2002 from 400m to 800m.

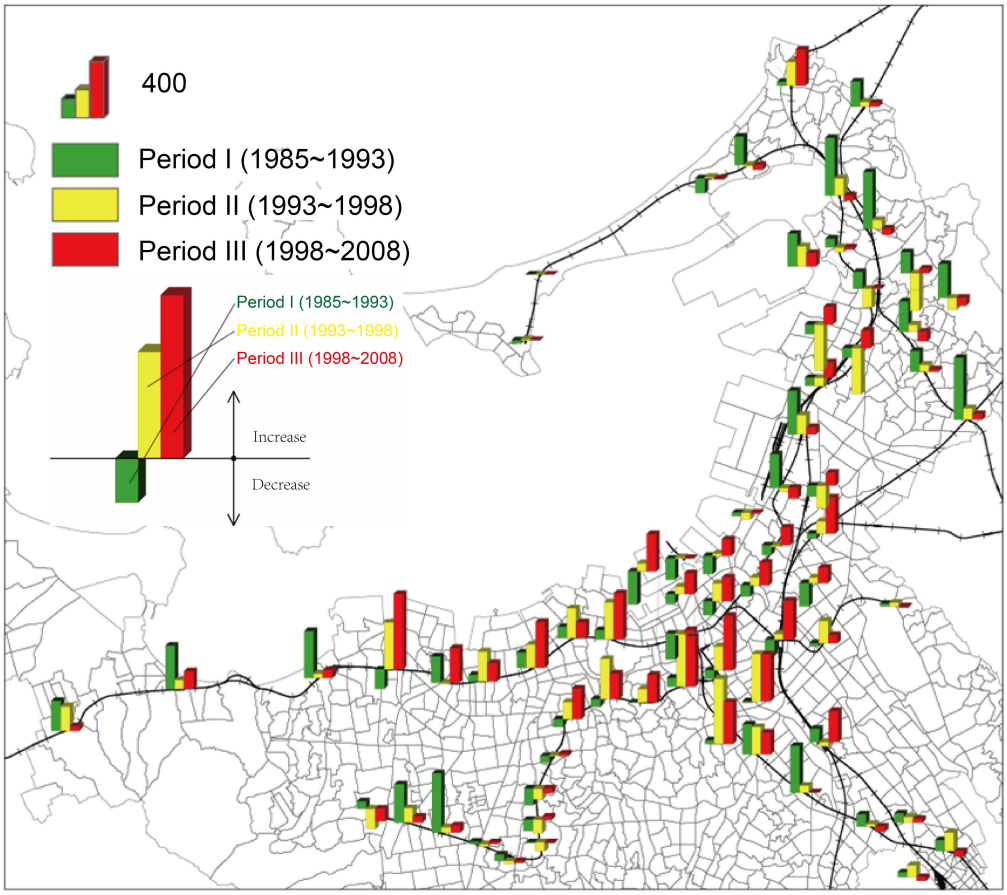


Fig. 2.9 Changes of development trend on the growth of population

This figure shows the average annual growth of population within the influence sphere of station during 3 periods. (See Fig. 2.9)

The green bar shows the annual growth of population in period one, which are introduced in the previous slide, from 1985 to 1993.

The yellow bar shows the one in period two, from 1993 to 1998

And the red bar shows the one in period three, from 1998 to 2008.

The bar above the horizontal line represents the increment.

The bar below the horizontal line represents the reduction.

We can see that increment of population in city center is happened in Period three, and the increment in suburbs is happened in Period one. Therefore, we can conclude that in recent years, the population growing phenomenon regressing from the suburbs to the city center has happened.

(4) Changes on development numbers and development area in and outside the station circle

From the proportion of development areas of inner and outer stations, comparing with the situation that the development proportion of outer station circles was about 45% in 1995, it can be seen that the proportion decreased in 2003 and the technology within an radius of 400 m around the station increased, then the development proportion of outer stations was 35%, and the development proportion within an radius of 400 m around the station was also 35%. We can see that the developing center is transferring to the areas within the radius of 400 m around the stations in recent years (see Fig. 2.10 and Table 2.11).

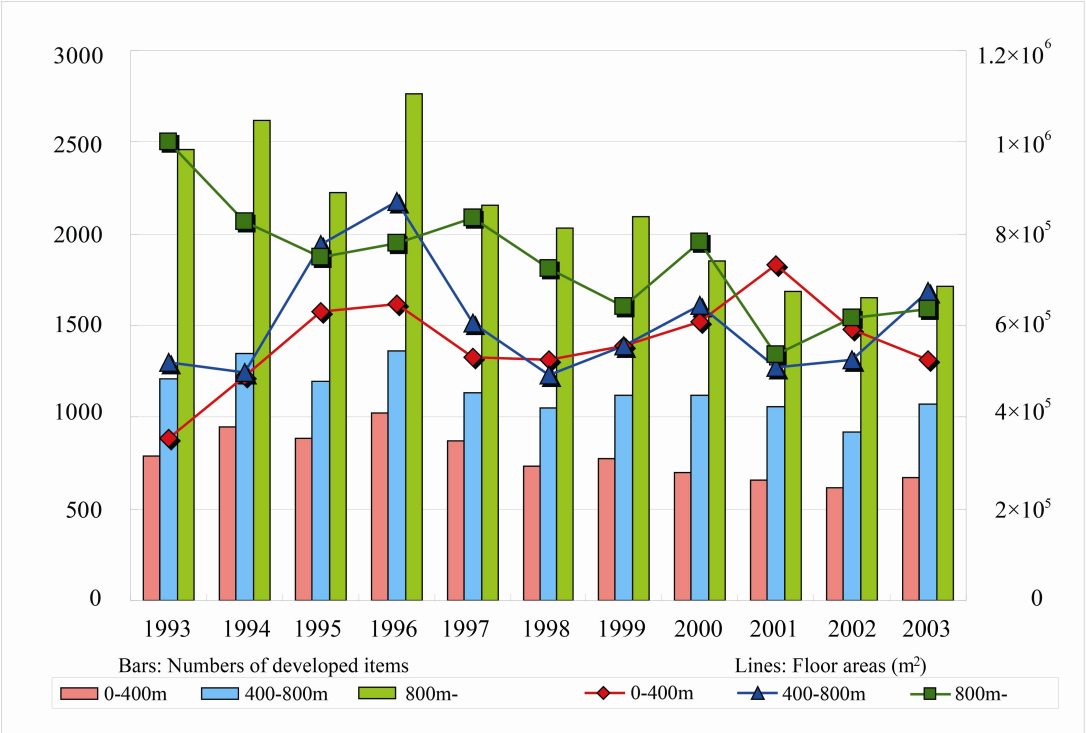


Fig.2.10 Change of development numbers of inner and outer station circle

Table 2.11 Change rate of development areas of inner and outer station circles (%)

Distance	1994	1996	1998	2000	2002	2004	2006	2008
0-400m	27	28.1	30.2	29.9	34.1	33.2	32.1	35.3
400-800m	27.4	37.9	28.3	31.7	30.3	34.2	33.2	30.6
Beyond 800m	45.5	33.9	41.5	38.4	35.6	32.1	36.3	40.2

2.5 CONCLUSION

Hermant (2012) has said that the design of railway station environments in South Africa and to a certain extent internationally, is based on rules of thumb. These rules, using general macroscopic principles for determining peak passenger loads are inadequate and misleading for detailed design purposes. The principles advocated in local design guideline documents are erroneous and ignore the highly variable flow nature or "micro-peaking" effects that typically occur within railway station environments. The railway situation of Fukuoka city is analyzed in this research, according to the collected material and data. It is clear that, comparing with the trend that the populations are increasing in Fukuoka City, the trend of passengers' amounts is decreasing. Furthermore, it also can be seen that developing center is transferring into the inner station circles, the proportion of detached houses is decreasing, and the proportion of tenement houses is increasing. Especially in the surrounding areas within a radius of 400 m of stations, the trend of building becomes obviously, which reflects the situation that more and more housings are built in the surrounding areas of the station. For about the passengers' amount, it appears a trend of decreasing in the whole. But for the respective view, the stations, which have been transformed, elevated and have relationship with the land readjustment project, increased. And there appears a trend of increasing after taking measures on these stations. By contrary, there appears the trend of passengers decreasing in the stations where no actions were taken. Therefore, these projects are very important for the passengers increasing and the developing of the surrounding sections.

REFERENCES

Alexander C A P. A fuzzy rule-based model for predicting precipitation in the Marion, Illinois station area [M]. Southern Illinois University at Carbondale, 2012.

Arnold O, Richter F, Fettweis G, et al. Power consumption modeling of different base station types in heterogeneous cellular networks[C]//Future Network and Mobile Summit, 2010. IEEE, 2010: 1-8.

Bafna, S. An introduction of space syntax. Environment and Behavior, Vol.35, 17-29, 2003.

Beckonert O, E Bollard M, Ebbels T, Keun H C, Antti, H, Holmes E, Nicholson J K. NMR-based metabonomic toxicity classification: hierarchical cluster analysis and k-nearest-neighbour approaches. Analytica Chimica Acta, 2003, 490(1): 3-15.

Bertolini L, Curtis C, Renne J. Station area projects in Europe and beyond: Towards transit oriented development [J]. Built Environment, 2012, 38(1): 31-50.

Bitter C, Mulligan G F, Dall'erba S. Incorporating spatial variation in housing attribute prices: a comparison of geographically weighted regression and the spatial expansion method. Journal of Geographical Systems, 2007, 9(1): 7-27.

Bodnár N, Kovács J, Török Á. Multivariate analysis of Miocene sediments: Rákóczi Square, new metro station area, Budapest, Hungary [J]. Central European Geology, 2011, 54(4): 391-405.

Capozza D R, Helsley R W. The fundamentals of land prices and urban growth. Journal of Urban Economics x, 1987, 295-306.

Cohen J P, Paul C M. The impacts of transportation infrastructure on property values: A higher-order spatial econometrics approach. Journal of Regional Science, 2007, 47(3): 457-478.

Damm D, Lerman S, Lerner-Lamm E, et a1. Response of urban real estate values in

anticipation of Washington Metro. Journal of Transport Economics and Policy, 2007, 14:315-336.

Curtner S, Flanders N, Greco M, et al. Opus Station Area Sustainable Development Plan [J]. 2010.

Farber S, Yeates M. A comparison of localized regression models in a hedonic house price context. Canadian Journal of Regional Science, 2006, 29(3): 405-420.

Ghebreegziabiher Debrezion & Eric Pels & Piet Rietveld. The Impact of Railway Stations on Residential and Commercial Property Value: A Meta-analysis, J Real Estate Finan Econ, 35, pp.161–180, 2007.

Godschalk D R. Land use planning challenges: coping with conflicts in visions of sustainable development and livable communities. Journal of the American Planning Association, 2004, 70(1): 5-13.

Hermant L F L. Video data collection method for pedestrian movement variables & development of a pedestrian spatial parameters simulation model for railway station environments [D]. Stellenbosch: Stellenbosch University, 2012.

Hess D P. Impact of proximity to light rail rapid transit on station-area property values in Buffalo, New York. Urban Studies,2007, 44(5): 1041-1068.

Hillier, B. and Penn, A. (2004). Rejoinder to Carlo Ratti, Environment and Planning, B: Planning and Design, vol.31, pp.501-511.

Homepage of City Office in Fukuoka City, http://www.city.fukuoka.lg.jpHonda M, Shimada Im. Multivariate Statistical Technique for Management. Japan: Publishing Department of Sanno and Management University, 1977.

Hou X, Zhang W, Lv G, et al. Study on the Influence of Regional Development around Station of HST-Taking Beijing South Station as an Example [J]. Urban Studies, 2012, 1: 005.

Ishida R, Izumi T, Nakatani Y. Simulation System of Tsunami Evacuation Behavior During an Earthquake Around JR Osaka Station Area [M]. Intelligent Systems for Crisis Management. Springer Berlin Heidelberg, 2013: 67-78.

Jia N, Xie M, Chai X. Development and Implementation of a GIS-Based Safety Monitoring System for Hydropower Station Construction [J]. Journal of Computing in Civil Engineering, 2011, 26(1): 44-53.

Jiang Y, Christopher Zegras P, Mehndiratta S. Walk the line: station context, corridor type and bus rapid transit walk access in Jinan, China [J]. Journal of Transport

Geography, 2012, 20(1): 1-14.

Kim C W, Phipps T T, Anselin L. Measuring the benefits of air quality improvement: a spatial hedonic approach. Journal of Environmental Economics and Management, 2003, 45(1): 24-39.

Kim J H. Linking land use planning and regulation to economic development: a literature review. Journal of Planning Literature, 2010, 26(1): 35-47.

Knight R L, Trygg L L. Evidence of land use impacts of rapid transit system. Transportation, 1977, 6: 231-248.

Li X, Yeh A G O. Analyzing spatial restructuring of land use patterns in a fast growing region using remote sensing and GIS. Landscape and Urban planning, 2004, 69(4): 335-354.

Li J Q, Yan J W. Exploration of Construction above Subway Station in Tianjin and Related Theories Study [J]. Advanced Materials Research, 2012, 575: 21-26.

Ma L H, Liang Q H, Liu Y F, et al. Safety Analysis on the Structure of an Existing Metro Station Impacted by the Construction of an Adjacent Building [J]. Applied Mechanics and Materials, 2012, 238: 777-782.

Makrí, M. and Folkesson, C.: Accessibility Measures for Analyses of Land Use and Traveling with Geographi-cal Information Systems, Proceedings of 2nd KFB-Research Conference, Institute of Technology, Lund, 1999.

Masahisa Honda, Kazuaki Shimada. (1977) Multivariate Statistical Technique for Management, Publishing Department of Sanno and Management University, Japan.

Pan H X, Shen Q, Zhao T. Commuting Mode Choice of Residents in a New Suburban Metro Station Area in Shanghai[C]. Western Regional Science Association 51st Annual Meeting, in Kauai, Hawaii. 2012.

Porta, S., Crucitti, P. and Latora, V.: The Network Analysis of Urban Streets: A Primal Approach, Environment and Planning B: Planning and Design, 33(5), pp.705 – 725, 2005.Penn, A. (2003). Space Syntax and Spatial Cognition, or Why the Axial Line? Environment and Behavior, vol.35, pp.30-65.

Qiu Z Y, Yang L. A Study on the Synergy Effects of Rail Transit Station Area[J]. Urbanism and Architecture, 2010, 4: 006.

Ratti, C. (2004). Space Syntax: Some Inconsistencies, Environment and Planning, B: Planning and Design, vol.31, 487-499.

Smith G. New rail station demand forecasting methodologies-a South Wales case study [J]. 2011.

Sohn K. Feature Mapping the Seoul Metro Station Areas Based on a Self-Organizing Map [J]. Journal of Urban Technology, 2013, 20(4): 23-42.

Valizadeh Kivi A, Sadaghiani M H, Ahmadi M M. Numerical modeling of ground settlement control of large span underground metro station in Tehran Metro using Central Beam Column (CBC) structure[J]. Tunnelling and Underground Space Technology, 2012, 28: 1-9.

Widanapathiranage R, Bunker J M, Bhaskar A. A microscopic simulation model to estimate Bus Rapid Transit (BRT) station service capacity with mixed stopping and non-stopping bus operation [J]. 2013.

Yang, S. J. (2005). Exploring Complex Networks by Walking on them, Physical Review E, vol. 71, 016107

Yang Z, Chen H. Study on Grey Land Area Selection Surrounding the Urban Railway Station [J]. Urban Studies, 2011, 1: 016.

Yano Keiji. (2006) Research by GIS on Changes of Enterprise Location among Stations in Kyoto, Ritsumeikan University Literature, Japan

Yasuhiko Yuize. (2000) Introduction to Econometrics by Excel, Toyo Economic Press Office, Japan.

Kong F Q, Guo Y L. Comprehensive Technology Research on China's Space Station Information System [J]. Manned Spaceflight, 2011, 2: 011.

Yuan S, Qi K, Guan J. Research on the Location Choice of the Optimal Variable Messages Signs in Consideration of the Effect of Traffic Guidance Information——Case Study of the Road Area of Beijing South Railway Station [J]. Journal of Transportation Systems Engineering and Information Technology, 2011: S1.

Zhao Y, Zhou X M, Yang X G, et al. Research on measures improving the region traffic at passenger terminal of Fengtai station in Beijing [J]. Railway Economics Research, 2011, 3: 006.

Zhuang X Y. A Discussion on the Uptown Environment in the 21st Century. Journal of Sichuan College of Architectural Technology, 2008:18.

Zhuang X Y., Zhao S C. Research on Influence of Railway Station Development and Changes of Land Use in Japanese Cities. Proceedings of the 7th International

Symposium on City Planning and Environmental Management in Asian Countries, Fukuoka, Japan, 2010.

Chapter Three

Annual Changes & Characteristics of Urban Environment within Influence Sphere of Stations

Chapter 3
Annual Changes and Characteristics of Urban Environment within Influence Sphere of Stations

3.1 INTRODUCTION

As the development of the project of land readjustment and buildings along stations in Fukuoka city, more and more buildings are actively built by the rebuilding of stations, the situation along railway-tracks has been changing at a rapid speed. Recently years, the residential areas in the center of a city are gradually appearing, which tendency is transferred to the suburbs of a city. Furthermore, modern society will still develop around the public traffic, thus, it is thought that peripheral urban development that centers on the train station becomes more and more important to the city planning that centers on public traffic in an environmental society in the future.

3.1.1 Overview of Contents

During recent years, city development is also being diffusion anywhere disorderly. In order to promote the integration of all kinds of urban functions in an intensive linking with the public transportation network, restructuring the urban structure and compacting the city has become an urgent task. Furthermore, the potential value of railway stations is attached great importance again in cities. Research on development of integration station with urban area has being carried out. On the other hand, as the development of land use around railway stations and subways, especially in recent years, the background problem has become serious in many parts, not only sparsely populated regions, but also central regions around stations. Generally, the developing situation of land use around railway stations can represent the developing situation of commerce, industry, business, entertainment, etc. It is said that the development of society is forming around a circle of stations, which can make an influence on people's life. Thus, for the better formation of the zones of railway stations, a further improvement of the convenience of railway stations is sought constantly.

Over the years in the past, some researchers have introduced a large number of development of railway and subway stations and the relationship between the urban land and stations and the varying importance of the stations in a city according to one criterion or another. These following studies have proved of great value in the analysis and understanding of the roles played by railway and subway stations in a city’s development, such as the theory of the rail transit and its development, impacts on land market, the influence on house price, the developing situation of the land use and building usage, the analysis on changes of the land price and house price, etc., as there are mainly four elements supporting the paper, the previous studies will also be shown in turn, which are as follows,

Handy (2005) said there is a connection between transportation and land use. Kestens et al (2006) introduce the household-level data into hedonic models in order to measure the heterogeneity of implicit prices regarding household type, age, educational attainment, income, and the previous tenure status of the buyers. Hess evaluated the influence on the housing price by the distance from Buffalo, NewYork, to the light railway stations. By using the price models and assessing the housing price of 14 light rail spots, he obtained the conclusion that each 1 foot away from the light

rail station, the average value of the house will add $2.31 or $0.99 (according to the linear distance calculations (Hess, 2007). Cohen and Paul (2007) evaluated the impacts of enhanced transportation systems on property values. Ryan reviews the relationship between transportation facilities, such as highways, heavy rail, and light rail transit system and property values.

As the development of surrounding areas of railway stations and stations themselves in Fukuoka, Japan, the relationship among those stations, environment improvement and urban renaissance project is becoming more and more important. Thus, by selecting small-scale railway stations in Fukuoka City as research objects, the paper focuses on the distribution situation, annual changes of land use, as well as their relationship with population and number of users, in order to analyze the situations of exploiting surrounding areas of railway stations. On one hand, focusing on land use around railway stations can catch the distribution and characteristics of community facilities, including educational facilities, the public and government facilities, etc. to clarify the actual conditions and secular changes of them. This research, which is based on the results of previous studies, is focused on surrounding areas of train stations and the convenience of shopping and further improvement in future. Solution ways are needed to promote compact urban development and provide basic information about the design, and distribution of the surrounding areas for the railway stations.

With the development of large-scale retailers and specialty stores, the shutter street of shopping streets becomes more and more serious. The shutter street is a street which was ever made of various branch shops with many closed-down shops or offices while this used to be a busy shopping district, with the taste of a "commercial town", but now, those shops are closing down, leaving the area mostly residential now.

3.1.2 Research Aims

This research mainly focuses on specific buildings and land use, changes of population and price of land around train stations and characteristics of railway stations. In this research, 68 stations in Fukuoka City are compared.

(1) Firstly, the research aims on analyzing the changing situation of the land use around stations in Fukuoka City;

(2) Moreover, it also aims to clarify what influence has been made on stations

development. Basing on the data of land use around railway stations and subways in Fukuoka, this research selects 68 stations as the research targets, which are compared and analyzed on the distribution of land use and building usage by extracting the POSMAP data on land use with the GIS including the commerce, the house, the government and education, the transportation and the green land, etc. In addition, the data are separated with two steps of five years, that is, 0-400m radius (Step.1) and 400-800m radius (Step. 2), which are categorized into groups according to the cluster analysis;

(3) After that, according to the comparison and analysis on the distribution of land use, such as commerce, housing, industry, agriculture, etc., the research aims on analyzing the changing situation of the land use around stations in Fukuoka and indicates the changing and relationship among passengers, population and development of land use around railway stations in past years in order to reveal and improve the present situation and convenience of railway stations for people's life further.

3.1.3 Research Framework

As the land use and building usage are two independent individuals, thus, beside the introduction and related works, there are two main components separated in the body part of this chapter 3, that is,

Component One focuses on annual changes and characteristics on land use in surrounding regions of Fukuoka railway and subway stations, which are as follows,

(1) Part 1 is focused on the research objects, research methods and purposes;

(2) Part 2 is formed with the selection of the target stations and investigated situations on the land use around stations;

(3) Part 3 is consisted by analyzing the developing status and secular changes of land use around target railway and subway stations associated with selecting special railway stations by cluster analysis in space and time;

(4) Part 4 is organized by the actual conditions and aging distribution of railway stations and summarizes the relationship among the population, passengers, land price and land use around railway and subway stations;

Component Two focuses on trend of changes on building usage in surrounding regions of Fukuoka railway and subway stations, which are as follows,

(1) Part 1 is focused on the research objects, research methods and research aims;

(2) Part 2 is formed with the selection of the target stations and investigated situations on building usage in surrounding regions of stations;

(3) Part 3 is consisted by analyzing the characteristics and trend of changes on building usage of railway and subway stations by cluster analysis in space and time;

(4) Part 4 is organized by the actual conditions and aging distribution of railway stations and summarizes the relationship between building usages and the population, passengers, land price;

After that, a summary of contents of the chapter 2 is put forward to, which has shown the analysis results and pointed out solution ways for problems.

3.2 RELATED WORKS

Li and Yeh (2004) have analyzed urban expansion and spatial restructuring of land use patterns in the Pearl River Delta of south China by using remote sensing and GIS. An innovative LUR method implemented in a GIS environment that reflects both temporal and spatial variability and considers the role of meteorology is presented by Su, Brauer, Ainslie, et al. (2008).

Mahr A, Katsahian S, Varet H, et al. (2013) have ever used a dataset of patients newly diagnosed as having GPA and MPA enrolled in five clinical trials. One cluster model included nine clinical baseline variables as input variables, and a second cluster model additionally included ANCA specificities. The clustering process involved multiple correspondence analyses followed by hierarchical ascendant cluster analysis. Zhang, Leung and Wang have applied the finite-mixture-model-based clustering algorithms to cluster post-landfall tracks of tropical cyclones making landfall over China (2013) analyze the effects that adhering to them have in different areas of firm management as synergy generators that are advantageous to the company. In 2013, López-Jiménez D. has applied the cluster analysis techniques has been applied in combination with ANOVA.. Cluster analysis reveals that there are five significant clusters in order to analyze the effects that adhering to them have in different areas of firm management as synergy generators that are advantageous to the company. Each cluster can be interpreted as different levels of perceptions about the effects of the codes of conduct in company management. Wu and Zhang (2013) has studied a new DifFUZZY clustering method, which was proposed by Ornella Cominetti and Anastasios Matzavinos for the complex data sets, is firstly applied to cluster the orientation data. The results are compared with the FCM method and the real-life data. Gazdar T, Benslimane A, Belghith A, et al. (2013) has got a conclusion that the election of dynamic CAs is based on a clustering algorithm where the cluster heads

will be CAs in their clusters and carried out a set of simulations to evaluate the performance of the proposed clustering algorithm in both urban and highway environments. It is illustrated that the high power and reliability of metabonomic data analysis using NMR spectroscopy together with chemometric techniques for the exploration and prediction of toxic effects in the rat (Beckonert et al., 2003). Timm et al (2004) have explored an approach to possibilistic fuzzy clustering that avoids a severe drawback of the conventional approach, namely that the objective function is truly minimized only if all cluster centers are identical. Based on the methodology and results, Farber (2004) has compared the results of the application of a number of spatial multivariate models to two 'global' models in a hedonic house price context. Bitter, Mulligan and Dall (2007) have compared two approaches to examine spatial heterogeneity in housing attribute prices within the Tucson, Arizona housing market: the spatial expansion method and geographically weighted regression (GWR). Domínguez,et al.have studied the monitoring system during 2010 which are analyzed by the cluster analysis (2013). Yang and Yeo (2013) have proposed a cluster-based network model which is composed of cells and nanosensors utilizing the properties of calcium signaling. The characterizations and advantages of the network model are presented along with the comparison with the biological experiment results. In 2013, Kumar P J S. has also used the cluster analysis to investigate the controls of leather industries on fluoride contamination in and around a tannery cluster in Vaniyambadi. De Noronha Vaz T has offered a new methodology to identify R&D and innovation clusters, on the basis of a regional analysis of innovation support systems in Portugal (2013). Tepavčević and Stojaković's research demonstrated that coupling procedural modeling with fuzzy and statistical analysis enables generation of infinite number of buildings representing the typical appearance of an architectural type and their variations, which is a reliable reproduction of characteristics of the real world buildings (2013). Daughney et al (2012) have used the hierarchical cluster analysis (HCA) as a means of assessing the representativeness of a groundwater quality monitoring network, using example datasets from New Zealand in order to characterize the ambient condition of the resource and identify spatial or temporal trends.

3.3 ANNUAL CHANGES AND CHARACTERISTICS ON LAND USE

3.3.1 The Research Objects, Data and Methods

(1) Research Objects

Fukuoka City, which has become the subject of research, has eight lines and 68 stations in total, that is, the JR Kagoshima Line, the JR Kashii Line, the JR Chikuhi Line, the Nishitetsu Omuta Line, the Nishitetsu Kaizuka Line, and the Fukuoka municipal subway (see Fig. 3.1). The annual development on 68 stations in eight routes that exist in the Fukuoka city are analyzed.

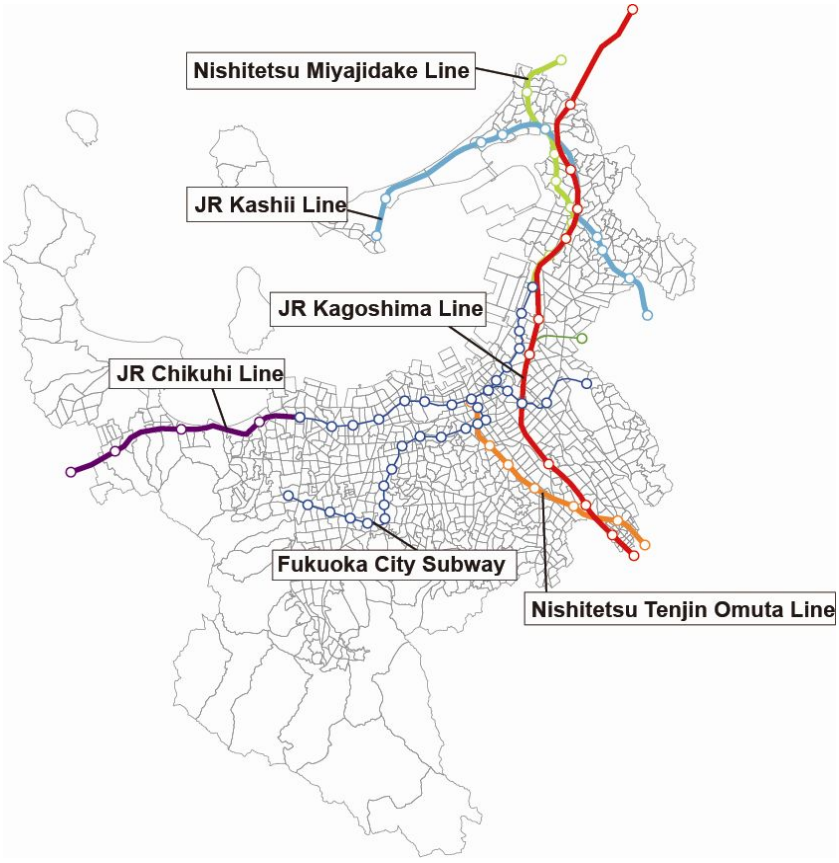


Fig. 3.1 Outline of Object Lines and Object Stations

(2) Overview of Data

Data which are used in this component are the data of land use, which are got by the POSMAP (from the original data on land use) in the four periods and five years (1985, 1993, 1998, 2003, 2008) at each station and the GIS (Geographic Information System) to extract each land use. The data of population and number of households, which are from the census of population of Fukuoka city and in units of chome (the chome is a very special street unit in Japan, actually, the "cho" in Japanese is a kind of unit for streets; and the "me" in Japanese presents the No., so, the 1 Chome means the first Avenue) at the time of 1985, 1990, 1995, 2000, 2005, 2010. The numbers of passengers, which are referred to the statistical books of Fukuoka and data of all routes of JR and Japanese western railways totaling for 36 years are collected from 1975 to 2011.The data of the Fukuoka city subway were collected up from the opening year 1981 to 2011 totaling for 30 years. The data of survey for prefectural land price and public reviewing land prices, which are from National Land Numeric Information Download Service of the homepage of the Ministry of Land, Infrastructure, Transport and Tourism, are collected up to point data of 28 years from 1983 to 2011. The data of architectural confirmation are ones of building confirmation of Fukuoka city from the year 1992 to the year 2004, totaling for 13 years. These data are all available, and then integrated by GIS. Basing on those above data, the research can be going on and these data above is the ones that are used in the Chapter 3.

(3) Analysis Methods

According to the background and the previous studies described above, by using relevant data on development status on land use and building usages, a series of further analysis is launched in the later research. At the same time, changes on the land use within and outside station zones and annual trend on development have been interpreted, thus, the developing trends of station zones have been definite. This research mainly focuses on changes of land use in the sphere of each station and comparison for changes on distance. The most convenient method for this research is to set station zones. There are about 1,100 chome existed In Fukuoka. In recent years, that number is increasing as the addresses are also changing. The research uses the GIS to integrate data. A geographic information system (GIS) is a "computer-based system for the integration and analysis of geographic data." It is a part of a "larger constellation of computer technologies for processing geographical data." The GIS software stores locations of features on the earth’s surface to allow identification of

different features on the same location. However, integration of GIS data has been more difficult, and information from the Internet and various materials is limited, so errors have been avoided as much as possible.

For the setting of stations, from January 2009, there are 68 stations in Fukuoka (except the Shinkansen, bullet train). The goal of this research is to analyze changes of land use by urban development with a focus on the station, within walking distance of the station; the range of 800-meter (800m) radius (within a 10-minute walk) from the station is set as a station zone. In order to identify the station by using data from the railway station of GIS, the circle of 800m radius from the central point of the station is set, which is in relation to the spatial location of chome. The step is as follows, firstly, the chome is overlap with the buffer circle; secondly, the chome should be included in the full circle of the buffer; thirdly, the center of the buffer is the station (see Fig. 3.2).

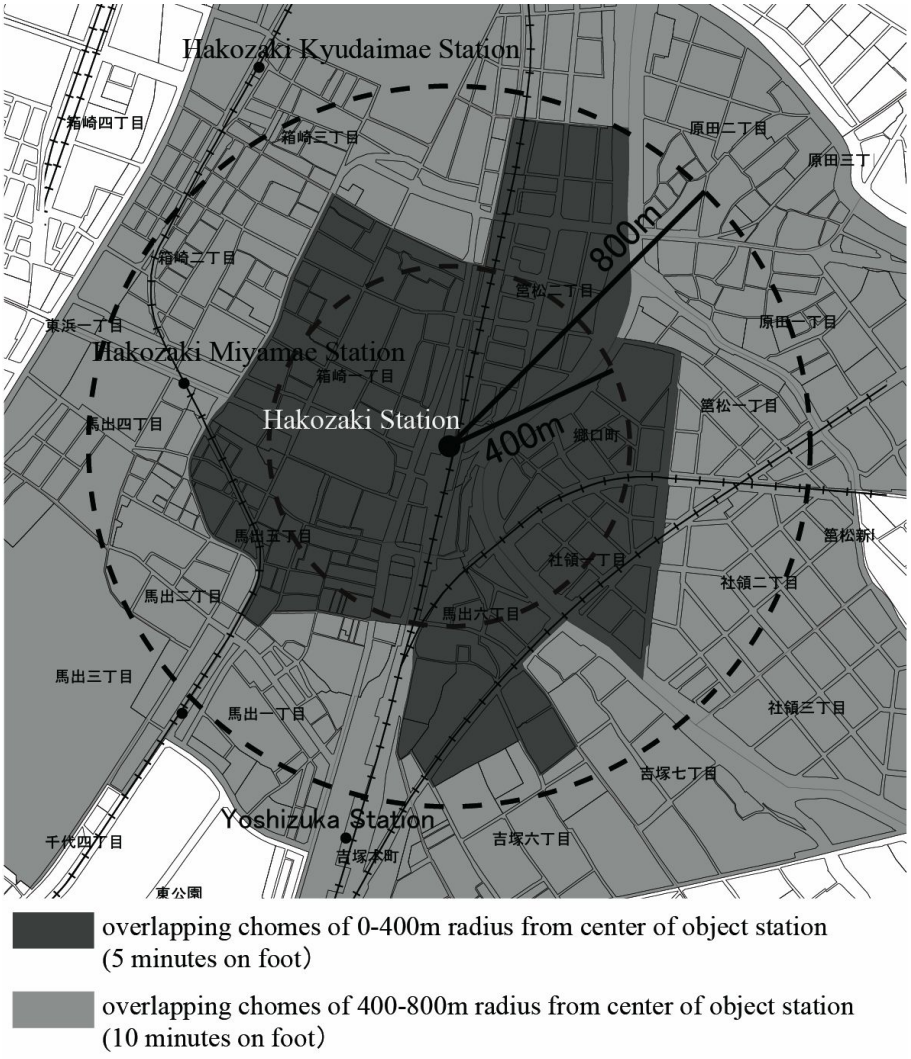


Fig. 3.2 Setting of station zones

The service catchment area of a railway station is set from the center of the station to 800m in radius (in the range of 10 minutes on foot), firstly, analyzing the land use from the center of the station to 400m in radius (in the range of 5 minutes on foot) for catching characteristics of each station; later, making an analysis from 400m to 800m in radius for catching space characteristics of each station and the trend outside the station is also caught. Afterwards, by analyzing stages gradually, that is, within 400m in radius and radius 400m-800m (Step.2) from the center of one station (Step.1), space of each station is understood to extend spatially. The trend of the land use in the station zone is investigated in a concrete method by the cluster analysis in each investigated year (1985, 1993, 1998, 2003, 2008) and each stage (Step.1, 2); finally, a change in the cluster attribute in the passing ages can be found. In addition, it is assumed that elements of the land use, the value of land, the population and the number of passengers are combined together in order to analyze the different feature of each cluster and each cluster's changes for each year..

