

JSTS

**JOURNAL OF SOCIETY
FOR TRANSPORTATION
AND TRAFFIC STUDIES**

VOL.2 No.1

MARCH 2011

The Future of Human Mobility

Special Issue

Non-motorized Transportation



PREFACE

Dear Readers,

Welcome to the second volume (Volume 2), issue number 1, of the JOURNAL OF SOCIETY for TRANSPORTATION and TRAFFIC STUDIES, an international peer-reviewed on-line journal. Four issues of the journal are published annually. This issue presents the general theme on public transportation with a special section on non-motorized transport, NMT. It includes a paper on the use of school bus service where factors influencing parental decisions regarding their child's use of school bus in Bangkok are described. The second paper deals with accessibility to mass transit system in the Bangkok Metropolitan Region (BMR), Thailand where two types of metro systems, the Mass Rapid Transit (MRT) and Bangkok Transit System (BTS) are operated. The third paper presents an alternative approach to evaluate a Transit – Oriented Development (TOD), using GIS as a tool; and SAGA city in Japan was selected as a case study. The fourth paper presents an analysis approach to study the effect of High-Speed Rail (HSR) development on regional economy, by utilizing the development cases of the Japanese Shinkansen. For the special issue on NMT, the paper presents an evaluation of a public-use bike system in Kasetsart University (KU). The KU bike project was implemented in August 2009 with the aim of allowing staff and students to borrow bikes free of charge to encourage the staff and students to use them, hence creating a green campus and a healthy community.

I trust you will enjoy reading this issue and find the information and research findings helpful.

Pichai Taneerananon
Professor

Chair of Editorial Board

Journal of Society for Transportation and Traffic Studies (JSTS)

Editorial Board

1. Prof. Dr. Pichai Taneerananon	Prince of Songkla University, Thailand (Chair)
2. Prof. Dr. Tien Fang Fwa	National University of Singapore, Singapore
3. Prof. Dr. Praipol Koomsap	Thammasat University, Thailand
4. Prof. Dr. Ulrich Brannolte	Bauhaus University, Weimar, Germany
5. Prof. Dr. Hokao Kazunori	Saga University, Japan
6. Prof. Dr. Csaba Koren	Szechenyi Istvan University, Hungary
7. Prof. Dr. Takashi Nakatsuji	Hokkaido University, Japan
8. Prof. Pol. Col. Pongson Kongtreekaew	Royal Thai Police Academy, Thailand
9. Prof. Dr. Akimasa Fujiwara	Hiroshima University, Japan
10. Assoc. Prof. Dr. Sorawit Narupiti	Chulalongkorn University, Thailand
11. Assoc. Prof. Dr. Junyi Zhang	Hiroshima University, Japan
12. Assoc. Prof. Dr. Sanjeev Sinha	National Institute of Technology Patna, India
13. Assoc. Prof. Dr. Sano Kazushi	Nagaoka University of Technology, Japan
14. Assoc. Prof. Dr. Viroat Srisurapanon	King Mongkut's University of Technology Thonburi, Thailand

Editorial Staff

1. Dr. Watchara Sattayaprasert	Mahanakorn University of Technology, Thailand (Chief)
2. Assoc. Prof. Dr. Vatanavongs Ratanavaraha	Suranaree University and Technology, Thailand
3. Dr. Suebpong Paisalwattana	Department of Highways, Thailand
4. Dr. Chumchoke Nanthawichit	Tran Consultant Co., Ltd.
5. Dr. Karin Limapornwanitch Systra	MVA (Thailand) Ltd
6. Dr. Kerati Kijmanawat	PCBK International Co., Ltd.
7. Dr. Ponlathap Lertworawanich	Department of Highways, Thailand
8. Dr. Danai Ruengsorn	Department of Highways, Thailand
9. Dr. Khuat Viet Hung	University of Transport and Communications, Viet Nam
10. Dr. Sudarmanto Budi Nugroho	Hiroshima University, Japan
11. Dr. Wichuda Satiennam Mahasarakham	University, Thailand
12. Dr. Chatchawal Simaskul	Office of Transport and Traffic Policy and Planning, Thailand
13. Dr. Sompong Paksarsawan	AMP Consultants, Thailand
14. Dr. Koonton Yamploy	Department of Highways, Thailand
15. Asst. Prof. Dr. Pawinee Iamtrakul	Thammasat University, Thailand (Secretary)

TABLE OF CONTENTS

General Issue : *Public Transportation*

Factor Influencing Parental Decision Regarding School Bus <i>Achara LIMMONTHOL, Jittichai RUDJANAKANOKNAD</i>	1
Behavioral Responses to Metro Accessibility: A Gap between Physical and Non-physical Approach <i>Duangporn PRASERTSUBPAKIJ, Vilas NITIVATTANANON, Pawinee IAMTRAKUL</i>	13
Alternative Approach for GIS Evaluation of Transit – Oriented Development: A Case Study of Saga City, Japan <i>Sunisa MENARIN, Pawinee IAMTRAKUL, Warapan PHONPRO, Manat SRIVANIT</i>	27
Effect of High-Speed Rail Development on The Progress of Regional Economy <i>Xuesong FENG, Quan YUAN, Peng JIA, Yoshitsugu HAYASHI</i>	46

Special Issue : *Non-motorized Transportation*

Application of Public-Use Bike System in Kasetsart University, Bang Khen Campus: Research and Reality <i>Supaporn Kaewko LEOPAIROJNA, Salila TRAKULVECH</i>	56
---	----

FACTORS INFLUENCING PARENTAL DECISION REGARDING SCHOOL BUS IN BANGKOK

Achara LIMMONTHOL
Graduate Student
Department of Civil Engineering
Faculty of Engineering
Chulalongkorn University
Patumwan, Bangkok 10330 Thailand
Fax: +66-02-251-7304
E-mail: jakajee_pink@hotmail.com

Jittichai RUDJANAKANOKNAD
Lecturer
Department of Civil Engineering
Faculty of Engineering
Chulalongkorn University
Patumwan, Bangkok 10330 Thailand
Fax: +66-02-251-7304
E-mail: jittichai@hotmail.com

Abstract: This research unveils the factors influencing parental decisions regarding their child's use of school bus in Bangkok. Five schools with school buses in Chatuchak District, inner Bangkok, were studied. This includes interviews of key managing teachers and questionnaire distribution to all Grade-4 students' parents. 419 of 619 questionnaires were returned and analyzed using descriptive statistics as well as logit choice model equations. The results reveal parents' characteristics that are likely to use school bus than others such as have business owners or business employees occupations, have high-level of education, have more than one child in a particular school, and have high income. Main reasons of why parents are not using the service are due to short school trip distance and Thai culture of parental care. However, schools could persuade these parents through lower school bus charges and improvement of bus condition.

Key Words: School Bus, Choice Model, Travel Behavior, Rideshare, Urban Transportation

1. INTRODUCTION

School bus is one of ridesharing modes for commuting to schools by children. School bus, if successfully implemented, would reduce peak-hour automobile travels by parents and alleviate congested public transportation system while increase student's travel safety. According to Road Safety Center (2008), although school bus system has been introduced in Thailand for more than 20 years, the popularity among Thai students and their parents is limited and the school bus' supportive programs by several agencies are considered to be unsuccessful. The Department of Land Transport (Not specified Year) had determined the preliminary problems of school

bus' low usage in Thailand. The examples of problems are: 1) expensive school charges due to high standard of legal operating vehicles, 2) risk awareness from students' parents towards school bus drivers and vehicles used, and 3) students' inconvenience in waiting for school bus schedule either at their home or at school, etc. However, these lists are mostly descriptive and none of previous studies have conducted research to understand these factors thoroughly.

This research's main objective is to understand what influences parents to allow their children use school bus for commuting from/to their school. To these ends, the researchers have conducted interviews of key managing teachers and distributed survey questionnaires to Grade-

4 students' parents (or guardians) at five selected schools in Chatuchak District, one of the business districts in Bangkok. The survey data were collected and then analyzed by descriptive statistics and logit choice model equations to quantitatively extract other main decision factors regarding the issues.

The remainder of the paper is organized as follows. Section 2 summarizes related background research. The schools selected for this study and questionnaires are described in Section 3. Section 4 presents the factors affecting school bus mode choice through descriptive statistics. Section 5 utilizes logit choice model equations in analysis of different factors. Then, the sixth and final section contains concluding remarks as well as areas of further research.

2. BACKGROUND

This Section will begin with the discussion of school bus in foreign countries, and followed by Thailand case. In each subsection, the overview of school bus operations is presented to summarize the existing situations, followed by researches relevant to school bus selection.

2.1 School Bus around the World

Regulations regarding school bus in many countries are pretty much concerned with safety standards. In the U.S, the National Highway Traffic Safety Administration, Department of Transportation, issues the Federal Motor Vehicle Safety Standards that regulate school bus standards with 37 specifications and separate school bus into 7 categories. In each category, the maximum allowable load and number of students are

specified such that the safety of school bus riders is similar to aircraft passengers (STN Media, 2009).

The factors that affect parents' decision in selecting mode choice for their students' school trip in each country are different since school buses are varied by their local standards, regulation, urban pattern, as well as sociocultural situations. Jansen (2008) reports that a distance from student home to school is significantly related to whether Danish students choose to walk, bike, or use school bus to school. It also points that road design and motorized traffic volumes do influence children mode choice to a limited extent. McMillan (2007) studies the school trip data in California, U.S. and concludes that urban form is important but not the only factor that affects school travel mode choice. Other factors like perceptions of neighborhood safety and traffic safety, household transportation options, and social/cultural norms may be equally important. Yeung, *et al.* (2008) also describes that the factor influence parental decisions regarding their child's use of active transport to school in Brisbane, Australia are child age, safe walking path, adult supervision, commuting distance, and child's fitness level. However, although focusing on school trip mode choice, they do not capture the factors influencing parents/guardians' decision regarding their child's use of school bus.

2.2 School Bus in Thailand

In Thailand, school bus can be grouped into two categories based on their vehicle type, i.e., a minibus or a van. Each type is enforced by different Thai law (Land Transport Act of 1979 and Vehicle Act of 1979) based on its size.

Currently, a van is more popular to be used as a school bus than a minibus since it is smaller and easier to maneuver in Bangkok congested traffic. Also, most residential areas in Bangkok are located on long and narrow streets with

substandard turning radii where a minibus is inaccessible. Most importantly, the cost of using a school bus van per student is lesser. Both laws have slightly different requirements as shown in Table 1 below.

Table 1. Summary of School Bus Legal Requirements in Thailand

Characteristic	Land Transport Act of 1979	Vehicle Act of 1979
Seating	12 people or more	8-11 people
Exterior Color	Yellow background with black strips	Not specified
Label	“school bus”	“school bus”
Sign Dimension	35× 85 cm.	25× 60 cm.
Text Height	25 cm.	15 cm.
Tools	Extinguisher	Extinguisher
	Break glass hammer	Break glass hammer
	Iron crow bar	

Numerous research publications in Thailand are concerned about school bus. However, most researches are focused on safety aspects only. Examples of these are: Karuhadech, P., *et al.* (2004) studying the safety of school bus travel in Bangkok, and, Kanitpong (2007) studying the causes of traffic accidents relating school bus operation and recommending strategies to prevent them. These studies investigate school bus vehicles and analyze accidents associated with school bus travel. They do not pinpoint the reasons of why parents choose or not choose school bus service. Studies that relate to parents’ decision regarding school bus are as follows:

Manomaipibul (2003) investigates factors of school trips that could result in students’ traffic accidents. It reveals that students’ mode of travels, travel times, and grade significantly relate to student safety. However, students who use school buses generally experience fewer accidents than other travel modes even with substandard school bus vehicles. It claims that

if school bus was improved, 40 percent of students’ parents would likely opt for the service.

Jintapitak and Thiengburanathum (2009) analyze the travel behaviors of students in Chiang- Mai Municipal Area (Northern Thailand). It covers school trips surveys from 357 high school students. The survey was analyzed by Chi-Square method at the level of significance of 0.01. It reports student characteristics resulting in their mode choices. Among them are student’ gender and’ age, parents’ occupations and education, household size, income and expenditure, and location, and number of workers, licensed drivers, and auto-ownership relates choice decision. This study although focuses on choice decision; it does not explicitly describe what causes parents choose school bus service. Also, the study area is in Chiang- Mai, where the traffic as well as sociocultural condition is different from Bangkok, Thailand’s Capital and one of the most congested cities in the world.

3. DATA COLLECTION AND GENERAL SCHOOL BUS PROFILE

In this study, Chatuchak District, one of major business districts in Bangkok, is selected. Chatuchak has several schools, as well as, large companies, shopping and commercial areas. It is one of the most congested areas in Bangkok. However, there are plenty of public transportation options, i.e., buses, vans, taxis, and two main heavy rail transits.

Many elementary (Grade 1-6) schools in Chatuchak District have operated school bus services. These schools either own buses themselves or hire contractors to operate under school's supervision. Five of them allowed the researchers to collect complete data. They are 1) Prachaniwet School, 2) Tubtong School, 3) Yaemsaard School, 4) Chindanukul School, and 5) Darathorn School. These schools own and operate school bus themselves. Only Prachaniwet School is a public school while the rest are private.

During September-November 2009, these school executives as well as school-bus related teachers were interviewed regarding characteristics of their school profile, e.g., number of students, teaching grades, and school bus management, e.g., bus occupancies, fare pricing, routing, profitability, etc.

Regarding profitability of school bus operations, all schools report that school bus operations are unprofitable or nearly break-even. The school bus fares charged to student parents are usually calculated by a fixed cost plus a variable cost (based on distance from school to students' pick-up/drop-off locations).

Generally, the collected fares can cover barely daily operating costs (labor and fuel costs). The maximum chargeable fares are regulated by the authority; however, schools have to purchase vehicles by their capitals. (Prachaniwet, the only public school in this study, received government support on school bus purchase.) Even with losses, schools still continue operating the service as a student support program to campaign rideshares and reduce traffic congestion at their gates. Due to government control on fare, the effects from school bus charge in each school can not be distinguished.