3.3.2 Typology of Cluster Analysis on Land Use

Cluster analysis is the task of assigning a set of objects into groups (called clusters) so that the objects in the same cluster are more similar (in some sense or another) to each other than to those in other clusters. In other words, the cluster analysis is one way that can make things into types and provide a certain convenience for analyzing things.

This chapter uses the "Euclidean distances" which is a kind of way in cluster analysis, to evaluate the distance among investigation places and defines parameters among clusters by using the "Ward" method. The ward method is one way to minimize the sum of squares of the data of the cluster. Ward's minimum variance method is a special case of the objective function approach originally presented by Joe H. Ward; he suggested a general agglomerative hierarchical clustering procedure, where the criterion for choosing the pair of clusters to merge at each step is based on the optimal value of an objective function.

This research uses the GIS (geographic information system) to extract POSMAP of station zones (land use) by the age, usage and distance. Used variables with respect to land use are, "commerce", "housing", "government and education", "transportation and warehousing", "park and green land", "open space used", "open space unused", "

agriculture", "forest", "water", "roads", "others" totaling 13 variables. For each station, the data are analyzed by age and separated with two steps, that is, step.1 is 0m-400m radius, Step.2 is 400m-800m radius, (1985, 1993, 1998, 2003, 2008) five age points × 2 distance categories (Step.1, 2) = 10 data (the number of samples is 1 data against 68 stations), are categorized into groups according to the cluster analysis by using the ward method for a data in order to catch changes in the categories, changes in land use and spatial characteristics of stations.

3.3.3 Result of Cluster Analysis on Land Use

Results of cluster analysis are as follows, in step.1 it can be divided into 7 clusters; in step.2 it can be divided into 5 clusters. The number of samples between clusters has been quite biased; step.1 is a clear cluster that represents land use; as a complex situation of land use, step.2, which is not so clear than step.1, presents characteristics of land use. Based on the results of step.1 and step.2, the spatial scale around the station can be pointed out. For example, it is classified into in step.1 and is classified as C in step.2. The patterns of stations can be classified into 7 × 5 = 35. Therefore, according to the form below, the yearly characteristics and changes of categories can be easily caught (see Table. 3.1).

Table 3.1 Result of Cluster Analysis

Route		Station	1985		1993		1998		2003		2008	
			Step1	Step2	Step1	Step2	Step1	Step2	Step1	Step2	Step1	Step2
Japan Railway (Kyushu Railway)	Kashii Line	Saitozaki	5	F	5	F	5	F	5	F	5	F
		Uminonakamichi	7	D	7	D	7	D	7	D	7	D
		Gannosu	5	E	5	E	5	E	5	E	5	E
		Nata	5	E	5	E	5	E	5	E	5	E
		Wajiro	5	D	5	D	5	D	5	C	5	C
		Kashiijingu	5	E	5	E	5	E	5	E	5	E
		Maimatsubara	5	C	5	C	5	C	5	C	5	C
		Doi	5	D	5	D	5	D	5	D	5	D
	Kagoshima Main Line	Chikuzenshingu*	5	D	5	D	5	D	5	D	5	D
		Kyusandai-mae	5	D	5	D	5	D	5	D	5	D
		Kashii	5	C	5	C	5	C	5	C	5	C
		Chihaya	3	C	3	C	3	C	3	C	3	C
		Hakozaki	5	C	5	C	5	C	5	C	5	C
		Yoshizuka	4	B	4	C	4	C	4	C	4	C
		Hakata	1	B	1	B	1	B	1	B	1	B
		Takeshita	5	B	5	C	3	C	3	C	3	C
		Sasabaru	5	C	3	C	3	C	3	C	3	C
		Minami-Fukuoka	5	D	5	D	5	D	5	D	5	D
	Chikuhi Line	Meinohama	3	C	3	C	3	C	3	C	3	C
		Shimoyamato	5	D	5	C	5	C	5	C	5	C
		Imajuku	6	E	6	E	6	E	6	E	6	E
		Susenji	6	D	6	D	6	D	6	D	6	D
Nishi-Nippon Railroad	Kaizuka Line	Najima	5	C	5	C	5	C	5	C	5	C
		Nishitetsu chihaya	3	C	3	C	3	C	3	C	3	C
		Kashiijingu	3	C	3	C	3	C	3	C	3	C
		Nishitetsu kashii	3	E	3	C	3	C	3	D	3	C
		Nishitetsu kashiikaenmae	5	D	5	D	5	D	5	D	5	D
		Karanohara	6	D	6	D	6	D	6	D	6	D
		Mitoma	5	D	5	D	5	D	5	D	5	D
	Tenjin Omuda Line	Nishitetsu Fukuoka Tenjin	1	B	1	B	1	B	1	B	1	B
		Yakuin	2	A	2	A	2	A	2	A	2	A
		Nishitetsu hirao	3	C	3	C	3	C	3	C	3	C
		Takamiya	3	C	3	C	3	D	3	C	3	C
		Ohashi	3	C	3	C	3	C	3	C	3	C
		Ijiri	5	C	3	C	3	C	3	C	3	C
		Zassyonokuma	5	D	3	D	3	D	3	D	3	D
Fukuoka City Subway	Kuko Line	Muromi	5	C	3	C	3	C	3	C	3	C
		Fujisaki	3	C	3	C	3	C	3	C	3	C
		Nishijin	3	C	3	C	3	C	3	C	3	C
		Tojinmachi	3	C	3	C	3	C	3	C	3	C
		Ohorikoen	2	B	2	C	2	D	2	C	2	C
		Akasaka	2	A	2	B	2	B	2	B	2	B
		Tenjin	1	B	1	B	1	B	1	B	1	B
		Nakasu-Kawabata	2	A	1	A	1	A	1	A	1	A
		Gion	2	A	1	A	2	A	2	A	2	A
		Higashi-Hie	2	B	2	B	2	B	2	B	2	B
		Fukuokakuko (Airport)	7	D	7	D	7	D	7	D	7	D
	Hakozaki Line	Gofukumachi	2	B	2	A	2	A	2	A	2	A
		Chiyo-Kenchoguchi	4	B	4	B	4	B	4	B	4	B
		Maidashi-Kyudaibyoinmae	4	B	4	C	4	C	4	C	4	C
		Hakozaki-Miyamae	4	C	4	C	4	D	3	D	4	D
		Hakozaki-Kyudaimae	4	B	4	D	4	D	4	D	4	D
		Kaizuka	4	B	4	D	4	D	4	D	4	D
	Nanakuma Line	Tenjin-minami	2	A	1	A	1	A	1	A	1	A
		Watanabe-dori	2	A	2	A	2	A	2	A	2	A
		Yakuin-odori	3	A	3	A	3	A	3	A	3	A
		Sakurazaka	5	C	3	C	3	C	3	C	3	C
		Ropponmatsu	3	C	3	C	3	C	3	C	3	C
		Befu	3	C	3	C	3	C	3	C	3	C
		Chayama	5	C	5	C	5	C	5	C	5	C
		Kanayama	5	C	5	C	5	C	5	C	5	C
		Nanakuma	4	C	4	C	3	C	3	C	3	C
		Fukudai-mae	4	E	4	E	4	E	4	E	3	E
		Umebayashi	5	D	5	D	5	D	5	D	5	D
		Noke	5	C	5	C	5	C	5	C	5	C
		Kamo	5	C	5	C	5	C	5	C	5	C
		Jiromaru	5	D	5	D	5	D	5	D	5	D
		Hashimoto	6	E	5	E	5	E	5	E	5	E

* The name of Chikuzenshingu Station has been changed into Fukkodai-mae Station in 2008

According to the result of cluster analysis, the features of cluster can be divided into these below ones, which are as follows,

(1) Step.1 0m~400m Radius

The features of the cluster analysis are as follows,

1. "Type of a city's centre", e.g. Hakata, Nishitetsu Fukuoka, etc.
2. "Type of business around a city's centre", e.g.Yakuin, Akasaka and Gofukumachi, etc.
3. "Type of medium density resident", e.g. Kashii, Ohashi, etc.
4. "Type of government, municipal Offices, education and public welfare", e.g. Yoshizuka, Fukushima University, etc.
5. "Type of low density resident", e.g. Wajiro, Chayama, etc.
6. "Type of resident + agriculture", e.g. Imajuku, Susenji, etc.
7. "Type of specific facilities", e.g. Umino Nakamichi, Fukuoka Airport, etc.

(2) Step.2 400m~800m Radius

The features of the cluster analysis are as follows,

A. "Type of places near the center of a city", e.g. Yakuin, Nakasu Kawabata, etc.
B. "Type of commerce around the center of a city", e.g. Hakata, Tenjin, etc.
C. "Type of medium density resident", e.g. Chihaya, Nishijin, etc.
D. "Type of low density resident + various uses", e.g. Wajiro, Zasyonokuma, etc.
E. "Type of low density resident", e.g. Gannosu, Imajuku, etc.

The cluster analysis in this chapter does not consider the variables of the population, the land price and the plot ratio.

3.3.4 Features and Secular Changes of the Cluster on Land Use

The detailed features of each category are shown in Table 3.2, Table 3.3, Table 3.4 and Table 3.5 separately, which can make clusters' features more obvious. Moreover, it is thought that the change in the land use is huge around stations in passing ages and the attribute of the cluster has also changed.

Table 3.2 Secular changes of land use of investigated object stations in 0-400m radius (%)

Cluster	Year	Commerce	House	Government & Education	Transportation	Park	Agriculture	Forest	Road
Group 1	1985	30.4	8.5	10.8	2.3	2.8	0.1	0.0	26.3
	1993	28.9	12.0	10.8	2.6	3.5	0.0	0.0	26.4
	1998	32.8	12.0	8.1	3.0	4.8	0.0	0.0	29.2
	2003	33.1	12.5	8.0	2.6	4.3	0.0	0.0	29.2
	2008	34.2	12.6	10.2	3.2	4.4	0.3	0.2	29.9
Group 2	1985	23.6	14.1	12.3	1.7	7.3	0.8	0.2	21.8
	1993	18.3	20.0	11.7	1.3	10.4	0.7	0.0	20.9
	1998	19.8	19.8	8.7	1.9	13.4	0.5	0.0	22.2
	2003	21.5	21.1	8.8	2.1	9.0	0.6	0.0	23.3
	2008	22.6	21.3	10.5	2.3	9.9	0.5	0.0	25.6
Group 3	1985	10.6	36.3	13.0	1.8	2.0	1.4	1.3	16.5
	1993	8.3	39.6	10.6	0.8	2.1	1.5	1.9	16.6
	1998	7.9	42.4	10.4	1.1	3.4	1.1	1.0	18.8
	2003	6.6	41.6	10.4	1.1	4.9	0.7	0.9	19.7
	2008	7.8	45.3	12.6	1.3	5.6	1.0	0.8	20.1
Group 4	1985	8.3	20.5	28.6	5.7	4.1	2.0	0.4	13.5
	1993	7.8	22.6	29.0	4.6	4.1	0.9	0.3	15.3
	1998	8.7	24.0	28.6	4.4	4.5	0.8	0.2	18.3
	2003	8.1	24.1	28.9	4.4	4.4	0.6	0.2	18.7
	2008	8.7	24.7	28.2	4.4	4.2	0.8	0.3	17.7
Group 5	1985	5.6	35.2	6.2	1.7	2.7	9.9	7.0	13.2
	1993	4.9	37.4	7.1	1.4	2.0	10.6	5.4	14.5
	1998	5.2	39.8	7.0	1.4	2.5	8.6	4.8	17.4
	2003	5.2	41.4	7.6	1.4	2.3	7.4	4.4	17.7
	2008	5.5	44.6	7.7	1.4	2.4	10.9	5.2	17.2
Group 6	1985	3.1	16.4	2.0	0.4	7.8	26.6	21.1	8.2
	1993	2.8	18.0	1.9	0.3	1.3	16.5	25.9	8.8
	1998	3.2	19.8	2.0	0.4	0.9	15.3	25.8	10.6
	2003	3.3	20.4	2.2	0.6	1.0	14.4	25.7	10.7
	2008	3.2	20.1	2.1	0.4	3.2	18.3	26.8	11.2
Group 7	1985	0.3	2.3	0.4	34.2	37.4	0.2	5.4	10.2
	1993	0.9	1.5	0.8	38.8	31.5	0.1	6.0	3.5
	1998	0.5	2.2	0.5	33.7	34.8	0.1	4.0	4.7
	2003	0.7	2.2	0.3	33.8	35.1	0.1	3.7	4.9
	2008	0.6	2.3	0.2	34.5	36.1	0.1	2.3	4.4

Table 3.3 Secular changes of population and land price of investigated object stations in 0-400m radius (%)

Cluster	Year	Population	Land Price	Passenger (per day)	Generation	Population Density	Plot Ratio
Group 1	**1985**	**8,331**	1,272,433	150,770	1.93	**68.6**	**233.9**
	1993	**5,675**	4,027,383	130,932	1.64	**57.7**	**225.4**
	1998	**5,522**	1,553,610	150,038	1.51	**56.9**	**219**
	2003	**7,875**	1,102,151	118,342	1.4	**54.3**	**242.1**
	2008	**7,956**	1,432,286	138,232	1.72	**62.5**	**253.8**
Group 2	**1985**	10,680	615,099	**12,900**	**2.11**	**88**	**128.5**
	1993	11,195	2,290,387	**18,956**	**1.72**	**86.9**	**120.6**
	1998	12,011	945,998	**17,249**	**1.61**	**94.1**	**116.9**
	2003	13,193	682,199	**16,459**	**1.49**	**107.2**	**132.1**
	2008	15,324	773,128	**16,332**	**1.52**	**92.3**	**136.7**
Group 3	**1985**	15,489	212,580	**17,331**	**2.39**	105.7	**71.1**
	1993	15,574	550,044	**20,457**	**2.06**	107.9	**56.5**
	1998	16,364	324,562	**20,495**	**1.95**	114.1	**59.4**
	2003	17,089	243,166	**13,971**	**1.9**	121.1	**72.3**
	2008	17,882	336,462	**18,231**	**2.23**	116.5	**73.6**
Group 4	**1985**	12,140	**192,613**	7,582	**2.14**	**59.5**	**78.8**
	1993	12,524	**574,176**	14,195	**1.81**	**71.7**	**77.2**
	1998	12,559	**292,891**	12,958	**1.72**	**71.9**	**64.9**
	2003	13,050	**185,717**	10,525	**1.69**	**74.7**	**70.1**
	2008	13,421	**233,615**	12,876	**1.73**	**72.1**	**63.7**
Group 5	**1985**	8,850	96,045	**7,857**	**2.63**	**70.3**	**38.2**
	1993	9,362	162,225	**6,447**	**2.48**	**73.2**	**36.5**
	1998	9,553	140,381	**6,078**	**2.35**	**73.9**	**37.2**
	2003	9,696	111,134	**4,959**	**2.28**	**76**	**39.7**
	2008	9,973	143,272	**6,327**	**2.33**	**73.2**	**38.4**
Group 6	**1985**	**6,399**	74,631	6,614	**3.16**	**27.1**	**13.8**
	1993	**8,172**	155,167	8,013	**2.51**	**33.8**	**17.9**
	1998	**9,066**	137,854	8,038	**2.4**	**37.5**	**19.7**
	2003	**9,367**	105,595	7,036	**2.4**	**38.7**	**20.9**
	2008	**9,226**	126,553	7,235	**2.66**	**40.2**	**22.3**
Group 7	**1985**	**893**	65,400	10,036	**2.48**	**2.5**	1.5
	1993	**998**	81,000	17,984	**2.16**	**2.6**	4.6
	1998	**1,095**	94,667	20,595	**1.92**	**3.1**	5.3
	2003	**1,056**	77,750	19,995	**1.92**	**2.9**	8
	2008	**1,232**	82,556	20,673	**2,17**	**3.3**	8.8

Table 3.4 Secular changes of land use of investigated object stations in 400-800m radius (%)

Cluster	Year	Commerce	House	Government & Education	Transportation	Park	Agriculture	Forest	Road
Group A	1985	24.0	20.4	10.1	2.0	3.1	0.1	0.3	22.3
	1993	21.2	22.7	10.0	1.8	2.9	0.1	0.8	23.3
	1998	23.2	23.5	8.7	2.1	5.0	0.1	0.1	24.5
	2003	22.6	24.4	9.1	1.8	4.8	0.0	0.1	24.6
	2008	25.5	23.2	9.2	1.9	5.1	0.1	0.3	26.7
Group B	1985	16.6	16.2	9.4	8.0	2.9	2.6	0.1	19.9
	1993	21.0	18.5	9.1	5.1	1.7	1.1	0.0	23.6
	1998	22.7	19.6	8.3	6.0	2.8	0.9	0.0	25.2
	2003	22.1	20.5	8.4	5.3	2.6	0.7	0.0	25.0
	2008	24.2	21.3	7.9	7.7	2.6	0.8	0.1	26.2
Group C	1985	6.5	34.6	11.8	1.7	4.0	4.3	2.4	15.7
	1993	6.4	36.6	12.3	2.1	4.5	3.0	1.8	16.4
	1998	6.7	40.0	11.1	1.5	5.6	2.6	1.5	17.5
	2003	6.4	41.4	11.5	1.3	6.0	2.1	1.3	18.2
	2008	6.2	44.6	12.7	1.8	5.5	2.2	1.2	19.8
Group D	1985	3.8	24.4	7.0	1.2	6.7	18.9	11.5	11.0
	1993	5.1	24.6	6.5	5.0	2.3	12.6	10.4	13.2
	1998	5.2	28.8	8.1	5.3	3.4	8.3	7.9	16.0
	2003	5.7	25.2	8.2	7.7	2.9	7.2	7.5	16.2
	2008	5.5	27.6	9.1	7.2	3.2	8.6	8.6	16.5
Group E	1985	1.2	10.4	4.2	0.4	6.9	7.2	36.2	18.4
	1993	1	12	7.3	0.1	4.6	6.5	48.5	6.2
	1998	1	13.1	5.1	0.2	9.1	5.8	43.2	7.1
	2003	1.2	13.6	6.9	0.2	10.1	5.2	41.1	7.9
	2008	1.3	14.2	7.8	0.3	10.9	5.8	44.2	9.6

Table 3.5 Secular changes of population and land price of investigated object stations in 400-800m radius (%)

Cluster	Year	Population	Land Price	Passenger (per day)	Generation	Population Density	Plot Ratio
Group A	1985	22,894	631,905	14,830	2.09	103.5	151.9
	1993	21,606	2,989,729	18,985	1.7	92.6	158.5
	1998	23,459	1,160,477	18,134	1.61	100.3	149.6
	2003	27,043	819,150	14,732	1.51	115.6	152.4
	2008	28,662	963,256	14,988	1.82	100.8	159.2
Group B	1985	15,450	537,918	50,731	2.17	71.7	92.3
	1993	14,987	3,284,758	110,960	1.75	77.7	124.3
	1998	15,732	1,214,688	103,901	1.64	86.7	116.3
	2003	19,061	816,420	99,359	1.51	98.8	125.9
	2008	19,002	1,144,552	126,879	1.66	93.7	133.6
Group C	1985	19,947	163,003	16,798	2.57	84	54
	1993	21,371	438,222	16,355	2.25	91.1	59.1
	1998	23,016	252,776	15,876	2.18	96.2	57.2
	2003	23,805	196,913	11,623	2.08	104.3	61.5
	2008	24,606	232,663	14,667	2.53	96.5	66.7
Group D	1985	6,585	80,220	6,997	2.79	36.4	23.9
	1993	9,091	169,810	12,801	2.39	49.4	32.8
	1998	9,983	187,828	12,776	2.18	45.3	38.9
	2003	9,866	122,320	9,840	2.18	48.7	35.2
	2008	9,956	168,432	11,223	2.67	49.8	34.2
Group E	1985	7,589	105,659	3,891	2.74	19.4	8.6
	1993	8,921	132,378	4,841	2.58	22.2	10.3
	1998	8,944	120,789	4,800	2.44	22.3	11.1
	2003	9,319	94,514	4,272	2.38	23.2	11.6
	2008	9,876	113,323	4,562	2.78	24.6	12.2

(1) 0m-400m Radius (Step.1)

a. Land Use

In the category "the center of a city", which shows a high percentage of the "Commercial Land" and "Road". And in the vicinity of the city center, the percentage of "Green Park" has been high. It is easily to find that the "Commercial Land" tends to be decreasing, 'Residential Land", and "Land for Roads" have been increasing year by year. Furthermore, the residential and road maintenance are getting on and on. The trend of decreasing passengers has a large impact on the road maintenance (see Table 3.2).

b. Population and Land Price

As the "plot ratio" in the downtown has being a high density of buildings, the density of buildings are also going higher than before. However, taking a look at the population, the "Government" and

"Medium-density Resident" is becoming higher in the suburbs of a city rather than "downtown of a city", and the center of a city has been full of other functions besides residential function. With respect to the land price, as it contains the bubble period, it has a sudden raise in 1993 after which it falls sharply. Population in large stations of the center of a city has been always reducing, and increasing in the suburb stations. In addition, the trend of the plot ratio can be seen within 400m from the centre of stations and the development is in progress around stations. The trend of population density is increasing rapidly in the range within 400m radius from the center of the station, at the same time, it can also be seen that the proportion of mansions is in an increase (see Table 3.3).

(2) 400m-800m Radius (Step.2)

The features of each category are shown in Table 3.4 and Table 3.5 which can make features more obvious.

a. Land Use

In the category "the center of a city", which shows a high percentage of the "House" and "Road". And near center of a city, the percentage of "Commerce Land" has been higher. It is easy to find that the "Commercial Land" tends to be decreasing, "Residential Land "and "Land for Roads" have been increasing year by year. The trend of decreasing passengers also has a large impact on the road maintenance (see Table. 3.4).

b. Population and Land Price

As the "plot ratio" in the downtown has being lower than it is in 0-400m, but the density of buildings are also going higher year by year. With respect to the land price, as it contains the bubble period, it has a sudden raise in 1993 after which it falls sharply. In 400-800m, the population in large stations of the center of a city has been always reducing, and increasing in the suburb stations (see Table. 3.5).

In this part, by performing a cluster analysis with respect to land use around the stations, here, basing on the results of previous research, this part can be summarized in the following new findings,

Firstly, the changes and tend of development on railway stations and subways of Fukuoka city have been interpreted in this chapter. As a result, most stations from 1985 to 2008 decline to changes gradually. Whereas this kind of changes tends to continue and has been confirmed in the investigation. In this situation, the land use on the commerce and housing in some stations have always been reducing which reveal a

phenomenon associated with the consume progression of society, and it should be emphasized in community development activities in the future.

On the other hand, as the obvious reduction of the land use on the agriculture, green land and water in some stations, the industry facilities have been transferred into the suburbs, this situation has been a remarkable phenomenon which can be said that the decline had a significant impact on forest, green land, water and other afforestation areas in the suburbs.

3.4 ANNUAL CHANGES AND CHARACTERISTICS ON BUILDING USAGE

3.4.1 Research Objects, Data and Analysis Methods

(1) Research Objects

The object city is focused on Fukuoka City and analyzes the secular development courses of eight routes at the station 68 stations that exist in the city, which are concerned with consisting street numbers and each point of the building usages.

(2) Overview of Data

Data which are used in this study are shown in the table below, that is, the data of the building usage, which uses the POSMAP (from data of land use and building use) in the five periods of (1985, 1993, 1998, 2003,2008) at each station and the GIS (Geographic Information System) to extract building usages. The numbers of passengers, which are referred to the statistical books of Fukuoka and data of all routes of JR and Japanese western railways totaling for 36 years are collected from 1975 to 2011.The data of the Fukuoka city subway were collected up from the opening year 1981 to 2011 totaling for 30 years. The data of architectural confirmation are ones of building confirmation of Fukuoka city from the year 1992 to the year 2004, totaling for 13 years. These data are all available, integrated, and then integrated in GIS.

(3) Analysis Methods

This research mainly focuses on changes of building usages in the sphere of each station and comparison for changes on distance. The most convenient method for this research is to set station zones. The goal of this research is to analyze changes of building usages with a focus on stations within walking distance of the station and uses the GIS to extract POSMAP data of stations (building usage) by the age, usage

and distance. The step is as follows, firstly, the zone is overlap with the buffer circle; secondly, the set zone should be included in the full circle of the buffer; thirdly, the center of the buffer is the station.

The service catchment area of a railway station is set from the center of the station to 800m in radius (in the range of 10 minutes on foot), firstly, analyzing building usages from the center of the station to 400m in radius (in the range of 5 minutes on foot) for catching characteristics of each station; later, making an analysis from 400m to 800m in radius for catching space characteristics of each station and the trend outside the station is also caught. Afterwards, by analyzing stages gradually, that is, within 400m in radius (Step.1) and 400m-800m in radius (Step.2) from the center of one station. The trend of the building usages in the station zone is investigated in a concrete method by the cluster analysis in each investigated year (1985, 1993, 1998, 2003,2008) and each stage (Step.1, 2); finally, a change in the cluster attribute in the passing ages can be found. In addition, it is assumed that elements of the building usages, the population, and the number of passengers are combined together in order to analyze the different feature of each cluster and each cluster's changes for each year.

3.4.2 Typology of Cluster Analysis on Building Usage

This paper uses the "Euclidean distances" to evaluate the distance among investigation places and defines parameters among clusters by using the "Ward" method. Used variables with respect to building usage are "business and hotel", "commerce and entertainment", "detached houses" "condominium", "government agencies and educational facilities", "transportation and warehousing facility", "industrial facilities", "others" totaling to 8 variables. For each station, the data are analyzed by age and separated with two steps, that is, step.1 is 0m-400m radius, Step.2 is 400m-800m radius, (1985, 1993, 1998, 2003,2008) five age points × 2 distance categories (Step.1, 2) = 10 data (the number of samples is 1 data against 68 stations), are categorized into groups according to the cluster analysis by using the Ward method for a data in order to catch changes in the category and between categories, changes in building usages and spatial characteristics of stations.

3.4.3 Result of Cluster Analysis on Building Usage

Results of cluster analysis are as follows, in step.1 it can be divided into 7 clusters; in step.2 it can be divided into 5 clusters. Based on the results of step.1 and step.2, the spatial scale around the station can be caught. Therefore, according to the cluster analysis, the yearly characteristics and changes of categories can be easily caught.

(1) Step.1 0m~400m Radius

The features of the cluster analysis are as follows,

I. "Type of a city's center"

II. "Type of business around a city's center"

III. "Type of medium density resident"

IV. "Type of government, municipal Offices, education and public welfare"

V. "Type of low density resident"

VI. "Type of resident + agriculture"

VII. "Type of specific facilities"

(2) Step.2 400m~800m Radius

The features of the cluster analysis are as follows,

A."Type of places near the center of a city"

B. "Type of commerce around the center of a city"

C. "Type of medium density resident"

D. "Type of low density resident + various uses"

E. "Type of low density resident"

3.4.4 Features and Secular Changes of the Cluster on Building Usages

(1) 0m-400m Radius (Step.1)

In the category "the center of a city", the percentage of "Business and Hotel", "Commerce and Entertainment" are accounted for about 70%, which is about 45% around the center of city, and 5% to 15% in the other categories. The categories of III, IV and V have been residential areas, which is an especial differing between the center of a city and suburbs of a city. According to those yearly changes, it can be clearly found that the percentage of "Detached Houses" is dramatically reducing, and the percentage of "Mansions" is rapidly increasing. It is going on from 1985 to 2008 (see Table 3.6).

Table 3.6 Secular changes of building usage of investigated object stations in 0-400m radius (%)

Group	Year	Business & Hotel	Entertainment	Detached House	Condominium	Government & Education	Transportation	Industry
I	1985	53.6	14.6	4.1	14.4	9.9	2.9	0.1
	1993	49.7	21.9	2.0	14.7	8.7	2.8	0.1
	1998	49.7	21.2	1.4	16.7	8.5	2.3	0.0
	2003	49.4	22.8	1.2	15.7	8.3	2.3	0.0
	2008	48.8	23.6	1.1	16.2	8.1	2.2	0.0
II	1985	36.3	10.4	13.6	23.1	11.8	3.5	1.0
	1993	32.1	9.5	6.4	35.3	12.3	3.1	0.9
	1998	33.8	6.5	4.8	41.5	9.5	2.6	0.8
	2003	37.2	7.2	4.1	38.9	8.7	2.8	0.8
	2008	36.8	6.7	3.5	37.2	8.6	2.7	0.8
III	1985	4.8	10.7	33.3	30.7	17.8	1.4	0.9
	1993	5.2	6.7	22.3	49.3	14.7	0.9	0.5
	1998	4.9	6.2	18.3	57.5	11.3	0.9	0.5
	2003	5.8	5.3	17.5	58.7	11.5	0.6	0.3
	2008	5.5	4.7	16.5	61.0	12.3	0.5	0.3
IV	1985	8.2	2.6	21.4	14.4	45.2	3.9	3.6
	1993	7.8	3.9	12.6	25.3	45.2	2.6	1.6
	1998	8.1	4.1	12.9	34.8	36.0	1.8	1.5
	2003	7.5	5.1	10.9	35.9	36.0	1.9	1.2
	2008	8.5	5.6	10.2	38.0	35.5	1.6	1.0
V	1985	3.3	2.9	51.6	17.9	13.3	2.3	7.0
	1993	2.5	3.3	40.4	29.5	16.7	1.6	5.2
	1998	2.9	3.5	40.3	35.7	12.7	1.4	2.7
	2003	2.8	4.0	36.8	37.4	12.6	1.4	2.8
	2008	2.6	4.7	33.2	39.1	11.6	1.2	2.6
VI	1985	2.7	4.4	48.5	20.9	7.8	1.7	13.1
	1993	1.6	5.0	41.7	31.2	8.6	1.2	9.5
	1998	2.2	4.8	36.0	41.2	5.5	1.3	8.0
	2003	2.6	5.3	34.5	42.5	5.9	1.1	7.1
	2008	2.3	4.9	32.2	45.6	5.2	1.3	7.2
VII	1985	1.9	2.2	71.1	4.8	9.5	7.1	1.5
	1993	7.5	6.1	18.5	9.6	7.8	46.0	0.3
	1998	4.5	12.6	13.9	14.1	6.3	44.0	0.3
	2003	3.4	12.1	9.9	8.9	3.8	58.5	0.2
	2008	3.3	11.7	8.8	8.2	3.5	62.8	0.2

(2) 400m-800m Radius (Step.2)

In the category "the center of a city", the percentage of "Business and Hotel", "Commerce and Entertainment" are decreasing year by year, which is about 37% around the center of city, and 5% to 20% in the other categories. Furthermore, the percentage of "Business and Hotel", "Commerce and Entertainment" has been always down than they are in the percentage of 0-400m. Residential areas, which also differ between the center of a city and suburbs of a city. However, the "Government" and "Medium-Density Resident" are becoming higher in the suburbs of a city rather than "downtown of a city", and the center of a city has been full of other functions besides residential function. According to those yearly changes, it can be clearly found that the percentage of "Detached Houses" is dramatically reducing, and the percentage of "Condominium" is rapidly increasing as well as 0-400m (see Table 3.7).

Table 3.7 Secular changes of building usage of investigated object stations in 400-800m radius (%)

Group	Year	Business & Hotel	Entertainment	Detached House	Condominium	Government & Education	Transportation	Industry
A	1985	37.0	12.7	13.6	23.6	8.3	3.1	1.2
	1993	36.7	18.4	5.8	26.5	9.3	2.3	0.5
	1998	33.8	17.7	4.7	33.0	7.7	2.1	0.4
	2003	33.8	18.9	4.1	32.7	7.6	2.1	0.4
	2008	33.5	16.8	3.8	34.5	7.2	2.0	0.3
B	1985	22.3	8.8	17.1	19.5	13.0	11.8	6.6
	1993	31.4	14.0	6.0	29.3	10.1	4.1	3.8
	1998	30.1	12.2	4.8	36.4	7.6	4.8	2.5
	2003	29.9	14.3	4.2	36.6	7.5	4.2	1.8
	2008	30.5	13.6	4.1	35.3	7.8	4.6	1.1
C	1985	5.2	2.7	38.3	27.1	21.9	2.4	1.6
	1993	5.6	3.9	23.4	41.3	20.6	2.0	2.4
	1998	5.6	3.4	23.0	50.8	14.0	1.2	1.4
	2003	6.0	3.7	21.2	51.6	14.1	1.2	1.4
	2008	6.6	3.5	20.2	55.8	14.7	1.2	1.5
D	1985	4.3	3.1	47.0	16.3	21.3	3.3	3.8
	1993	6.0	3.1	28.4	23.3	15.5	17.2	5.3
	1998	6.5	3.0	28.2	32.7	14.8	9.0	4.2
	2003	6.2	4.0	23.2	31.9	16.0	13.4	3.6
	2008	6.3	4.2	24.5	30.8	17.7	16.9	6.2
E	1985	2.5	2.4	53.2	20.9	19.2	1.3	0.4
	1993	1.2	2.5	43.7	32.3	16.9	1.6	0.5
	1998	1.5	2.6	42.1	37.4	12.7	1.8	0.5
	2003	2.0	3.0	39.6	37.1	14.8	0.5	0.6
	2008	3.3	2.5	37.7	36.2	13.8	1.7	0.8

3.5 FACTORS AND CHARACTERISTICS FOR CLUSTERS MOVING

3.5.1 Factors for Moving among Clusters

According to the above analysis, it can be shown that the residential quarters have made remarkable changes in the station zones. Moreover, it has been a feature that the ratio of green land is highly raising. It is also especially remarkable that the tendency of development of apartment houses is changing into more and more mansions. Furthermore, the ratio between transportation and warehousing facilities has been consistently rising.

Further speaking, the situation on changes of clusters can be clearly found according to the changing tendency. The most frequent change among clusters is in the years 1985 to 1993. One factor has been mentioned, that is, categories of 10 stations has been changing in step.1. In addition, the clusters of 9 stations have been caught in step.2. Later, in the period of 1993 to 1998, it can be found that there are clusters of 2 stations in step. 1 and 3 stations in step.2. Furthermore, from 1998 to 2008, it can be found that there are clusters of 2 stations in step. 1 and 3 stations in step.2. In addition, some stations have shown no various changes at all. After the year of 1993, the tiny changes among clusters are also continuing, according to the above analysis, those stations which have no various changes are also keeping on developing in each group.

3.5.2 Characteristics of the Stations Distribution in Fukuoka

As what have been shown in Fig. 3.3, Fig. 3.4, Fig. 3.5 and Fig. 3.6, the distribution of stations of each cluster is a shape of a Y-looking which centers of commerce, business, medium density resident, low density resident, government, municipal offices, education and public welfare, are all in a hierarchical and classified urban structure and have a methodic land use.

Moreover, in 1985, low density resident that existed in medium density resident was very narrow; in 2008, those places that were around stations are gradually becoming the residential quarter of medium density resident and making an expansion from center of a city to outside scale.

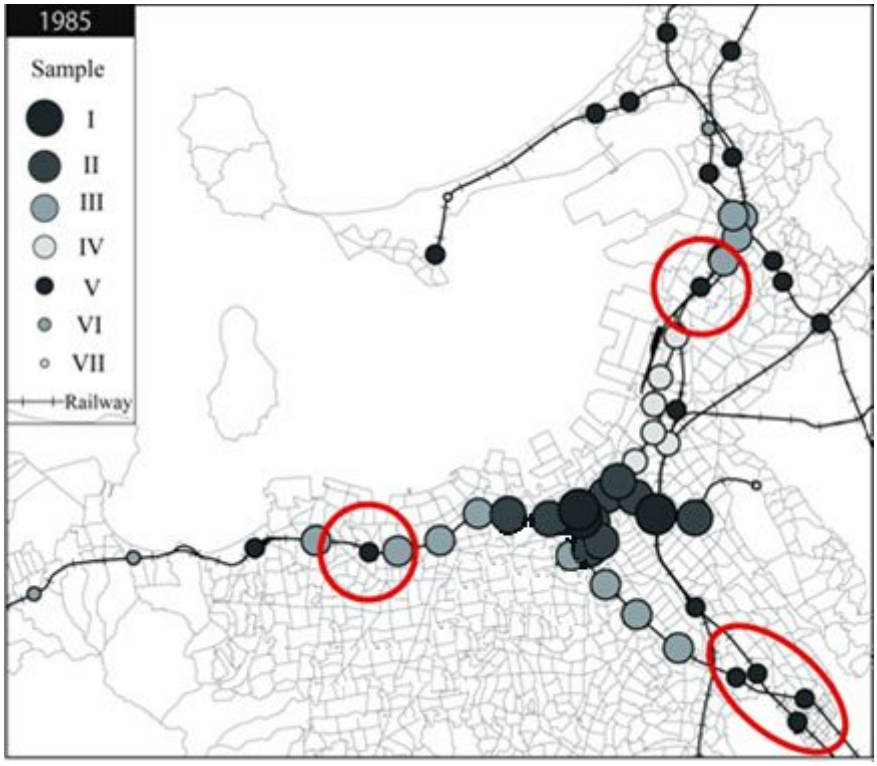


Fig. 3.3 Step.1 Secular Cluster Changes of Stations Distribution in 1985

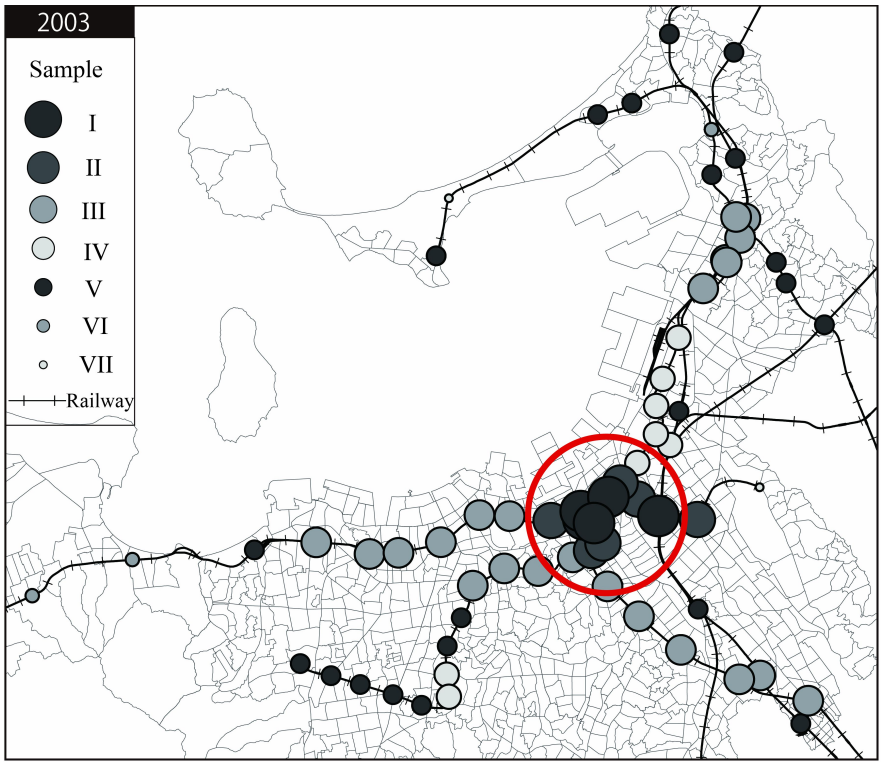


Fig. 3.4 Step.1 Secular Cluster Changes of Stations Distribution in 2008

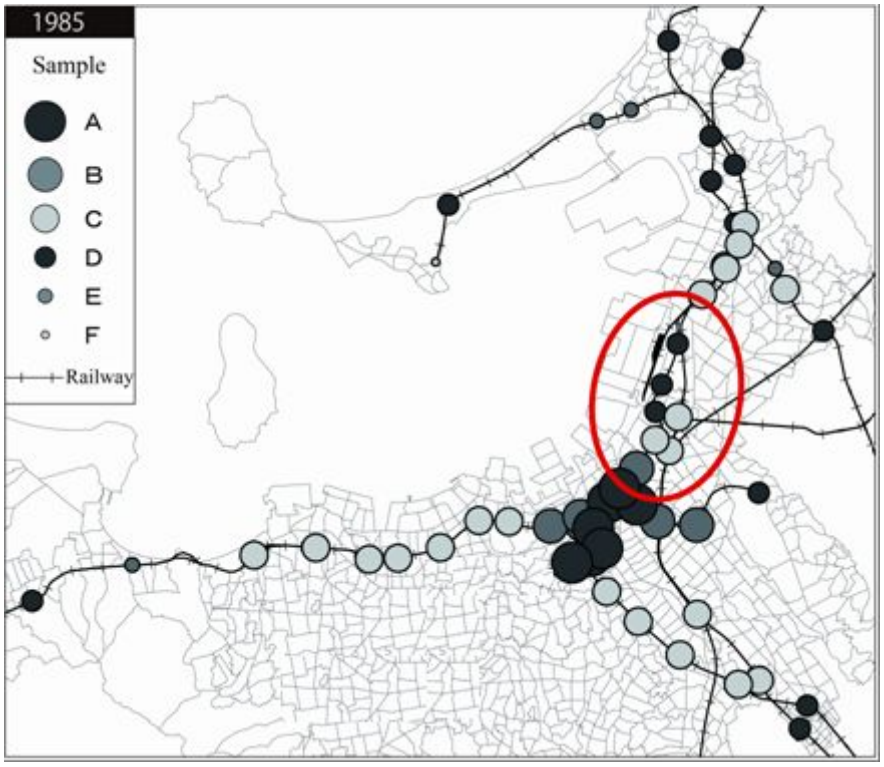


Fig. 3.5 Step.2 Secular Cluster Changes of Stations Distribution in 1985

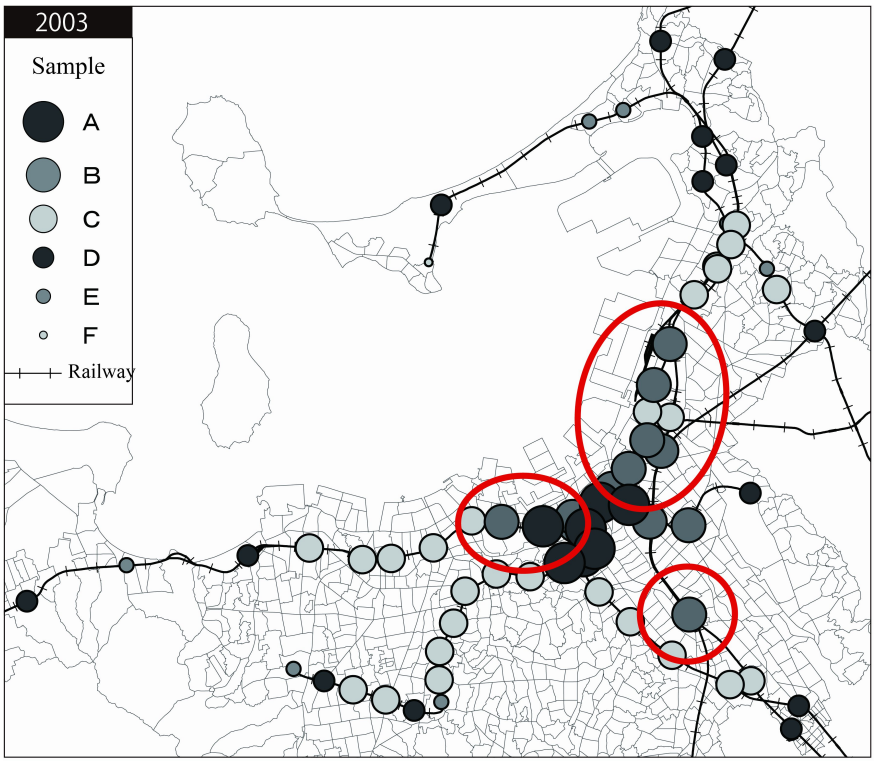


Fig. 3.6 Step.2 Secular Cluster Changes of Stations Distribution in 2008

3.6 SECOND-TIME CLUSTER ANALYSIS

3.6.1 Research Objectives

Fukuoka City, which has become the object of this research, has eight lines in total, that is, the JR Kagoshima Line, the JR Kashii Line, the JR Chikuhi Line, the Nishitetsu Omuta Line, the Nishitetsu Kaizuka Line, and three lines of the Fukuoka municipal subway. According to the second-time on cluster analysis, the research analyzes 52 stations without the stations of Nanakuma Line. As the stations of Nanakuma Line are founded in 2005, so their characteristics and changes on stations' types have not been shown clearly, thus, the research in this chapter has got rid of them and paid main attention on 52 remaining stations. Consequently, the annual development on 52 stations in eight lines are analyzed.

Data which are used in this research are shown in the table below, that is, the data of land use and building usage, which use the POSMAP (from data of land use and building usage) in the five periods of (1985, 1993, 1998, 2003, 2008) at each station and the GIS (Geographic Information System) to extract each land use and building usage. The data of population and number of households, which are from the census of population of Fukuoka city and in units of chome (the chome is a very special street unit in Japan, actually, the "cho" in Japanese is a kind of unit for streets; and the "me" in Japanese presents the No., thus, for instance, the 1 Chome means the first Avenue) at the time of 1985, 1990, 1995, 2000, 2005, 2010. The numbers of passengers, which are referred to the statistical books of Fukuoka and data of all routes of JR and Japanese western railways totaling for 36 years are collected from 1975 to 2011. The data of the Fukuoka city subway were collected up from the opening year 1981 to 2011 totaling for 30 years. The data of survey for prefectural land price and public reviewing land price, which are from National Land Numeric Information Download Service of the homepage of the Ministry of Land, Infrastructure, Transport and Tourism, are collected up to point data of 28 years from

1983 to 2011 in all. The data of architectural confirmation are ones of building confirmation of Fukuoka city from the year 1992 to the year 2004, totaling for 13 years. These data above is the ones that are used in the Chapter 5.

According to the background and the previous studies described above, by using relevant data on development status on land use and building usages, a series of further analysis is launched in the later research. At the same time, changes on the land use within and outside station zones and annual trend on development have been interpreted, thus, the developing trends of station zones have been definite. Basing on the data of land use and building usages around railway and subway stations in Fukuoka, this research selects 52 stations of 8 lines as the research targets, which are compared and analyzed basing on the distribution of land use by extracting the POSMAP data on land use by using the GIS. In addition, the data are separated with two steps of five periods, that is, 0m-400m radius (Step.1) and 400m-800m radius (Step.2), which are categorized into several representative groups by using the cluster analysis in order to interpret the characteristics of the stations and classify the stations further. Moreover, basing on the results of second-time cluster analysis, the research has made a predictive analysis which aims to find the characteristics and conditions on changes of stations in annual periods, consequently, taking one station as the example, the station which had ever been A type, after several years, it has changed from A type into B type, and after the development of several years, it has a trend that is changing into C type, etc. And finally, which type the station will be changing into can be calculated.

3.6.2 Research Methods

1) This research mainly focuses on changes of land use in the sphere of each station and comparison for changes on distance. Thus, the most convenient method for this research is to set station zones and extract data by the GIS. The goal of this research is to analyze changes of land use of urban development with a focus on the station; thus, the range of 800-metre (800m) radius (within a 10-minute walk) from the station is set as a station zone. In order to identify the station by using data from railway stations, the circle of 800m radius from the central point of the station is set, which is in relation to the spatial location of chome. Firstly, analyzing the land use from the center of the station to 400m in radius (in the range of 5 minutes on foot)

for catching characteristics of each station; later, making an analysis from 400m to 800m in radius for catching space characteristic of each station and the trend outside the station is also caught.

2) In addition, according to the method of factor analysis, the research extracts six variables from 13 variables and makes similar ones into together in order to form a more convenient base for the cluster analysis later.

3) Afterwards, by analyzing stages gradually, that is, within 400m in radius and radius 400m-800m (Step.2) from the center of one station (Step.1), space of each station is understood to extend spatially. The trend of the land use in the range of station is investigated in a concrete method, that is, the cluster analysis, the research analyzes data of land use in each investigated year (1985, 1993, 1998, 2003 and 2008) and each stage (Step.1, 2); Finally, a prediction is done for getting out the future changing conditions on stations.

3.6.3 Factor Analysis

According to the data of population (source: Statistics for Fukuoka Residents), the number of passengers of 68 stations in the five years of 1985,1993,1998,2003,2008 (source: Statistics Book of Fukuoka) and land use data (source: data for all Chome and data of City Planning Basic Survey of Fukuoka City from Fukuoka City Hall), then by using the GIS (Geographic Information System) and POSMAP, 13 variables of 5 years can be got, and for being analyzed by a more clear and convenient way, the research uses the factor analysis to make similar ones be chosen into six groups together.

$$x_i = \mu_i + \alpha_{i1}F_1 + \alpha_{i2}F_2 + \alpha_{i3}F_3 + \varepsilon_i \quad i=1,\ldots,24$$

More specifically, the factors which are less than one will be omitted, and six factors can be remained, then, the relationship between factors and 13 variables can be presented in the form of "Component Matrix", and in order to make these factors have a better reflection on the original variables, a matrix is multiplied by these factors, that is, the " Component Transformation Matrix", thus, the relationship of

transferred factors and original basic variables can be caught. This figure illustrates the positions of the 13 variables on the coordinate system of the first three factors, then, the relationship between the conversion factors and original basic variables can be got, that is, the "Rotated Component Matrix". This figure means the rotated principal components load diagram.

3.6.4 Second-time Cluster Analysis

This research focuses on the railway stations and subways of Fukuoka city in order to clarify the trend of changes and development on them. With the survey of land use around railway stations and subways of Fukuoka, the research selects 52 stations as the research targets, which are compared and analyzed on the distribution of building usages, such as the business and hotel facility, the commerce and entertainment facility, the transportation facility, industry facility, etc., by extracting the POSMAP data on building usages with the GIS. Furthermore, for catching characteristics of the environment of train stations located in Fukuoka City, the paper uses the cluster analysis to analyze the characteristics of annual changes on land use around stations, the number of passengers and the distribution of the number of population. Furthermore, taking into consideration of walking distance, station zones, location of railway routes and the condition of population distribution, the paper sets the range of 0-400m radius and 0-800m radius from the center of stations and makes the cluster analysis on 52 stations. This research uses the “Euclidean distances” to evaluate the distance among investigation places and defines parameters among clusters by using the “Ward” method. The Ward method is one way to minimize the sum of squares of the data of the cluster. Ward's method is a criterion applied in hierarchical cluster analysis. Ward's minimum variance method is a special case of the objective function approach originally presented by Joe H. Ward; he suggested a general agglomerative hierarchical clustering procedure, where the criterion for choosing the pair of clusters to merge at each step is based on the optimal value of an objective function. This objective function could be "any function that reflects the investigator's purpose". Many of the standard clustering procedures are contained in this very general class. To illustrate the procedure, Ward used the example where the objective function is error sum of squares, and this example is known as Ward's method or more precisely Ward's minimum variance method. In this research, the

data are analyzed by 52 stations selected as the research targets, which are compared and analyzed on the distribution of land use as well as other important influencing factors including the population and passenger. According to the factor analysis, it can be classified into 6 categories, that is, the commerce, the house, the government and education, the park and green land, the road and others. Furthermore, the data are analyzed by 5 years, separated with two steps, that is, 0-400m radius (Step. 1) and 400-800m radius (Step. 2), in addition, five-age points multiply 2 distance categories (Step.1, 2) that makes 10 series of data (each series of data corresponding to 52 stations), and are categorized into groups according to the cluster analysis by using the Ward method so that the spatial characteristics of stations can be hold and the research can indicate the changing types of each station in the past five years.

Basing on the data of population, the number of passengers and land use data of 52 stations in the five years of 1985, 1993, 1998, 2003, 2008, the paper performs the standardization of above various data and bases on the method of Square Euclidean Distance to do the cluster analysis. Furthermore, by using the factor analysis for calculation of land-use data, the 13 variables are combined into 6 categories, that is, “commerce", “housing", "government and education", "parks and green space", " roads " and "others". Then, all chome data in 400m radius and 800m radius from main entrances of stations and configuration ratio of land use are aggregated, also, the calculation of the population around the station is assumed that the distribution area has a prorating population of uniformly-chome which is contained within a 400m and 800m acreage.

In this research, space constraints permit only representative work to be cited. Thus, the result of cluster analysis of the latest data of 2008 is interpreted exhaustively below. Results of cluster analysis are as follows, in step.1 0m-400m radius, it can be divided into 6 clusters; in step.2 400m-800m radius, it can be also divided into 6 clusters. Basing on the results of step.1 and step.2, the spatial scale around each station can be caught. Therefore, according to forms and figures below, the yearly characteristics and changes of categories can be easily caught.

Firstly, for a more intuitive cognition on characteristics of each cluster, samples of types are shown in the figures below,

Step.1 0m-400m radius

After the cluster analysis, according to the above Table, the types of groups have

been divided into 6 groups, and the types are as follows,

Group 1 "Type of Commerce"(11 stations):

Nishitetsu Fukuoka, Yakuin, Nishitetsu Hirao, Nishitetsu Kashii, Kashii Harazonomae, Akasaka, Tenjin, Nakasu Kawabata, Gion, Hakata, Higashi Hire.

Group 2 "Type of the Municipal Office and Education Agency" (8 stations):

Chikuzen Shingu, Kyusandaimae, Saitozaki, Takaraha, Gofukumachi, **Chiyokenchiguchi,** Maidashi Kyudai Byoin Mae, Hakozaki Kyusandai Mae.

Group 3 "**Type of High-density Residential Area**"(13 stations):

Kashii, Meinohama, Ganosu, Doi, Ijiri, Najima, Hshii Gumae, Tonahara, Mitoma, Fujisaki, Nishijin.

Group 4 "Type of Medium-density Residential Area"(10 stations):

Yoshitsuka, Takeshita, Sasahara, Minami Fukuoka, Shimoyamato, Nata, Wajiro, Ohashi, Kaizuka, Hakozaki Miyamae.

Group 5 "Type of Low-density Residential Area"(6 stations):

Chihaya, Hakozaki, Imajuko, Susenji, Zayonokuma, Fukuoka Kuko.

Group 6 "Type of Space and Others"(4 stations):

Mai Matsubara, Nishitetsu Chihaya, Tojinmachi, Ohori Koen.

As what has been shown in Table 3.8, the results of cluster analysis of 0m-400m radius of 52 stations have been divided into 6 groups in step 1. 0-400m radius.

Table 3.8 Result of cluster analysis in 0-400m radius (including land use, population and passengers)

Groups	Stations	Lines[1]	Land Use (%)						Passenger (person/day)	Population (person)
			Commerce	House	Government & Education	Park & Green land	Road	Others		
Commerce	Nishitetsu Fukuoka Tenjin	NNR	29.8	26.8	5.4	0.7	24.6	12.6	50,188	7,176
	Yakuin	NNR	16.8	46.3	6.6	1.2	21.7	7.4	12,678	17,368
	Nishitetsu hirao	NNR	6.2	59.7	4.1	2.1	22.0	5.9	4,348	22,901
	Nishitetsu kashii	NNR	16.3	45.0	5.2	2.2	16.4	14.9	1,170	16,441
	Nishitetsu kashiikaenmae	NNR	31.2	12.5	31.9	1.9	13.8	8.7	967	7,595
	Akasaka	FCS	27.6	31.5	13.6	0.1	20.6	6.7	9,628	14,234
	Tenjin	FCS	40.1	12.1	8.2	5.2	28.2	6.2	43,591	6,305
	Nakasu-Kawabata	FCS	38.9	14.2	10.3	3.2	25.8	7.6	9,353	6,439
	Gion	FCS	32.5	9.2	10.3	0.9	29.4	17.7	4,431	9,395
	Hakata	FCS	39.2	6.6	7.1	4.1	24.0	19.0	39,699	8,758
	Higashi-Hie	FCS	28.0	18.7	1.3	1.2	25.7	25.2	5,663	9,407
	Average		27.9	25.7	9.5	2.1	22.9	12.0	16,520	11,456
Government & Educaton	Chikuzenshingu[2]	JR	0.8	45.7	19.6	4.4	16.4	13.1	8,177	8,338
	Kyusandai-mae	JR	4.11	30.4	42.6	1.7	16.5	4.6	4,549	10,955
	Saitozaki	JR	0.7	47.4	17.6	2.2	10.8	21.4	613	2,498
	Takamiya	NNR	8.1	37.2	22.2	4.1	22.1	6.3	6,843	22,368
	Gofukumachi	FCS	23.1	14.4	27.0	2.2	23.5	10.0	1,986	12,661
	Chiyo-Kenchoguchi	FCS	19.3	20.7	26.4	0.8	25.4	7.4	2,315	15,624
	Maidashi-Kyudaibyoinmae	FCS	6.6	17.5	32.6	15.7	20.3	7.4	2,912	10,017
	Hakozaki-Kyudaimae	FCS	8.9	47.9	13.9	5.2	20.5	3.7	2,325	15,080
	Average		8.9	32.7	25.2	4.5	19.4	9.2	3,425	12,193
High Density Residence	Kashii	JR	1.3	60.0	10.1	2.8	13.1	12.8	8,493	13,842
	Meinohama	JR	13.3	59.7	3.2	10.0	0.0	13.7	4,259	16,329
	Gannosu	JR	2.3	60.6	0.1	0.4	15.9	20.6	244	3,985
	Kashiijingu	JR	2.3	52.1	3.5	9.1	16.3	16.7	645	12,879
	Doi	JR	8.2	58.4	0.7	3.5	1.0	28.2	802	7,714
	Ijiri	NNR	7.1	52.6	2.4	1.0	16.6	20.4	7,986	17,218
	Najima	NNR	1.2	53.4	5.8	5.0	13.6	21.0	629	11,714
	Kashiimiyamae	NNR	2.4	53.1	2.9	2.5	17.0	22.1	880	13,713
	Tonoharu	NNR	3.7	52.1	1.0	1.1	19.6	22.6	380	12,058
	Mitoma	NNR	4.3	52.2	3.7	3.2	17.6	19.0	1,184	10,303
	Muromi	**FCS**	**4.7**	**64.0**	**7.1**	**0.4**	**20.6**	3.1	5,154	16,831
	Fujisaki	FCS	5.1	60.7	6.2	1.9	19.5	6.5	7,316	17,242
	Nishijin	FCS	16.6	50.8	3.8	0.8	21.7	6.3	14,910	19,607
	Average		5.6	56.1	3.9	3.2	14.8	16.4	4,068	13,341
Middle Density Residence	Yoshizuka	JR	12.9	38.9	14.2	1.7	17.2	15.1	7,178	15,693
	Takeshita	JR	3.6	41.9	9.6	1.6	17.2	26.0	3,696	11,406
	Sasabaru	JR	4.2	51.6	2.2	4.1	19.6	18.3	2,694	14,703
	Minami-Fukuoka	JR	4.7	47.5	13.2	2.0	20.4	12.2	6,113	7,591
	Shimoyamato	JR	3.2	45.7	9.2	1.5	14.8	25.7	1,561	10,319
	Nata	JR	0.0	50.8	11.4	2.1	19.5	16.2	875	11,235
	Wajiro	JR	5.9	50.2	7.6	0.8	14.4	21.1	1,110	9,467
	Ohashi	NNR	8.4	46.4	7.3	1.0	23.4	13.5	12,596	20,859
	Kaizuka	FCS	6.4	46.3	1.1	10.7	22.3	13.2	4,587	13,639
	Hakozaki-Miyamae	FCS	8.3	43.5	11.5	2.7	22.3	11.7	2,210	4,233
	Average		5.8	46.3	8.7	2.8	19.1	17.3	4,262	11,915
Low Density Residence	**Chihaya**	**JR**	**4.2**	**31.5**	**12.1**	**2.0**	**13.9**	36.4	5,128	12,488
	Hakozaki	**JR**	**14.8**	**33.0**	**8.3**	**1.7**	**8.9**	33.3	2,992	8,675
	Imajuku	JR	6.3	38.2	0.5	0.4	11.8	42.8	3,119	8,027
	Susenji	JR	1.4	10.2	0.9	0.1	5.9	81.6	3,430	8,016
	Zassyonokuma	NNR	15.9	36.5	6.5	0.6	21.6	18.9	5,653	13,806
	Fukuokakuko (Airport)	FCS	3.9	38.0	6.0	9.4	15.5	27.3	14,343	2,112
	Average		7.7	31.2	5.7	2.4	12.9	40.0	5,778	8,854
Unused space & Others	Maimatsubara	JR	3.8	52.5	1.3	6.2	18.5	17.8	664	10,660
	Nishitetsu chihaya	NNR	3.9	26.6	12.8	2.0	12.1	42.7	1,208	12,499
	Tojinmachi	FCS	2.4	27.9	3.2	21.5	11.6	33.4	6,367	14,599
	Ohorikoen	FCS	4.6	7.5	14.7	40.2	18.2	14.8	5,394	17,188
	Average		3.7	28.6	8.0	17.4	15.1	27.1	3,408	13,737

[1] JR: Japan Railway (Kyushu railway); NNR: Nishi-Nippon Railroad; FCS: Fukuoka City Subway

[2] The name of Chikuzenshingu Station has been changed into Fukkodai-mae Station in 2008

The characteristics of each group can be summarized briefly as follows,

Step.1 0-400m Radius

(1) Group 1 "Type of Commerce" (11 stations)

The "commerce" in this kind of group has occupied the highest average among all the groups and it also has been a relatively high ratio of the passengers per day as well as the population. The composition ratio of residential areas is the lowest ratio of land use in this kind of group. The reason is many stations are focused in the downtown and neighborhood districts where there are so many residential areas distributed there. Many persons go shopping and enjoy the amusements in stations of this group, but choose to live in other groups. Thus, stations in this group is gradually becoming a commerce-focused center. Furthermore, it is obviously shown that the percentage of "park and green land" is very low, but "road" in Group 1 occupies the highest percentage among all the groups.

(2) Group 2 "Type of the Municipal Institution and Educational Facility"(8 stations)

The composition ratio of "municipal institution and educational facility" in this group is up to 25% which is especially higher than other groups. According to the investigation, it is no doubt that the percentage of municipal offices and education facilities is much more than other districts. Thus, it can be thought that there is a high ratio for land use of municipal institutions, schools and other educational facilities founded around stations in this group. Moreover, the percentage of commerce in this group is much lower than Group 1. The percentage of "house" in this group is similar to Group 5 "Low-density Residential Area" which states there are not so many houses built around municipal offices and schools. The percentage of "road" in this group is the second only to the Group 1 as the highest percentage of "road".

(3) Group 3 "Type of High-density Residential Area" (13 stations)

The composition ratio of government and education institutions of this kind of group are less than other groups which is only 3.9% in average. "Park and green land" in this group is in a lower average than some other groups. The commerce of this group also occupies a low ratio, but according to the field survey, some stations in this group are developing the commerce gradually, thus, this kind of area will become a sub-central district only to the Group 1 in future. In addition, it is no doubt that the

"house" plays an obviously important role in this group. This group is located in the high-density residential areas, so it is a district that has a high frequency use on railway stations.

(4) Group 4 "Type of Medium-density Residential Area" (10 stations)

The percentage of "house" in this group is the second-highest number of all the groups in the type of "High-density Residential Area". There is a higher ratio of the population in this kind of group which is due to a higher density residential areas. However, the percentage of "park and green land" is also very low in this group which is only up to 2.8%. The ratio of "road" and "other" is in the middle place among 6 groups which is up to 19% and 17% separately. But some stations, such as the Yoshitsuka station is developing faster than before, not only in commerce, but also in transportation and road.

(5) Group 5 "Type of Low-density Residential Area" (6 stations)

The percentage of housing in this group is up to 31.2% which is lower than Group 3 and Group 4. The population in this kind of group is the least one among all the groups and the data of population is abstracted from the GIS by doing mesh on population. Moreover, it is worth paying attention to the percentage of "other" which occupies the highest percentage among all the groups, that is 40%. According to the fieldwork, stations and land use of this kind of group always have various other functions, such as the transportation, trade communication, industry, etc. There are also many unused land here that will be considered into future planning programme.

(6) Group 6 "Type of Green Space, Unused Land and others" (4 stations)

The passenger per day of this kind of group is the least among those groups, and the category "other" is the second only to the percentage of "other" in the Group 5 as the most percentage of "other". The average ratio of "house" of this group is not very high but not very low which is the second only the percentage of "house" in the Group 1. It is worth referring to that the average ratio of the "park and green land" is the highest one among all the groups. It explains that there are so many green space in stations of this kind of group which is very beneficial for sustainable development of urban modernization.

Step.2 400-800m radius

After the cluster analysis, according to the above Table, the types of groups have been divided into 6 groups, the types are as follows,

Group 1 "Type of Commerce"(8 stations):

Nishitetsu Fukuoka, Akasaka, Tenjin, Nkasu Kawabata, Gion, Hakata, Higashi Hire, Gofukumachi.

Group 2 "Type of the Municipal Institution & Educational Facility"(6 stations):

Ohashi, Kaizuka, Fujisaki, Chiyokenchiguchi, Maidashi Kyudai, Hakozaki Kyudai Mae.

Group 3 "Type of High-density Residential Area"(12 stations):

Chikuzen Shingu, Sasahara, Zayonokuma, Kashijingu, Mai Matsubara, Nishitetsu Hirao, Takaraha, Ijiri, Kashii Hanazonomae, Mitoma, Muromi, Nishijin.

Group 4 "Type of Medium-density Residential Area"(12 stations):

Kyusandaimae, Kashii, Chihaya, Takeshita, Minami Fukuoka, Meinohama, Shinoyanamoto, Yakuin, Nishitetsu Chihaya, Kashii Miyamae, Nishitetsu Kashii, Tonohara, Hakozaki Miyamae.