Table 2 shows the number of students using school bus and total students in each school. It shows that Yaemsaard, Tubtong, and Chindanukul have high school bus usage levels of 45.0%, 44.5% and 40.0%, respectively. This is followed by Darathorn (22.1%). Prachaniwet has the lowest usage level of 7.7%. The average of school bus use is 20.1% of all students.

Besides teacher interviews, these schools authorized the researcher to distribute questionnaires to their students' parents. 619 questionnaires were distributed and 419 of them were returned (represented 68% of total population) as shown in Table 2.

Table 2. School Bus Profile and Questionnaires

School	School bus type	No. of buses	# students Using school bus	Total students	% School bus usage	No. of questionnaires	
						Distributed	Returned
Prachaniwet	Minibus	6	132	1718	7.7%	160	103
Tubtong	Van	7	144	323	44.5%	99	67
Yaemsaard	Van	11	180	400	45.0%	150	101
Chindanukul	Van	5	68	170	40.0%	130	89
Darathorn	Van	1	19	86	22.1%	80	59

The students focused in this study are Fourth Grade students (Grade 4) only. They are approximately at the ages of 10. At this young age in Bangkok, they cannot take public transportation by themselves. They generally walk (in case that their houses are in close proximity to school), are picked-up/dropped-off by their parents through private autos/taxis, or use school bus. Note that bikes are not popular among children in urban Bangkok area due to safety concerns since inner Bangkok has no sufficiently safe bike paths for daily commuting.

Questions in the survey can be grouped into three main categories, i.e., 1) general household data, 2) student's travel mode to and from school, 3) factors affecting their decision whether to opt school bus service for their children. The analysis of data based on these questionnaires is shown in Section 4 and 5.

4. DESCRIPTIVE STATISTICAL ANALYSIS

This section summarizes descriptive statistical analysis from the interviews and questionnaires in each aspect as followed:

4.1 Level of Satisfaction

Two important features that are key performance indices reflecting how successful the school bus are percentage of students who use school bus to total students (already shown in Table 1) and parents' satisfaction towards school bus service. In the survey, parents who use school bus graded their satisfaction towards the service. They gave the score from 5 (Most Satisfied) to 1 (Least Satisfied). Then, their scores in each school are averaged and shown in the right column of Table 3. From the table, these satisfaction scores correspond with researchers' field observations, i.e., very good-condition vans for Yaemsaard, good-condition vans for Tubtong and Chindanukul, school buses, a medium-condition van for Darathorn, and poor-condition minibuses for Prachaniwet. Unsurprisingly, bus conditions and satisfaction scores correlate pretty well with usage percentages, i.e., a school with better-condition vehicle and higher level of satisfaction typically has higher school bus usage percentage.

Table 3. School Bus Usage and Satisfaction

School	Percentage of students using school bus	School bus satisfaction score Mean (S.D.)	Satisfaction rank
Prachaniwet	7.7%	3.07 (0.70)	5
Tubtong	44.5%	3.60 (1.14)	3
Yaemsaard	45.0%	4.03 (0.74)	1
Chindanukul	40.0%	3.80 (0.71)	2
Darathorn	22.1%	3.15 (0.69)	4

4.2 Parents' Profile

The parents' profile, their occupations and highest level of education, affect the decisions to allow their child to use school bus.

Table 4 shows the percentages of parents that choose school bus for their child at each school, separated by their occupations. By average, 26.7% of parents who returned questionnaires use school bus service. However, the data point out the percentage differences among each occupation.

From Table 4, parents who are business owners and employees use school bus the most. This might be due to the punctuality and strictness of their working hours. Also, this group has the highest income among all to pay for service charge. This is followed by independent workers and government officers, with less strictness of their working hours. On the other hands, independent retailers use school bus less since the opening hours of most retailers are late in the morning.

Table 4. Student parents' occupation

Parent's occupation	No. of surveys	No. of parents choosing school bus from surveys	Percentage of parents choosing school bus
Government officer	97	25	25.8%
Independent worker	36	9	25.0%
Business employee	105	37	35.2%
Business owner	31	12	38.7%
Independent retailer	71	10	14.1%
Housewife	78	19	24.4%
Total	419	112	26.7%

Table 5 displays the percentages of parents that choose school bus, separated by their highest level of education. It was found that parents with Bachelor's degree or higher

generally use school bus (higher than average). These parents commonly have busy working schedule, have more income to pay for the service, or are confident in school service.

Table 5. Student parents' highest level of education

Parent's level of education	No. of surveys	No. of parents choosing school bus	Percentage of parents choosing school bus
Elementary school	19	2	10.5%
High school	52	13	25.0%
Bachelor's degree or higher	348	97	27.9%
Total	419	112	26.7%

4.3 Comments from Parents who Choose School Bus

To understand how parents decide whether to choose school bus, the questionnaires are separated into two groups of parents, i.e., use school bus, or not use. The parents using school bus were asked to rank the top-three characteristics of school bus operations that affect their decision. Then, these characteristics were scored and ranked from 5-Most Important to 0- Least Important for each school, with the average for each characteristic as shown in Table 6 below.

Table 6 shows that top school bus characteristics that affect parents' decision in most school are driver's skill and manner, and closely followed by vehicle standard. These two characteristics reflect parents' strong attitudes towards their child safety. Teacher's close monitoring is also important. However, teachers have limited control over safe school bus operations as drivers and vehicles. In addition, punctuality, fare pricing, and drop-off/pick-up location are less important.

Table 6. Important school bus characteristics from parents' perspective

Rank	School bus characteristics	Score (5-Most important to 0- Least important)					Average score
		Prachaniwet	Tubtong	Yaemsaard	Chindanukul	Darathorn	
1	Driver's safety skill	5	5	4	3	4	4.2
2	Standard vehicle	4	2	3	5	5	3.8
3	Teacher's monitoring	2	4	5	1	3	3.0
4	Punctuality	1	1	2	2	2	1.6
5	School bus fare	3	0	0	4	1	1.6
6	Drop-off location	0	3	1	0	0	0.8

4.4 Comments from Parents who Drop-off/Pick-up Students themselves

The parents who drop-off/pick-up students themselves were asked to answer why they are not currently using school bus. They ranked the top-three reasons of pick-up/drop-off students themselves. Then, these reasons were scored and ranked from 7-Most Important to 0-Least Important for each school, with the average for each characteristic as shown in Table 7 below.

Table 7 reveals that pick-up/drop-off reasons can be grouped into three categories by their importance. First, students living close to their schools are less likely to use school bus and parents might feel convenient pick-up/drop-off students themselves. Next, Thai parents (as well as most Asian countries) feel responsible, attentive, and protective to their child. Lesser

important reasons are fear of traffic accidents, high school bus fares, and no school bus route offered. The data also show that child's unpunctuality, child's preference, and inconvenient school bus schedule are unimportant to their decision since children have plenty of free time and can wait for possibly inconvenient school bus schedule.

Follow up from the above questions, the parents were also asked what the school should improve in the school bus service such that they are likely to choose the service for their students. They ranked the top-three service improvements. Then, these improvements were scored and ranked from 4-Most Important to 0-Least Important for each school, with the average for each characteristic as shown in Table 8 below.

Table 7. Why parents choose to pick up/drop off students by themselves

Rank	School bus characteristics	Score (5-Most important to 0- Least important)					Average score
		Prachaniwet	Tubtong	Yaemsaard	Chindanukul	Darathorn	
1	Short travel distance	7	6	7	7	6	6.6
2	Take care of students	6	7	6	6	7	6.4
3	Fear of traffic accidents	2	5	4	5	5	4.2
4	High school bus fare	3	4	3	4	4	3.6
5	No route offered	5	3	5	3	2	3.6
6	Student's unpunctuality	4	2	2	1	1	2.0
7	Student preference	1	1	1	2	3	1.6
8	Inconvenient schedule	0	0	0	0	0	0.0

Table 8. What schools should improve to increase school bus riders

Rank	Improvement to increase school bus riders	Score (4-Most important to 0- Least important)					Average score
		Prachaniwet	Tubtong	Yaemsaard	Chindanukul	Darathorn	
1	Cheaper school bus fare	3	3	4	4	4	3.6
2	Better vehicle condition	4	4	0	3	3	2.8
3	Safer driver	2	2	3	2	2	2.2
4	Stricter teacher control	1	1	2	1	0	1.0
5	Schedule adjustment	0	0	1	0	1	0.4

Table 8 illustrates that parents are most likely to choose school bus if school bus fare is cheaper and/or school bus condition is better. The exception is Yaemsaard School, which its vans are in very good condition. Safer driver is a bit less concerned. This reflects their school bus drivers are already well-trained and do not require close or strict control by teacher. Finally, schedule adjustment would be done at last to increase school bus ridership.

5. CHOICE MODEL ANALYSIS

To understand the effects of each factor quantitatively, a simple choice model of whether parents choose school bus service or not. The analysis was done through the assumption of standard two-choice logit model

and STATA software package with maximum likelihood algorithm was used. The independent variables include number of students parents have in the particular school (*STU*), one-way distance from student house to school (*DIS*), monthly household income (*INC*), and number of vehicles in the household (*VEH*). The analysis was separately done for each school since each school has varied quality of school bus services, distinct school location, as well as a unique mix of parents' profiles. These different features for each school are captured by the constant in the model. The logit choice model equation for each school *i* is shown in Eq.1:

$$V_i = \beta_{0i} + \beta_{1i} \times STU + \beta_{2i} \times DIS + \beta_{3i} \times INC + \beta_{4i} \times VEH \quad (\text{Eq. 1})$$

where,

- V_i = mean utility function of parents' school bus decision from school *i*
- β_{0i} = model constant for school *i*
- STU = number of students in the school from the same family
- DIS = one-way school trip distance (km)
- INC = monthly household income (in 10,000 Baht)
- VEH = number of vehicles in the household

Table 9 shows the coefficients of independent variables in the model. The model was created such that a positive utility value ($U_i = V_i + \varepsilon_i$) represents a choice of using school bus service;

therefore, positive coefficients for independent variables mean that variables have positive effect on choosing school bus. The descriptions of coefficient analysis are described next.

Table 9. Coefficients in school bus mode choice model for each school

Factor	Coefficient	Prachaniwet	Tubtong	Yaemsaard	Chindanukul	Darathorn
Constant	β_0 p-value	-0.621 (0.657)	-2.805 (0.079)	4.436 (0.036)	-7.657 (0.000)	-2.918 (0.210)
No. of students from the same household	β_1 p-value	-2.005 (0.059)	-1.667 (0.075)	-3.140 (0.001)	-2.521 (0.002)	-1.727 (0.169)
One-way school trip distance (km)	β_2 p-value	0.008 (0.809)	0.033 (0.626)	-0.063 (0.397)	-0.010 (0.936)	0.041 (0.638)
Household monthly Income (in 10^4 bath)	β_3 p-value	0.325 (0.034)	0.762 (0.001)	1.093 (0.000)	0.749 (0.002)	0.800 (0.039)S
No. of vehicle in the household	β_4 p-value	Too few data set	Too few data set	-4.736 (0.007)	-2.09 (0.027)	Too few data set
Pseudo R^2		0.136	0.347	0.563	0.331	0.331

5.1 Constant

Constant values compare the likelihood of using school bus in each school if all independent variables are similar. However, a lower constant value does not mean poorer school bus service. A unique school location could also result in a lesser school bus usage. In addition, parents' profiles and their popularity towards school bus use for each school is different.

5.2 No. of students in school from the same household

From Table 9, all schools have negative β_1 -values. It means that if parents have more than one children studying in the same particular school, they are likely to pick-up/drop-off students by themselves. This is due to cost of using school bus for more than one child is linearly multiplied. In contrast, parents who pick-up/drop-off several children at the same school by their own cars generally costs the same as parents with only one child.

5.3 Distance of school trip

From table 9, all coefficient values are very minimal (not over 0.05 per km) with very high p-values. This concludes that school trip distance does not significantly affect choosing school bus service. This could be explained by too short distance might support parents to dropoff/ pick-up their child(s) themselves; while too long distance might mean inconvenient school bus schedule or drop-off/pick-up locations are too far from their homes.

5.4 Household Income

From Table 9, all schools have negative β_3 -values. It means that if parents have more household income, they are likely to use school bus services because they can afford such expensive school bus charges resulting from high legal standards of school bus vehicles. This corresponds to the elasticity theory of demand, which states that a positive income elasticity of demand is associated with normal goods. It also infers that children who use school bus in Bangkok are mostly come from a high-income family.

5.5 No. of vehicles in the household

From the analysis, effects of the number of vehicles in the household on school bus choice can not be concluded for Prachaniwet, Tubtong and Darathorn due to few available data, while Yaemsaard and Chindanukul have negative β_4 -values with near-zero p-values. It means that if parents have more vehicles in the household, they are likely to pick-up/drop-off students by themselves.

5.6 Pseudo R^2

Pseudo R^2 is often used as a goodness-of-fit measure that shows reliability of the model with higher values indicating better model fit. From Table 9, all schools except Prachaniwet have high (>0.3) pseudo R^2 values. It means that the model fits well with all four private schools, while Prachaniwet, the only public school in the list, might have external factors that are not captured by the model.

6. CONCLUDING REMARKS

Descriptive statistically analysis as well as a logit choice model analysis yield factors influencing parents' decision in using school bus service in Bangkok. The data show that parents who work as business owners or employees are more likely to use school bus than other occupations. This is similar to parents with Bachelor's degree or higher level of education. In addition, the main reasons of

why parents are not using the services are due to short school trip distance and Thai-cultural parental care. However, if schools would like to increase more school bus ridership, they could do that through offering lower school bus charges and/or improvement of school bus condition. Furthermore, the analysis shows that the number of students that parents have in the same school and parents' household income are correlated with parents' decision. From a logit choice model analysis, it concludes that parents who have more than one child in the same school, have less household incomes, and own more cars are likely to pick-up/drop-off students by themselves. However, the effects of each factor could be different in degrees depending on school type, and school bus characteristics.