Group 5 "Type of Low-density Residential Area + Others"(8 stations):

Hakozaki, Yoshitsuka, Imajuko, Nata, Wajiro, Doi, Zasshonokuma.

Group 6 "Type of Green Land + Roads"(6 stations):

Saitozaki, Ganosu, Najima, Tojinmachi, Ohori Koen, Fukuoka Kuko.

The results of cluster analysis of 400m-800m radius of 52 stations have also been divided into 6 groups in step 2. 400-800m radius (see Table 3.9).

Table 3.9 Result of cluster analysis in 400m-800m radius (including land use, population and passengers)

Groups	Stations	Lines[1]	Land Use (%)						Passenger (person/day)	Population (person)
			Commerce	House	Government & Education	Park & Green land	Road	Others		
Commerce	Nishitetsu Fukuoka Tenjin	NNR	40.8	32.7	8.2	6.9	10.9	0.5	50,188	17,652
	Akasaka	FCS	30.3	36.0	18.7	10.8	3.1	1.1	9,628	22,808
	Tenjin	FCS	42.9	29.7	9.9	6.4	10.4	0.8	43,591	19,468
	Nakasu-Kawabata	FCS	38.9	25.6	12.5	11.3	11.0	0.7	9,353	19,494
	Gion	FCS	31.6	23.6	17.6	10.1	16.0	1.2	4,431	20,025
	Hakata	FCS	39.7	28.7	5.5	8.7	14.1	3.3	39,699	23,238
	Higashi-Hie	FCS	36.2	21.7	2.5	14.3	13.4	11.9	5,663	12,992
	Gofukumachi	FCS	42.8	17.8	13.5	7.8	16.7	1.4	1,986	19,008
	Average		37.9	27.0	11.0	9.5	11.9	2.6	20567.4	19335.6
Government & Education	Ohashi	NNR	5.2	50.9	19.2	9.0	12.2	3.5	12,596	19,941
	Kaizuka	FCS	10.9	20.0	42.7	6.5	12.5	7.5	4,587	3,736
	Fujisaki	FCS	6.2	56.2	24.7	5.9	5.5	1.5	7,316	32,764
	Chiyo-kenchoguchi	FCS	27.2	27.0	22.4	12.3	9.3	1.9	2,315	18,209
	Maidashi-Kyudaibyoinmae	FCS	14.9	36.6	35.2	6.0	3.4	4.0	2,912	24,677
	Hakozaki-Kyudaimae	FCS	9.9	30.8	36.2	7.8	11.4	3.9	2,325	6,055
	Average		12.4	36.9	30.1	7.9	9.0	3.7	4954.7	17563.7
High Density Residence	Chikuzenshingu[2]	JR	7.6	58.5	4.8	8.7	10.7	9.8	8,177	7,711
	Sasabaru	JR	12.2	58.9	5.7	10.7	8.9	3.8	2,694	22,606
	Susenji	JR	7.6	60.6	3.6	8.6	16.4	3.2	5,653	8,086
	Kashiijingu	JR	2.0	59.1	12.2	19.3	2.2	5.1	645	17,556
	Maimatsubara	JR	5.4	57.6	12.5	16.0	3.9	4.6	664	18,169
	Nishitetsu hirao	NNR	11.8	65.0	11.1	6.1	3.7	2.3	4,348	36,633
	Takamiya	NNR	8.7	61.2	14.9	9.1	3.3	2.9	6,843	17,853
	Ijiri	NNR	6.0	67.8	2.6	11.8	6.4	5.4	7,986	22,273
	Nishitetsu kashiikaenmae	NNR	5.8	59.7	8.0	14.2	5.8	6.6	967	10,755
	Mitoma	NNR	3.1	63.2	9.3	9.2	4.1	11.1	1,184	9,222
	Muromi	**FCS**	**4.7**	**65.0**	**9.6**	**5.7**	**12.9**	2.2	5,154	25,941
	Nishijin	FCS	7.1	64.9	17.6	5.9	3.9	0.5	14,910	30,412
	Average		6.8	61.8	9.3	10.4	6.9	4.8	4935.4	18934.8
Middle Density Residence	Kyusandai-mae	JR	5.2	50.6	13.9	15.1	9.1	6.1	4,549	13,351
	Kashii	JR	7.6	52.4	12.2	15.3	7.1	5.4	8,493	20,938
	Chihaya	JR	8.2	54.5	7.0	18.8	9.8	1.7	5,128	23,837
	Takeshita	JR	10.9	44.4	18.3	8.2	14.0	4.2	3,696	19,724
	Minami-Fukuoka	JR	14.0	47.6	6.4	9.7	19.6	2.8	6,113	15,353
	Meinohama	JR	13.3	51.2	11.4	10.3	11.4	2.3	4,259	31,255
	Shimoyamato	JR	5.9	46.4	5.2	4.9	10.4	27.1	1,561	20,329
	Yakuin	NNR	26.3	47.3	9.7	8.7	6.3	1.8	12678.0	36,454
	Nishitetsu chihaya	NNR	9.4	53.9	8.9	17.0	9.3	1.5	1,208	2,051
	Kashiimiyamae	NNR	8.6	46.5	13.9	19.5	9.0	2.6	880	20,715
	Nishitetsu Kashii	NNR	16.3	45.0	5.2	2.2	16.4	14.9	1,170	14,295
	Tonoharu	NNR	2.8	50.2	6.3	22.5	6.2	12.1	380	6,852
	Hakozaki-Miyamae	FCS	8.3	43.5	11.5	2.7	22.3	11.7	2,210	11,168
	Average		10.5	48.7	10.0	11.9	11.6	7.2	4025.0	18178.6
Low Density Residence & Others	**Hakozaki**	**JR**	**15.5**	**35.5**	**11.9**	**12.3**	**17.0**	7.7	2,992	27,880
	Yoshizuka	JR	16.6	38.9	14.2	1.7	7.3	21.3	7,178	21,481
	Imajuku	JR	4.3	36.1	2.1	21.3	5.5	30.8	3,119	6,019
	Nata	JR	6.0	39.4	19.4	10.3	3.6	21.3	875	4,578
	Wajiro	JR	11.3	32.5	4.2	25.7	5.3	21.1	1,110	16,458
	Doi	JR	18.1	35.8	1.5	10.2	4.7	29.8	802	12,493
	Zassyonokuma	JR	5.7	21.3	9.0	8.7	2.9	52.4	3,430	13,203
	Average		11.1	34.2	8.9	12.9	6.6	26.3	2786.6	14587.4
Green land & Transportation	Saitozaki	JR	1.9	23.6	2.2	53.1	2.8	16.5	613	1,180
	Gannosu	JR	0.7	16.8	2.4	65.6	1.1	13.5	244	3,771
	Najima	NNR	6.3	35.5	6.8	13.2	32.3	5.9	629	20,428
	Tojinmachi	FCS	5.8	47.2	11.1	22.9	12.7	0.3	6,367	26,075
	Ohorikoen	FCS	10.3	29.4	19.7	20.0	19.1	1.5	5,394	14,336
	Fukuokakuko (Airport)	FCS	1.2	6.1	0.3	3.8	83.3	5.3	14,343	3,227
	Average		4.4	26.4	7.1	29.8	25.2	7.2	4598.3	11502.8

[1] JR: Japan Railway (Kyushu railway); NNR: Nishi-Nippon Railroad; FCS: Fukuoka City Subway

[2] The name of Chikuzenshingu Station has been changed into Fukkodai-mae Station in 2008

The characteristics of each group can be summarized briefly as follows,

Step.2 400-800m Radius

Group 1 "Type of Commerce" (8 stations): it has been a relatively high ratio on "commerce", whose occupancy is the most among all the groups. The average of passenger per day and population also have the highest percentage in all groups. Thus, not only do stations in this group have a large flow of passengers, but also the busiest section of Fukuoka, especially the Tenjin Station and the Hakata Station, there are so many persons come and go shopping and passengers come and go to work or travel that it has formed a rather big zone of business. Under the influence of it, this big zone is becoming bigger and bigger, even continues to play a central role in facilitating the surrounding regions' growth and prosperity. Moreover, the percentage of "house" of land use is very low in this group, from the Table 3.9, it can be seen clearly that this group and group 6 are all in a low percentage on "house" which is higher in other four groups. The composition ratio of "road" is a little higher than some groups, but not all the ones, however, the percentage of "road" is the highest among all the groups in 0m-400m radius. Furthermore, the ratio of "park and green land" is not so high and also not so low, just a middle rate as well as 0m-400m radius. It is worthy referring that "others" in this group is the lowest among all the groups which is only 2.6% in average. It is shown that unused space, forest and water are less than other areas.

Group 2 "Type of the Municipal Institution and Educational Facility"(6 stations): the percentage of "educational facility" of land use in this group is up to 30%, which is especially higher than the other five groups. It is thought that there is a high ratio of middle schools, universities and other educational and government institutions founded focusing on stations in this group, such as Kyushu University and Fukuoka's city hall. According to the field survey, it is no doubt that the percentage of municipal offices and education facilities is much more than other districts. Moreover, the percentage of commerce in this group is obviously much lower than Group 1. The ratio of "house" in this group is similar to Group 5 "Low-density Residential Area + Others" which is almost the same situation in 0m-400m radius. The percentage of "others" in this group is the second only to the Group 1 as the lowest percentage which illustrates a lower ratio of unused land and forest, etc. The average of passenger per day is not so high, but not very low in this

group and much lower than Group 1.

Group 3 "Type of High-density Residential Area" (12 stations): the number of passengers and the composition of land use of "commerce" in this kind of group is lower than other groups, but the population is not in a low average, but much higher than some groups. Furthermore, "housing" plays a very important role in this group. Stations of this group are all located in high-density residential areas, so it has been a district that has a high frequency use on houses. Thus, people usually demand a high dwelling environment quality in this kind of district. The composition ratio of municipal institutions and educational facilities in this group are a little less than other four groups except Group 2 "Type of the Municipal Institution and Educational Facility", which is only 9.3% in average. "Road" in this group is in a lower average than four groups except Group5 "Type of Low-density Residential Area + Others". The percentage of "commerce" in this group also very low, but according to the field survey work, as the growing large amount of housing needs, more and more shopping malls and restaurants are founded in this kind of districts, such as in Susenji station, there has been some new restaurant opened around this station in order to supply a more convenient service for those who are living around the station. It is just one example, and there are so many new-opened facilities for shopping or food in these stations so that more and more people begin to live here, and more and more people who have been always living here are not willing to remove away, thus, it is the reason that the percentage of "house" is highest one in all the groups.

Group 4 "Type of Medium-density Residential Area" (12 stations): The percentage of "house" in this group is the second-highest number of all the groups, which determines a relatively high rate of commerce and road. There is also a higher ratio on the population in this kind of group which is due to a relatively high density residential areas. However, the percentage of "park and green land" is a little high in this group which can reach to 11.9%. The ratio of "road" and "other" is in the middle place among 6 groups which is up to 11.6% and 7.2% separately. But some stations, such as the Yakuin station which is gradually focusing on development of commerce; the percentage of "government and education" of the Takeshita station reaches to 18.3% which is faster than other stations in this group; the percentage of "park and green land" reaches up to 22.5% which is higher than the average 11.9% of this group; in the category of "road", the percentages of Minami Fukuoka station and

Hakozaki Miyamae station have a higher rate than other stations, that is, 19.6% and 22.3% separately, which indicate a highly developing road for people's life demand. Furthermore, not only in unused land, but also in forest and others, there is a high percentage on Shimoyamato station which is up to 27.1% in this group.

Group 5 "Type of Low-density Residential Area" (8 stations): The percentage of housing in this group is up to 34.2% which is lower than Group 3 and Group 4, thus, it is the low-density residential area and the amount of passenger per day is the lowest one among all the six groups. As this group is low-density residential area, so the passengers are also lower than other groups. Moreover, the ratio of "park and green land" reaches to 12.9% that has been already the second highest ratio among all the groups. Although the percentage of residential area is lower than Group 3 and Group 4, the ratio of "others" is the most highest among all the six groups which has already reached up to 26.3%. This data has also shown that there is a high ratio on unused land, forest in this group. According to the data of population which has been abstracted from the GIS, it has made clearly that the population in this group is the second little only to Group 6 "green land + road". According to the fieldwork, stations in this kind of group are charged with other various tasks besides basic ones and there are also many unused land here that will be used in the future.

Group 6 "Type of Green Land and Road" (6 stations): the percentage of three categories "commerce", "house" and "municipal institution and educational facility"of this group is the lowest among all the groups" which is 4.4%, 26.4% and 7.1% separately. The percentage of "park and green land" and "road" are the highest in all the groups which is 29.8% and 25.2% separately. It is worthy to mention that the percentage of Ganosu station is the highest one in this group which has been up to 65.6% on "park and green land" and the percentage of Fukuoka Kuko station is the most one in this group which has been up to 83.3% on "road". This is an evident indication that different station has different key on development. Moreover, in this group, there are so many green space which is very beneficial for sustainable development of a city.

As what have mentioned above, six groups in 0m-400m radius and six groups in 400m-800m radius have been classified. After that, for a further intuitive analysis, having the categorized results now allows depicting the results in some simple pie charts, as illustrated in Table 3.8. This is the base of the selection of target stations

when performing the analysis on chosen target stations. From the above interpretation, we can make some clear points, such as following,

1) Although the number of construction is diminishing in Fukuoka, the apartment project has fundamentally unchanged. Meantime, there is a phenomenon that the distribution of the project seems to return back to downtown.

2) The development of apartments in downtown is concentrated in the south area of the national road, the number of large projects has grown, especially in surrounding area of Haruyoshi and Sumiyoshi. For the development of narrow road area is being progressed, the subject in the future is keeping balance for overall infrastructure enhancement.

3) In airport line and Omuta line, the railway and arterial traffic was in process of overall transformation, the regional core that owns commercial center is scattered. The station is mixed up with massive infrastructure, railway network and highway network then could not form urban streets, along with suburban station got the pursuit of high utilization will become one of the urban problems. In Nanakuma Line, there are more single residential house and residual agricultural land, so that there is certain space of development. Based on promotion of TOD in the future, it is necessary to conduct integration of transformation in accordance with commercial center model.

3.7 CONCLUSIONS

3.7.1 Summary

Basing on the data of land use and building usages around railway and subway stations in Fukuoka, this research selects 68 stations of 8 lines as the research targets, which are compared and analyzed basing on the distribution of land use by extracting the POSMAP data on land use by using the GIS. In addition, the data are separated with two steps of five periods, that is, 0m-400m radius (Step.1) and 400m-800m radius (Step.2), which are categorized into several representative groups by using the cluster analysis in order to interpret the characteristics of the stations and classify the stations further. Moreover, basing on the results of second-time cluster analysis, the research has made a predictive analysis which aims to find the characteristics and conditions on changes of stations in annual periods, consequently, taking one station as the example, the station which had ever been A type, after several years, it has changed from A type into B type, and after the development of several years, it has a trend that is changing into C type, etc. And finally, which type the station will be changing into can be calculated.

Furthermore, the changes of land use and building usage around stations are also analyzed specifically in this paper including their influence for the population and the land price in order to indicate characteristics of space using around stations. After the burst of the economic bubble in 1996, although the development of surrounding areas of stations is a little slower, and the stores and restaurant are in the decreasing tendency in 0m-400m zones of stations, the trend of development is still changed into the suburb regions of station zones. By representing the changes around stations in Fukuoka City, this paper is hoped to be useful for further research in future.

The specification of the directionality of a spatial extension in Step.2 by the cluster analysis (400m -800m cluster), which will be considered in a wider subject,

that is, not only do the analysis by land use, but also expand it by adding the number of passenger in 400m-800m radius, the population into cluster analysis, etc. in order to find out the most important factor of influence and the degree of influence during the development of railway stations.

A large number of large-scale commercial facilities tend to the suburbs and commerce has been hollowing out of the center of a city, which has become a major and deregulated social problem in Japan today. Not only a small city, but also a central city, such as Fukuoka, have been affected seriously. Furthermore, in recent years, the environment problem has also been paying more and more awareness on and improving the environment problem around railway stations has also been promoted gradually. This research is taking into account the above social background and focuses on the railway stations and subways of Fukuoka city in order to clarify the tend of changes and development on them. After the burst of the economic bubble in 1996, although the development of surrounding areas of stations was a little slower, also the stores and restaurant are in the decreasing tendency in 0m-400m zones of stations, the key spots of development is moving outside the center of station zones. This research mainly analyzes data of building usage by the method of cluster analysis around stations in Fukuoka. Furthermore, the features of a spatial extension around stations are also clarified. The changes of building usages around stations are also analyzed specifically in this paper including their influence for the population in order to indicate characteristics of space using around stations. For the purpose of sustainable development, more useful and meaningful ways on developing stations and their surrounding areas will be put forward to, which may provide a reference for the re-development.

Moreover, according to the results of cluster analysis, the land use and building usage will be analyzed further by multiple regression analysis on the base of the degree of influence for the number of passengers.

After that, basing on the investigated data, an advanced research will be expanded on the forecasting of developing trend on the land use around stations. Prognostic charts of the forecasting can show a more clear variation tendency on the development of land use in future five years, ten years, even more ones which can also establish detailed information and anticipate future needs. Thus, the railway development and applications can be given a more comprehensive way to be shown.

For the purpose of sustainable development, more useful and meaningful ways on developing stations and surrounding regions will be put forward to.

A large number of large-scale commercial facilities tend to the suburbs and commerce has been hollowing out of the center of a city, which has become a major and deregulated social problem in Japan today. Not only a small city, but also a central city, such as Fukuoka, has been affected seriously. In addition, the environment problem has been paying more and more awareness on and improving the environment problem around railway stations has also been promoted gradually in recent years.

This research selects 68 stations as the research target, compares and analyzes the distribution of land use, such as commerce, housing, industry, agriculture, etc. The integration development of the urban railway and subway with the land use can play a comprehensive effect, do not only improve the efficiency of the land development and increase government revenue, but also bring a stable number of passengers for the railway and subway. The core issue of the integration development for the railway and subways with land development is a scientific analysis on the quantitative relationship between stations and land price. Thus, the research has an important theoretical significance and practical significance that can be able to provide solutions for integration development.

Moreover, three interpretations are put forward in the research, which are as follows,

Firstly, it is no doubt that the formation of whole large comprehensive transportation and communication system of the railway and subway stations has played an obvious added-value role for the surrounding land price and housing price. As there are improvement on further prosperity of commerce, business and traffic conditions in this kind of regions, the commerce and transportation has gradually become the main developing key in the surrounding areas where a new hot spot or vice-commercial district is forming, thus, the effect has been increasingly apparent in future.

For the added-value land as the municipal construction, the government should reserve in advance so that it can be put into the later development and construction. In addition, in some areas where the commerce, the business, the industry and the transportation have been in the good condition areas, the added-value effect on the

land price and the real estate is more obvious. For this reason, the real estate developers should try to choose such a location for the priority development.

3.7.2 Future Work

This research is only the beginning of a series of other related research studies. It opens the door for a variety of studies that can investigate the effects of development on the land use and building usage. However, to make the present research fully operational, further development is required and taken into account other factors such as: calibrating the influence factors, integration of more influence factors and testing their accumulative affects. There are a number of possible topics for further work in this research, that is,

The research will also discuss the developing trend of stations in future work, in order to make this theoretical idea more useful for explaining the state of urban structure, stations' developing trend will be divided into several different types, specifically speaking, the research will abstract a part of stations, but not all the stations, which have obvious changes in different years (from the year of 1985, 1993, 1998, 2003 and 2008, totally five years), during this period, the stations that have special and obvious changes will be chose and made further analysis in later research work. For instance, in 1985, it is what type of station? But after five or ten-year development, what type of station it has grown up? Then after twenty-year change, what type of station it will be changing into? ... It is hoped to become a part of important guideline for other research and future urban development.

One of the preconditions of the above research is to make a prediction on changes on land use and building usage in future, therefore, a useful, believable and practicable method for future predicting is necessary.

REFERENCES

Ahmed M U, Banaee H, Loutfi A. Health Monitoring for Elderly: An Application Using Case-Based Reasoning and Cluster Analysis[J]. ISRN Artificial Intelligence, 2013, 2013.

Avouac J, Huscher D, Furst D E, et al. Expert consensus for performing right heart catheterisation for suspected pulmonary arterial hypertension in systemic sclerosis: a Delphi consensus study with cluster analysis[J]. Annals of the rheumatic diseases, 2013.

A Research Report Concerning on Urban Structure of Fukuoka City, Fukuoka Asian Urban Research Laboratory, Japan, 2005.

Babalik-Sutcliffe E. Urban rail systems: Analysis of the factors behind success. Transport Reviews, 2002, 22(4): 415-447.

Bafna, S. An introduction of space syntax. Environment and Behavior, Vol.35, 17-29, 2003.

Beckonert O, E Bollard M, Ebbels T, Keun H C, Antti, H, Holmes E, Nicholson J K. NMR-based metabonomic toxicity classification: hierarchical cluster analysis and k-nearest-neighbour approaches. Analytica Chimica Acta, 2003, 490(1): 3-15.

Bitter C, Mulligan G F, Dall'erba S. Incorporating spatial variation in housing attribute prices: a comparison of geographically weighted regression and the spatial expansion method. Journal of Geographical Systems, 2007, 9(1): 7-27.

Capozza D R, Helsley R W. The fundamentals of land prices and urban growth. Journal of Urban Economics x, 1987, 295-306.

Cohen J P, Paul C M. The impacts of transportation infrastructure on property values: A higher-order spatial econometrics approach. Journal of Regional Science, 2007, 47(3): 457-478.

Damm D, Lerman S, Lerner-Lamm E, et a1. Response of urban real estate values in

anticipation of Washington Metro. Journal of Transport Economics and Policy, 2007, 14:315-336.

Daughney C J, Raiber M, Moreau-Fournier M, et al. Use of hierarchical cluster analysis to assess the representativeness of a baseline groundwater quality monitoring network: comparison of New Zealand's national and regional groundwater monitoring programs[J]. Hydrogeology Journal, 2012, 20(1): 185-200.

Davis M A, Heathcote J. The price and quantity of residential land in the United States[J]. Journal of Monetary Economics, 2007, 54(8): 2595-2620.

De Noronha Vaz T, Galindo P V, Nijkamp P. Modelling R&D and Innovation Support Systems–Analysis of Regional Cluster Structures in Innovation in Portugal[R]. Tinbergen Institute, 2013.

Domínguez M, Fuertes J J, Alonso S, et al. Power Monitoring System for University Buildings. Architecture and Advanced Analysis Tools[J]. Energy and Buildings, 2013.

Duncan M. The impact of transit-oriented development on housing prices in San Diego, CA. Urban Studies, 2011, 48 (1): 101-127.

Dowall D E, Leaf M. The price of land for housing in Jakarta[J]. Urban Studies, 1991, 28(5): 707-722.

Farber S, Yeates M. A comparison of localized regression models in a hedonic house price context. Canadian Journal of Regional Science, 2006, 29(3): 405-420.

Fukuoka City Statistics Book. Fukuoka City, Japan, 2000.

Gazdar T, Benslimane A, Belghith A, et al. A secure cluster‐based architecture for certificates management in vehicular networks[J]. Security and Communication Networks, 2013.

Ghebreegziabiher Debrezion & Eric Pels & Piet Rietveld. The Impact of Railway Stations on Residential and Commercial Property Value: A Meta-analysis, J Real Estate Finan Econ, 35, pp.161–180, 2007.

Godschalk D R. Land use planning challenges: coping with conflicts in visions of sustainable development and livable communities. Journal of the American Planning Association, 2004, 70(1): 5-13.

Golub A, Guhathakurta S, Sollapuram B. Spatial and temporal capitalization effects of light rail in phoenix from conception, planning, and construction to operation.

Journal of Planning Education and Research, 2012, 32 (4): 415-429.

Handy, S.L. and Niemeier, D. A. Measuring Accessibility: an Exploration of Issues and Alternatives, Environ-ment and Planning A, 29(7) pp.1175-1194, 1997.

Handy S. Smart growth and the transportation-land use connection: What does the research tell us? International Regional Science Review, 2005, 28 (2): 146-167.

Hess D P. Impact of proximity to light rail rapid transit on station-area property values in Buffalo, New York. Urban Studies,2007, 44(5): 1041-1068.

Honda Masaku, Shimada Im. Multivariate Statistical Technique for Management. Japan: Publishing Department of Sanno and Management University, 1977.

Iwatani M. A GIS Fundamental Study on Location Tendency of Condominium and TOD Promotion Plan, Architectonics Research, Graduation Thesis Outline Collections, 2002.

Kaufman L, Rousseeuw P J. Finding groups in data: an introduction to cluster analysis, 2009, 344, Wiley-Interscience.

Kestens Y, Thériault M, Des Rosiers F. Heterogeneity in hedonic modeling of house prices: looking at buyers' household profiles. Journal of Geographical Systems, 2006, 8(1): 61-96.

Kim C W, Phipps T T, Anselin L. Measuring the benefits of air quality improvement: a spatial hedonic approach. Journal of Environmental Economics and Management, 2003, 45(1): 24-39.

Kim J H. Linking land use planning and regulation to economic development: a literature review. Journal of Planning Literature, 2010, 26(1): 35-47.

Knight R L, Trygg L L. Evidence of land use impacts of rapid transit system. Transportation, 1977, 6: 231-248.

Kumar P J S. Impact of Leather Industries on Fluoride Dynamics in Groundwater Around a Tannery Cluster in South India[J]. Bulletin of environmental contamination and toxicology, 2013: 1-6.

Li X, Yeh A G O. Analyzing spatial restructuring of land use patterns in a fast growing region using remote sensing and GIS. Landscape and Urban planning, 2004, 69(4): 335-354.

Lin T C, Evans A W. The relationship between the price of land and size of plot when plots are small[J]. Land Economics, 2000: 386-394.

López-Jiménez D, Bueno S, Gallego M D. A Cluster Analysis for Determining the

Effects of Codes of Conduct in the Business Administration[M]//Emerging Trends in Computing, Informatics, Systems Sciences, and Engineering. Springer New York, 2013: 253-261.

Luca Bertolini, Tejo Spit: Cities on rails: the redevelopment of railway station areas, Routledge, New York, 2001.

Luca Bertolini. Nodes and places: complexities of railway station redevelopment: European Planning Studies, 4(3), pp.331-345, 1996.

Mahr A, Katsahian S, Varet H, et al. Revisiting the classification of clinical phenotypes of anti-neutrophil cytoplasmic antibody-associated vasculitis: a cluster analysis[J]. Annals of the Rheumatic Diseases, 2013, 72(6): 1003-1010.

Makrí, M. and Folkesson, C. Accessibility Measures for Analyses of Land Use and Traveling with Geographi-cal Information Systems, Proceedings of 2nd KFB-Research Conference, Institute of Technology, Lund, 1999.

Morancho A B. A hedonic valuation of urban green areas. Landscape and Urban Planning, 2003, 66: 35-41.

Paez A, Uchida T, Miyamoto K. Spatial association and heterogeneity issues in land price models. Urban Studies, 2001, 38(9): 1493-1508.

Porta, S., Crucitti, P. and Latora, V. The network analysis of urban streets: a primal approach. Environment and Planning B: Planning and Design, 33(5), 705-725, 2005.

Ping X Q, Chen M Y. Real Estate Financing, the Price of Land and the Trend of Housing Price. World Economy, 2004.

Ratti C. Environment and Planning B: Planning and Design, 2004, 31: 487 - 499.

Rosenthal S S, Helsley R W. Redevelopment and the urban land price gradient[J]. Journal of Urban Economics, 1994, 35(2): 182-200.

Ryan S. Property values and transportation facilities: Finding the transportation-land use connection. Journal of Planning Literature, 2011, 13 (4): 412-427.

Song B, Gao B. A causality test for housing and land prices: 1998-2006[J]. Modern Economic Science, 2007.

Su J G, Brauer M, Ainslie B, Steyn D, Larson T, Buzzelli M. An innovative land use regression model incorporating meteorology for exposure analysis. Science of the total environment, 2008, 390(2): 520-529.

Tepavčević B, Stojaković V. Procedural modeling in architecture based on statistical

and fuzzy inference[J]. Automation in Construction, 2013.

Timm H, Borgelt C, Döring C, Kruse R. An extension to possibilistic fuzzy cluster analysis. Fuzzy Sets and Systems, 2004, 147(1): 3-16.

Ward P, Jimenez E, Jones G. Residential land price changes in Mexican cities and the affordability of land for low-income groups[J]. Urban Studies, 1993, 30(9): 1521-1542.

Wu J, Zhang Z X. Cluster Analysis for Orientation Data Using DifFUZZY Method[M]//New Frontiers in Engineering Geology and the Environment. Springer Berlin Heidelberg, 2013: 157-161.

Yang Y, Yeo C K. Design and analysis of a cluster-based calcium signaling network model[C]//Consumer Communications and Networking Conference (CCNC), 2013 IEEE. IEEE, 2013: 574-579.

Yano Keiji. Research by GIS on Changes of Enterprise Location among Stations in Kyoto, Ritsumeikan Literature, Japan, 2006.

Yasuhiko Gen. Introduction to Econometrics by Excel, Toyo Economic Press Office, Japan, 2000.

Yano K. Research by GIS on Changes of Enterprise Location among Stations in Kyoto, Ritsumeikan Literature, Japan, 2006.

Zhang W, Leung Y, Wang Y. Cluster analysis of post-landfall tracks of landfalling tropical cyclones over China[J]. Climate Dynamics, 2013: 1-19.

Zhuang X Y. A Discussion on the Uptown Environment in the 21st Century. Journal of Sichuan College of Architectural Technology, 2008:18.

Zhuang X Y., Zhao S C. Research on Influence of Railway Station Development and Changes of Land Use in Japanese Cities. Proceedings of the 7th International Symposium on City Planning and Environmental Management in Asian Countries, Fukuoka, Japan, 2010.

Zhuang X Y., Zhao S C. A Case Study on Trend of Changes of Building Usages on Surrounding Areas of Fukuoka Railway Stations and Subways. Proceedings of the 9th International Symposium on Architectural Interchanges in Asia, Gwang-ju, Korea, 2012.

Zhuang X Y. Zhao S C. A Study on Annual Changes of Urban Environment in Surrounding Regions of Railway Stations. Journal of Architecture and Urban Design, Kyushu University, 2013, 23:1-8.

Chapter Four

Impact Degree of Land Use & Building Usage within Influence Sphere of Stations

Chapter 4
Impact Degree of Land Use and Building Usage within Influence Sphere of Stations

4.1 INTRODUCTION

With the development of social economy and speeding up of urbanization, the growth speed of cars in the city is much faster than the growth of road traffic infrastructures. The construction of the urban rail traffic has entered into a high-speed development stage. And the road transportation system has burdened to afford the growth of cars' growing number of a city. The vehicle emission pollution such as the carbon monoxide, the hydrocarbons, the nitrogen oxides and photochemical products have always being harmful to residents' health, and the buildings and destroyed the ecological environment. Thus, traffic congestion, hardly any parking space, environmental degradation, etc. have become a common fault of a city.

4.1.1 Overview of Contents

Almost all the countries that have been after a painful twists and turns, vividly choose

to develop the public transport in priority and created a lot of experience being worth promoting. The United States and Europe have experienced allowing the car developing free to the regression of paying great attention to the construction of the public transport. From the excessive pursuit for individual action free to the correct direction of sustainable development, it is a lesson learned and an experience being worth using for reference. It is generally believed that establishing a urban rail transit as the backbone and a regular public transportation as the auxiliary system of urban public transportation is the only feasible way to solve the urban traffic problem during a period of time in the future. The urban railway and subway is a safe, comfortable, convenient, fast, effective and environment-beneficially urban infrastructure system and plays an active role to reduce problems such as the shortage of land resources, the traffic congestions and the air pollution, which many cities are facing. It is imperative to analyze the quantified effects of the rail transit development on the adjacent land use and building usage in order to establish a complementary relationship between the development of rail transit, the influence on the population, land price and the use of the adjacent land.

The theory of land use has been extended to address the dynamics of urban growth and decline. This extension has fundamental implications. First, the determinants of urban spatial structure are different in static and dynamic models. For example, in a static mono-centric model, lot sizes increase and densities decrease with distance from employment since equilibrium land rents decline to offset the rising cost of commuting. However, in a dynamic model with durable housing and myopic landowners, urban development is an incremental process, where densities depend solely on economic conditions at the time of development. Densities may nevertheless decline with distance, because economic conditions change over time in particular ways (incomes increase or transportation costs fall), but land rents and prices and population densities may also rise with commuting distance.

In Fukuoka city, as the development of the project of land readjustment and buildings along stations, more and more buildings are actively built by the rebuilding of stations, the situation along railway-tracks has been changing at a rapid speed. Recently years, the residential areas in the center of a city are gradually appearing, which tendency is transferred to the suburbs of a city. Furthermore, modern society will still develop around the public traffic, thus, it is thought that peripheral urban

development that centers on the train station becomes more and more important to the city planning that centers on public traffic in an environmental society in the future. With the development of large-scale retailers and specialty stores, the shutter streets of shopping streets become more and more serious. The shutter street is a street, which was ever made of various branch shops with many closed-down shops or offices while this used to be a busy shopping district, with the taste of a "commercial town", but now, those shops are closing down, leaving the area mostly residential now.

Furthermore, Fukuoka-based Kyushu Economic Research Center reported that the more people left the Kyushu-Okinawa region than moved here in 2012, resulting in the first excess outflow of population in two years. The 4,860-person drop was attributed to a decline in the number of people moving in from regions affected by the Great East Japan Earthquake and nuclear power plant incident coupled with an increase in the number of people moving back to those regions in connection with disaster reconstruction efforts. Aside from Fukuoka and Okinawa, every prefecture in the region experienced excess outflow, led by Nagasaki and Kagoshima with respective declines of 4,906 and 3,599 persons. Meanwhile, Fukuoka experienced an increase of 9,221 persons, with over 60% of the new population originating in the Kyushu region (Source: Nishinippon News).

According to the background described above, by using relevant data on development status of land use and building usages, a series of analysis is launched. After that, changes on the land use within and outside station zones and annual developing trend have been interpreted, thus, the developing trends of Fukuoka station zones have been definite. Basing on the data of land use and building usages around railway stations and subways in Fukuoka, this research selects 68 stations and 8 lines as the research targets, which are compared and analyzed basing on the distribution of land use by extracting the POSMAP data on land use with the GIS. In addition, the data are separated with two steps of five years, that is, 0-400m radius (Step. 1) and 400-800m radius (Step. 2).

Basing on those above backgrounds, the influence on population, land price and passengers against the changes of surrounding regions and the influence degree on annual changes of stations zones also need to be solved. Thus, the paper aims to catch the influence degree on annual changes of land use by analyzing different distances of surrounding regions in station zones, moreover, analysis on the developing trend by

the method of quantitative analysis is carried out, that is, the Multiple Regression Algorithm.

4.1.2 Research Aims

(1) Firstly, by using relevant data on development status of land use and building usages, a series of analysis is launched. After that, changes on the land use within and outside station zones and annual developing trend have been interpreted, thus, the developing trends of Fukuoka station zones have been definite.

(2) Secondly, by using the multiple regression method, our work aims to catch the changes of the influence degree on the population, land price and passengers by analyzing the development of the utilization status of the land use and the building usages.

(3) Thirdly, by carrying out the analysis on the developing trend and influence degree by the method of quantitative analysis and multiple regression, the relationship among the population, land price, passengers, changes of land use and building usages can be got; after that, it shows analysis results and points out solution ways for those problems and the next step in future.

The process is, initially, we abstract annual data of the land use and buildings usage within the radius of 0~400m and 400~800m of the railway and subway stations in Fukuoka, Japan, by the GIS. Then, we analyze the relationship between 13 factors of the land use and 8 factors of the building usage, as well as the population, land price and passengers by the quantitative expression method. Followed, by choosing several categories of land use and building usage as explanatory variables, we analyze the degree of influence that the selected categories of land use and building usage affected on the population, land price and passengers by the multiple regression method. With detailed analysis and research, the specific impacts of the population, land price and passengers caused by the land use and building usage are achieved. It is shown that this research can help to the further development of the land use and building usage in the future.

4.1.3 Research Framework

This chapter is consisted of five parts as follows,

(1) Part 1 is focused on the general introduction including the research background,

previous studies and research objectives;

(2) Part 2 is formed with the research objects, that is, the selection of the target stations and an overview of data in hand;

(3) Part 3 is consisted by analyzing the developing status and annual changes on the land use and building usage on 68 target stations and the data is got from Geographic Information System;

(4) Part 4 is working on by using another method of multiple regression analysis in order to find the influence on population, land price and passengers and the influence degree brought from changes of land use and building usage. In addition, the relationship among the population, land price, passengers, changes of land use and building usages can be got;

(5) Part 5 is a summary of this chapter, which shows the analysis results and points out solution ways for those problems and the next step in future.

4.2 RELATED WORKS

Over the years, researchers have introduced a large number of developments of railway and subway stations and the relationship between the urban land and stations and the varying importance of the stations in a city according to one criterion or another. These following studies have proved of great value in the analysis and understanding of the roles played by railway and subway stations in a city’s development, such as the theory of the rail transit and its development, impacts on land market, the influence on house price, the developing situation of the land use and building usage, the analysis on changes of the land price and house price, etc., as there are mainly three elements supporting the paper, the previous studies will also be shown in turn, which are as follows,

Sustainable development and livable communities represent the big visionary ideas of contemporary urban planning. But attempts to implement these popular visions can encounter a host of conflicts. The future of land use planning may well depend on how it copes with these conflicts. (Godschalk, 2004). Wang and Yu (2012) have made a research on characteristics of urban landscape in the time-spatial pattern which can give us as a reference for characteristics of land use in the time-spatial pattern. The influence of transit-oriented development (TOD) on the San Diego, CA, condominium market has been measured and indicates that TOD has a synergistic value greater than the sum of its parts. It also implies a healthy demand for more TOD housing in San Diego (Duncan, 2010). Kim (2010) examines how land use planning and regulation may affect regional economic prosperity by reviewing relevant literature. Handy (2005) said there is a connection between transportation and land use. Kestens et al (2006) introduce the household-level data into hedonic models in order to measure the heterogeneity of implicit prices regarding household type, age, educational attainment, income, and the previous tenure status of the buyers. Hess evaluated the influence on the housing price by the distance from Buffalo, NewYork,

to the light railway stations. By using the price models and assessing the housing price of 14 light rail spots, he obtained the conclusion that each 1 foot away from the light rail station, the average value of the house will add $2.31 or $0.99 (according to the linear distance calculations (Hess, 2007). Cohen and Paul (2007) evaluated the impacts of enhanced transportation systems on property values. Ryan reviews the relationship between transportation facilities, highways, heavy rail, and light rail transit systems and property values. There are also some researchers who have studied the similar subjects with this paper Luca (1996), Luca and Tejo (2001), Makri and Folkesson (1999), Porta et al. (2005), Ratti (2004).

It is illustrated that the high power and reliability of metabonomic data analysis using NMR spectroscopy together with chemometric techniques for the exploration and prediction of toxic effects in the rat (Beckonert et al, 2003). Timm et al (2004) have explored an approach to possibilistic fuzzy clustering that avoids a severe drawback of the conventional approach, namely that the objective function is truly minimized only if all cluster centers are identical. Li and Yeh (2004) analyzed urban expansion and spatial restructuring of land use patterns in the Pearl River Delta of south China by using remote sensing and GIS. Based on the methodology and results, Farber (2004) has compared the results of the application of a number of spatial multivariate models to two 'global' models in a hedonic house price context. Bitter, Mulligan and Dall (2007) have compared two approaches to examine spatial heterogeneity in housing attribute prices within the Tucson, Arizona housing market: the spatial expansion method and geographically weighted regression (GWR). Yan Zhuang has analyzed the impact of subway station on commercial land values and used the methods of linear regression, analysis of regression to indicate the subway stations' significant impacts on the commercial land price, and on this basis, the model of the spatial relations between land prices and distances was established (Zhuang, 2007). An innovative LUR method implemented in a GIS environment that reflects both temporal and spatial variability and considers the role of meteorology is presented by Su, Brauer, Ainslie, et al. (2008). Yano (2006) has done a research by GIS on Changes of Interprise Location among Stations in Kyuto which has been useful reference for this paper. There are also some research methods which have inspired key points of this paper (Babalik-Sutcliffe (2002), Bafna (2003), Handy and Niemeier (1997), Honda (1977), Iwatani (2002), Kim et al. (2003), Yasuhiko (2000)

and Zhu and Wang (2005)).

Naceur (2013) has made a case study of Bouakal, Batna which focused on the impact on how modifications of urban space in informal settlements influence residents' quality of life and examined the effects of urban improvement in Bouakal. From this article, we can see the influence on urban development and the relationship between the urban space and the settlemetns. Knight and Trygg (1977) have drawn the impacts of rapid transit systems on urban development. It is concluded that rapid transit can have substantial growth-focusing impacts. Golub, Guhathakurta and Sollapuram (2012) have shown that proximity to light rail transit (LRT) stations positively affects property values and the land price. The growth of urban has implications for the price of land. In a static context, land price is proportional to the price of land at the boundary of an urban area equals the value of agricultural land rent. In a dynamic context, neither property holds. The previous research has shown that land price has four additive components: the value of agricultural land rent, the cost of conversion, the value of accessibility, and the value of expected future rent increases. It is also shown that, in a dynamic context, an efficient land market naturally produces a gap between the price of land at the boundary (minus conversion cost) (Capozza and Helsley, 1987). Rosenthal and Helsley(1994) have demonstrates a new methodology for recovering vacant urban land prices in areas that have already been developed. They also estimate the price of vacant land based on properties that were sold and redeveloped. The price of developed land is also estimated based on properties that were sold and not redeveloped. Various tests overwhelmingly support the hypothesis that housing is redeveloped when the price of vacant land exceeds the price of land in its current use. This result provides support for various theoretical models of urban spatial growth and indicates that one can recover vacant urban land prices by examining redeveloped properties. There has been a case that discusses the distribution of land prices in Jakarta using information provided on a neighborhood basis by experienced real estate brokers. Analysis of the data in Jakarta shows the relative importance of infrastructural provision and tenure for land prices (Dowall and Leaf, 1991). Lin and Evans (2000) have ever analyzed the relationship between the price of land and size of plot when plots are small. Another case analysis on the land price is the price of residential land in Mexico declined significantly in real terms during the 1980s. Land prices appear to follow a cyclical trend, which tracks Mexico's

macro-economic performance (Ward, Jimenez and Jones, 1993). On the research of changes on the land price, Pin and Chen (2004) establish a data set about 35 metropolitan in China by basing on the "Survey of China's real estate industry" (1999-2002), and the effects of government policy about land price control, and credit supply on the development of real estate industry have been discussed. They also have found out that the effect of lower land price is larger then the effect of higher housing price on the real estate investment, and foreign capital is one of the most active factors in promoting the expansion of China's real estate industry recently. A formal relationship between the dynamics of house prices, structures costs and land prices has been found and thereby construct the first constant-quality price and quantity indexes for the aggregate stock of residential land in the United States. In a range of applications we show that these series can shed light on trends, fluctuations and regional variation in the price of housing (Davis and Heathcote, 2007). Zeng and Zhang (2006) have explored the relationship between land price and housing price. Methods of positive analysis and econometrics analysis were employed. The result implies that interactive effects do exist in the short term in Wuhan, in which the land price has more effects on house price than that of house on land, while in the long term there has no significant casual relationship between them. Moreover, Song and Gao (2007) have also concludes that land price is independent of housing price and land price is Granger cause of housing price in the short run, while housing and land price interact as both cause and effect in the long run. Thus the key to curb housing price is to control land price in the near future, and to rationalize land supply and to guide housing construction planning in the long term. Damm et al. (2007), Ghebreegziabiher et al. (2007), Morancho (2003), and Paez et al. (2001) have done a similar research with this paper which are useful references for it.

Basing on those above research background and previous studies, three points can be got, that is,

(1) According to the review of previous studies, they are mostly focused on the analysis on the urban railway stations and the impact on the increasing value of real estate in surrounding areas, however, the impact on the development of land use, the increase and decrease on the size of the population, the rise and fall of land prices and the adding and reducing on passengers per day are hardly studied on;

(2) Almost all the existing studies are mainly focused on the industrial real estate and

the residential price, but less involved in the relationship between the urban development and the land price, therefore, this research mainly concentrates on the impact on the land price by annual change on the land use by taking the example of Fukuoka, Japan;

(3) The previous studies have a little demonstrational analysis on combining the time effect and the space effect together. Thus, this paper analyzes the impacts on the population, land price and passengers as the changes of land use by using the multiple regression analysis in order to provide a reference for the development of the real estate and urban planning and hope to form a large comprehensive transportation system in different directions and different construction periods.

4.3 Quantitative Analysis

4.3.1 Research Target

Fukuoka City, which has become the object of this research, has eight lines and 68 stations in total, that is, the JR Kagoshima Line, the JR Kashii Line, the JR Chikuhi Line, the Nishitetsu Omuta Line, the Nishitetsu Kaizuka Line, and three lines of the Fukuoka municipal subway, which have been shown in Fig. 3.1. The annual developments on 68 stations in eight lines that exist in the Fukuoka city are analyzed. Data that are used in this research are the data of land use and building usage, which use the POSMAP (from data of land use and building use) in the four periods of (1985, 1993, 1998, 2003,2008) at each station and the GIS (Geographic Information System) to extract each land use and building use. The data of population and number of households, which are from the census of population of Fukuoka city and in units of chome (the chome is a very special street unit in Japan, actually, the "cho" in Japanese is a kind of unit for streets; and the "me" in Japanese presents the No., so, the 1 Chome means the first Avenue) at the time of1985, 1990, 1995, 2000, 2005, 2010. The number of passengers is obtained using the statistical books of Fukuoka and the data for over 36 years, that is, from 1975 to 2011, for all routes of JR and the Japanese western railways (Fukuoka City Statistics Book (2000)). The data of the Fukuoka city subway were collected up from the opening year 1981 to 2011 totaling for 30 years. The data of survey for prefectural land price and public reviewing land prices, which are from National Land Numeric Information Download Service of the homepage of the Ministry of Land, Infrastructure, Transport and Tourism, are collected up to point data of 28 years from 1983 to 2011 in all. The data of architectural confirmation are ones of building confirmation of Fukuoka city from the year 1992 to the year 2004, totaling for 13 years. These data are all available and integrated by GIS.

4.3.2 Quantitative Analysis on Land Use

Firstly, about the quantitative analysis method, it is worth mentioning that Yang et al (2012) have ever made a research on analyzing the functional areas—urban centers with the most highlighted contradictions in terms of intensive land use. In the research, they have taken into account three aspects of intensive use, i.e., buildings, lands and traffic as well as multiple evaluation factors basing on quantitative research methods. The methods and patterns that they conducted gave us some hints on our research, in our research, we also use the quantitative research method for getting the data of the average size and percentage of the areas distinguished by the factors of land use and building usage within a radius of 0m-400m and 400-800m of the stations in every 5 years. Further, Yang et al have conducted the research horizontally by means of quantitative and comparative studies on each individual factor, developed the evaluation model for intensive land use in urban centers and analyzed the driving forces of intensive land use from buildings, land use, roads, etc. It is no doubt that their ideas on the research have provided a certain useful reference for us.

In our research, according to the data of Table 4.1, we can see the average size and percentage of the areas distinguished by the factors of land use and building usage within a radius of 0-400m of the stations in every 5 years. From this table, it can be seen that the influencing factors of the land use are 13 ones, that is, the commerce, the house, the government, the industry, the transportation, the park and green land, the used space, the unused space, the agriculture, the forest, the water, the road and the others. In order to find out the annual changes of land use, the average size and percentage of each factor in five years have been calculated out. The average size is got by using the method of GIS, the original data of 68 stations in five years of 1985, 1993, 1998, 2003 and 2008 are led into the GIS, after that, the radius zone of 0-400m can be localized and make a buffer analysis on the radius zone, then the size of 13 main factors of land use can be extracted. Furthermore, the commerce of 68 stations is added together, and then the average value can be got, the rest average value of other factors have been done in the same manner.

Table 4.1 Average size and percentage of the areas distinguished by the factors of land use and building usage within a radius of 0-400m of the stations

Usages	Factors	1985		1993		1998		2003		2008	
		Size	%	Size	%	Size	%	Size	%	Size	%
Land Use	Commerce	138022	0.09	127835	0.09	131513	0.09	123401	0.08	145618	0.11
	House	387788	0.26	433517	0.29	461733	0.31	468085	0.32	373923	0.27
	Government	160896	0.11	163573	0.11	154044	0.10	157325	0.11	150949	0.11
	Industry	23663	0.02	24065	0.02	20293	0.01	15647	0.01	17049	0.01
	Transportation	66626	0.04	67459	0.04	60880	0.04	60452	0.04	67208	0.05
	Park & Green Land	91902	0.06	78408	0.05	94134	0.06	92237	0.06	82513	0.06
	Used Space	64180	0.04	112112	0.07	88970	0.06	90437	0.06	99622	0.07
	Unused Space	66017	0.04	2228	0.00	15454	0.01	18876	0.01	12656	0.01
	Agriculture	96872	0.06	71196	0.05	61362	0.04	51183	0.03	53343	0.04
	Forest	75153	0.05	65642	0.04	57433	0.04	54116	0.04	51159	0.04
	Water	62037	0.04	58929	0.04	58890	0.04	50248	0.03	49594	0.04
	Road	218417	0.15	229623	0.15	262692	0.18	268087	0.18	231944	0.17
	Others	41223	0.03	65286	0.04	24509	0.02	29445	0.02	24599	0.02
Building Usage	Business & Hotel	173136	0.19	190420	0.19	58890	0.05	50248	0.04	56587	0.04
	Entertainment	74919	0.08	95591	0.10	262692	0.21	268087	0.20	298180	0.21
	Detached House	253115	0.27	169521	0.17	24509	0.02	29445	0.02	26759	0.02
	Condominium	197625	0.21	319214	0.32	174314	0.14	189675	0.14	175360	0.13
	Government	177849	0.19	179512	0.18	80311	0.06	90381	0.07	92568	0.07
	Transportation	25238	0.03	22347	0.02	154533	0.12	150489	0.11	164435	0.12
	Industry	25789	0.03	15386	0.02	376890	0.30	404691	0.31	443681	0.32
	Others	7080	0.01	4986	0.01	133449	0.11	141532	0.11	131265	0.09

From Table 4.1, it can be found that the percentage of commerce, the government, the transportation, the park and green land, the forest and the water are almost no changes in the five years. The reason is, in recent years, the development of Fukuoka, Japan keeps in a steady status and the factors such as the government and the transportation have been in no changes. The percentage of the house and the road are keeping in increase and the percentage of the industry and the agriculture are keeping in decrease which is caused by the development of the tertiary industry. With the

development of urban, more and more buildings for people's living appear and more houses are needed. At the same time, for the convenience, the road which is necessary in people's life has also been exploiting. As the rapid development of the tertiary industry, the percentage of the industry and the agriculture has always been in a slower and slower developing situation. Moreover, the percentage of the used space, the unused space and the others are always changing, sometimes in increase, and sometimes in decrease, and there is no change while the used space is put together with the unused space. It is explained that the above factors are uncertain ones, thus, the changes of them are undefined, and for example, the used space can also become the unused when it is in abandoned situation.

From Table 4.1, it can also be seen that the influencing factors of the building usage are 8 ones, which are abstracted by the same method as well as the data of land, use. The factors of building usage are as follows, the business and hotel, the entertainment, the detached house, the condominium, the government, the transportation, the industry and the others, totaling 8 ones. It can be found that the percentage of the entertainment, the transportation, the industry and the others are keeping in a certain increase from 1985 to 2008, as the speeding up of the urbanization in Fukuoka and people's basic need, people have paid more and more attention on the development of entertainment and transportation. The percentage of the business and hotel, the detached house, the condominium and the government has been in decrease which is shown that more and more buildings on housing are converted into other functions. As the development of the tertiary industry, the percentage of the entertainment has always been in an increasing situation.

4.3.3 Quantitative Analysis on Building Usage

Table 4.2 shows the average size and percentage of the areas distinguished by the factors of land use and building usage within a radius of 400-800m of the stations in every 5 years. From this table, it can be seen that the influencing factors of the land use are also 13 ones and the same method is used to analyze the average size of land use and building usage which is the same as Table 4.1.

Table 4.2 Average size and percentage of the areas distinguished by the factors of land use and building usage within a radius of 400-800m of the stations in every 5 years

Usages	Factors	1985		1993		1998		2003		2008	
		Size	%	Size	%	Size	%	Size	%	Size	%
Land Use	Commerce	196445	0.08	183934	0.08	198669	0.08	191734	0.08	141297	0.07
	House	562102	0.24	640781	0.27	723468	0.29	694969	0.29	514814	0.26
	Government	211252	0.09	230662	0.10	217120	0.09	221171	0.09	155946	0.08
	Industry	37701	0.02	42909	0.02	38384	0.02	30932	0.01	29765	0.01
	Transportation	55977	0.02	58321	0.02	63177	0.03	68655	0.03	76671	0.04
	Park & Green Land	147528	0.06	120689	0.05	162815	0.07	163203	0.07	154182	0.08
	Used Space	132693	0.06	174438	0.07	135821	0.06	127597	0.05	115249	0.06
	Unused Space	123947	0.05	2555	0.00	49212	0.02	53842	0.02	55434	0.03
	Agriculture	153718	0.06	113249	0.05	100183	0.04	79578	0.03	59854	0.03
	Forest	219711	0.09	245084	0.10	220756	0.09	202234	0.09	213979	0.11
	Water	101186	0.04	94091	0.04	100454	0.04	88290	0.04	86325	0.04
	Road	396461	0.17	358217	0.15	407518	0.17	402862	0.17	335579	0.17
	Others	44648	0.02	102679	0.04	48679	0.02	48419	0.02	48522	0.02
Building Usage	Business & Hotel	101186	0.06	94091	0.05	100454	0.05	88290	0.05	96712	0.05
	Entertainment	396461	0.23	358217	0.19	407518	0.22	402862	0.21	465223	0.23
	Detached House	44648	0.03	102679	0.05	48679	0.03	48419	0.03	50021	0.02
	Condominium	236774	0.14	250076	0.13	229640	0.12	246101	0.13	253345	0.12
	Government	91719	0.05	130001	0.07	116470	0.06	137405	0.07	112031	0.05
	Transportation	358538	0.21	244262	0.13	242053	0.13	217374	0.11	300188	0.15
	Industry	305666	0.18	476485	0.25	576586	0.31	601798	0.31	605233	0.29
	Others	208842	0.12	219459	0.12	163455	0.09	169739	0.09	177549	0.09

In Table 4.2, the percentages of the commerce, the government, the water, the road and the others are almost keeping in a stable situation which shows the facilities, such as the commerce and the government have tended into a constant state after a rapid period of development. From Table 4.2, it can also be found that the percentage of the house, the transportation, the park and the green land have maintained in a certain increase. It is led by gradually increasing on houses in the radius of 400-800m, as the close relationship between the house and the transportation, thus, the latter one

has been developing as well as the former. It is worthy referring that the industry and the agriculture are in decreasing trend in the radius of 400-800m which has been shown clearly in Table 4.2. There are also three special factors, the used space, the unused space and the forest which have been in a fluctuant trend from 1985 to 2008. In the building usage of Table 4.2, the business and hotel and the detached house maintain into a steady situation. The percentage of industry has been in an increase and the others are in a decreasing trend. By the way, the percentages of entertainment, the condominium, the government and the transportation are in an increase with the fluctuation in the five years.

4.3.4 Population, Land Price and Passengers

Table 4.3 explains the total population within the radius of 0-400mand 400-800m, average land price and total passengers per day of 68 stations from 1985 to 2008. From this table, it can be found that the land price in those periods keeps in fluctuation which is the top in 1993 and the lowest one in 1985. For the population, both in the radius of 0-400m and 400-800m, the population is always keeping in an increase as the influence of development around stations. Furthermore, the passengers keep in a fluctuation

Table 4.3 Total population within the radius of 0-400m and 400-800m, average land price and total passengers per day of the stations in every 5 years

Factors		Unit	1985	1993	1998	2003	2008
Population	0-400m	Person	716897	758989	766953	793541	839899
	400-800m	Person	1017245	1094192	1125024	1176516	1252527
Land Price		Japanese Yen	255304	869364	404673	289023	339232
Passengers		Person/ day	1844817	2711356	2757008	2565824	2633687

4.4 Regression Algorithm

The regression algorithm is used in this research, which is a statistical technique for estimating the relationships among variables. It includes many techniques for modeling and analyzing several variables, when the focus is on the relationship between a dependent variable and one or more independent variables. The regression analysis is the most popular analysis mode in multivariate analytic method, which is the representative of the "predictive and forecasting mode". It is also used to understand which among the independent variables are related to the dependent variable, and to explore the forms of these relationships. More specifically, the regression analysis helps one understand how the typical value of the dependent variable changes when any one of the independent variables is varied, while the other independent variables are held fixed. Most commonly, the regression analysis estimates the conditional expectation of the dependent variable given the independent variables, that is, the average value of the dependent variable when the independent variables are fixed. Less commonly, the focus is on a quantile, or other location parameter of the conditional distribution of the dependent variable given the independent variables. In all cases, the estimation target is a function of the independent variables called the regression function. In regression analysis, it is also of interest to characterize the variation of the dependent variable around the regression function, which can be described by a probability distribution.

Moreover, in the regression analysis, if there are two or more independent variables existed, it is called multiple regressions. In fact, a phenomenon is often associated with a plurality of factors, basing on the optimum combination of the plurality of independent variables, the dependent variable can be predicted or estimated, which is more effective and more realistic than forecasting or estimating by using only one variable.

This research uses the variable selection method of multiple regression analysis,

that is, the method of reducing variables and the method of increasing variables, in order to choose relevant variables. After that, by making the partial regression coefficients being standardized, the influence degree of annual changes of land use in surrounding regions of railway and subway stations can be defined clearly. In addition, the variable whose absolute value of partial regression coefficients is more than 1 after being standardized, from the angle of its relationship with multi-collinearity, if the absolute value of partial regression coefficients of the received variable is not a suitable one but unsuitable for further analysis, all the variables will be recombined again or again and again until a appropriate variable can be caught.

4.4.1 An Outline of Data

Based on the above analysis, using a geographic information system, that is, the GIS, extracting the POSMAP data on land use and building usages of station zones, further grouping those data on land use and building usage by the cluster analysis, then, the paper organizes the data according to different time, different application and different distance by using the method of multiple regression analysis. The used variables in terms of land use are "Commerce", "House", "Government and Education", "Transportation", "Park and Green Land", "Used Land", "Unused Land", "Agriculture", "Forest", "Water", "Road" and "Others" totally 13 variables; the used variables in terms of building usages are "Business and hotel", "Entertainment", "Detached house", "Condominium", "Government and Education", "Transportation", "Industry" and "Others" totally 8 variables. By using those above variables, the multiple regression analysis can be in processed.

4.4.2 Formulas of the Multiple Regression Analysis

The process for the multiple regression analysis is as follows,

Firstly, the paper uses the variable selecting method of the multiple regression analysis, which is the way of variables reduction and the way of variables increase. Then, according to the factors and the explanatory variables, the multiple regression analysis can be done as follows,

$$f = a_0 + a_1 x_1 + a_2 x_2 + \ldots + a_n x_n$$

where f is the theoretical value, a_n is the partial regression coefficient, and x_n is the explanatory variable.

In the calculation process of multiple regression algorithm, the *t* and *P* values are the basic ones and also usually used as reference values. Then, basing on the *t* value and the *P* value, the process restructures the variables and carries out the multiple regression analysis by ignoring the variable *x*.

There are several conditions which are, the *t* value and the *P* value are positive ones, the relevant variable *r*, the partial regression coefficent a and the symbol are consistent, besides that, the absolute value of the partial regression coefficients which has been standardized is minus 1, while the above conditions are all met, the variables being remained finally have become the basic factors for the regression analysis. Furthermore, grasping the influence degree of each basic factor quantitatively from the standardized partial coefficients is the final step for the process of the multiple regression method.

4.4.3 Variations of Influence Degree on the Time and the Distance

(1) Influence Degree on Population

Comparing Step.1 with Step.2, there are more variables selected in Step.1. Concerning about the multiple regression analysis on the population, there is a trend that variables related to land use are frequently used in the multiple regression analysis. In addition, from the Table 4.4, the influence degree which is got from variables on land use is tend to be minus, while the influence degree which is got from variables on building usages is tend to be increasing comparatively. The reason that more variables are selected in step.1 is because the categories of land use around the station have been definite. And in step.2, a range of 400~800m radius from the center of the station is abstracted, which made it a doughnut shape, and the land use becomes totally different depending on directions which is the impact of the "geographical orientation".

From the angle of different years and different usages, it can be seen that the influence of the “apartment” in step.1 is going higher and higher every year. It is considered to be that high development on mansions around the center of each station has a great effect on the amount of population. In addition, step.2, which is compared

to step.1, the influence degree of “apartment” becomes higher, and the floor area of the apartment within 400~800m radius is of great proportion. “Business & Hotel” is tending to be selected in step.1 and the value of influence degree is all minus. It shows that the location of business facilities has a negative impact on the population within a 400m-radius range. In addition, the influence degree on “road” in step.1 has been obviously becoming bigger. As the development of road, the population leads to a growing trend. Thus, the positive influence on city planning for road development has been revealed clearly.

In relation to land use, even if most variables other than “house” and “road” selected, are almost minus. The selected variables, which are minus value, include the “government”, “transportation & warehouse”, “used space” and “agriculture”. These variables, especially within a radius of 400 meters, have a negative impact on the increase of the amount of population.

According to the calculating and analyzing process on data, it can be seen that the regression equation and every variable coefficient have finished the significance test, and the R2 value, which has been adjusted, is fitting well. The regression coefficients are shown in Table 4.4. The regression equation shows that the growth of the population near the railway stations and subway stations grows more and more; however, the population density being far away from the railway stations and subway stations is gradually growing in recent years, it is because the housing price and land price which are adjacent to the railway stations and subway stations are higher than ones which are far away from the railway stations and subway stations, thus, more and more persons begin to choose living far from the rail transit sites in recent years, after all, it is not so noisy and relatively quiet; and it also has some shopping malls and convenient for people’s everyday life. Moreover, the closer the distance is, the higher the population density will be. It is worthy referring that being got close to, the higher the land price is. Some peripheral areas around the railway and subway stations have not been developed well and not been utilized enough, the commerce and service is not so high level as well as other stations, thus, it has a lower population density while it is closer to this kind of districts.

Table 4.4 Degree of influence on population by the factors of land use and building usage within the radius of 0-400m and 400-800m in every 5 years

Usages	Factors	0-400m					400-800m				
		1985	1993	1998	2003	2008	1985	1993	1998	2003	2008
Land Use	Commerce						-0.33			0.06	
	House	0.43	0.47	0.44	0.19	0.23		0.52		0.49	0.51
	Government	0.08	-0.02								0.12
	Industry			-0.12							
	Transportation		-0.08				0.09				
	Park & Green Land		-0.08	-0.34				-0.07			
	Used Space			-0.21	-0.10						
	Unused Space			0.27		0.25					
	Agriculture	-0.10	-0.14								
	Forest										
	Water										
	Road		0.26	0.25	0.19	0.16					
	Others	0.08						-0.10			0.11
Building	Business & Hotel		-0.32	-0.37	-0.22	-0.20					
Usage	Entertainment										
	Detached House	0.28			0.17		0.52			0.61	
	Condominium	0.52	0.48	0.68	0.81		0.75	0.59	0.96	0.70	0.86
	Government						0.10	0.07		0.03	
	Transportation										
	Industry										
	Others										
Variables	Chosen Variables	6	8	8	6	4	5	5	1	5	4
	Revised R2	0.86	0.90	0.97	0.96	0.92	0.89	0.94	0.87	0.97	0.96

According to the regression equation, the variables, which have an effect on the population density, are not so complex.

The paper has summarized two points, which are as follows,

1) Firstly, generally speaking, the distance which is far from the railway stations and subway stations has a lower population density relatively;

2) Secondly, it has been testified that the commerce, the school and the green land have a positive impact on changes on the population density, that is to say, if a shopping mall or a school or both of them are found around one station in a less-developed region, then this region must be developing gradually, so it is no doubt a positive impact.

(2) Influence Degree on Land Price

According to the results from multiple regressions analysis on population, which have been shown in Table 4.4, comparing step.1 with step.2, no obvious difference on the number of selected variables can be found. However, the corrected determination coefficient of step.1 is higher, which is favorable as a regression equation, while the multiple regression analysis on land price has used more variables related on building usages frequently. In addition, the influence degree of variable related on the land use is minus, while the variables related to the building usages seem to be plus comparatively. The reason that the corrected determination coefficient of the regression equation becomes higher in step.1, which is almost the same to the multiple regression analysis on the population, is because there are clear and definite categories on the land use around stations. In step.2, as the different direction, the land use also becomes really complicated, and there is tolerance in variation, which makes it a lower determination coefficient.

From the angle of different years and different usages, in step.1, “detached house” in 1985 is chosen frequently, while after the year 1993, “apartment” becomes widely in use, which compared to detached house has a larger impact on land price. In addition, unlike the “population”, as the primary factors of greater influence on land price, such as business and hotel, commerce and entertainment facilities, all the factors have a positive impact on land price. In recent years, it is considered that the influence degree on the apartment becomes higher and higher, which made it an important factor for the land price.

In relation to land use, the influence degree of housing is to be minus, which reveals that the land prices will fall with the spreading of land for housing. The reason seems to be that the expand of detached house will lead to low land prices in the low-density residential area, Furthermore, fewer and fewer variables are selected in step.2, and the whole trend is to be mixed and difficult to be grasped. “House”,

"business and hotel", "commerce and entertainment" and "apartment", "commercial and entertainment", "Business & Lodging", "residential land" are tending to be selected.

According to the calculating process of the regression equation and every variable coefficient, it is clear that they have been finished the significance test, and the R2 value, which has been adjusted, is fitting well. The regression coefficients are shown in Table 4.5. The regression equation shows that the land price near the railway stations and subway stations usually gets a high price; the closer the rail transit site being got close to, the higher the land price is. Some peripheral areas around subway stations have not been developed well and utilized enough, and houses which have been built are almost apartments, the flourishing degree of surrounding commerce and service is not so high, thus, the closer this kind of districts being adjacent to, the lower the land price is.

During a period, the influence of rail transit on land prices is in the form of parabola. The situation is, the distance which is too close to the rail transit sites will bring a certain negative externalities, such as crowded traffic, noisy traffic flow and crowded people are the reasons for this kind of phenomenon. For instance, the land price, which is higher to the Kashii JR Station, can indicate the effect and impact of vice-center district in a city. While some stations' land price tend to be in a low tendency, due to a lower orientation on land price than other stations', so that the land price become lower than districts being far away from this area.

According to the regression equation, the variables which can put an influence on the land price are not a few but very complex. The paper has summarized three points as follows,

1) The farther being from the railway stations and subway stations, the lower the land price will be; in opposite, the closer being from the railway stations and subway stations, the higher the land price will be, which has been testified by the data, facts and investigation;

2) There is a positive effect from parks and schools, that is to say, if a park or a school or both of them are planning and finally found around one station in a less-developed region, then this region must be growing gradually and become prosperous; if some buildings such as a shopping mall or school can be found in a developing region, it will be more prosperous than before;

3) The relationship between the distance (from some very important stations, such as the Tenjin Subway Station, etc.) and land price appears to be a cubic curve. Being outside from this kind of stations, has experienced the rise, the fall and the rise in the process in turn, which indicates that the influence on the land price has been gradually emerged from the starting of construction to the ending of it.