This research is a starting point to explore parents' decisions in choosing school bus service for their child. Future research is needed by collecting data from more schools in other Bangkok areas, such as Central Business District (CBD), suburb Bangkok, etc. Moreover, this research is done through G-4 students' parents only. Parents with children at different ages could possibly yield different decision criteria. Lastly, school bus regulations and management at each school should thoroughly be studied to determine school bus improvement alternatives as well as their benefits and costs to both providers and users.

ACKNOWLEDGEMENTS

The authors would like to thank Prachaniwet School, Tubtong School, Yaemsaard School(Ladprao), Chindanukul School and Darathorn School that provided relevant information and allowed questionnaire distribution to their students' parents. In addition, the authors would like to thank Associate Professor Dr. Sorawit Narupiti and Dr. Chatchawal Simaskul who gave some valuable suggestions for this article.

This work was generously funded by the Research Assistance Scholarship from the Faculty of Engineering, Chulalongkorn University, and the Young Teacher Research Development Scholarship from the Thailand Research Fund (TRF).

REFERENCES

- Chintapitak, N. (2009) Behaviors of school trips in Chiang Mai municipality zone, **Proceedings of the Sixth National Transport Conference**, Phitsanulok, Thailand, 36-41.
- Department of Land Transport (Not Specified Year) **Security of school bus: start at yourself, the transportation safety**. Engineering and Safety Bureau, Department of Land Transport, Ministry of Transport, Thailand.
- Kanitpong, K. (2007) **Project to study the academic performance reasons and accident prevention guidelines for shuttle students**, Bureau of Health Promotion Fund. National Health Foundation, Thailand.
- Karuhadech, P., *et al.* (2004) **Security program go back to school with shuttle students in Bangkok**. Health Research Network, National Health Foundation, the Thailand Research Fund.
- Jansen, S.U. (2008) How to obtain a healthy journey to school. **Transportation Research Part A, No. 42**, 475-486.
- Manomaipibul, A. (2003) Securing program go to school with shuttle students in Bangkok: How student go to school. **Vajira Medical journal 51**, March-August 2007, 121-128.
- McMillan, T. E. (2007) The relative influence of urban form on a child's travel mode to school. **Transportation Research Part A, No. 41**, 69-79.
- Road Safety Center (2008) **22 Years of School Bus Efforts have failed**. [Online] <http://www.roadsafetythai.org>, Access on September 23, 2009.
- STN Media (2009) **School Transportation News**. [Online] <http://www.stnonline.com>, Access on September 20, 2009.
- Yeung, J., *et al.* (2008) Child transport practices and perceived barriers in active commuting to school. **Transportation Research Part A, No. 42**, 895-900.

BEHAVIORAL RESPONSES TO METRO ACCESSIBILITY: A GAP BETWEEN PHYSICAL AND NON-PHYSICAL APPROACH

Duangporn PRASERTSUBPAKIJ
Urban Environmental Management
School of Environment, Resources and
Development, Asian Institute of Technology,
P.O.Box4, Klong Luang, Pathumthani, 12120,
Thailand
Tel: +66 (0) 2524 7353
E-mail: Duangporn.Prasertsubpakij@ait.ac.th

Vilas NITIVATTANANON
Assistant Professor
Urban Environmental Management
School of Environment, Resources and
Development, Asian Institute of Technology,
P.O.Box4, Klong Luang, Pathumthani, 12120,
Thailand
Tel: +66 (0) 2524 5601
E-mail: vilasn@ait.ac.th

Pawinee IAMTRAKUL
Assistant Professor
Urban Environmental Planning and Development,
Faculty of Architecture and Planning
Thammasat University
Klongluaung, Pathumtani 12121
Fax: ++662-986-9605-6
Email: apawinee@hotmail.com

Abstract: Innovative accessibility policy should encapsulate the combination of versatile aspects of metro access regarding physical and non-physical approach. Access strategies should be focused on behavior responses of different user groups and the appearance of intent-oriented action related accessibility that was explored from user's satisfactions and attitudes related quality of services. The study area of this research is the Bangkok Metropolitan Region (BMR), Thailand, where two types of metro systems including Mass Rapid Transit (MRT) and Bangkok Transit System (BTS) are operated. Data collection of this study was based on participatory approach and questionnaire survey. The findings showed the gap between physical and non-physical accessibility performance that need to concern for planner in providing sustainable transportation policy.

Key Words: Behavioral responses, Accessibility, Non-physical approach

1. INTRODUCTION

1.1 Physical and non-physical approach of metro accessibility

Metro systems or rail-based transit systems have a crucial role in urban transportation infrastructure and services to support the

passengers and freight mobility requirements of large urban agglomerations and demonstrate the concept of Environmentally Sustainable Transport (EST). Bangkok has two major metro systems including BTS skytrain and MRT subway. However, the modal share of metro commuting still has a small proportion in many developing countries compared with other

motorized modes, especially cars (World Conference on Transport Research Society and Institute for Transport Policy Studies, 2004). To promote metro travelling, improving accessibility is a vital. However, based on previous researches related to metro accessibility approach, the term “access” has been interpreted too narrowly in limited dimension by transport-based theory, especially physical accessibility approach. However, there is a multiplicity of ways in which to extensively enrich the theoretical understanding of accessibility by taking more social, economic, and behavioral components into account (Cheng *et al.*, 2007). It is a concept of *true access* (Becker, 2004) that integrates various aspects of access theory with a focus on both physical and non-physical access perspectives. Regarding physical accessibility point of views, three indices of distances, times and costs were examined by taken a minority of the behavior’s influences among variety of user groups. Some previous studies Vandenbulcke *et al.* (2008) and Zhu and Liu (2004) examined the impact of metro access based on accessibility indicators regarding spatial-based theory, but give a low priority on individual access. Chalermpong (2007), Bae *et al.*, (2003), Du and Mulley (2007), and Hess and Almeida (2007) tried to investigate the link between location-based accessibility and economic value, but may not underlie decisions the influence of behavioral factors. This traditional approach may be failure to provide the effective strategies in developing sustainable accessibility policies that lead to undesirable consequences. Commuting with good mobility but poor travel satisfaction i.e., under situation of unsafe and uncomfortable illustrate unsustainable access.

1.2 Behavior responses to accessibility

In the absence of prior researches, context of behavior responses on access can be viewed from individual actions and intentions in response to accessibility. For example, the explanation of how people choose transport modes to reach the station or the user’s feelings related access facilities. The policy innovation from this study can be addressed from how we improve access for all by concerning public response to access. Non-physical accessibility approach also relates commuter’s satisfactions and attitudes in level of quality of service. Level of service factors consists of directness of route, continuity of route, information availability and comfort. Such factors effect how people with different abilities, ages, genders, and socioeconomic status access metro services. Attitudes play often a key role in providing all people equal opportunities to access transport services, mainly disadvantage groups i.e., low-income, elderly and disabilities.

Therefore, innovative approach presents a way of integrating the transport behavior and equity issue that provides a framework for understanding variation of mobility practices among different user groups. This paper investigates both physical accessibility performance (i.e., geographical aspect and transport aspect) and non-physical accessibility performance (i.e., access behavior and intent among different groups) and examines the divergence between them. This investigation can contribute to the design of sustainability transportation policies related accessibility and long-term urban metro-transit intervention.

1.3 Aims and Objectives of the research

The objectives of the research reported are threefold; first, to identify the existing situation of metro accessibility belonging to physical access and non-physical access, mainly in behavior responses of different user groups; second, to measure the appearance of intent-oriented action related accessibility that was explored from user's satisfactions and attitudes related quality of services so as to discuss the divergence between the prevalence of physical and non-physical approach; and third, to provide effective strategies and policies that aim to enhance accessibility of metro systems. This study gives particular attention to the investigation of user's behavior and attitudes on metro accessibility and the comparative between the prevalence of physical accessibility and what people feel to the access systems of this transport mode.

For this exploration, both qualitative and quantitative data from primary and secondary sources have been gathered to elicit the accessibility performance measurement. The

pilot study was conducted to study user's behavior on metro access and egress and the contribution from pilot results built knowledge of survey. The performance results described in this paper provide innovative policy to improve metro accessibility for all in BMR and other urban areas.

2. METHODOLOGY

2.1 Approach

Multifaceted concept in measuring metro accessibility performance regarding physical and non-physical approach should be aggregated and examined true accessibility in order to provide effective policies and strategies to accomplish such paradigm. It is important that the knowledge of behavior responses can be included in accessibility-based theory to fulfill the gap of metro accessibility studies in order to improve access for all.

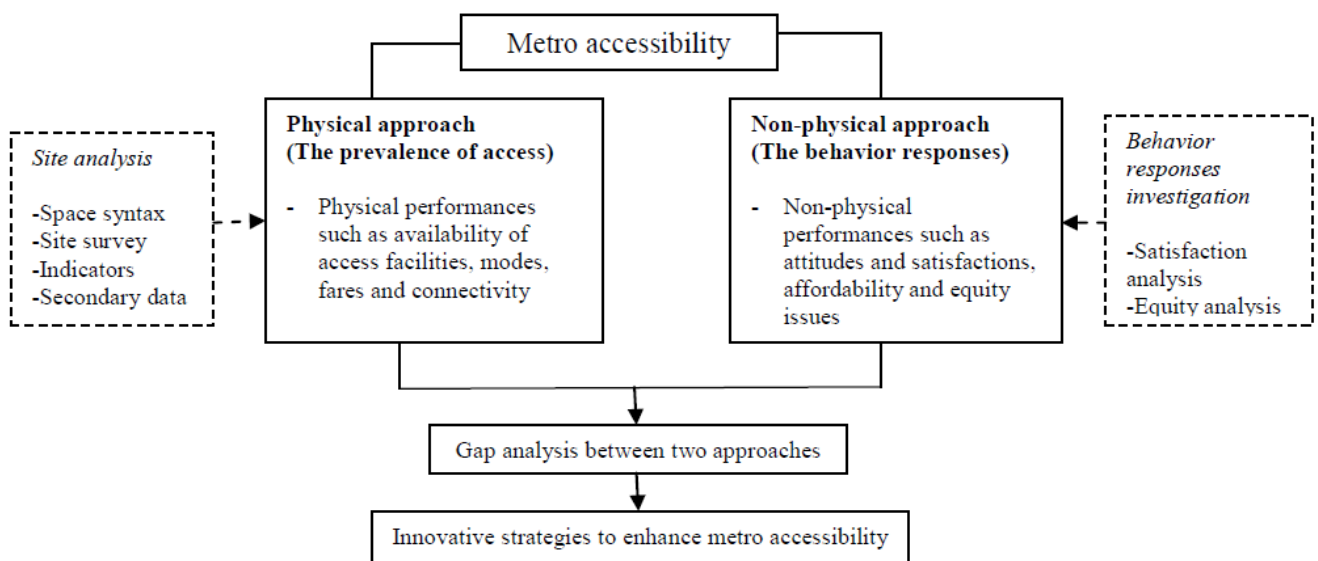


Figure 1. Research approach

2.2 Tools of investigation

2.2.1 In-depth interview

Extensive stakeholder consultation is undergone by semi-structured interview concerning disaggregation of stakeholder involvement regarding participatory approaches. There are 23 representatives of various groups of stakeholders related to this study including commuters disaggregated by age, gender and disabled people, Bangkok Metropolitan Administration (BMA), metro company, transport administration, academic experts that take different roles and responsibilities, and associate with how metro accessibility in BMR were taken into account.

2.2.2 Questionnaire survey

Findings based on in-depth interview of questionnaire survey that consists of opened-end and closed-end questions. The respondents on site stations were asked their e-mail address in case the researcher needs more information on re-testing and checking validity. The questionnaire structure consists of 3 parts. The first part has questions related to socio-economic characteristics and individual travel information of the respondent namely, sex, age, income, education, car-ownership, occupation, mode used to stations, etc. The second part aims to examine the aspect of land use. The third part of questionnaire is an essential part on a basis of attitude or level of satisfaction test. Each question on this part is formed by sentence related to level of satisfaction based on 5-point Likert scale from „Strongly dissatisfaction to „Strongly satisfaction. The questions included statements about attitudes to access facilities related availability and quality,

satisfaction of information availability, continuity of route, directness of route and comfort. Data is collected via face-to-face interviews. In the case of respondents are highly educated, they will be asked to self-administer the questionnaire; otherwise the interviewer filled the question based on respondent's verbal response.

2.2.3 Sampling

Based on questionnaire survey, sampling design needs to be considered. The metro users comprise of BTS sky-train users and MRT users in Bangkok Metropolitan Region (BMR). The appropriate sample size for a population-based survey is determined largely by three factors: (i) the estimated prevalence of the variable of interest (ii) the desired level of confidence and (iii) the acceptable margin of error. For a survey design based on a simple random sample, the sample size required can be calculated according to the following formula:

$$n = \frac{Z^2 \times (p) \times (1-P)}{c^2} \quad (\text{Eq. 1})$$

Where; n = sample size

Z = confidence level at 95% (standard value of 1.96)

p = percentage of picking a choice expressed as decimal e.g. 0.5

c = confidence interval, expressed as decimal e.g. 0.1 for 10 percent

In an effort of conducting survey, 600 questionnaires will be distributed to metro's commuters at 6 metro stations by using purposive sampling based on data sharing of variety group of users disaggregated by gender, age, disabilities, income and location.

2.2.4 Site selection

The approach was to create passenger surveys at metro stations within BMR study area. Most of metro stations were located in business or commercial areas or high potential development area. The study selected 6 site stations of metro systems that consists of 3 stations of BTS skytrain (Mo Chit, Saphan Taksin, and Chong Nonsri) and 3 stations of MRT subway (Chatuchak Park, Hua Lumphong, and Petchaburi) to assess the metro accessibility in BMR. The key criteria used for selecting site stations belonging to ability to be visibly monitored and examined metro accessibility characteristics, factors and impacts based on adequate data supporting research process. Metro stations in BMR present different characteristics in terms of functions of stations including terminal, interchange and normal stations which should be considered simultaneously with the site selection criteria based on Rubin (2007). The generation of criteria and functions of stations bear configuration of cross-check test structure and score indicating.