Table 4.5 Degree of influence on land price by the factors of land use and building usage within the radius of 0-400m and 400-800m in every 5 years

Usages	Factors	0-400m					400-800m				
		1985	1993	1998	2003	2008	1985	1993	1998	2003	2008
Land Use	Commerce						0.78	0.23			0.21
	House	-0.15	-0.49	-0.53	-0.42	-0.33	-0.30			-0.22	
	Government										
	Industry									0.28	
	Transportation						-0.24				
	Park & Green Land										
	Used Space						0.18				
	Unused Space	-0.03									
	Agriculture										
	Forest										
	Water							-0.17			
	Road			-0.09	-0.14				0.23		
	Others							0.21			
Building	Business & Hotel	0.86	0.55	0.77	0.87	0.78	-0.39		0.68		
Usage	Entertainment	0.15	0.33	0.30	0.25	0.20	0.32	0.52		0.43	0.49
	Detached House	0.18									
	Condominium		0.33	0.43	0.42	0.46		0.21	0.15	0.36	0.22
	Government										
	Transportation	-0.11									
	Industry										
	Others										
Variables	Chosen Variables	6	4	5	5	4	6	5	3	4	3
	Revised R2	0.92	0.90	0.94	0.92	0.94	0.65	0.84	0.77	0.86	0.78

(3) Influence Degree on the Passengers

Both in step.1 and step.2, few variable are selected, besides, the corrected determination coefficient becomes lower. Variables of land use and building usage have little impact on the number of passengers, which can be considered that there are also some other factors having an impact on the number of passengers.

Comparing step.1 with step.2, the corrected determination coefficient of step.1 tends to be higher, and the selected variables have an effect on the number of passengers, while in step.2 the corrected determination coefficient is tend to be low, thus, it is hard to say whether the selected variables have an impact on the number of passengers or not.

In step.1, the variable of "transportation and warehouse" is tending to be selected, which indicates that the number of passengers is affected. Also, the "commercial land" in step.2 is tending to be selected, from which it can be said that the number of passengers tends to be increasing with commercial land increase.

According to the calculating and analyzing process on data, the regression coefficients are shown in Table 4.6. The regression equation has shown that the number of passengers near the railway stations and subway stations appears to be much more than the suburban districts and the low-density stations; at the same time, the number of passenger of government and education-type stations also has a high percentage which has a relationship with everyday using frequency. A rail transit, which is mainly consisted by the commerce, the green land and the educational facilities usually, has a high frequency on the number of passengers. Furthermore, some stations, which have not been well developed and utilized enough, have a low number of passengers because of the relatively underdeveloped business, etc. Therefore, the effects of the development on the commerce, business, and transportation can thus be seen in Table 4.6.

Table 4.6 Degree of influence on passengers by the factors of land use and building usage within the radius of 0-400m and 400-800m in every 5 years

Usages	Factors	0-400m					400-800m				
		1985	1993	1998	2003	2008	1985	1993	1998	2003	2008
Land Use	Commerce				-0.40			0.40	0.76	0.56	0.62
	House		0.60				-0.94				
	Government										
	Industry										
	Transportation										
	Park & Green Land										
	Used Space	0.52									
	Unused Space										
	Agriculture										
	Forest										
	Water										
	Road										
	Others										
Building	Business & Hotel				0.44		-0.75				
Usage	Entertainment	0.42	0.48			0.49					
	Detached House	-0.40									
	Condominium						0.72		0.72		0.72
	Government										
	Transportation	0.51	0.30	0.96		0.88					
	Industry										
	Others										
Variables	Chosen Variables	4	3	1	2	2	3	1	2	1	2
	Revised R2	0.63	0.65	0.80	0.80	0.80	0.33	0.40	0.60	0.34	0.44

4.5 CASE STUDY

IMPACT ON THE CHANGES OF LAND USE DUE TO URBAN DEVELOPMENT

In order to get the effects of urban development, an analysis on four specific cases are considered, which are as follows,

(1) Firstly, with the opening of the airport line subway in 1981, the established city has been developing and the effects given to the established city with the opening of the Fukuoka subway are analyzed in this paper.

(2) Secondly, analyzing the influence of the land readjustment projects to the changes of land use and building usage and impacts on population and passengers in the land readjustment projects including the land readjustment projects of Shiobara, the land readjustment projects of Meinohama and the land readjustment projects of Kashii (new vice-secondary urban central district today).

(3) The third one is the "new stations" which were established around the year of 1985, most of the stations established at this time are relatively small scale since most of them play a complementary role. However, with the stations being founded, some influence has been brought to changes in land use and building usage.

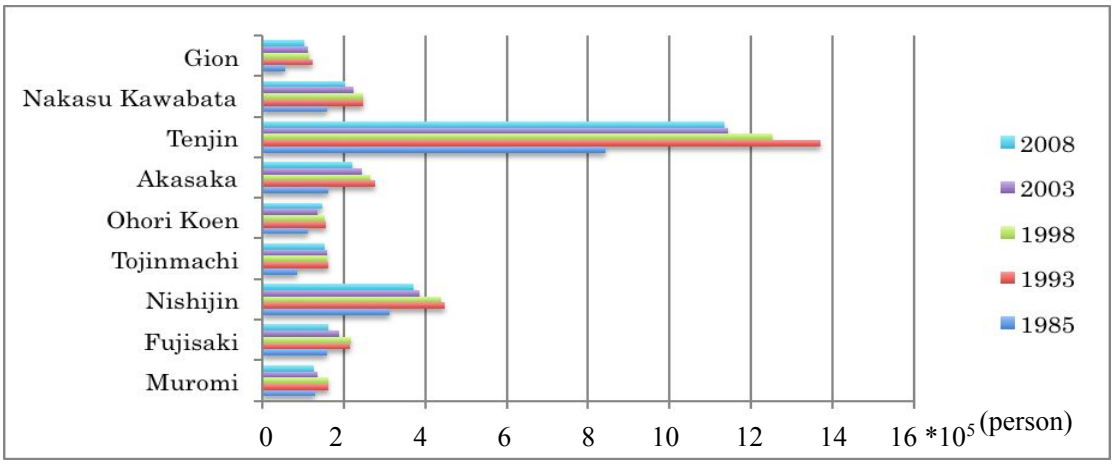
(4) Fourthly, according to the impact of planning decision on Fukuoka Subway Nanakuma Line which was opened in 2005 (The planning was made in 1996). After the planning was carried out, the influence that is brought to the land use and exploitation around stations is put into research. This paper extracts subway stations from the Chayama Station to the Hashimoto Station which have no relationship with the railway stations before and interprets the impact of the planning decision brought to surroundings areas.

4.5.1 Impact on the Established Streets and Roads

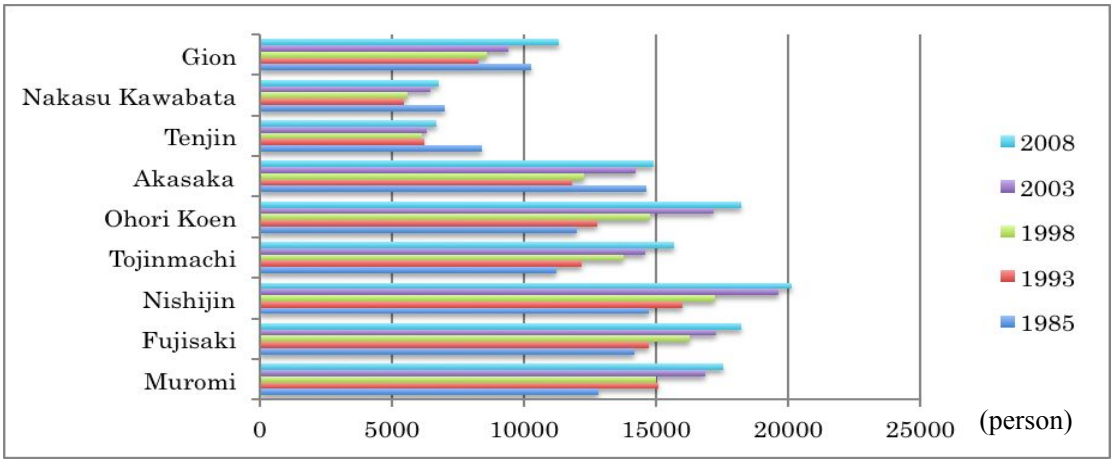
In order to find the effects of the opening of the subway of the airport line, an analysis

of 9 stations of subway of the airport line from the "Gion Station" to "Muromi Station" were carried out over time. As a result, the number of passengers is in the decline and the population is reducing at the stations in downtown, such as "Akasaka Station", "Tenjin Station", "Gion Station" and "Nakasu Station" in stage Ⅰ, while stations away from the center areas of the city have an increasing tendency throughout the investigation period. (see Fig. 4.1)

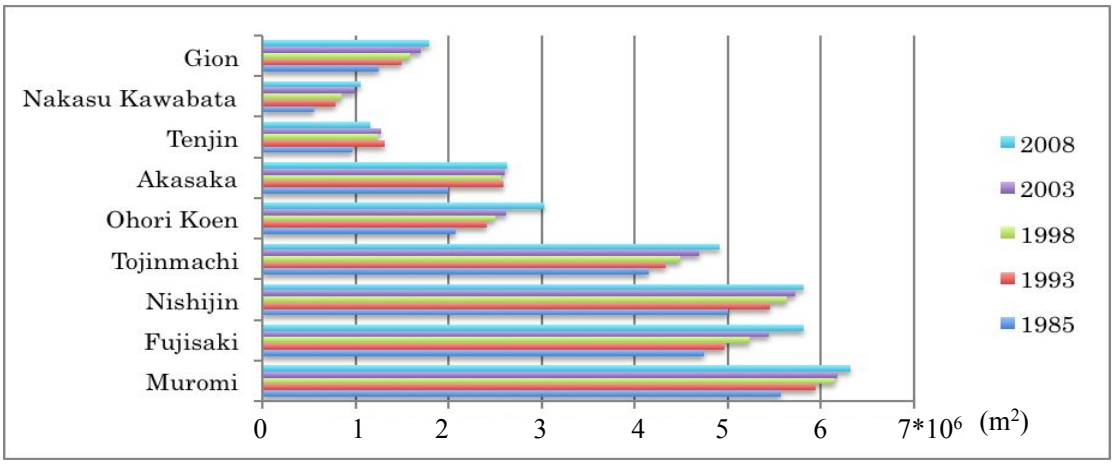
The floor area has been always increasing except the "Tenjin Station", "Tojin Station" and "Akasaka Station", which indicates most stations are being developed. The area of the apartment has an increasing trend in downtown stations and stations from Ohori Park to Muromi. The area of business is gradually concentrated around the stations in downtown which also has an increase in recent years.



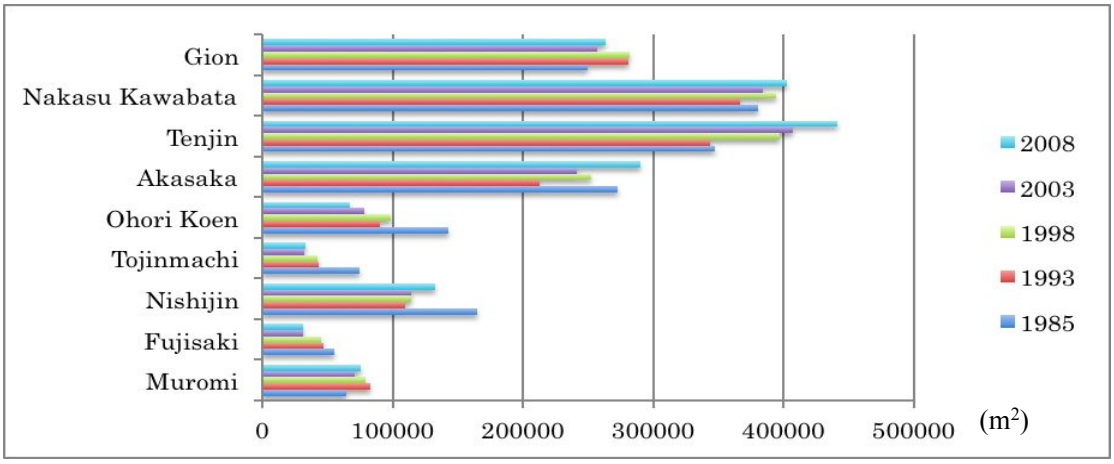
(a) Passenger



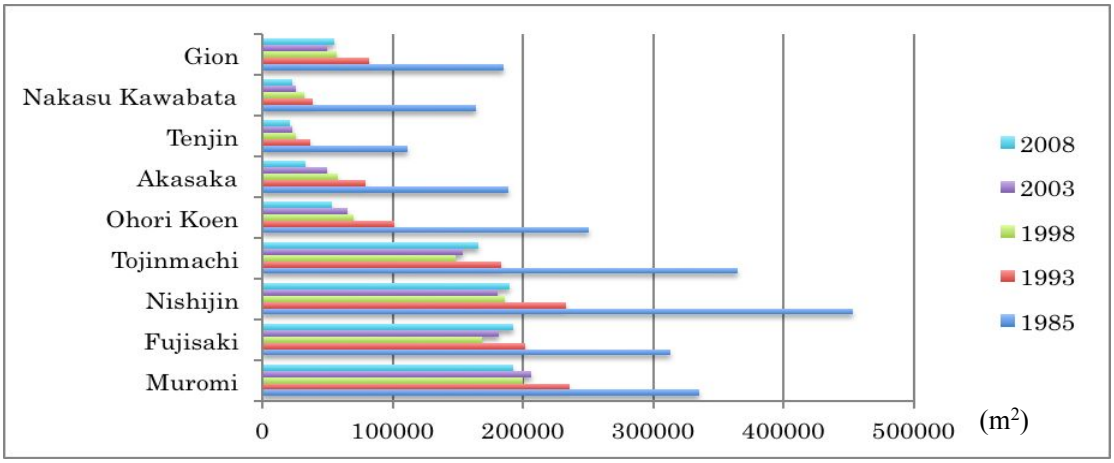
(b) Population



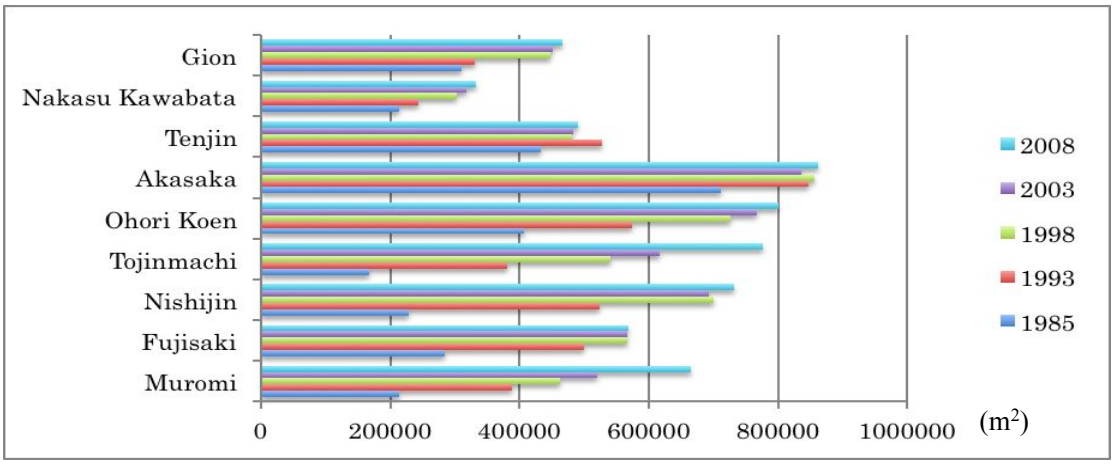
(c) House



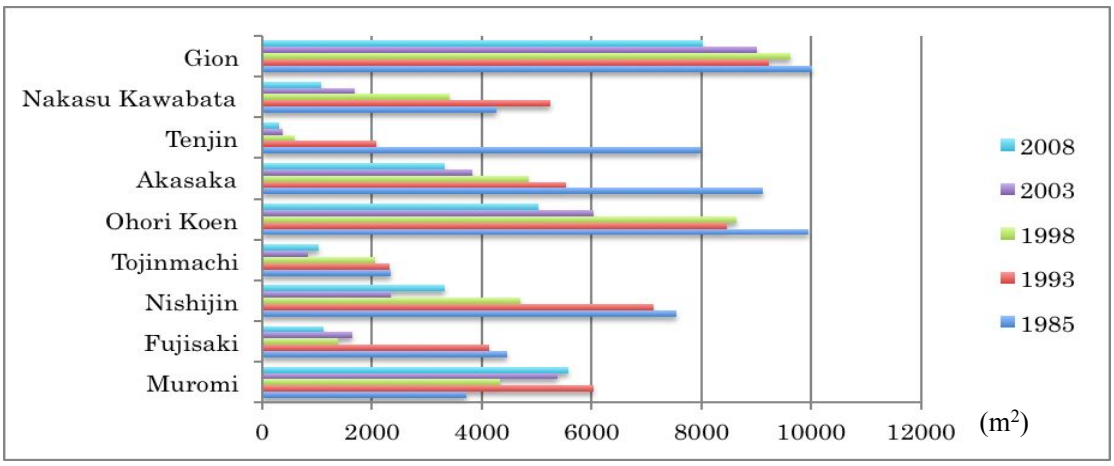
(d) Commerce



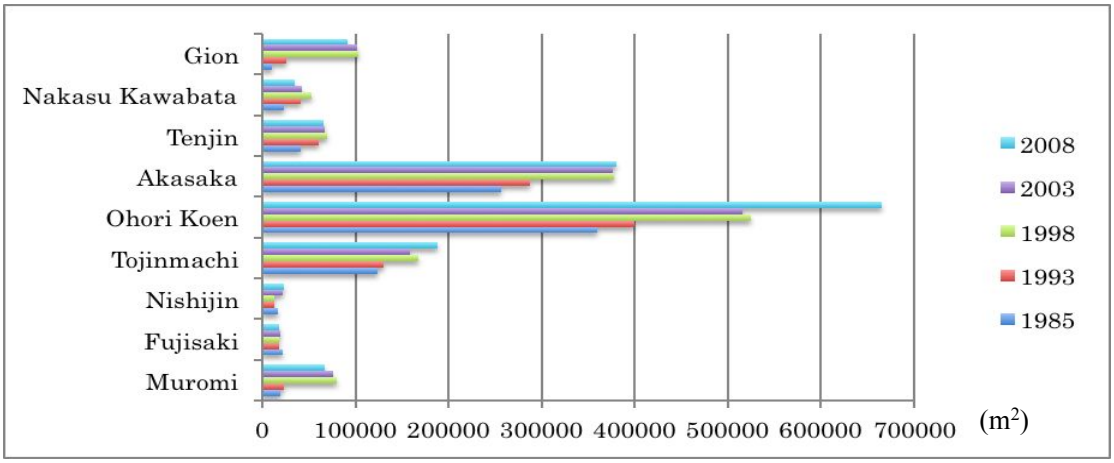
(e) Detached House



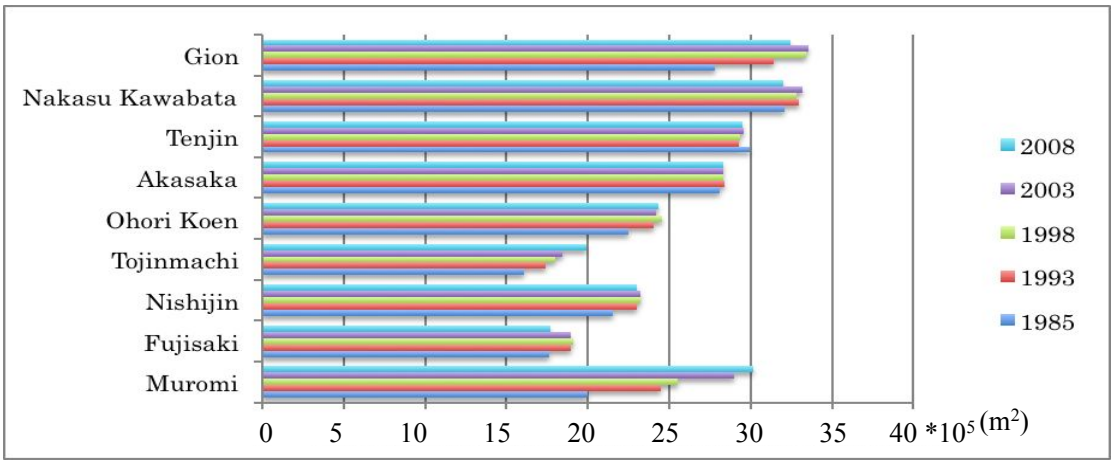
(f) Condominium House



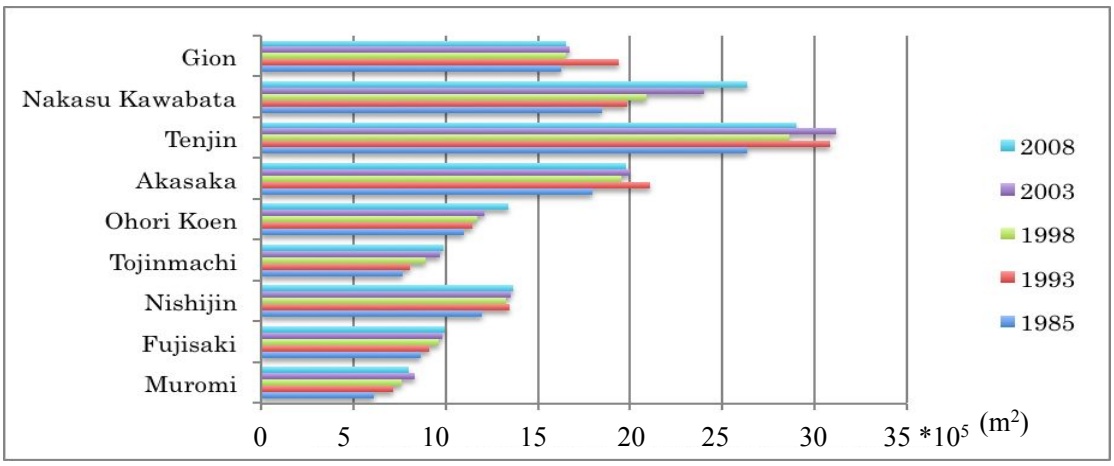
(g) Industry



(h) Park & Green Land



(i) Road



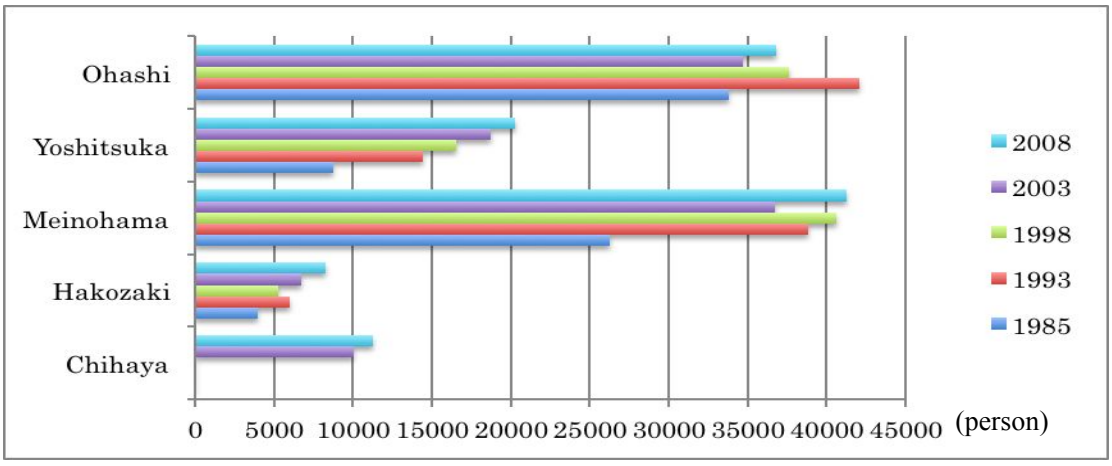
(j) Gross Floor Area

Fig. 4.1 Impact on the Established Streets and Roads

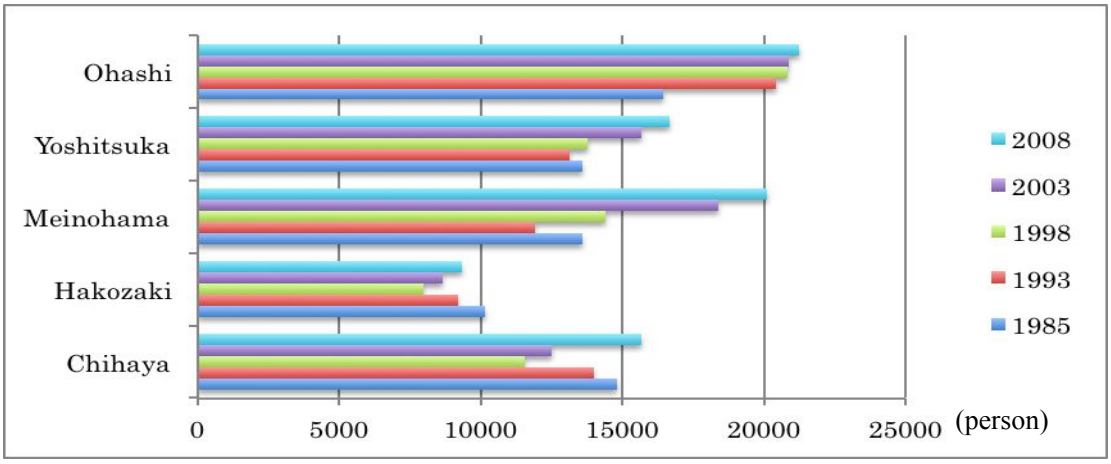
4.5.2 Impact on Land Readjustment Projects

For interpreting the influence on stations' surroundings due to the land readjustment projects including the land readjustment projects of Meinohama, the land readjustment of Kashii and elevated projects around stations, as a result, it can be seen that the number of passengers has a trend of increase at "Yoshizuka Station" and "Hakozaki Station" which have been elevated. (see Fig. 4.2)

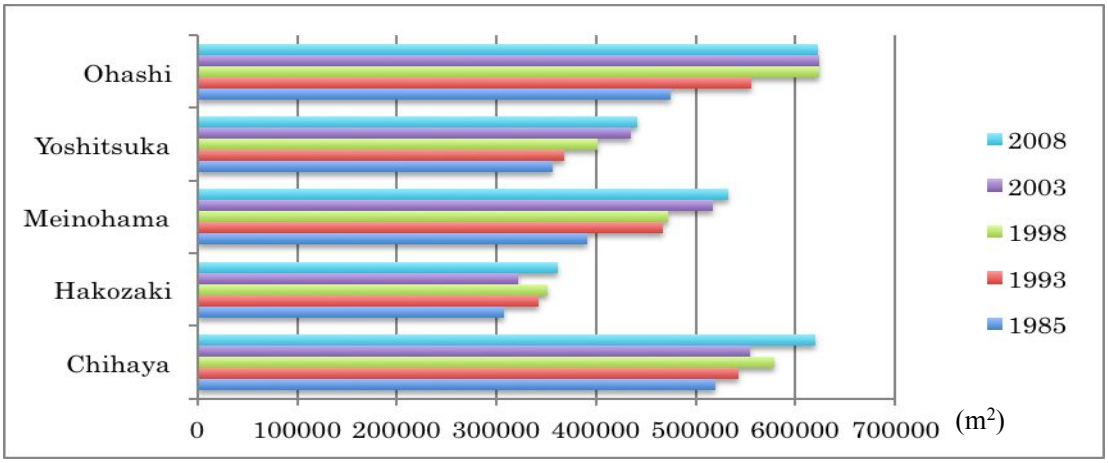
Throughout the investigation, it can be found that the impact of land readjustment projects is becoming huge, the area of roads increasing about twice and the area of apartment is increasing at about 3-4 times.