2.2.5 Site analysis

Site analysis was conducted within study area in order to investigate physical metro accessibility performances based on some methods including space syntax techniques, site survey, indicators selection and secondary research.

- Overview of site stations

BTS and MRT site stations were established in high development areas in BMR with business and commercial reasons. Diversity of uses

nearby station areas is a major driver of intense activity centers that can enhance accessibility. It is not surprising that the population, housing and physical surroundings density at site stations are very high. Based on observation, site stations present a variety of feeder modes including bus, passenger van, taxi, hired motorcycles, boat and other para-transit modes. People always choice access and egress modes relying on price and time use. Another issue is related to facilities design. Some stations have a good quality of access facilities i.e., a smooth pavement surface and the available of elevators, staircases and escalators that can reduce travel time with a higher walk speed or making the walk seem less unpleasant. BTS stations provide staircases and escalators (about two meters wide) accommodated within a two to three meter wide sidewalk. For MRT stations, it offers elevators and escalators. However, not all stations present the good availability and quality of facilities. This situation affects uneasy access to the disadvantaged groups such as elderly, pregnant women and disabled people. Furthermore, the stations do not provide special facilities for such identifiable groups.

- Space syntax analysis

This study applied space syntax method to assess the connectivity of site stations. The illustration of connectivity performance was done based on ArcView 3.2 and Photo shop softwares (Figure 2). The findings demonstrated *the index (line)* that includes number of connected transportation routes, *average connectivity* and *average integration* in each site station. Regarding the results, MRT-Hua Lumpong presents highest potential connectivity (average connectivity = 2.85). The

station presents a high linkage with transportation networks. In opposite, BTS-Saphan Taksin illustrated the lowest average connectivity with 40 index (line) because route networks are obstructed by the Chao Phraya River.

- Physical accessibility indicators and performances

Physical accessibility performances were indicated by 4 aspects of mixed use, connectivity, access facility prevalence, and the availability of facilities for disadvantages groups i.e., disabled people. The study applied 40 indicators (Rubin, 2007) that compatible

with accessibility conditions to exemplify existing access situations at site stations. According to this investigation, criteria was established in three level of high (score=1.00), medium (score=0.50) and low (score=0.00). The study assessed the performance belonging to physical access indicators and calculated the score average. The findings demonstrated that BTS Mochit and MRT Chatuchak park present high physical accessibility because of high mixed use, mode connectivity, the availability of access facilities for disadvantaged group.

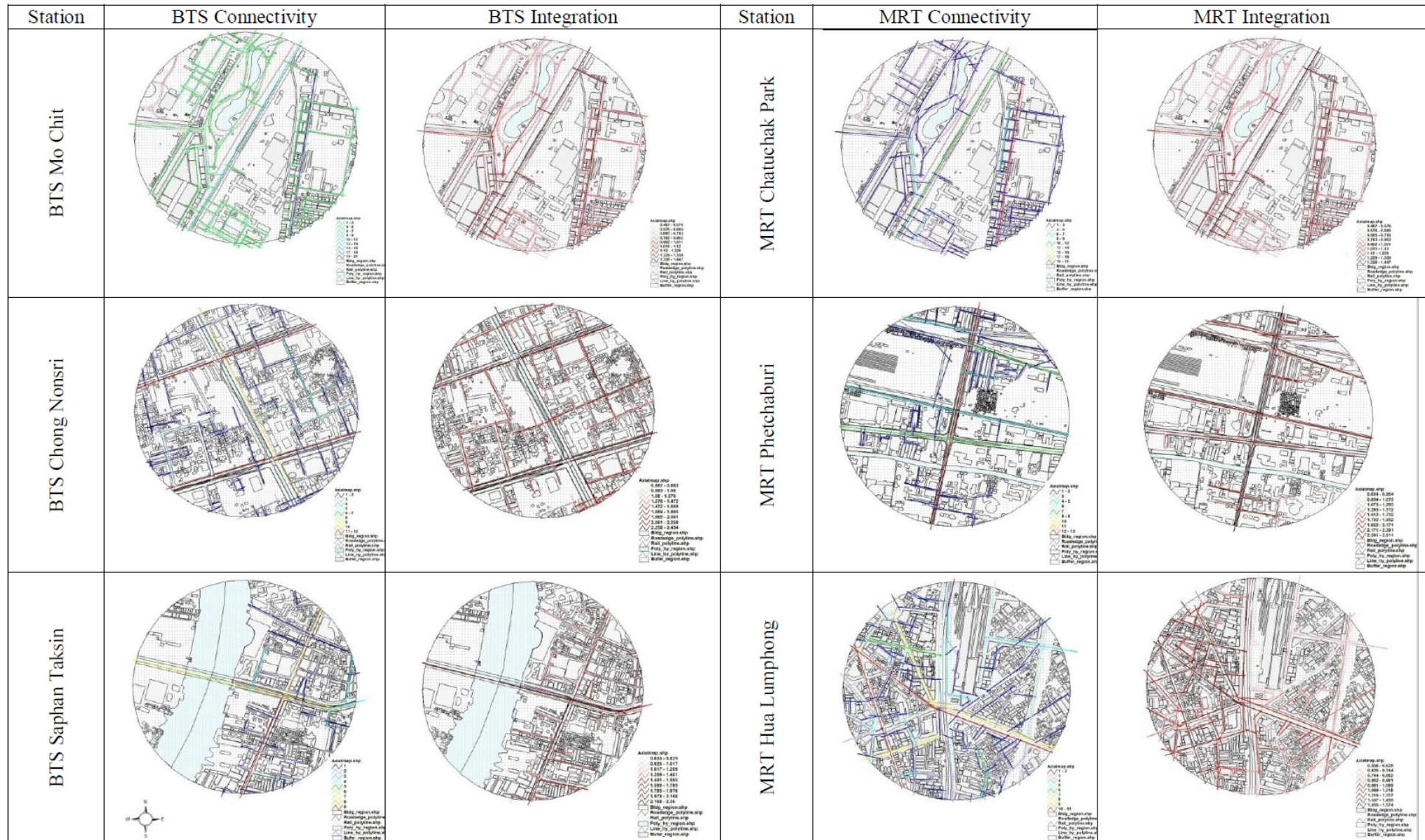


Figure 2. Site analysis by space syntax method

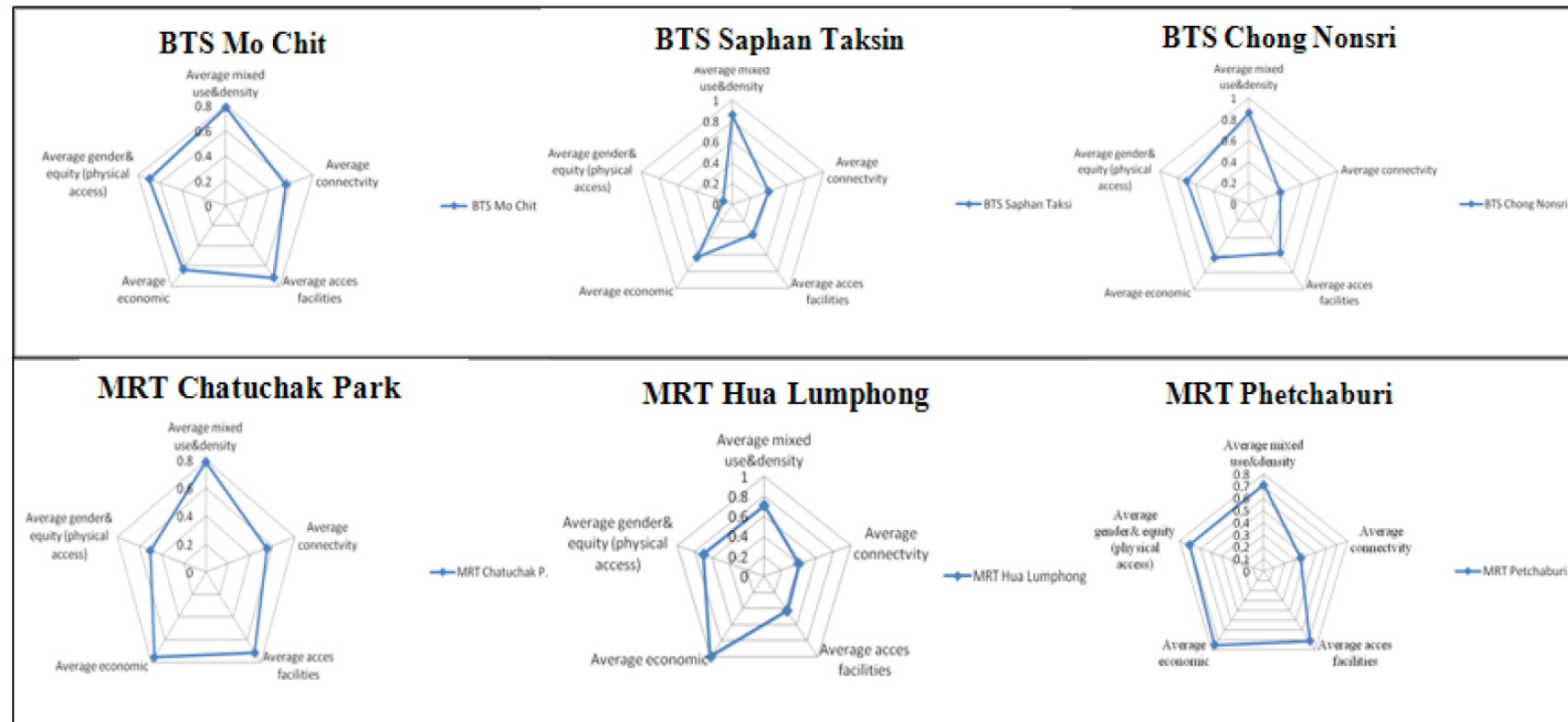


Figure 3. Physical access performance illustrated by stations

3. BEHAVIOR RESPONSES

3.1 Existing access behavior

Researcher traced 25 passengers each station in order to investigate their access and egress behavior by focusing on equity aspects. The tracing process started from defining and selecting interested groups regarding gender, elderly and disabilities. Access and egress to station created problems to both men and women in waiting and catching feeder modes. At night, women are vulnerable in park and ride that were located to walkable distance from station. Women also have to cope with overcrowded and irregular public transport that used for access to and egress from station. Disabilities continue to face problems related to access mode opportunities, negative attitudes and environmental barriers. Women with disabilities faced certain unique disadvantages compared with disabled men in many cases, i.e., feeder mode availability, special facilities for disabled people, universal signaling, elevators and sidewalk. Certain groups of elderly are obviously disadvantaged at present as to their personal accessibility. These groups need special attention when access-enhancing policies are designed. Women and disabilities in old edge suffer economic disadvantages due to gender biases in labour markets, person coverage and income generation opportunities. Despite, they got incentive from metro service but they have to spend more to catch taxis because of lack of convenience in catching bus or other modes.

3.2 The access's feelings and determinants affecting attitudes

Based on results from questionnaire survey, a total of 49% were male and 51% were female. 7% of them were elderly (age > 60 years old) and 2.7% of them were disabled people. For the results, Majority (about 70%) gave opinion that they faced difficult access to metro services. *More than half of people who live nearby station and in the condition of high connectivity (High physical access) also feel in the same direction.* Furthermore, psychosocial determinants affecting attitudes towards access's feelings have been investigated. Satisfaction and sense of belonging factors were shown to have strong correlation. The results also present the variety of opinion among user groups according to various conditions of such factors as shown in Figure 4. In addition, *affordability, occupation, and education also elicit high influence to the access's feelings.*

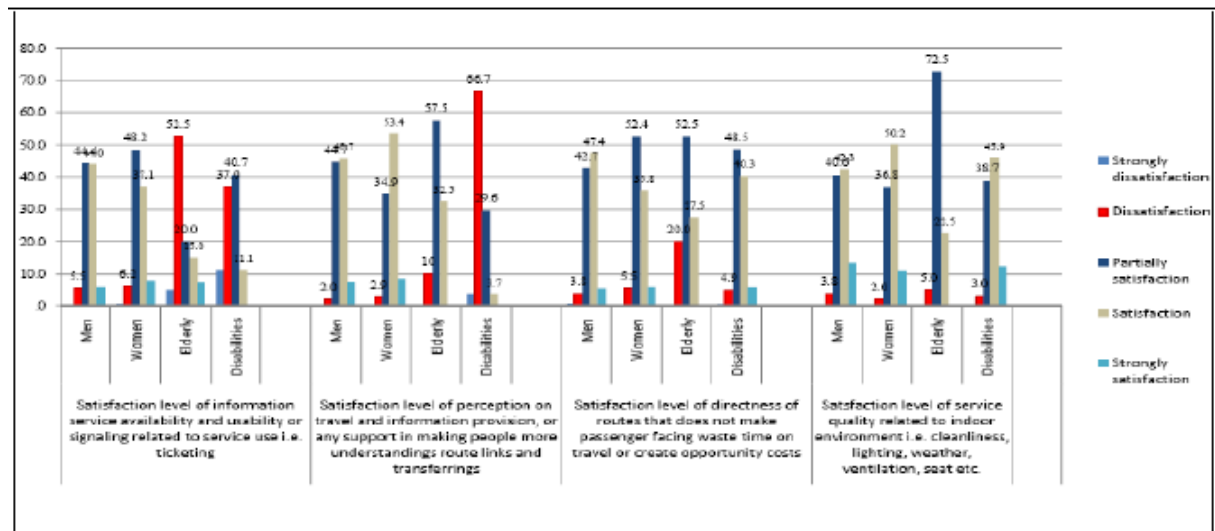


Figure 4. Satisfaction on level of service disaggregated by various user groups

3.3 Perception on access facilities

Facility environment such as access facilities (i.e., sidewalk, staircases, escalators, elevators, skywalk way) or park and ride facilities is high influence on metro access. The data from opinion survey results was disaggregated by interested groups of men, women, elderly and disabilities. Most of users satisfied on the

availability of access facilities, however, the majority of respondents has partially satisfied on the convenience and the quality of access facilities. For the design arrangements related connectivity, it showed significantly different among user groups. Elderly and disabilities feel inconvenience in access facilities due to poorly universal design (Figure 5).

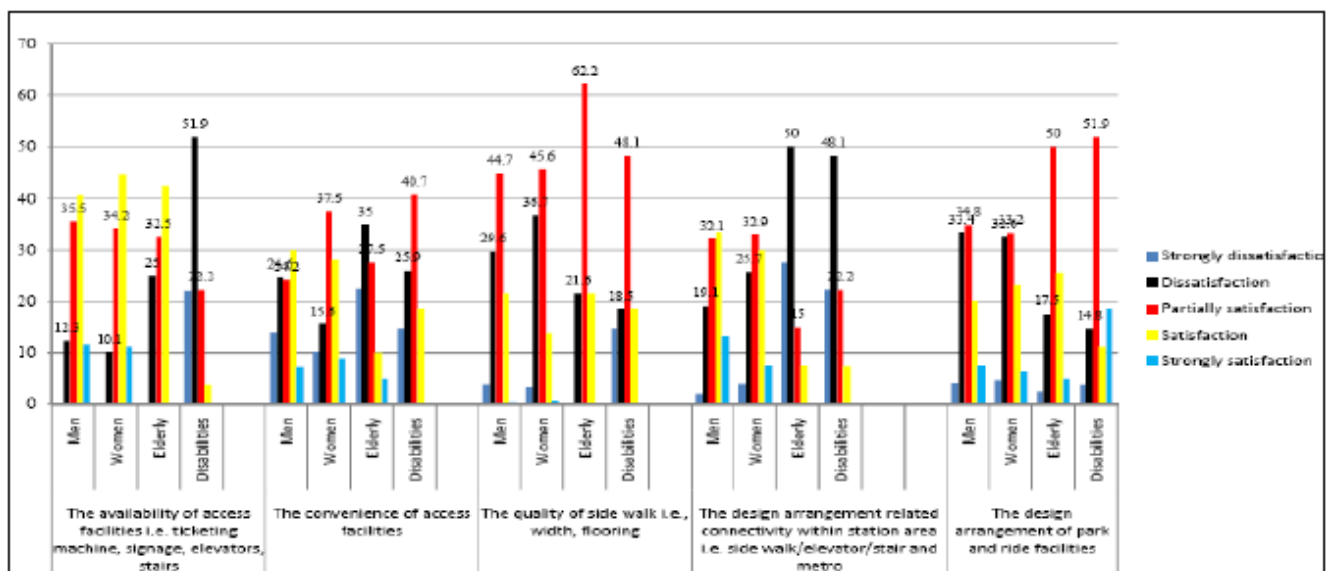


Figure 5. Perception on access facilities disaggregated by various user groups

3.4 Socio-economic and equity: comparison of access performance among use groups

In survey, respondents were asked the origin and destination location, access/egress time and costs. Researcher used available information to calculate the total, access and egress distances (km), costs (baht/trip) and times (minutes), and then the data was disaggregated by gender, age and disabilities so as to investigate the access and egress performance among interested groups. The estimation data indicated that the average total travel times from origin to destination is about 40-60 minutes. Users lost times in waiting and catching modes, and walking to station. For the costs of travelling, researcher calculated in the basis of feeder costs and metro fare rates depending on distances (varying flat fares). Average total

expenditures per trip in each individual is about 60-80 Baht, in case of daily-use, people have to spend for travelling 2,400-4,000 Baht/month. People who earn less than 10,000 Baht faced limited access to services.

Elderly and disabled passengers were suffered from access rather than nonelderly and nondisabled travellers. They spent more time in walking access to station and faced limited transportation. The findings also illustrated that such groups who engage a long trip with about 40-60 minutes, they have to spend around more than 80 Baht for one way trip. From data collection at site station, most of them got incentive from services or were considered to be free. However, the greater costs were derived from feeder costs.

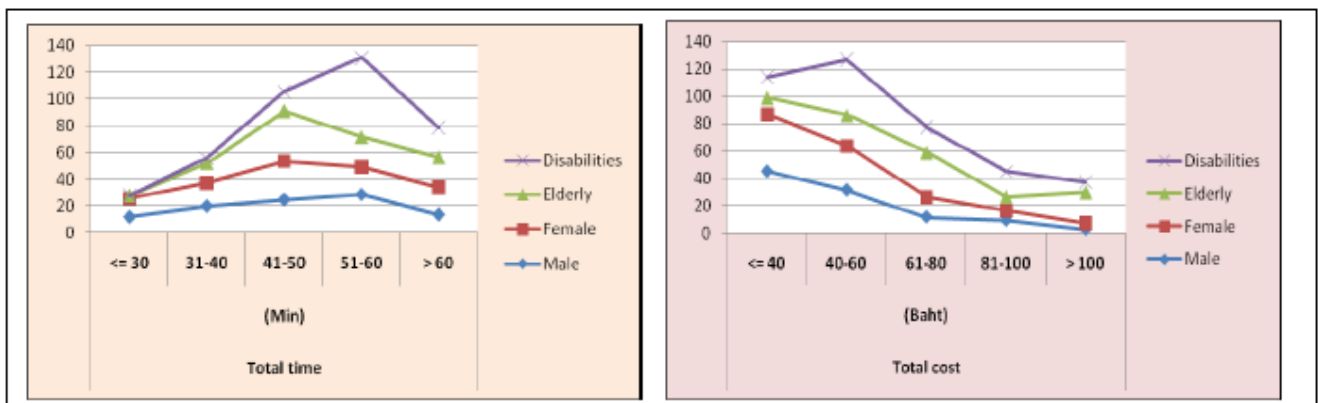


Figure 6. Total times and costs disaggregated by various user groups

4. DISCUSSION

4.1 Gap Analysis: Physical and Non-physical approach

The highlight of this paper is to illustrate the divergence between the accessibility performance between physical and non-physical accessibility approach. Physical

accessibility can be seen from mixed use, connectivity, the prevalence of access facilities and fare rates. The physical performances demonstrate high accessibility at BTS-Mo Chit and MRT-Chatuchak Park because of good connectivity and high density and mixed use. Other stations such as MRT Hua Lumphong and BTS Chong Nonsri also represent the high accessibility regarding mixed-use, density of

employment and the availability of access facilities for disadvantaged groups, especially disabled people. However, the results based on behavior responses show that the attitudes of users who live nearby site stations that have high physical accessibility and commuters who live in the area of the availability of mode connectivity still faced difficulty on access to metros. It means that physical access theory may be not enough to investigate the true accessibility performance. The research tested the relationship of some psychosocial determinants and the access s feeling that the findings validate the influences of satisfaction and sense of belonging factors according Chi-square test. Furthermore, different user groups have different feeling on access and performance that make equity issue become interesting. The behavior action related accessibility from various groups reports the important of non-physical approach. Disadvantaged groups, especially elderly and disabled people always faced problems on access though they live in the location with good connectivity and get incentive from metro services. They have to spend more times on access and pay higher costs than the other groups. The reasons of this situation can be drawn from the behavior intention among different groups that is motivated by various individual factors (e.g., income, education, occupation and perception on access). Although the research did not specifically compare alternative theoretical model of behavior, the findings present broadly support the essential of the combination between physical and non-physical accessibility approach.

4.2 Innovative Policies and Strategies

Policy intervention can be concerned on the motivation public accessibility to metro services by focusing on the equity access of various commuter groups and the integration of knowledge of physical and non-physical accessibility based approach. The first consideration related enhancing physical accessibility should be in place, especially metro facility design that clearly benefit to various users regarding behavioral responses. To improve connectivity at station, sidewalks and other support facilities such as staircases, escalators and elevators should be provided with appropriate and sufficient in size and quality to accommodate the demand of all users, mainly disadvantaged groups. Moreover, improving mode connectivity for access to and egress from stations is essential. It is the fact that there is different in the ability of access among various users that need different practices. Programs should be concerned on providing variety of public transportation modes serving disadvantaged users, mainly disabilities and elderly group with a consideration of resonable fare rates and equity in mobility needs. Second, the availability and the quality of level of services such as the information of route travel, mode transferring, quality of indoor environment that fit for all user groups need to incorporate in to plans. Third, politcal intervention should encourage the role of formal and informal education for various user groups to foster the sense of belonging to metro services and to promote the equality benefits for disadvantaged groups. And Finally, incentive-based should be provided to commuters regarding equity concern and behavior responses. In this case, we need to combine the physical access policy with non-

physical access concern i.e., highlighting on the environment attractiveness of access condition that make people feel comfortable and convenient on travel.

5. CONCLUSIONS AND RECOMMENDATIONS

This research has illustrated that the gap of behavior responses in the investigation of metro accessibility performance in terms of affordability, psychosocial and equity aspects. Our findings in respect of socio-economic aspect discussed disadvantaged groups i.e., urban poor, elderly and disabled people faced access problems to metro services, although they live in the location with good physical accessibility. Furthermore, behavior intention among different groups influences to metro accessibility induced by a variety of individual factors including income, education,

occupation and perception on access. Psychosocial factors, mainly satisfaction and sense of belonging affect attitudes towards access's feelings. Majority satisfied on the availability of access facilities; however, with a concern of equity access among user groups, elderly and disabilities feel inconvenience in such access due to the quality and the availability of universal design and facility support. Our investigations present broadly support the essential of the combination between physical and non-physical accessibility approach that should be considered on policy formation. For further studies, the model development for metro accessibility measurement based on integration approach and its application for related transport modes would be challenged that can provide strategies for making a sustainable urban transportation plan and policy.

ACKNOWLEDGEMENTS

The authors would like to thank all key informants from the Office of Transport Policy and Planning (OTP), Ministry of Transport, Thailand, Bangkok Metropolitan Administration (BMA), Mass Rapid Transit Authority (MRTA), Bangkok Mass Transit System Public Company Limited (BTSC), and Bangkok Metro Public Company Limited (BMCL) and metro users for providing the valuable information.

REFERENCES

- Bae, C. H. C., Jan, M. J. and Park, H. (2003) The impact of Seoul's subway line5 on residential property values, **Transport Policy**, Vol. 10, Issue 2, 85-94.
- Becker, U. (2004) Access and accessibility, sustainable development, and transportation: How to measure efficiency in transport?. In access to destinations - rethinking the transportation future of our region, Presented at President's 21st Century Interdisciplinary Conferences, University of Minnesota, USA, November, 2004.

- Chalermpong, S. (2007) Rail transit and residential land use in developing countries: Hedonic study of residential property prices in Bangkok, Thailand, In Transportation Research Record: **Journal of the Transportation Research Board, No. 2038**, TRB, National Research Council, Washington, D.C., 111-119.
- Cheng, J., Bertolini, L. and le Clercq, F. (2007) Measuring sustainable accessibility, In Transportation Research Record: **Journal of the Transportation Research Board, No. 2017**, TRB, National Research Council, Washington, D.C., 16-25.
- Du, H. and Mulley, C. (2007) The short-term land value impacts of urban rail transit: quantitative evidence from Sunderland, UK, **Land Use Policy, Vol.24, Issue 1**, 223-233.
- Hess, D. B. and Almeida, T. M. (2007) Impact of proximity to light rail rapid transit on station-area property values in Buffalo, New York, **Urban Studies, Vol. 44, No. 5-6**, 1041-1068.
- Likert, R. A. (1932) Techniques for the measurement of attributes, **Archives of Psychology, Vol. 140**, 1-55.
- Lucas, K., Marsden, G., Brooks, M. and Kimble, M. (2007) Assessment of capabilities for examining long-term social sustainability of transport and land use strategies, In Transportation Research Record: **Journal of the Transportation Research Board, No. 2013**, TRB, National Research Council, Washington, D.C., 30-37.
- Lundberg, J. and Kristenson, M. (2008) Is subjective status influenced by psychosocial factors?, **Social Indicators Research, Vol. 89, No. 3**, 375-390.
- Prasertsapakij D., Nitivattananon, V. and Iamtrakul, P. (2009) Sustainable metro accessibility performance indicators: An integrated approach to multi-dimensional assessment. Proceedings of the Eastern Asia Society for Transportation Studies, Vol.7, Surabaya, Indonesia, 16-19 November, 2009.
- Rubin, J. (2007) **Transit-Oriented Development: Conclusions from the UCTC TOD Benchmark Study**, University of California Transportation Center, Berkeley, California.
- Vandenbulcke, G., Steenberghen, T. and Thomas, T. (2008) Mapping Accessibility in Belgium: A Tool for Land-Use and Transport Planning?. **Journal of Transport Geography, Vol. 17, Issue 1**, 39-53.
- World Conference on Transport Research Society and Institute for Transport Policy Studies (2004) **Urban Transport and the Environment: An International Perspective**, Oxford: Elsevier.
- Zhu, X. and Liu, S. (2004) Analysis of the impact of the MRT system on accessibility in Singapore using an integrated GIS tool, **Journal of Transport Geography, Vol. 12, No. 2**, 89-101.