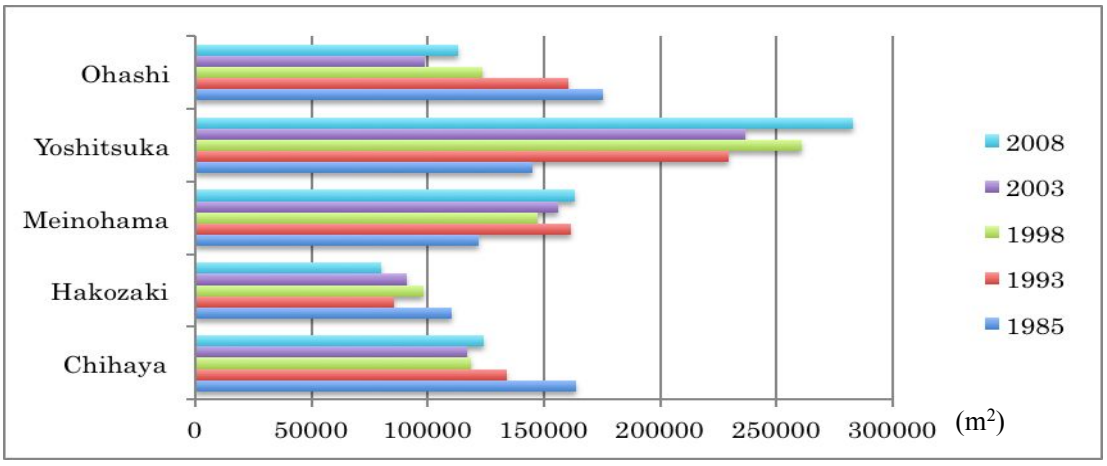
(a) Passenger



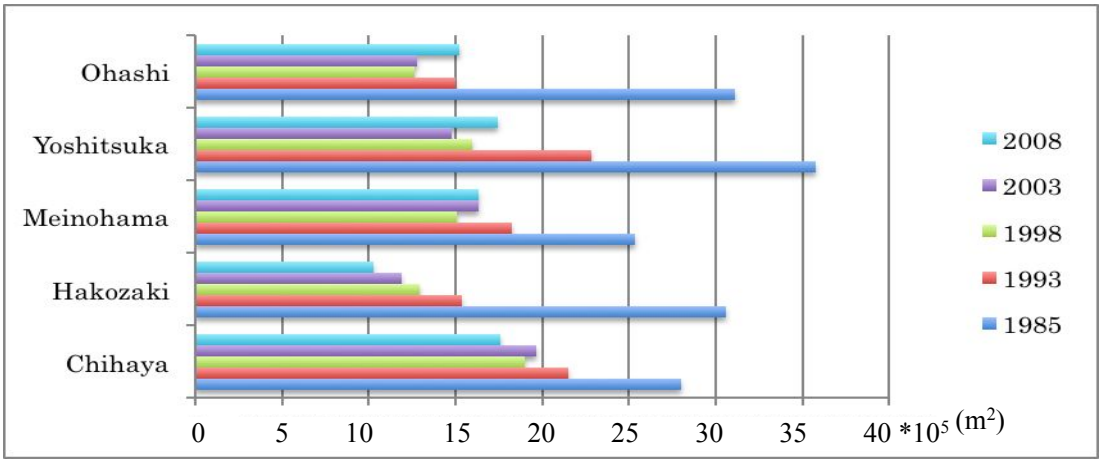
(b) Population



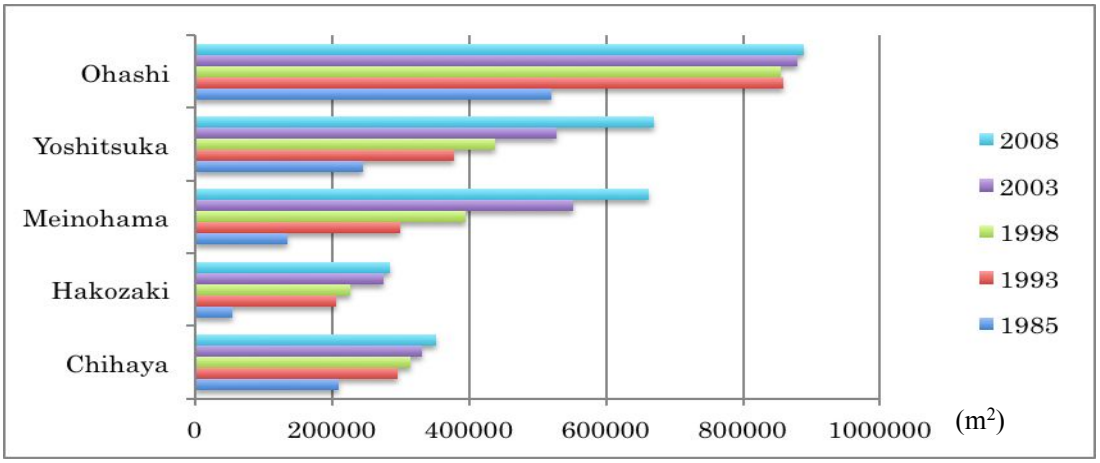
(c) House



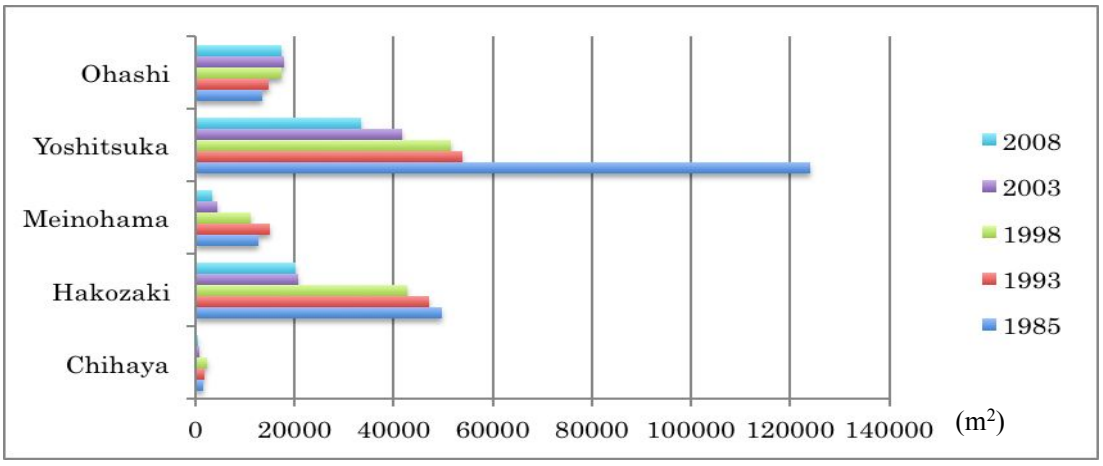
(d) Commerce



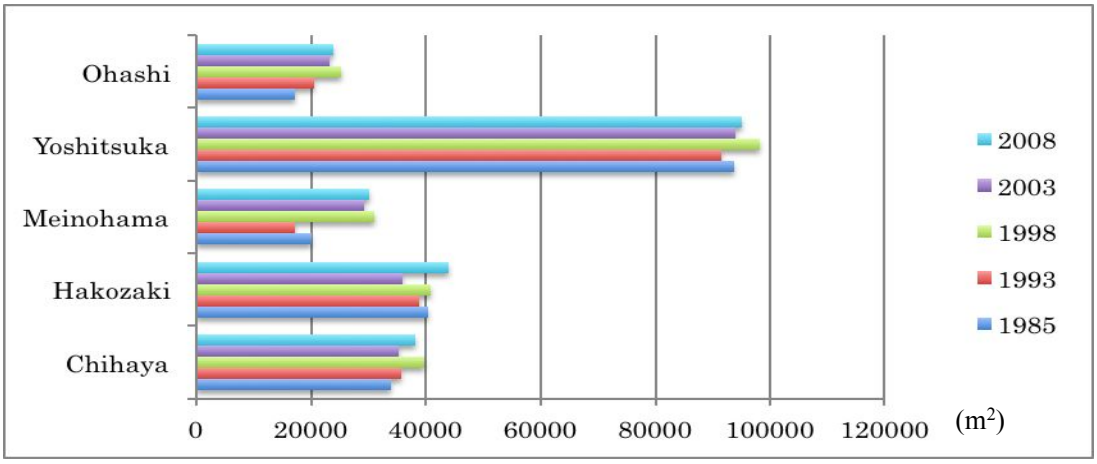
(e) Detached House



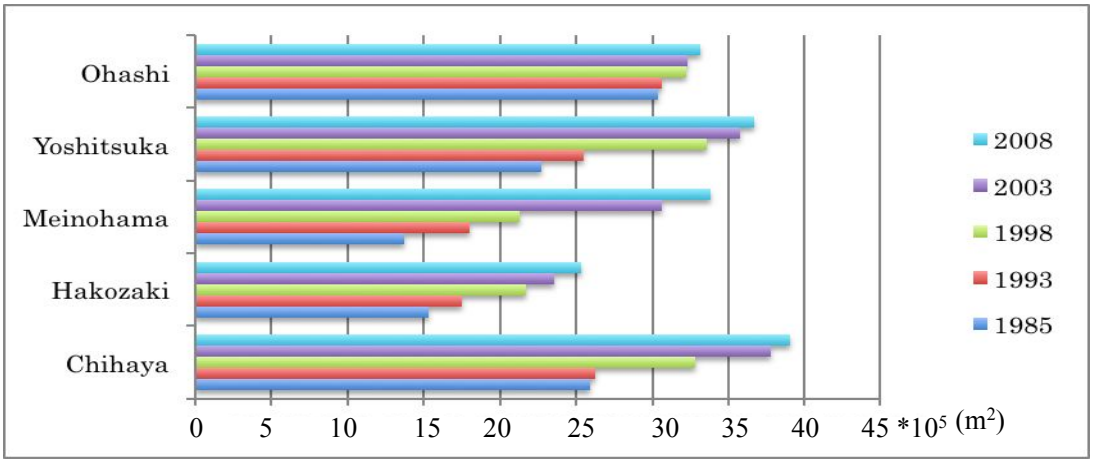
(f) Condominium House



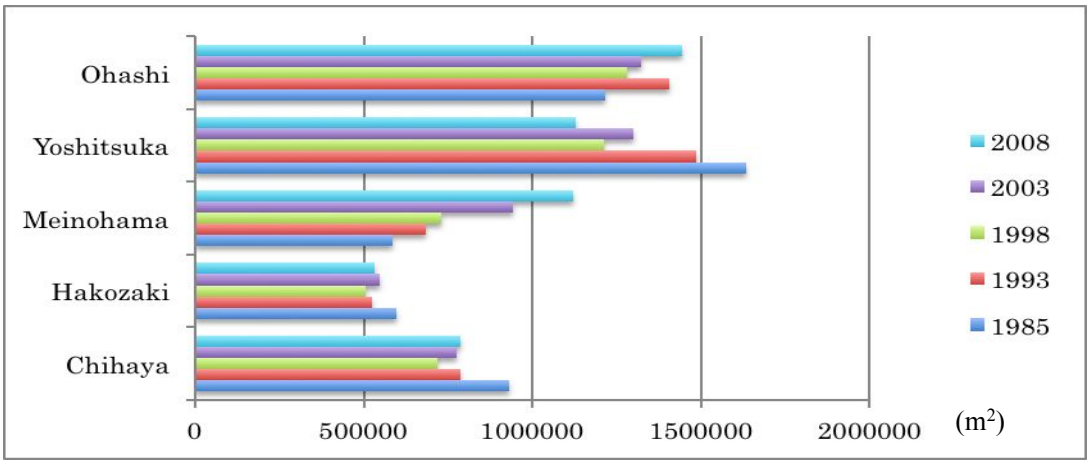
(g) Industry



(h) Park & Green Land



(i) Road



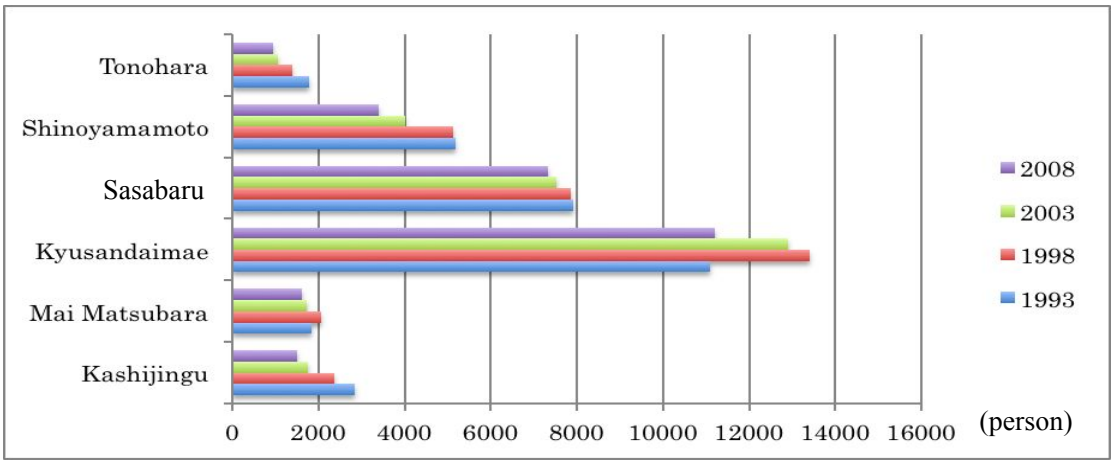
(j) Gross Floor Area

Fig. 4.2 Impact on Land Readjustment Projects

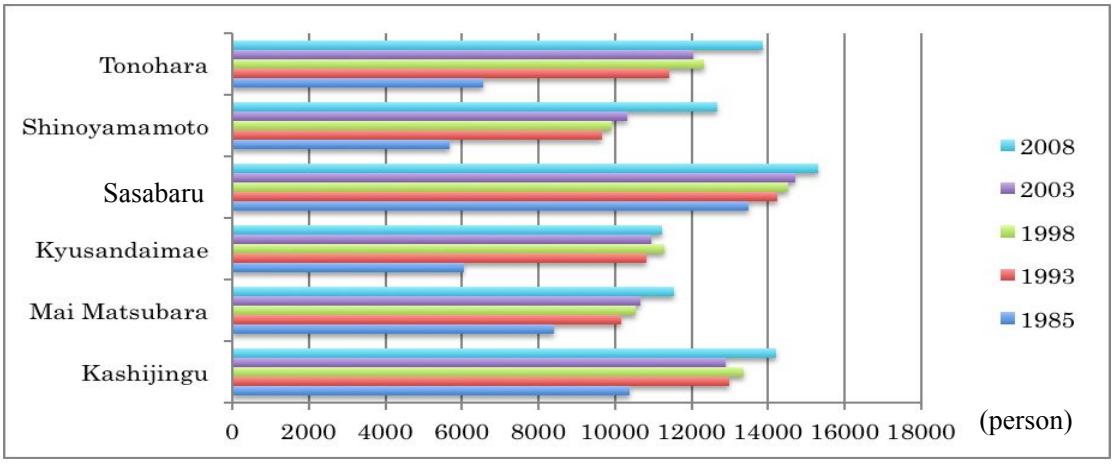
4.5.3 Impact on the Foundation of New Stations

For finding the impact of the location of the new stations, the analysis is unfolded by abstracting five new opened stations including the "Kyusandaimae Station" and "Shimoyamato Station", etc. which were established in 1985. After that, it can be found that the number of passengers has been reducing in stage Ⅲ, which reveals the population has soared since the new stations had been established. (see Fig. 4.3)

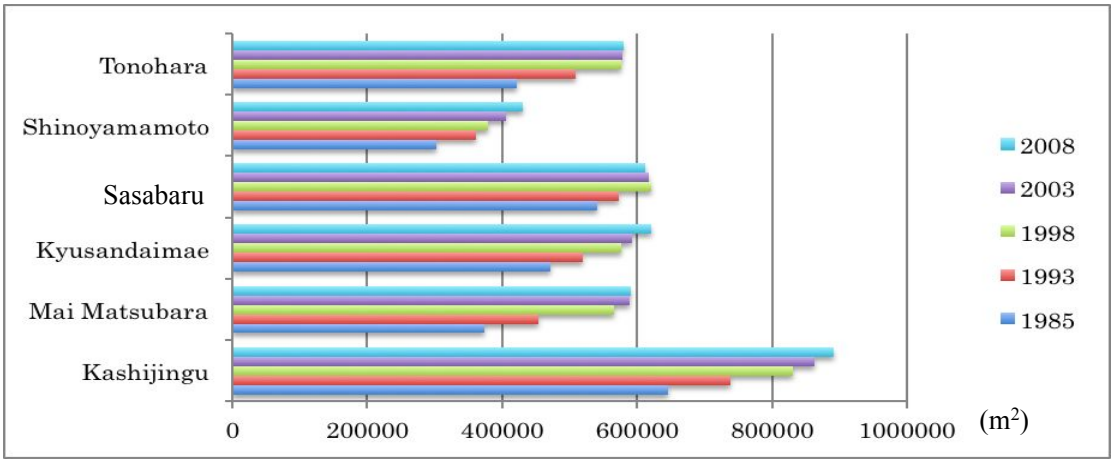
The floor area has increased rapidly during the stage Ⅰ when new stations were established. In recent years, the scale of stations is relatively decreasing except those big stations like the "Sasabaru Station" and the "Kyusandaimae Station". It shows the development in small stations have been decreasing. Also, the area of apartment has been increasing at 3-5 times around big stations such like "Sasabaru Station", "Kyusandaimae Station" and "Tonohara Station" near the universities, but the "Kashii Jingu Station", "Maimatsubara Station" and "Shimoyamato Station" in which the detached house is spreading in the low-density residential areas get an increase of 1.5 to 2 times.



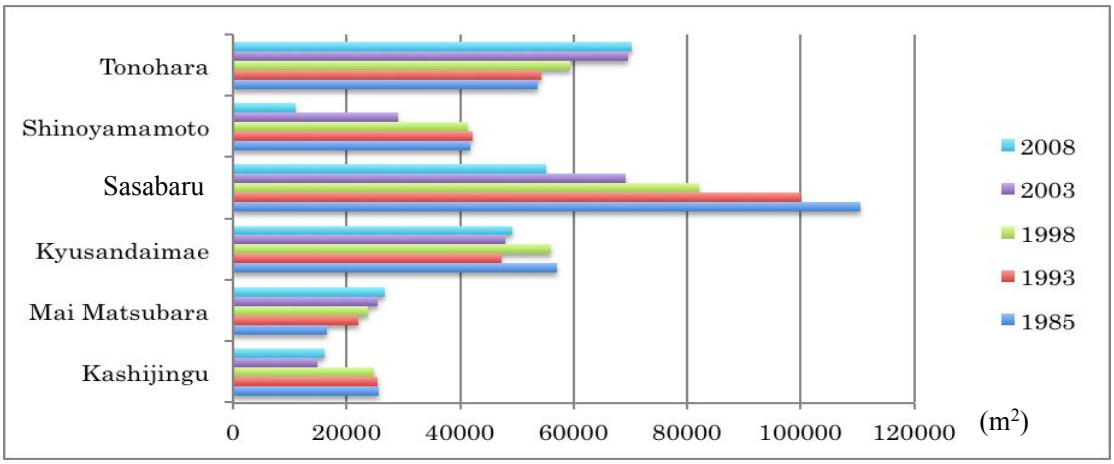
(a) Passenger



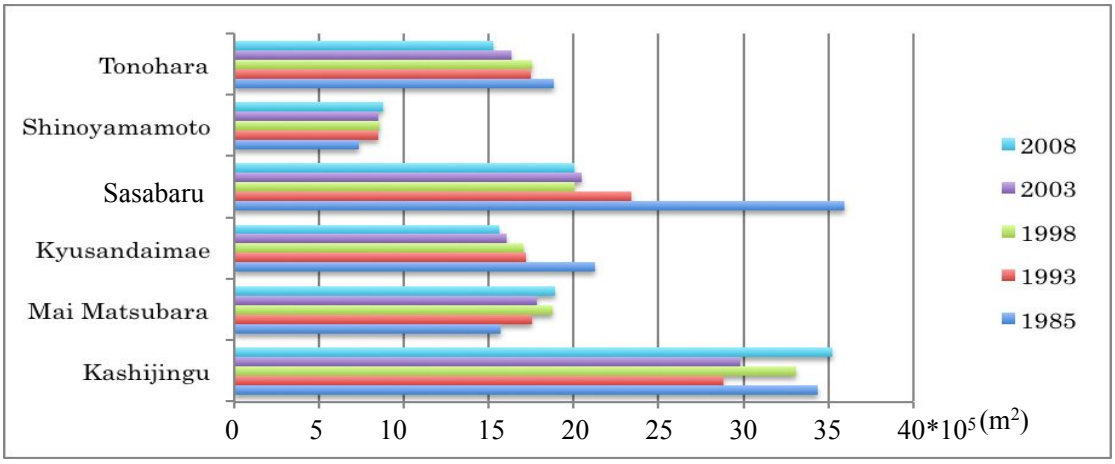
(b) Population



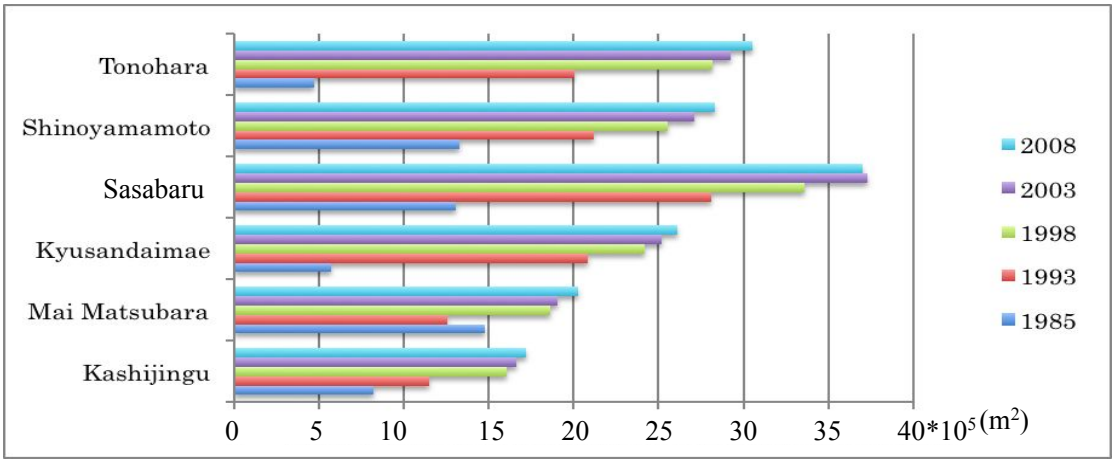
(c) House



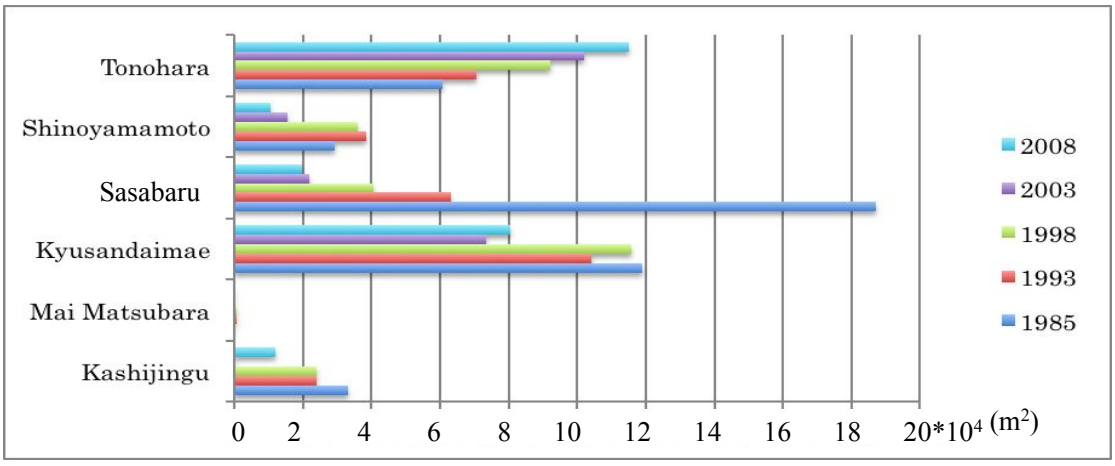
(d) Commerce



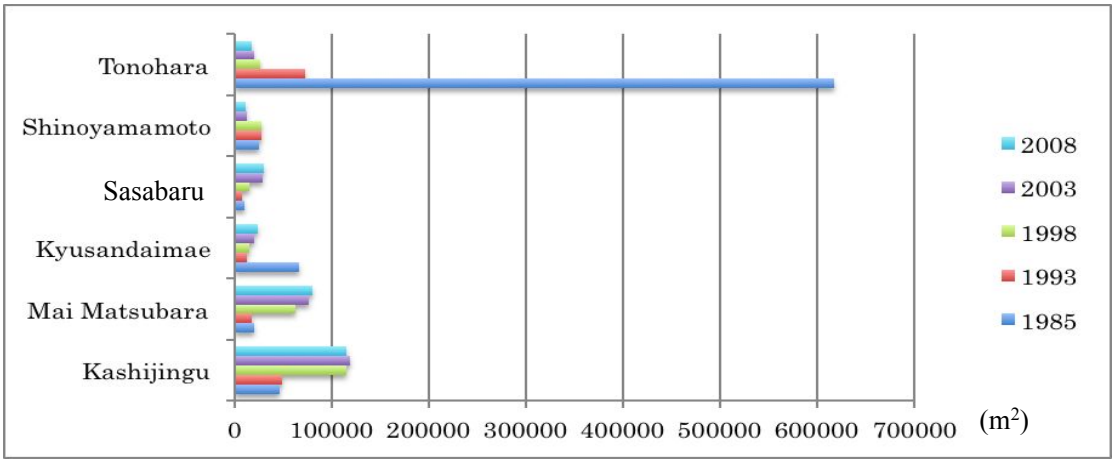
(e) Detached House



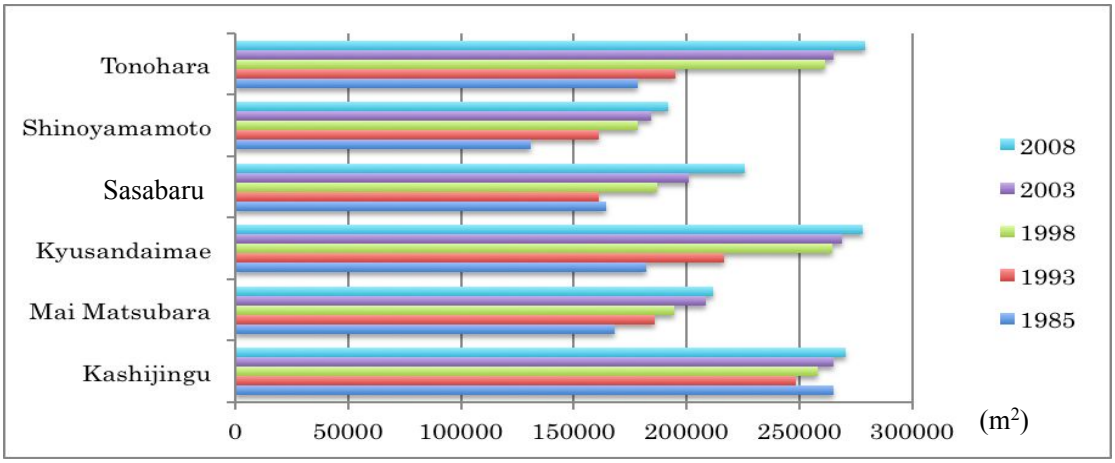
(f) Condominium House



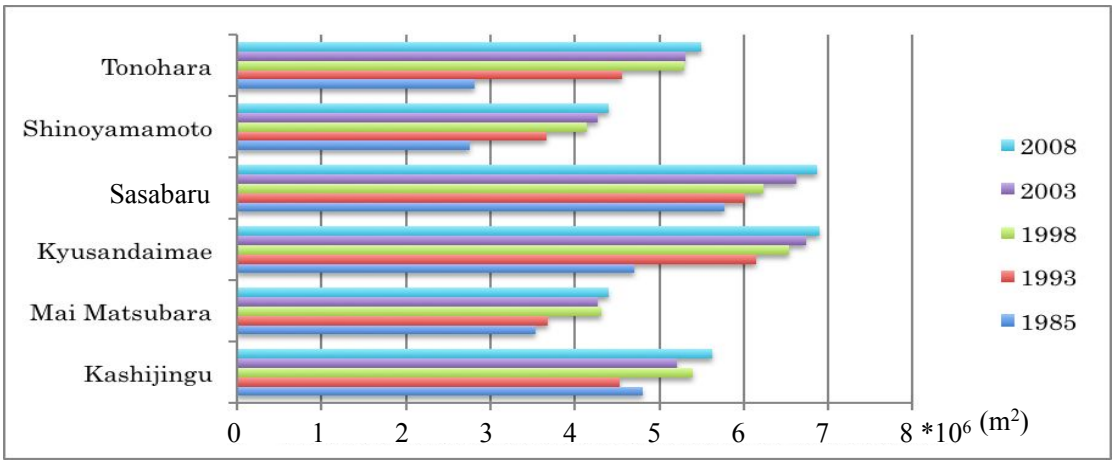
(g) Industry



(h) Park & Green Land



(i) Road



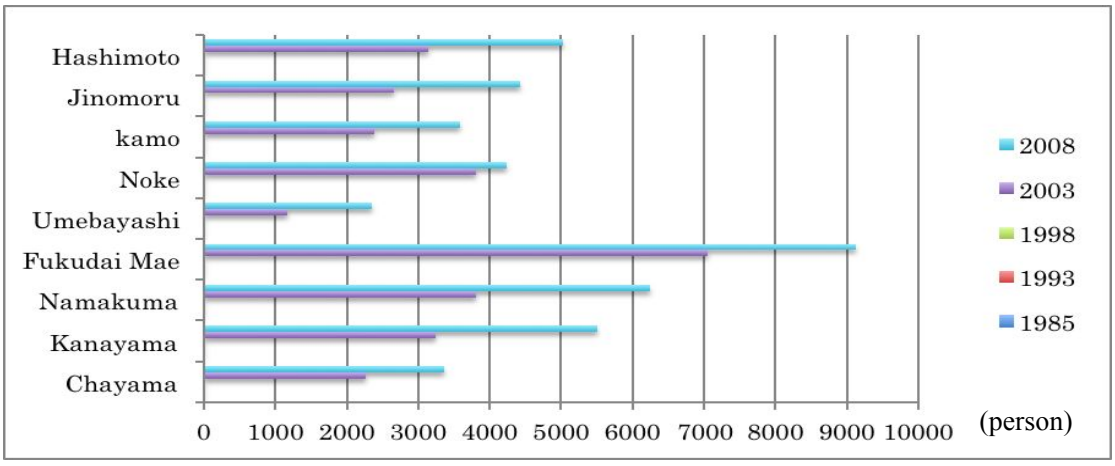
(j) Gross Floor Area

Fig. 4.3 Impact on the Foundation of New Stations

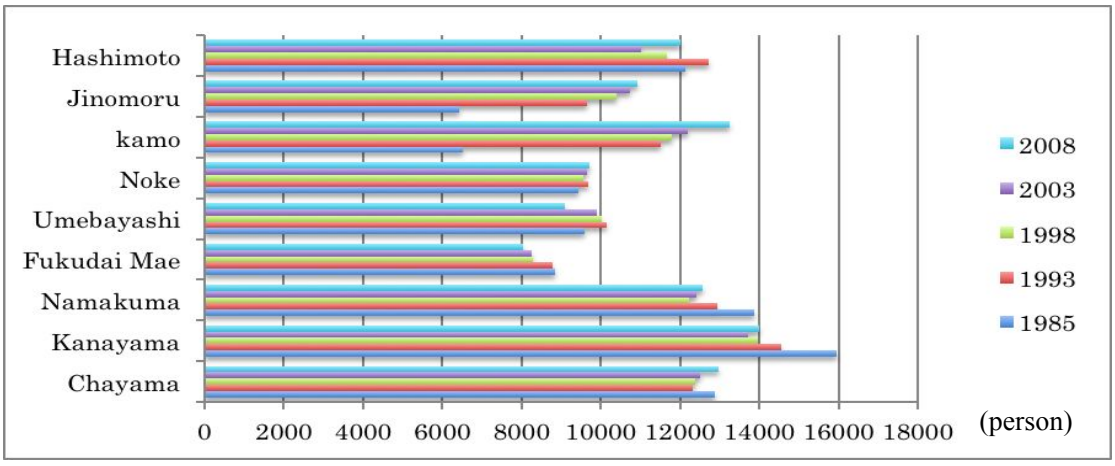
4.5.4 Impact on Planning Decisions on Nanakuma Line, Fukuoka Subway

For finding the impact of planning decisions on the Fukuoka City Subway Nanakuma Line, the research abstracts 9 subway stations including the "Hashimoto Station" and the "Chayama Station" so that the development of surrounding areas and the impact of planning decisions to surroundings areas from stage Ⅱ to stage Ⅲ can be interpreted. (see Fig. 4.4)

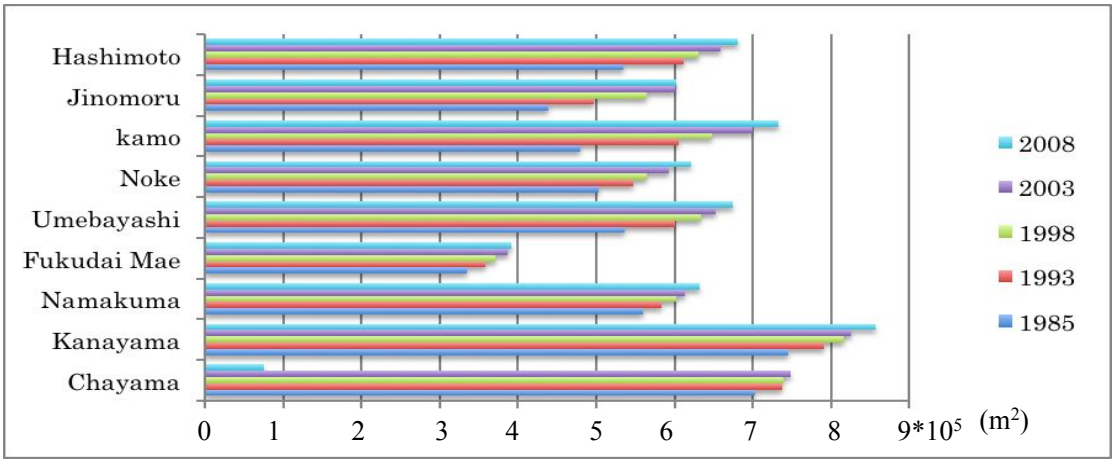
The noticeable changes on road area have shown the road maintenance being in progress since the planning decision was made in 1996. Furthermore, the total floor area and the area of apartment stay almost the same in stage Ⅲ which indicates the influence brought from the planning decisions tends to be small.