ALTERNATIVE APPROACH FOR GIS BASED EVALUATION OF TRANSIT-ORIENTED DEVELOPMENT: A CASE STUDY OF SAGA CITY, JAPAN

Sunisa MENARIN
Undergraduate Student
Faculty of Architecture and Planning
Thammasat University
Klongluaung, Pathumtani 12121
Fax: ++662-986-9605-6
Email: sunisa_spm@hotmail.com

Pawinee IAMTRAKUL (Ph.D.)
Assistant Professor
Faculty of Architecture and Planning
Thammasat University
Klongluaung, Pathumtani 12121
Fax: ++662-986-9605-6
Email: apawinee@hotmail.com

Warapan PHONPRO
Undergraduate Student
Faculty of Architecture and Planning
Thammasat University
Klongluaung, Pathumtani 12121
Fax: ++662-986-9605-6
Email: tuey_wara@hotmail.com

Manat SRIVANIT
Lecturer
Faculty of Architecture and Planning
Thammasat University
Klongluaung, Pathumtani 12121
Fax: ++662-986-9605-6
Email: s.manat@gmail.com

Abstract: Transit-Oriented Development has well known as an alternative approach in sustainable transportation planning and management. However, one of the key drive factors is the pedestrian-oriented for ultimately support transit ridership. Saga city as a representative of an emerging provincial city with declining in urbanizing was selected as a study area. This study attempts to integrate multi-factors for evaluation process, e.g. physical conditions, population and socio-economic to perform land suitability analysis for station area planning and development. The analysis also derived a weight-score of influencing variables base on an Analytic Hierarchy Process (AHP) and display by GIS based. Then, the conceptual plan to overcome weakness of existing station was recommended and could bring about the suitability condition for sustaining station area development.

Key Words: Transit Oriented Development (TOD), Urban Planning, Land use, GIS

1. INTRODUCTION

A challenge facing several cities in urbanized region is required an allocation of planning and policy for maintaining high quality of life while remain economically viable. Transportation has become one of the key factor in the consideration for an approach to alleviate urban sprawl by improve mobility while encourage economic and social perspective (Chisholm, 2002). TOD has become an alternative approach to integrate transport and land use

into planning process for locating new construction and redevelopment in and around transit-station nodes. The best potential benefits of these are contributed on social, environmental, and fiscal. Focusing growth around transit stations capitalizes on expensive public investments in transit by producing local and regional benefit to improvements in all the areas mentioned above. More intensive mix-use development can allow an expansion in walking and bicycle within the neighborhood, and less automobile use means less

consumption of fossil fuels, less air and noise pollution, and decrease spending times on the transportation (Federal Transit Administration, 2004). As a consequence, TOD can be an effective tool in curbing sprawl, reducing traffic congestion, and expanding housing choices.

To understand the current situation of TOD, Saga city which has been also anticipating the declining of the station area utilization was selected as a case study to incorporate sustainable planning toward transit oriented development. Along with this development, the station area development can be consequently guided by the comprehensive plan which including identity, infrastructure, attractions, intensity/density, pedestrian connections, greenways, site layout, urban design, car parking/bicycle parking/motorcycle parking management, drop-off area and public space. An identity of station can be also designed to represent of place, which will enhance the recreation area and play an essential part as a gathering place. The development plan includes land uses design for different housing type, offices, retail, personal services, hotels, restaurant, coffee café and other services. Additionally, the station plan is also designed to create visual interesting for suitable allocation of both vehicular and pedestrian access as well as sufficient number of parking space. Therefore, the specific development requirements for the study care can be provided as guidance for officials, developers and community leaders seeking answers to the possible alternative for station area improvement for their communities within time constrain.

2. REVIEW LITERATURE

Transit-Oriented Development is the exciting new fast growing trend in creating vibrant, livable communities. It has been also known as Transit Oriented Design, or TOD that consistent with the idea of the creation of compact, walkable communities and intermodal public transportation. This makes it possible to develop a higher quality life without complete dependence on a car for mobility and survival. Base on this concept, to accommodate the distance of walkable area, the neighborhood can be redevelop or infill with a mix-use included residential, employment and shopping buildings and uses (Beimborn and Rabinowitz, 1991). To encourage walkability environment, the pedestrian-friendly connections should be allocated within the surrounding community by supporting pedestrian use and access (Wiley, 2006 and Cuningham , 2007). Therefore, TOD has been considered as one of the effective approaches that can be applied to promote high-density, mixed-use business/residential neighborhood centers for development around transit station and corridors. It is also contemplated as a smart growth strategy, due to it facilitates the process of direct the growth of a sustainability perspective and it coordinates land use and transportation plan efficiency in term of land and infrastructure utilization (Pace, 2007)

There are a number of factors that influence on the transit oriented development. It includes the rapid development while growing desire for quality of life (Roberts and Todd, 2006). This is due to the traditional development always relying on the constructing more highways that always have led to more sprawl and, eventually, more congestion. However, to deal with the

concept of TOD, there are several factors concern with the planning process both physical and nonphysical aspects. Several researchers attempted to apply analytical tool to assess multi factors. One of the powerful tools in planning is contemplation of the Analytic Hierarchy Process (AHP) which was also applied base on the concept of setting of the methodology to compare criteria with respect to factors influence on TOD. Base on this method, the well-defined mathematic structure of matrices and their associate right eigenvector's ability can be used to generate approximate weights (Saaty, 1994 and Forman and Gass, 2005). The AHP uses a fundamental scale of assessment for land-use, transportation and social perspective which can be employed to compare and rank criterion for land suitability. This analysis can be in term of both descriptive and prescriptive model of decision making.

Furthermore, to incorporate the multi-criteria analysis as afore mentioned, visualization is required for a communication process in planning. Due to the performance of

Geographic Information System (GIS), it can be also applied to build the geographic database for land suitability assessment for Saga-train station area using multifactor spatial analysis. As the weight of different variables were determined depending on the AHP evaluation. All scored variables, which restored in vector-based geo-databases, then were converted into the raster-based datasets overlay analysis which provide more advantage in the map algebra technique (NCDENR, 2005). The analyzed factors by using application of GIS based on the Potential Surface Analysis (PSA) technique has been used for analysis included with overlaying and Weighting-Rating Model for the suitable area (McHarg, 1971). There are certain types of design components that can effectively encourage the primer of smart growth. The following list of "Transit Friendly Design Guide; flows from the Calgary Transportation Plan in 1995" provides an overview of components for successful TOD. Figure 1 demonstrates the integration of transportation management and land-use planning as composed successful TOD design.

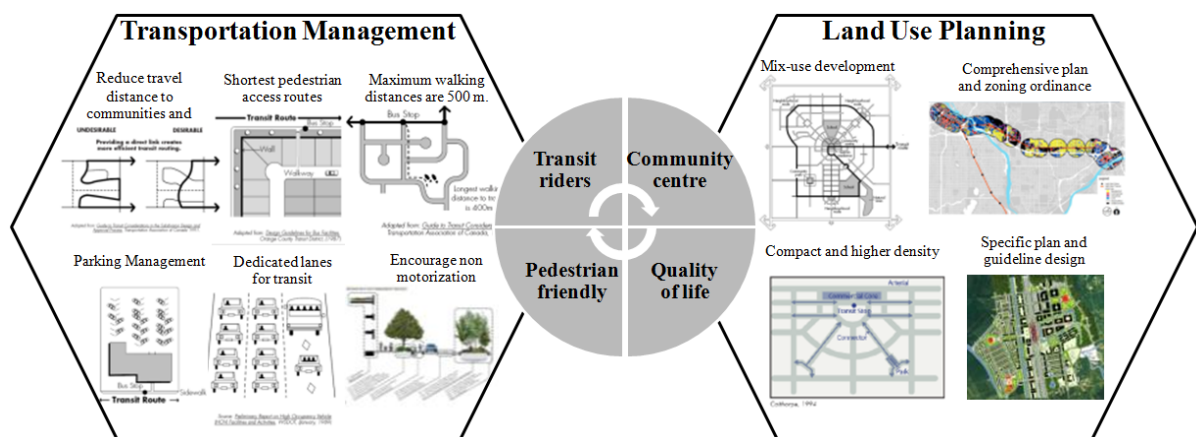


Figure 1. Principle components contribute to transit friendly development

Certain benefits of TOD make it provide useful aspects than from conventional development approaches. This benefit is abundant that consist of higher quality of life, overall better public health, economic development, community character, environment quality, transit use and other (Belzer and Autler, 2002). A key component for a successful Transit-Oriented Development is the mix of land uses, with higher densities and the continual expansion of transit with significant pedestrian improvements. To reach this ultimate aim of development, the proximity area to a transit stop will be designed for core commercial area within an average one-fourth mile walking distance of a transit stop. Secondary Area will be allocated of lower density housing, school, parks, and commercial and employment uses for up to one mile biking distance. Finally, in order to encourage and facilitate successful transit-oriented development, a full range of public facilities must be placed to accommodate the type of mixed-use neighborhood development that is desired (ULI, 1994). The mix use in a TOD provides an alternative development pattern to overcome constrain of traditional suburban development by emphasizing a pedestrian-oriented environment and reinforcing the use of public transportation. With the design of mix residential, retail, office, open space, public space utilization will be encourage within comfortable walking distance along with an options for residential densities and building intensities specified (Clancy and McKinney, 2002).

3. A METHODOLOGICAL ISSUE

Step 1: Existing Condition Analysis

The beginning step of this study is to perform the exploration of physical characteristic and gathering public opinion from questionnaire survey which is in a part of primary data. Follow by, the investigation information data from concern agencies and government officers about traffic data, geography information system, population and socio-economic trends, etc. Then, this study analyzed all existing data both qualitative and quantitative data such as environment, transportation, infrastructure, urban structure, and activities in station area.

Step 2: Suitability Analysis

After, gathering all necessary data, the land suitability analysis (LSA) which is a GIS-based process is performed for evaluating the suitability of land for transit-oriented development. It consists of two major outputs of an environmental composite map and a land suitability map. The environmental composite map represents the extent and overlap of natural features and environment conditions that indicate the capacity and limitations natural systems for urban development. The land suitability map demonstrates the relative suitability of land in a planning area for station area development. Finally, this step can provide result of land use, transportation, infrastructure, and social perspective which can be integrated by potential surface analysis (PSA) with the derived their weights base on an analytic hierarchy process (AHP).

Step 3: Site Analysis

The suitability location of site can be derived base on previous step. This step is aimed to provide in-depth understanding the characteristic of different suitability for each site. The site analysis is an inventory complete as a preparatory step to site planning or conceptual planning. A careful and complete analysis of a site and its surrounding context, can lead for the linkage between spatial analysis and TOD concept for sustainable land use planning.

Step 4: Conceptual Plan and Master Plan

The integration of suitability analysis and site analysis can be performed as a basis constructive conceptual plan of TOD at Saga Railway station. A conceptual plan with its

master plan was developed to provide a vision of the future land development around station area. It was designed to serve as a tool for decision marking on future development proposals. Master plan is the most importance tool for help planners and concerned authorities for implementation. Base on the result of suitability and site analysis, assessment of the scenario conceptual plan can be estimated.

Step 5: Planning and design guideline

The final step of this study is in order to guide station area development that is the primary mains of articulation and implementing. This transit-oriented development could be used as an effective tool to provide the policy and planning design framework for allow the implementation of a broad mix of transit supportive uses.

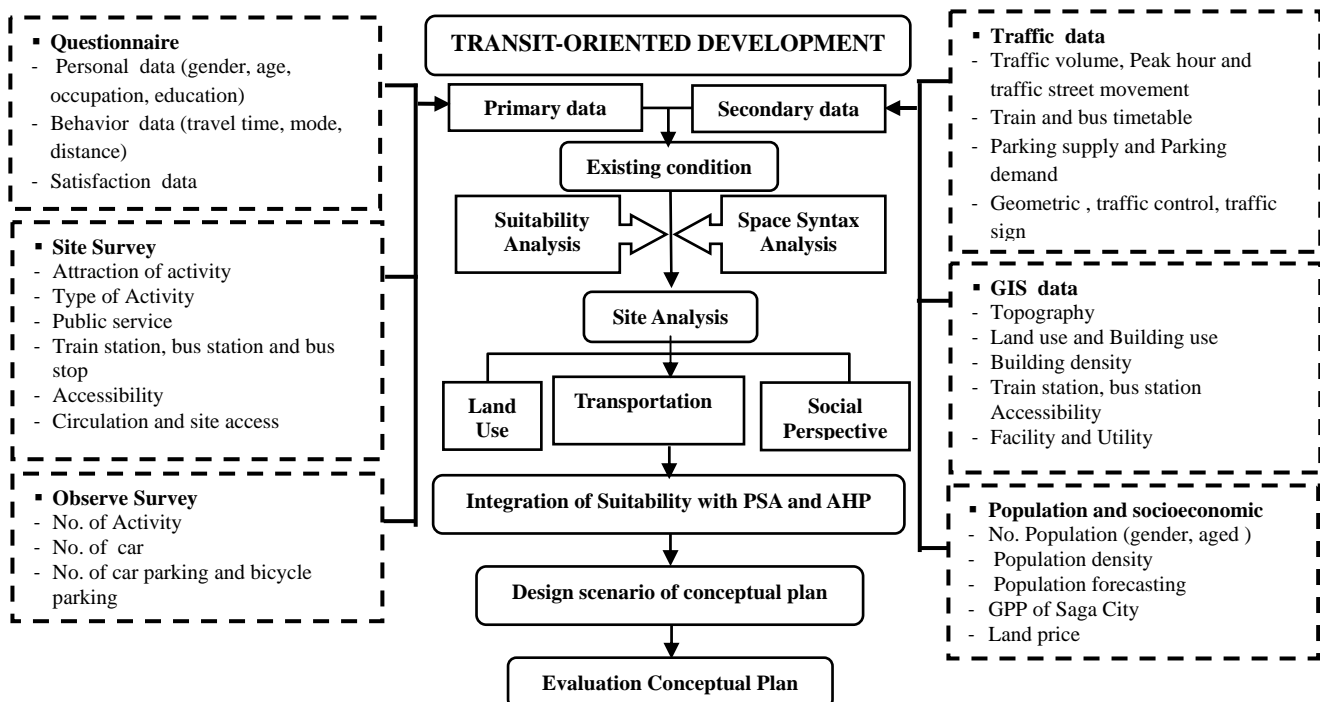


Figure 2. Methodology of this study

4. STUDY AREA: SAGA STATION AREA

4.1 Geography and hydrology

Saga-urban city is located in the southeast portion of Saga prefecture, on the island of Kyushu, Japan. Since 2005, the city has expanded through merging with the neighboring town of Morodomi, Yamato and Fuji and the village of Mitsuse from Kanzaki

District to form the new city of saga. Afterward in 2007, the town of Higashiyoka, Kawasoe and Kubota were also in united into Saga. The city has become very long north to south in the shape (Figure 3). It is now located in the boundary of Ariake Sea to the south and Fukuoka Prefecture to the southeast and north. The northern half of the city contains the Sefuri Mountains

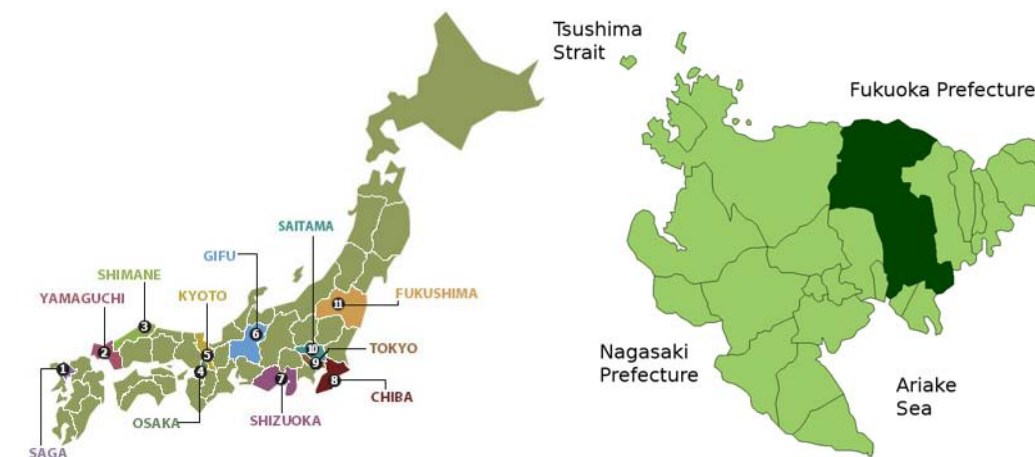


Figure 3. Saga prefecture, Japan

4.2 Demography Characteristics

A population of Saga Prefecture and Saga Cities has been declining which average rate were -0.0109 and -0.0106 in accordance (Figure 4). Saga Prefecture includes of five principles, e.g. Saga, Karatru, Tosu, Imari, and

Takeo. Saga Cities was 238,891 people in 2008 (30.7 percents). However, Saga city represents the highest numbers of population in Saga principals, but the demography has been decreasing each year. According, it affected to economic activity, employment, mitigation, community interaction, and urbanization.

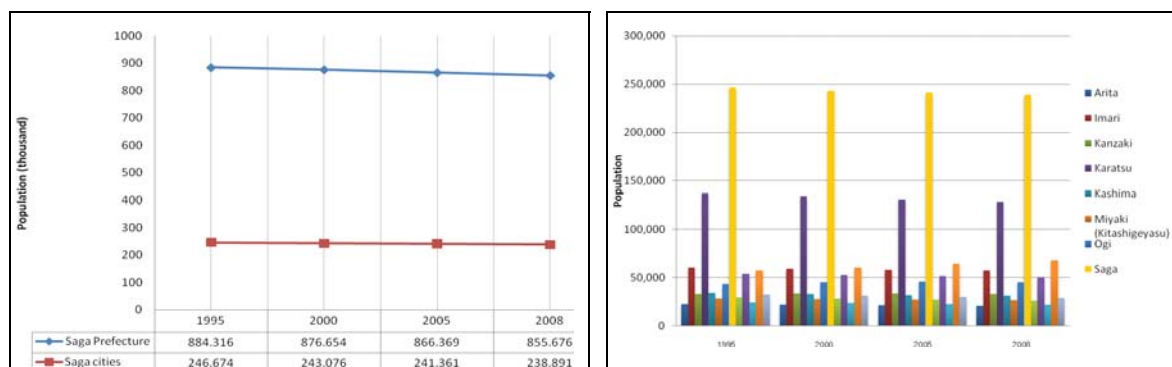


Figure 4. Saga populations in different cities

4.3 Land Use and Building Use Characteristics

The existing of Saga cities consist of commercial, residential, industrial, farmland, forestland, paddy, public land, transportation, water and others (Figure 5). The highest shares of Saga-urban area is residential that is 12.249 square kilometers (52.09 percent), public land that is 2.990 square kilometers (12.72 percent), and road is 2.829 (12.04 percent).

The current building characteristic can be decied in Figure 6 that comprise of commerce, office, accommodation, apartment, amusement, public office, warehouse, industry and others . The highest shares of Saga-urban area is belong to housing type that is about 3.153 square

kilometers (54.38 percent), apartment that is 0.466 square kilometers (8.03 percent), temple shrine is 0.404 square kilometers (6.97 percent) and commerce is 0.315 square kilometers (5.44 percent). For building density, the existing data indicates that the urban development has concentrated on the south of the city. The intensity of this location might be due to the history of urban form that has induced on the development including the extensive infrastructure in the site, e.g. Saga castle park, Saga University. Inconsistently, the distribution of the population also indicates the same trends, the red color represents high population density and the green color represents low density.

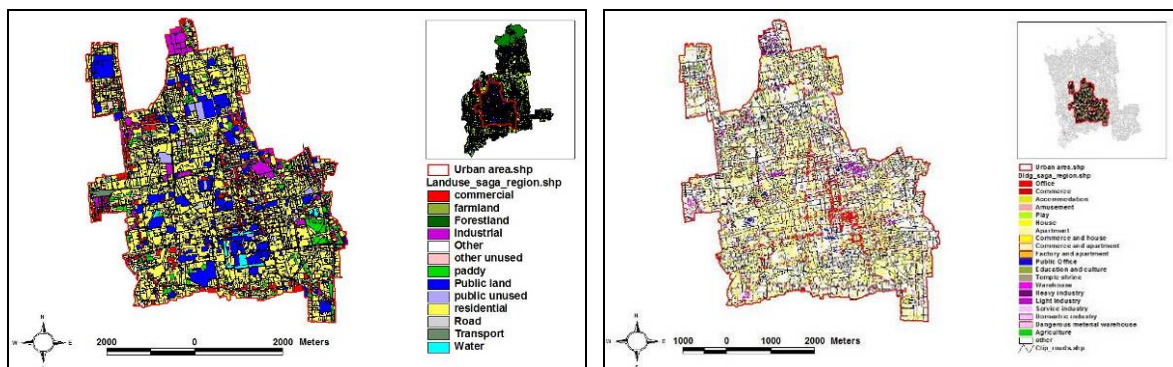


Figure 5. Land use and building use in study area

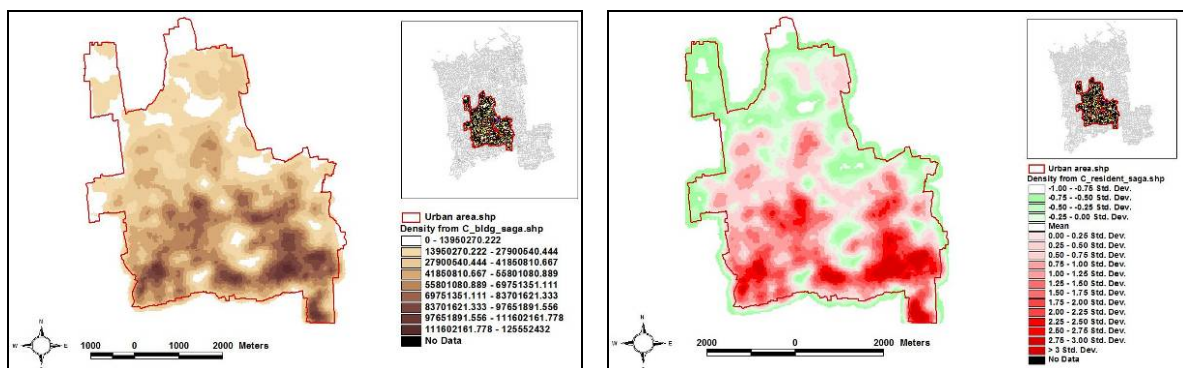


Figure 6. Building density and population distribution

4.4 Infrastructure and Transportation Characteristics

The category of road hierarchy categorized according to their function and capacity. This hierarchy comprises of highways, main roads, collector and local roads. The related connectivity was derived base on the concept of

space syntax analysis as displayed in Figure 7. This is base on the information of walkability networks, exhibits accessibility value in term of the relative connectivity and integration of those spaces. A number of accesses and intersect point was obtained from the application of GIS-based analysis tool.

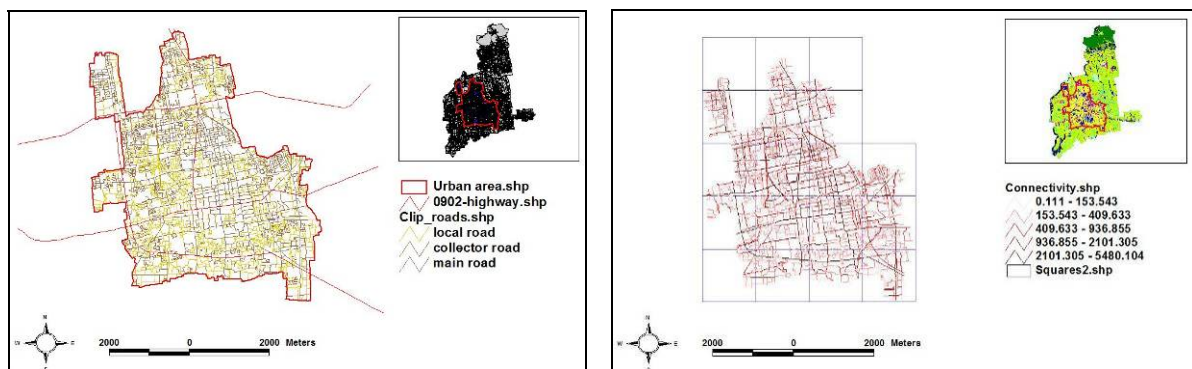


Figure 7. Road hierarchy and connectivity value

Traffic volumes demonstrate by the network of highway and main roads. These volume maps are used ensuring traffic flows with respect to hierarchy and connectivity. The public transit route was also considered in this study which indicates bus route, bus start-terminal, and bus

stops location. Most of bus services and facilities area dispersed throughout the southern part which represents high density historic area and the northern part which represents a low density suburban area (as shown in Figure 8).

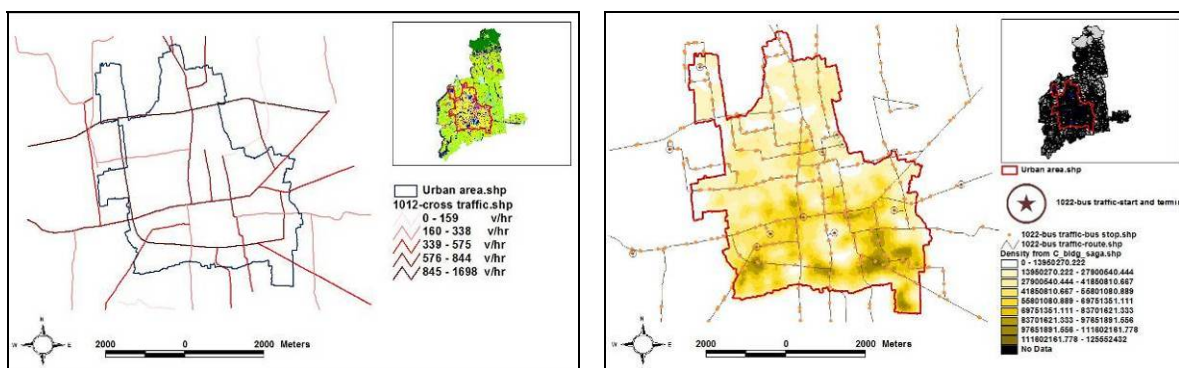


Figure 8. Traffic volume and bus route, bus start-terminal and bus stop

5. SITE ANALYSIS

Saga-rail station development area consists of difference type of land use and building use. The analysis was performed with existing radius of 500 meters, 1 kilometer, 1.5 kilometer, and 2 kilometers as seen in Figure 9. Geographic Information System (GIS) was applied to display and facilitate the suitability analysis of land use and building use proportion in radius area.

5.1 Site characteristics within 2 km.

5.1.1 For the land use of 500 meters, the majority of land use in this area is the residential which is 0.272 square kilometer (35 percent), follow by road (156,370.06 square kilometer or 20 percent), and commercial (0.139 square kilometer or 18 percent). For building use of 500 meters, the area of house is 44,301.34 square meters (24 percents), office is 33,147.08 square meters (18 percent), commerce is 19,730.41 square meters (11 percent about), and commerce and house is 18,783.34 square meters (10 percent).

5.1.2 Land use of 1 kilometer, the residential is approximately 1.049 square kilometer (45 percent), public land is 0.398 square kilometer (17 percents), road is 0.259 square kilometer (11 percents), industrial is 0.221 square kilometer (9 percents), and commercial is 0.193 square kilometer (8 percents. Building use of 1

kilometer, house is 4209.15 square meters (43 percents), temple shrine is 65,136.65 square meters (11 percents), light industrial is 58,770.31 square meters (10 percents), commercial is 40,828.79 square meters (7 percents).

5.1.3 Land use of 1.5 kilometer, residential is 1.779 square kilometer (46 percents), other land use is 0.641square kilometer (16 percents), public land is 0.522 (13 percents), and road is 0.453 square kilometer (12 percents). Building use of 1.5 kilometer, house is 472,582.74 square meters (52 percents), temple shrine is 72,870.97 square meters (8 percents), commerce and house is 63,032.07 square meters (7 percents), and commerce is 60138.20 (7 percents).