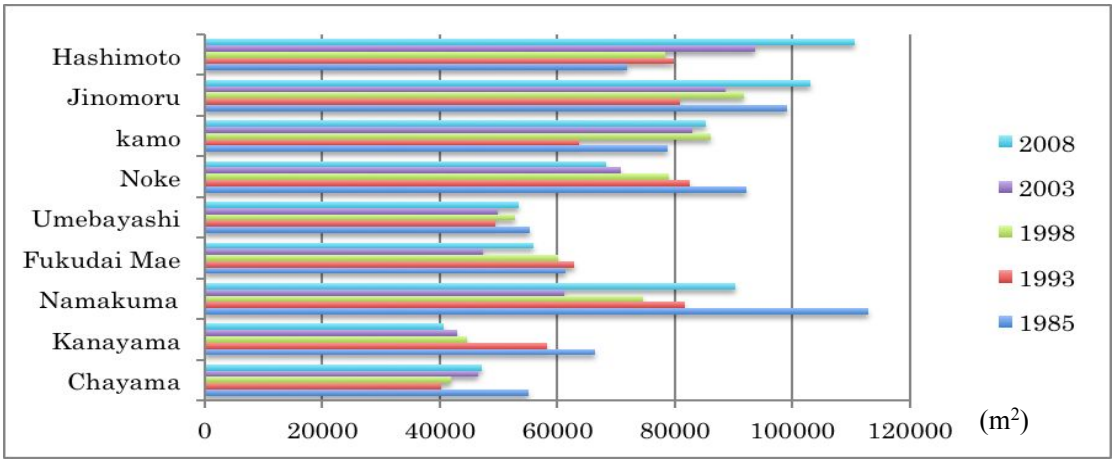
(a) Passenger



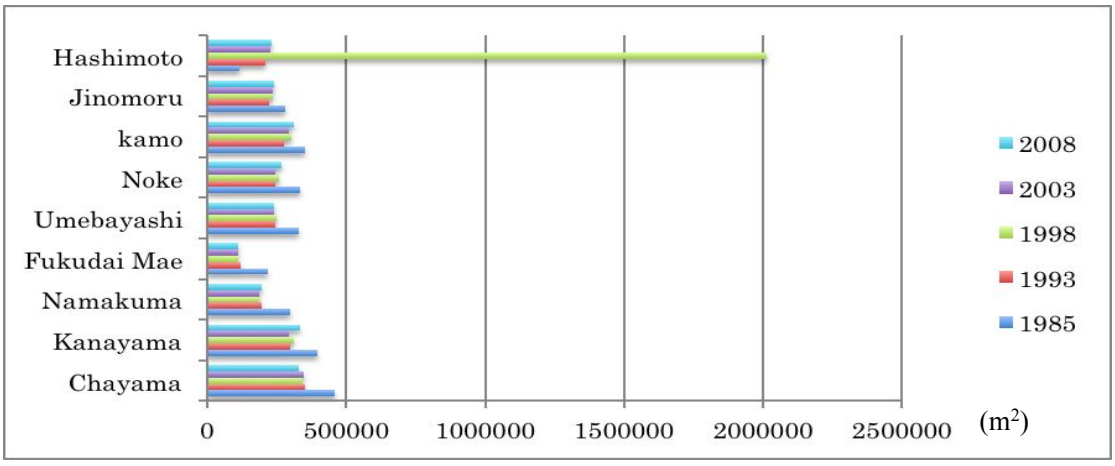
(b) Population



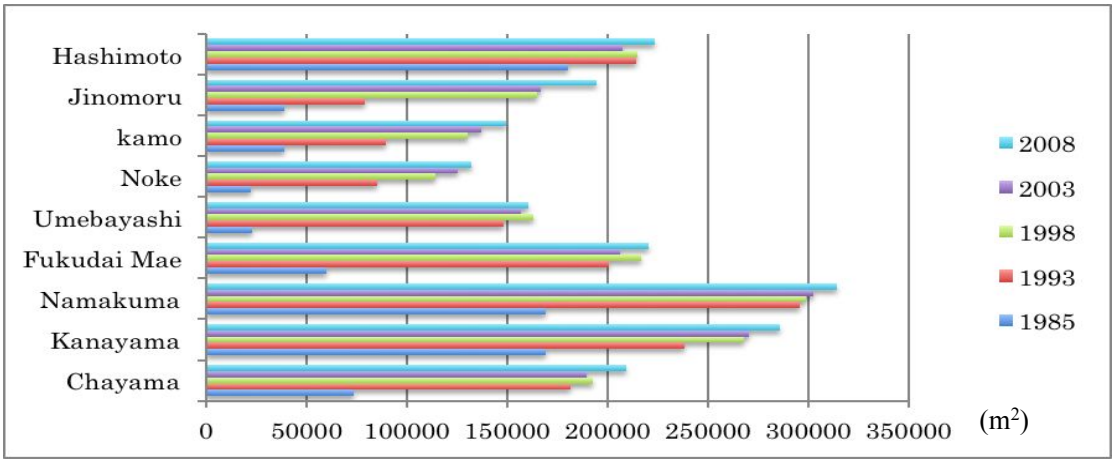
(c) House



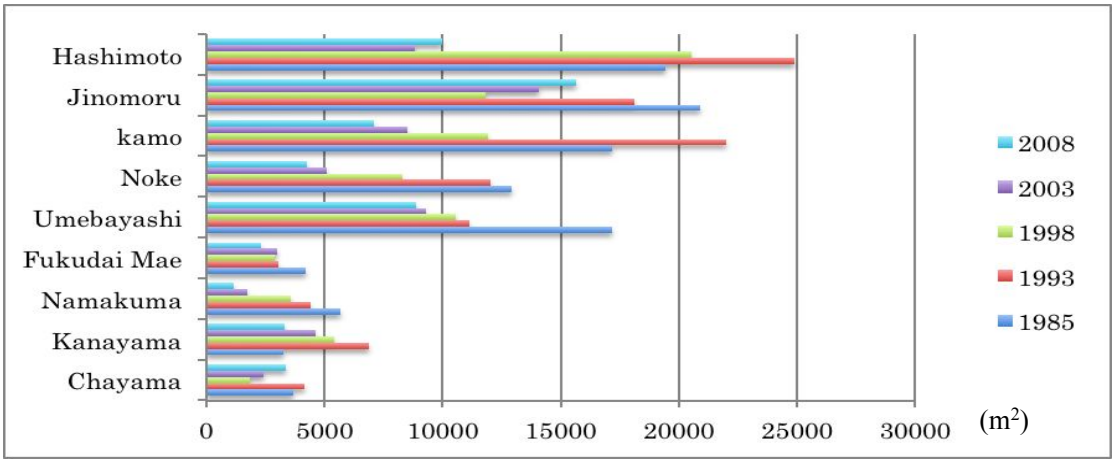
(d) Commerce



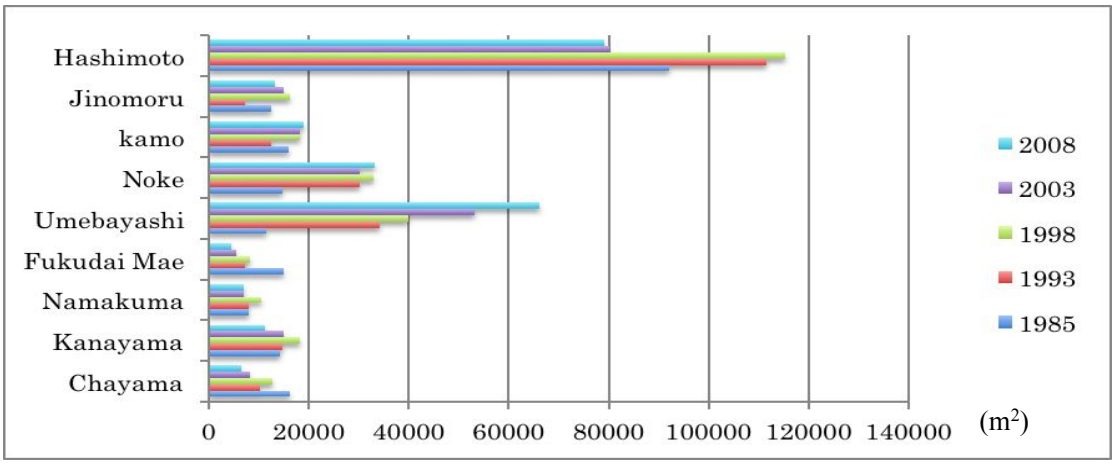
(e) Detached House



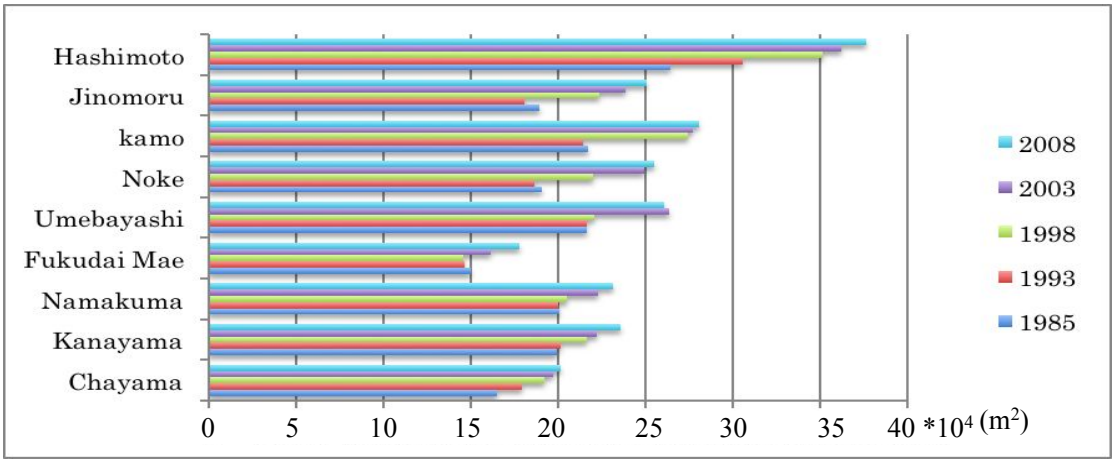
(f) Condominium House



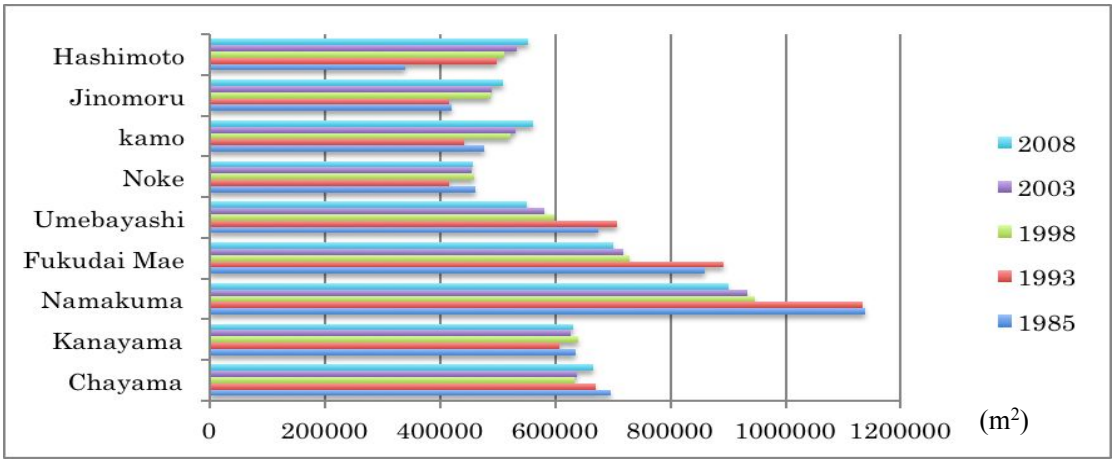
(g) Industry



(h) Park & Green Land



(i) Road



(j) Gross Floor Area

Fig. 4.4 Impact on Planning Decisions on Nanakuma Line, Fukuoka Subway

4.6 CONCLUSIONS

4.6.1 Conclusions

This research selects 68 stations as the research target, compares and analyzes the distribution of 13 factors of land use and 8 factors of building usage, and indicates the relationship between the factors and the population, land price and passengers around railway and subway stations every 5 years in a period of 24 years (1985, 1993, 1998, 2003, 2008), by using the multiple regression analysis. In addition, by taking categories in land use and building usage as explanatory variables, this chapter shows changes on land use and building usages around the urban railway and subway stations and the influence on population, land price and passengers in the quantitative expression method.

Furthermore, in this chapter, the research also analyzes the influence degree of changes on land use and building usage to population, land price and passengers by using the multiple regression analysis.

After that, by giving four representative and specific examples on the influence of land use and building usage and after comparing them by annual year, it becomes clear that a series of gradual changes of land use and building usage and their influence and influence degree on surrounding areas and people's everyday life.

The integration development of the urban railway and subway with the land use can play a comprehensive effect, do not only improve the efficiency of the land development and increase government revenue, but also bring a stable number of passengers for the railways and subways. The core issue of the integration development for the railway and subways with land development is a scientific analysis on the quantitative relationship between stations and land price. Thus, the research has an important theoretical significance and practical significance that can be able to provide solutions for integration development.

Moreover, three interpretations are put forward in the research, which are as

follows,

(1) Firstly, it is no doubt that the formation of whole large comprehensive transportation and communication system of the railway and subway stations has played an obvious added-value role for the surrounding land price and housing price. As there are improvement on further prosperity of commerce, business and traffic conditions in this kind of regions, the commerce and transportation has gradually become the main developing key in the surrounding areas where a new hot spot or vice-commercial district is forming, thus, the effect has been increasingly apparent in future.

(2) From the point of the time, the space and the distance, the land price and buildings which have a short distance to stations with commercial-centered type can rise more and more, oppositely speaking, the railway stations and subway stations, which are mainly unused-centered space, have a relatively small rising opportunity.

(3) For the added-value land as the municipal construction, the government should reserve in advance so that it can be put into the later development and construction. In addition, in some areas where the commerce, the business, the industry and the transportation have been in the good condition areas, the added-value effect on the land price and the real estate is more obvious. For this reason, the real estate developers should try to choose such a location for the priority development.

Consequently, not only does this research method use in Fukuoka City, but also can be generally applied to other cities or other countries. In the situation of rapidly developing on the transit transportation in the world, we hope this research can be a reference for it.

4.6.2 Future Work

According to the related investigations of land use and building usage around railway stations and subway stations in the past two decades, one of the most important and consistent findings is that making the changes and development on land use and building usage analyzed and understood by using the method of multiple regression analysis. Concerns of accessible places, more particularly method generally deals with the problem of the influence degree of the land use and building usage on population, land price and passengers in order to serve a spatially and timely distributed demand.

This research is only the beginning of a series of other related research studies. It

opens the door for a variety of studies that can investigate the effects of development on the land use and building usage. However, to make the present research fully operational, further development is required and taken into account other factors such as: calibrating the influence factors, integration of more influence factors and testing their accumulative affects. There are a number of possible topics for further work in this research,

(1) Integrate the calculations with mathematical derivation. This would allow a wide range of user to study the influence degree on surrounding areas of changes and development of stations. Calculating the measures on math. Thus, it will get a more precise result on the influence degree.

(2) Incorporate more traffic tools, such as the bus, etc. which is also an influencing element of traffic tools in the city so that the research can be richer.

(3) The research will also discuss the developing trend of stations in future work, in order to make this theoretical idea more useful for explaining the state of urban structure, stations' developing trend will be divided into several different types, specifically speaking, the research will abstract a part of stations, but not all the stations, which have obvious changes in different years (from the year of 1985, 1993, 1998, 2003 and 2008, totally five years), during this period, the stations that have special and obvious changes will be chose and made further analysis in later research work. For instance, in 1985, it is what type of station? But after five or ten-year development, what type of station it has grown up? Then after twenty-year change, what type of station it will be changing into? ... It is hoped to become a part of important guideline for other research and future urban development.

(4) One of the preconditions of the above research is to make a prediction on changes on land use and building usage in future, therefore, a useful, believable and practicable method for future predicting is necessary.

(5) Of course, the outcomes of Fukuoka City cannot be used directly in other cities. Only some of these results can be learned and transferred in the proper outcome and then being used in some cities. However, in the nearest future, we plan to target in more cities and in more countries. Therefore, we can conclude a more detailed and comprehensive outcome which can help the urban planners in planning the cities, especially the development of districts nearing around the subway and railway stations.

REFERENCES

A Research Report Concerning on Urban Structure of Fukuoka City. Fukuoka Asian Urban Research Laboratory, 2005, Japan.

Babalik-Sutcliffe E. Urban rail systems: Analysis of the factors behind success. Transport Reviews, 2002, 22(4): 415-447.

Bafna S. An Introduction of Space Syntax, Environment and Behavior, 2003,35:17-29.

Beckonert O, E Bollard M, Ebbels T, Keun H C, Antti, H, Holmes E, Nicholson J K. NMR-based metabonomic toxicity classification: hierarchical cluster analysis and k-nearest-neighbour approaches. Analytica Chimica Acta, 2003, 490(1): 3-15.

Bitter C, Mulligan G F, Dall’ erba S. Incorporating spatial variation in housing attribute prices: a comparison of geographically weighted regression and the spatial expansion method. Journal of Geographical Systems, 2007, 9(1): 7-27.

Capozza D R, Helsley R W. The fundamentals of land prices and urban growth. Journal of Urban Economics x, 26(3),1989, 295-306.

Cohen J P, Paul C M. The impacts of transportation infrastructure on property values: A higher-order spatial econometrics approach. Journal of Regional Science, 2007, 47(3): 457-478.

Damm D, Lerman S, Lerner-Lamm E, et a1. Response of urban real estate values in anticipation of Washington Metro. Journal of Transport Economics and Policy, 2007, 14:315-336.

Davis M A, Heathcote J. The price and quantity of residential land in the United States[J]. Journal of Monetary Economics, 2007, 54(8): 2595-2620.

Dowall D E, Leaf M. The price of land for housing in Jakarta[J]. Urban Studies, 1991, 28(5): 707-722.

Duncan M. The impact of transit-oriented development on housing prices in San Diego, CA. Urban Studies, 2011, 48 (1): 101-127.

Farber S, Yeates M. A comparison of localized regression models in a hedonic house price context. Canadian Journal of Regional Science, 2006, 29(3): 405-420.

Fukuoka City Statistics Book, Fukuoka City, Japan, 2000.

Ghebreegziabiher D, Eric P, Piet R. The impact of railway stations on residential and commercial property value: a meta-analysis. J Real Estate Finan Econ, 2007, 35:161–180.

Godschalk D R. Land use planning challenges: coping with conflicts in visions of sustainable development and livable communities. Journal of the American Planning Association, 2004, 70(1): 5-13.

Golub A, Guhathakurta S, Sollapuram B. Spatial and temporal capitalization effects of light rail in phoenix from conception, planning, and construction to operation. Journal of Planning Education and Research, 2012, 32 (4): 415-429.

Handy S. Smart growth and the transportation-land use connection: What does the research tell us? International Regional Science Review, 2005, 28 (2): 146-167.

Handy S L, Niemeier D A. Measuring accessibility: an exploration of issues and alternatives, environment and planning, 1997, 29(7): 1175-1194.

Hess D P. Impact of proximity to light rail rapid transit on station-area property values in Buffalo, New York. Urban Studies,2007, 44(5): 1041-1068.

Honda M, Shimada Im. Multivariate Statistical Technique for Management. Japan: Publishing Department of Sanno and Management University, 1977.

Iwatani M. A GIS Fundamental Study on Location Tendency of Condominium and TOD Promotion Plan, Architectonics Research, Graduation Thesis Outline Collections, 2002.

Kaufman L, Rousseeuw P J. Finding groups in data: an introduction to cluster analysis, 2009, 344, Wiley-Interscience.

Kestens Y, Thériault M, Des Rosiers F. Heterogeneity in hedonic modeling of house prices: looking at buyers' household profiles. Journal of Geographical Systems, 2006, 8(1): 61-96.

Kim C W, Phipps T T, Anselin L. Measuring the benefits of air quality improvement: a spatial hedonic approach. Journal of Environmental Economics and Management, 2003, 45(1): 24-39.

Kim J H. Linking land use planning and regulation to economic development: a literature review. Journal of Planning Literature, 2010, 26(1): 35-47.

Knight R L, Trygg L L. Evidence of land use impacts of rapid transit system. Transportation, 1977, 6: 231-248.

Li X, Yeh A G O. Analyzing spatial restructuring of land use patterns in a fast growing region using remote sensing and GIS. Landscape and Urban planning, 2004, 69(4): 335-354.

Lin T C, Evans A W. The relationship between the price of land and size of plot when plots are small[J]. Land Economics, 76(3), 2000: 386-394.

Luca B. Nodes and places:complexities of railway station redevelopment: European Planning Studies, 1996, 4(3): 331-345.

Luca B, Tejo S. Cities on rails: the redevelopment of railway station areas, Routledge, New York, 2001.

Makrí M, Folkesson C. Accessibility Measures for Analyses of Land Use and Traveling with Geographi-cal Information Systems, Proceedings of 2nd KFB-Research Conference, Institute of Technology, Lund, 1999.

Morancho A B. A hedonic valuation of urban green areas. Landscape and Urban Planning, 2003, 66: 35-41.

Naceur F. Impact of urban upgrading on perceptions of safety in informal settlements: Case study of Bouakal, Batna. Frontiers of Architectural Research, 2013, 2: 400-408.

Paez A, Uchida T, Miyamoto K. Spatial association and heterogeneity issues in land price models. Urban Studies, 2001, 38(9): 1493-1508.

Ping X Q, Chen M Y. Real Estate Financing, the Price of Land and the Trend of Housing Price. World Economy, 2004.

Porta S, Crucitti P, Latora V. The Network Analysis of Urban Streets: A Primal Approach, Environment and Planning: Planning and Design, 2005, 33(5):705 – 725.

Ratti C. Environment and Planning B: Planning and Design, 2004, 31: 487 - 499.

Rosenthal S S, Helsley R W. Redevelopment and the urban land price gradient[J]. Journal of Urban Economics, 1994, 35(2): 182-200.

Ryan S. Property values and transportation facilities: Finding the transportation-land use connection. Journal of Planning Literature, 2011, 13 (4): 412-427.

Song B, Gao B. A causality test for housing and land prices: 1998-2006[J]. Modern Economic Science, 2007.

Su J G, Brauer M, Ainslie B, Steyn D, Larson T, Buzzelli M. An innovative land use regression model incorporating meteorology for exposure analysis. Science of the total environment, 2008, 390(2): 520-529.

Timm H, Borgelt C, Döring C, Kruse R. An extension to possibilistic fuzzy cluster analysis. Fuzzy Sets and Systems, 2004, 147(1): 3-16.

Wang M, Yu B. Landscape characteristic aesthetic structure: Construction of urban landscape characteristic time-spatial pattern based on aesthetic subjects. Frontiers of Architectural Research, 2012, 1: 305-315.

Ward P, Jimenez E, Jones G. Residential land price changes in Mexican cities and the affordability of land for low-income groups [J]. Urban Studies, 1993, 30(9): 1521-1542.

Yasuhiko G. Introduction to Econometrics by Excel, Toyo Economic Press Office,Japan, 2000.

Yang J Y, Yang Y, Tang W. Development of evaluation model for intensive land use in urban centers. Frontiers of Architectural Research, 2012, 1: 405-410.

Yano K. Research by GIS on Changes of Enterprise Location among Stations in Kyoto, Ritsumeikan Literature, Japan, 2006.

Zeng X, Zhang A. A study on the relationship between land price and housing price: granger-causality test and its implication [J]. China Land Science, 2006.

Zhuang X Y. A Discussion on the Uptown Environment in the 21st Century. Journal of Sichuan College of Architectural Technology, 2008:18.

Zhuang X Y., Zhao S C. Impact Analysis of Land and Building Usage of Station Areas on Population, Land Price and Passengers: A case study in Fukuoka, Japan. Frontiers of Architectural Research, 2014, 3.

Zhuang Y, Zhuang X. Impact of Subway Stations on Commercial Land Prices. China Land Science, 2007, 21 (4).

Chapter Five

General Conclusions and Prospects

Chapter 5
General Conclusions and Prospects

5.1 SYNOPSIS

As the decline of population and the growth of global environmental issues, social economic situation is always changing at present time, such as severe financial constraints, and the urban development is also being diffusion anywhere disorderly. In order to promote the integration of all kinds of urban functions in an intensive linking with the public transportation network, restructuring the urban structure and compacting the city functions has become an urgent task nowadays.

Furthermost, the potential value of railway and subway stations is attached great importance again in cities. Research on development of integration on stations with the urban area has being carried out. With the decreasing in surrounding shops, the purchasing of daily necessities is becoming more and more inconvenience, as well as the coming of the aging society. The central urban area, such as the area around stations declines not only in outer suburbs, but also in city centers. The shops of daily necessities and fresh food decrease sharply in shopping streets. The railway station gathers commercial and business functions. In order to promote the formation of

intensive urban area, the convenience of station should be enhanced further. In addition, the other potential of railway stations development should be found in process, residents, urban development and activation of railway stations and subways should be also integrated together. On the other hand, as the development of land use around railway stations and subways, especially in recent years, the background problem has become serious in many parts, not only sparsely populated regions, but also central regions around stations. Generally, the developing situation of land use around railway stations can represent the developing situation of commerce, industry, business, entertainment, etc. It is said that the development of society is forming around a circle of stations, which can make an influence on people's life. Thus, for the better formation of the zones of railway stations, a further improvement of the convenience of railway stations is sought constantly.

As the development of surrounding areas of railway stations and stations themselves in Fukuoka, Japan, the relationship among those stations, environment improvement and urban renaissance project is becoming more and more important. Thus, by selecting small-scale railway stations in Fukuoka City as research objects, the paper focuses on the distribution situation, annual changes of land use, as well as their relationship with population and number of users, in order to analyze the situations of exploiting surrounding areas of railway stations. On one hand, focusing on land use around railway stations can catch the distribution and characteristics of community facilities, including educational facilities, the public and government facilities, etc. to clarify the actual conditions and secular changes of them.

This research, which is based on the results of previous researches, is focus on surrounding areas of train stations and the convenience of shopping and further improvement in future. Solution ways are needed to promote compact urban development and provide basic information about the design, and distribution of the surrounding areas for the railway stations.

Recently, the potential value of railway stations is becoming more and more important in many cities. In order to promote the formation of intensive urban areas, the convenience of stations should be enhanced further. Selecting 68 stations as the research objects, this research focuses on the railway stations and subways of Fukuoka city in order to clarify the trend of changes and development on them. With the survey of the land use around railway stations and subways of Fukuoka, the

research selects 68 stations as the research targets, which are compared and analyzed on the distribution of land use, such as the commerce, the house, the government and education, the park and green land, etc., by extracting the POSMAP data on land use with the GIS. Furthermore, for each station, the data are analyzed by 5 years, separated with two steps, that is, 0-400m radius (Step. 1) and 400-800m radius (Step. 2), in addition, five-age points multiply 2 distance categories (Step.1, 2) that makes 10 series of data (each series of data corresponding to 68 stations), and are categorized into groups according to the twice cluster analysis by using the Ward method so that the spatial characteristics of stations can be hold and the research can indicate the changing tend and relationship among population and passengers and land use around railway stations and subways in the past five years.

According to the above five chapters, some highlights can be summarized like this,

1) A methodology is presented for integration and optimization.

2) An integrated model is developed on the basis of the operation strategies.

3) A genetic algorithm is applied for optimizing the installed capacities.

4) The methodology that we propose is validated in practice.

5.2 CONCLUSIONS

Basing on the interpretation of Chapter 1, Chapter 2, Chapter 3 and Chapter 4, it can be concluded as following points, that is,

(1) Firstly, this research discusses the state and problems of land use and building usage in Fukuoka by the approach of quantitive analysis, based on the description, "influence sphere of stations", which will be focused on in this dissertation, is defined. In addition, it describes the changes of land use and the trend of development in the inner and outer places of "influence sphere of stations" in recent years by referring the data of land use and building usage of these spheres.

(2) Secondly, basing on the data of land use around railway stations and subways in Fukuoka, this research selects 68 stations as the research targets and abstracts annual data of the land use and buildings usage with two steps of five years, that is, 0-400m radius (Step.1) and 400-800m radius (Step. 2), which are categorized into groups according to the cluster analysis. Then, the relationship can be analyzed between 13 factors of the land use and 8 factors of the building usage, as well as the population, land price and passengers. The data are compared and analyzed on the distribution of land use and building usage by extracting the POSMAP data on land use with the GIS including the commerce, the house, the government and education, the transportation and the green land, etc.

(3) Thirdly, this research compares and analyzes the distribution of land use, such as commerce, housing, industry, agriculture, etc. The integration development of the urban railway and subway with the land use can play a comprehensive effect, do not only improve the efficiency of the land development and increase government revenue, but also bring a stable number of passengers for the railway and subway. The core issue of the integration development for the railway and subways with land development is a scientific analysis on the quantitative relationship between stations and land price. Thus, the research has an important theoretical

significance and practical significance that can be able to provide solutions for integration development.

(4) Fourthly, this research is working on by using another method of multiple regression analysis in order to find the impact on population, land price and passengers and the influence degree brought from changes of land use and building usage. In addition, the relationship among the population, land price, passengers, changes of land use and building usages can be got; by carrying out the analysis on the developing trend and influence degree by the method of quantitative analysis and multiple regression, the relationship among the population, land price, passengers, changes of land use and building usages can be got; after that, it shows analysis results and points out solution ways for those problems and the next step in future.

(5) Furthermore, according to the analysis in the research, the land price and buildings which have a short distance to stations with commercial-centered type can rise more and more, oppositely speaking, the railway stations and subway stations, which are mainly unused-centered space, have a relatively small rising opportunity. it is no doubt that the formation of whole large comprehensive transportation and communication system of the railway and subway stations has played an obvious added-value role for the surrounding land price and housing price. As there are improvement on further prosperity of commerce, business and traffic conditions in this kind of regions, the commerce and transportation has gradually become the main developing key in the surrounding areas where a new hot spot or vice-commercial district is forming, thus, the effect has been increasingly apparent in future.

(6) This research is carried out a variety of studies that can investigate the effects of development on the land use and building usage. However, to make the present research fully operational, further development is required and taken into account other factors such as: calibrating the influence factors, integration of more influence factors and testing their accumulative affects.

5.3 PROSPECTS

A large number of large-scale commercial facilities tend to the suburbs and commerce has been hollowing out of the center of a city, which has become a major and deregulated social problem in Japan today. Not only a small city, but also a central city, such as Fukuoka, has been affected seriously. In addition, the environment problem has been paying more and more awareness on and improving the environment problem around railway stations has also been promoted gradually in recent years.

This research mainly analyzes the land use around stations in Fukuoka City by the cluster analysis method. Furthermore, the features of a spatial extension around stations are also clarified. The changes of land use and building usages around stations are also analyzed specifically in this paper including their influence for the population and the land price in order to indicate characteristics of space using around stations. After the burst of the economic bubble in 1996, although the development of surrounding areas of stations is a little slower, also the stores and restaurant are in the decreasing tendency in 0m-400m zones of stations, the key spots of development is moving outside the center of station zones. By representing the balance arrangement around stations and perceptible regionality in Fukuoka City, this paper is hoped to be useful for urban planning in future.

This research is taking into account the above social background and focuses on the railway stations and subways of Fukuoka city in order to clarify the trend of changes and development on them. According to a small case study, the research intends to analyze the relationship between the population, passengers and land use. Specifically speaking, with the survey of the distribution of land use on time 1985, 1993, 1998, 2003 and 2008, the research tries to grasp the actual conditions and secular changes on population, the number of passengers and the land use. Here, basing on the results of previous research, this research can be summarized in the following new findings,

(1) Firstly, the changes and tend of development on railway stations and subways of Fukuoka city have been interpreted in this research. This research is focused on analyzing station zones with step. 1 0-400m and step. 2 400-800m from the center of each station. As a result, most stations from 1985 to 2008 decline to changes gradually. Whereas this kind of changes tends to continue and has been confirmed in the investigation. In this situation, the land use on the commerce and housing in some stations have always been reducing which reveal a phenomenon associated with the consume progression of society, and it should be emphasized in community development activities in the future

(2) On the other hand, as the obvious reduction of the land use on the agriculture, green land and water in some stations, the industry facilities have been transferred into the suburbs, this situation has been a remarkable phenomenon which can be said that the decline had a significant impact on forest, green land, water and other afforestation areas in the suburbs.

(3) Future research will include the specification of the directionality of a spatial extension in Step.2 by the cluster analysis (400 -800m cluster), which will be considered in a wider subject. The analysis on railway stations divide main roads into several parts will be especially important in future. For the purpose of sustainable development, more useful and meaningful ways on developing stations and their surrounding areas will be put forward to, which may provide a reference for the land use and re-development. In this situation, station and station are especially noted which have been confirmed by all kinds of data. In addition, the result of analyzing the trend of type changes on 68 stations in five years can finger in a situation that there is a trend of somewhat integrated development on these investigated stations. For instance, a type of commerce-centered station group in the year of 1985 has become a type of housing-centered one in the year of 2008; a type of suburb station group in the year of1998 has developed into a type of industry-centered one in the year of 2003, and continuing changes into industry-centered type, or maybe other type which can be focused on further.

According to the above interpretation, developing and improving the convenience of environment around railway stations has become an urgent task in the future. Thus, considering those stations which have special, strange changes and conflicts that are

related to the commerce, industry, green land, etc. must be planning a deployment plan and measures. It also must be a continuous research later.

REFERENCES

Duncan M. The impact of transit-oriented development on housing prices in San Diego, CA. Urban Studies, 2011, 48 (1): 101-127.

Farber S, Yeates M. A comparison of localized regression models in a hedonic house price context. Canadian Journal of Regional Science, 2006, 29(3): 405-420.

Fukuoka City Statistics Book, Fukuoka City, Japan, 2000.

Ghebreegziabiher D, Eric P, Piet R. The impact of railway stations on residential and commercial property value: a meta-analysis. J Real Estate Finan Econ, 2007, 35:161–180.

Godschalk D R. Land use planning challenges: coping with conflicts in visions of sustainable development and livable communities. Journal of the American Planning Association, 2004, 70(1): 5-13.

Golub A, Guhathakurta S, Sollapuram B. Spatial and temporal capitalization effects of light rail in phoenix from conception, planning, and construction to operation. Journal of Planning Education and Research, 2012, 32 (4): 415-429.

Handy S. Smart growth and the transportation-land use connection: What does the research tell us? International Regional Science Review, 2005, 28 (2): 146-167.

Handy S L, Niemeier D A. Measuring accessibility: an exploration of issues and alternatives, environment and planning, 1997, 29(7): 1175-1194.

Hess D P. Impact of proximity to light rail rapid transit on station-area property values in Buffalo, New York. Urban Studies,2007, 44(5): 1041-1068.

Honda M, Shimada Im. Multivariate Statistical Technique for Management. Japan: Publishing Department of Sanno and Management University, 1977.

Iwatani M. A GIS Fundamental Study on Location Tendency of Condominium and TOD Promotion Plan, Architectonics Research, Graduation Thesis Outline Collections, 2002.

Kaufman L, Rousseeuw P J. Finding groups in data: an introduction to cluster analysis,

2009, 344, Wiley-Interscience.

Kestens Y, Thériault M, Des Rosiers F. Heterogeneity in hedonic modeling of house prices: looking at buyers' household profiles. Journal of Geographical Systems, 2006, 8(1): 61-96.

Kim C W, Phipps T T, Anselin L. Measuring the benefits of air quality improvement: a spatial hedonic approach. Journal of Environmental Economics and Management, 2003, 45(1): 24-39.

Kim J H. Linking land use planning and regulation to economic development: a literature review. Journal of Planning Literature, 2010, 26(1): 35-47.

Knight R L, Trygg L L. Evidence of land use impacts of rapid transit system. Transportation, 1977, 6: 231-248.

Li X, Yeh A G O. Analyzing spatial restructuring of land use patterns in a fast growing region using remote sensing and GIS. Landscape and Urban planning, 2004, 69(4): 335-354.

Lin T C, Evans A W. The relationship between the price of land and size of plot when plots are small[J]. Land Economics, 2000: 386-394.

Luca B. Nodes and places:complexities of railway station redevelopment: European Planning Studies, 1996, 4(3): 331-345.

Luca B, Tejo S. Cities on rails: the redevelopment of railway station areas, Routledge, New York, 2001.

Makrí M, Folkesson C. Accessibility Measures for Analyses of Land Use and Traveling with Geographi-cal Information Systems, Proceedings of 2nd KFB-Research Conference, Institute of Technology, Lund, 1999.

Morancho A B. A hedonic valuation of urban green areas. Landscape and Urban Planning, 2003, 66: 35-41.

Paez A, Uchida T, Miyamoto K. Spatial association and heterogeneity issues in land price models. Urban Studies, 2001, 38(9): 1493-1508.

Ping X Q, Chen M Y. Real Estate Financing, the Price of Land and the Trend of Housing Price. World Economy, 2004.

Porta S, Crucitti P, Latora V. The Network Analysis of Urban Streets: A Primal Approach, Environment and Planning: Planning and Design, 2005, 33(5):705 – 725.

Ratti C. Environment and Planning B: Planning and Design, 2004, 31: 487 - 499.

Rosenthal S S, Helsley R W. Redevelopment and the urban land price gradient[J]. Journal of Urban Economics, 1994, 35(2): 182-200.

Ryan S. Property values and transportation facilities: Finding the transportation-land use connection. Journal of Planning Literature, 2011, 13 (4): 412-427.

Song B, Gao B. A causality test for housing and land prices: 1998-2006[J]. Modern Economic Science, 2007.

Su J G, Brauer M, Ainslie B, Steyn D, Larson T, Buzzelli M. An innovative land use regression model incorporating meteorology for exposure analysis. Science of the total environment, 2008, 390(2): 520-529.

Timm H, Borgelt C, Döring C, Kruse R. An extension to possibilistic fuzzy cluster analysis. Fuzzy Sets and Systems, 2004, 147(1): 3-16.

Ward P, Jimenez E, Jones G. Residential land price changes in Mexican cities and the affordability of land for low-income groups [J]. Urban Studies, 1993, 30(9): 1521-1542.

Yasuhiko G. Introduction to Econometrics by Excel, Toyo Economic Press Office,Japan, 2000.

Yano K. Research by GIS on Changes of Enterprise Location among Stations in Kyoto, Ritsumeikan Literature, Japan, 2006.