5.1.4 Land use of 2 kilometer, residential is 2.538 square kilometer (46 percents), other is 0.971 square kilometer (18 percents), public land is 0.889 square kilometer (14 percents), and road is 0.663 square kilometer (12 percents). Building use of 2 kilometers, house is 662,362.969 square meters (57 percents), temple shrine is 99,809.56 square meters (9 percents), apartment is 95863.47 square meters (8 percents), and commerce and house is 66,452.02 square meters (6 percents).

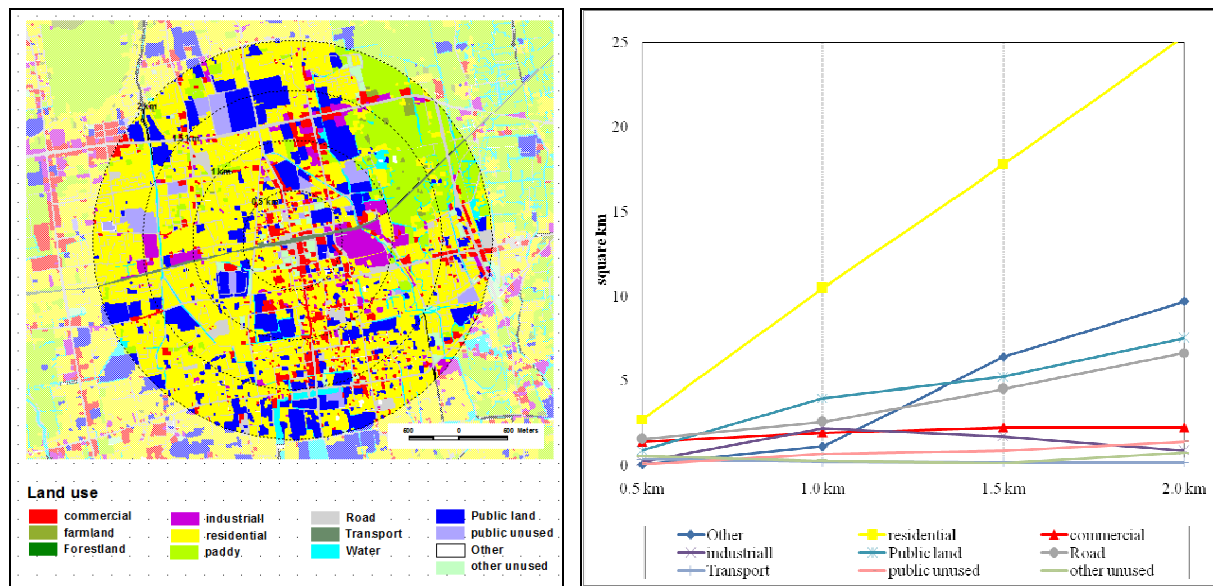


Figure 9. Land use within radius 2 km.

5.2 Saga-JR station

Station area consist of bus terminal and rail station areas where the facility services of pedestrian-oriented are connected together and join intermodal travel mode between bus service and express train service (as seen in Figure 10). The bus station has facility services for bus passengers such as bus route information, bus timetable, blind path, restroom, seats, can machine and many convenient shops. The train station provides facility services for train passengers similar to those at the bus station but provides the service with a mixture of shops. Therefore, the train station area could attract more activities than the bus station due to the varieties of available shops and services.

5.2.1 Road Network Conditions

The existing road network has a main highway, number 29 pass though the study area. The main roads directly connect to the station area and highway number 30, 264, and 267 are the main roads and collector roads in the station's road network. There are local roads pressed along two sides of the railway and connect to the highway. The connectivity and accessibility flow and capacitate present the superior condition as illustrated in Figure 11. However, peak period still face with a traffic-jam and unsafe condition and some part along main bus route may not encourage pedestrian- friendly for walkability.

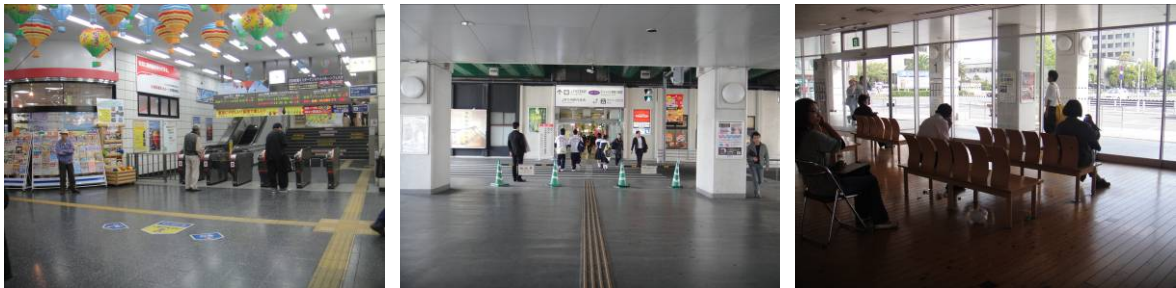


Figure 10. Connection between bus station and Saga-JR station



Figure 11. Road network conditions of Saga-JR station in 500 m.

- **Pedestrian-Oriented**

The station area encourages a non-motorization and pedestrian-friendly environment, which provides a walkable environment that is convenient, comfortable, safe, and leads directly to transit. It is designed with different surface materials such as concrete for bicycle paths, crosswalks, and footpaths, as depicted in Figure 12.

- **Bus Service**

The bus station is located as the main terminal of intermodal mode of bus and train travel. It is composed of a bus route map or start-terminal, bus times, and numbers of bus services. It is concentrated in the Saga-urban area which provides sufficient support to passengers in the service area as demonstrated in Figure 13.



Figure 12. Pedestrian-oriented characteristic



Figure 13. Bus schedule, bus start-terminal, and bus route

- **Parking Service**

This station provides vehicle parking spaces such as a bicycle parking, motorcycle parking, and plenty of car parking. It is located close to the station area as shown in Figure 14.

- **Urban Structure**

In the vicinity area of station, there are high building densities with high stories for buildings such as commercial, offices, and apartments (as seen in Figure 15). Next to the proximity area of the station, lower building density is distributed for area of commerce and houses. This major character of building type composes of two or three story of high floor area ratio.



Figure 14. Bus schedule, bus terminal, and bus route



Figure 15. Urban structure and building characteristic

6. LAND SUITABILITY ANALYSIS

Spatial analyst is a tool for create and manage spatial data modeling process that provide as a extension ArcGIS used ModelBuilder for land suitability analysis. This tool allows the process of analysis to be enable to determine the potential of area for development according to

several factors with weights and values. The derivation of new information (rating score) from existing data can be used to determine land suitability. The criteria for land suitability development were classified into three main criteria as demonstrated in Figure 16.

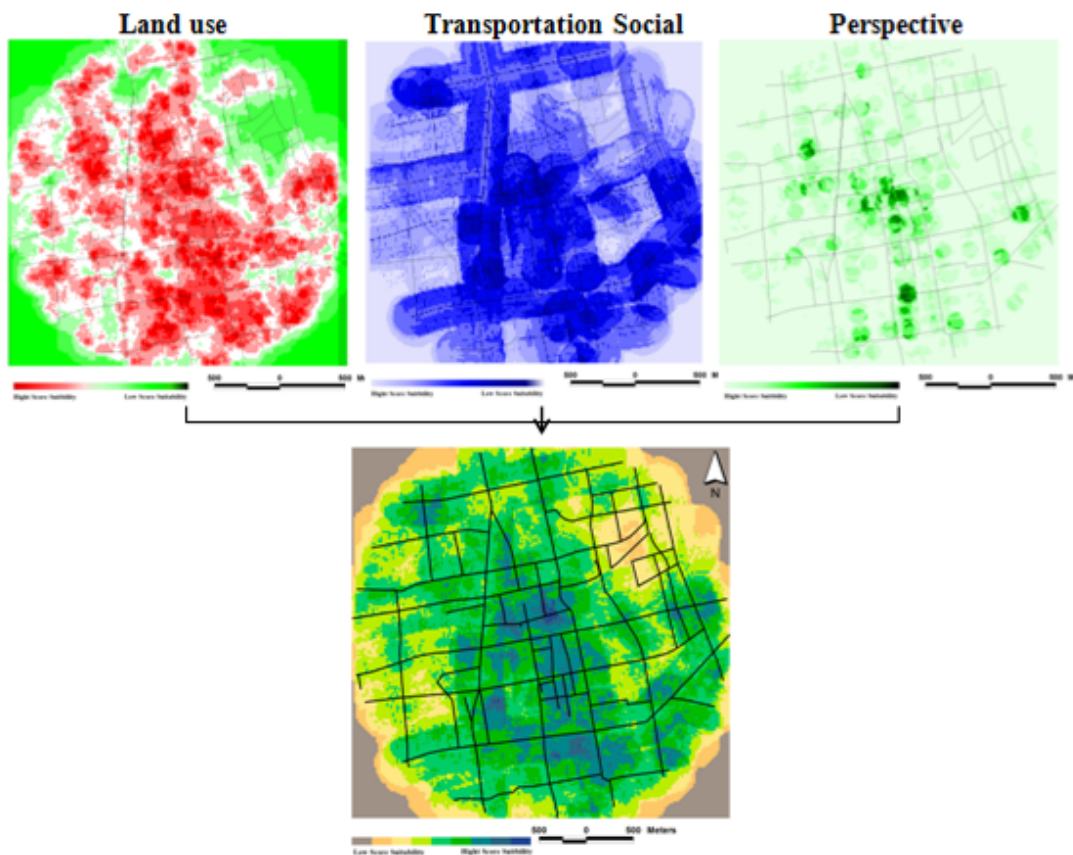


Figure 16. Land suitability analysis

The importance of difference criteria was weighted base on experts' value by the application of analytic hierarchy process (AHP). The finally weights for each criteria of constituent land use, transportation and social perspective are 0.3541, 0.4212 and 0.2247, respectively. The detail of land suitability analysis can be explained in detail as flows:

6.1 Land Use Aspect

The result of suitability analysis for land use aspect can be explored in detail as follows;

- Residential Area was 0.1726 weights score that component of distributions of house, accommodation, apartment, and residential area in land use theme.

- Commercial area was 0.1588 weights score that component of office, commerce, amusement and commerce complex in building use theme.
- Mixed-use area was 0.1759 weights score that component of commerce-house, commerce-apartment, and factory-apartment in building use theme.
- Industrial area was 0.0832 weights score that component of warehouse, heavy industry, light industry, service industry, domestic industry, and dangerous materials warehouse in building use theme.
- Agriculture area was 0.0974 weights score that component of agriculture in building use theme, rice field, and field in land use theme.
- Open space was 0.1641 weights score that component of forest, natural area, water, public open space, vacant land, and others in land use theme.
- Community center was 0.1480 weights score that component of public office, education and culture, and temple shrine in building use theme.

6.2 Transportation aspect

On the view point of transportation aspects, the experts evaluate its important in difference views as follows;

- Road hierarchy was 0.1452 weights score that are component of highway; main roads, collector roads and local roads.
- Connectivity was 0.1778 weights score that was determined by an axwoman extension of ArcView for analysis values of road network conditions.
- Bus service was 0.1909 weights score that compose of bus start-terminals, bus routes, and bus stops.

- Non-motorization was 0.1842 weights score that describe the pedestrian way and bicycle route.
- Parking was 0.1557 weights score that comprise of parking building service and parking surface.
- Traffic volume was 0.1463 weights score that explain the condition of traffic volume (veh/hr) and traffic volume change (1990, 1994,1997,1999, and from survey)

6.3 Social Perspective

For social perspective, difference dimensions of public views can be expressed as follows;

- Security was 0.2563 weights score that explain the condition of risk of low security such a round casket, place without of sight, and others.
- Road Safety was 0.2763 weights score that can demonstrate the risk of accident such as large intersection, corner of building, curve way, and others.
- Comfort and Convenient was 0.1560 weights score that describe the comfort condition of environment such as availability of bus and train service, connection between bus-to-train station, and others.
- Equity was 0.1742 weights score that demonstrate the availability of facilities and service provided for young, elderly, handicap, and others.
- Aesthetic was 0.1371 weights score that compose of attractive environment, historic building, appropriate urban design, and others.

Land suitability analysis, which considered 3 major factors into the analysis (land use, transportation, and social perspective). In order to ultimate land utilization especially around Saga station and the downward area, the integration of suitability analysis base on the PSA and AHP were applied. The result of analysis was shown in Figure 18 which demonstrates the blue color of the highest land suitability for transit oriented development. The land suitability located on approximately 500 meters apart from station and along the main highway roads (highway number is 29, 30 and 264).

7. CONCLUSIONS AND RECOMMENTATIONS

Transit oriented development policies intended to provide general development concept of the urban-station area planning. To apply this concept, specific Saga-station area plan has been used to define the overall vision, densities, land use, site layout and design, parking supply, circulation, urban form and open space. Therefore, the propose design concept of the area can be used to control and support the future activities. Base on the result of land suitability analysis, Saga arena, and the surrounding area are available to add more activities to utilize the land uses for promote

rigorous commercial area. Pedestrian was also designed to facilitate connectivity of people's activities. Moreover public space was also designed for people to get such a rest in this city and utilize for activities in the neighborhood scale. In the area of low development potential, it can be designed those to be residential area as before. Furthermore, it also can be created streetscape for privation of residential area by the concept of livable city. Thus, the conceptual plan of development for Saga Station can be proposed in the next section. The conceptual plan for TOD is required as a guideline for planning of station area. Base on the propose conceptual plan for TOD at Saga station (as depicted in Figure 17), the assessment conceptual scenario can be performed by considering of several criteria as shown on Table 2.

The main factors effect of transit development concept which was focused in this study are floor area ration, max use, commerce area, open space, non-motorization and connectivity. The conceptual plan A is highest shares of weight-score assessment that derived base on development planning with the consideration of land suitability, site analysis, and requirement from questionnaire survey.

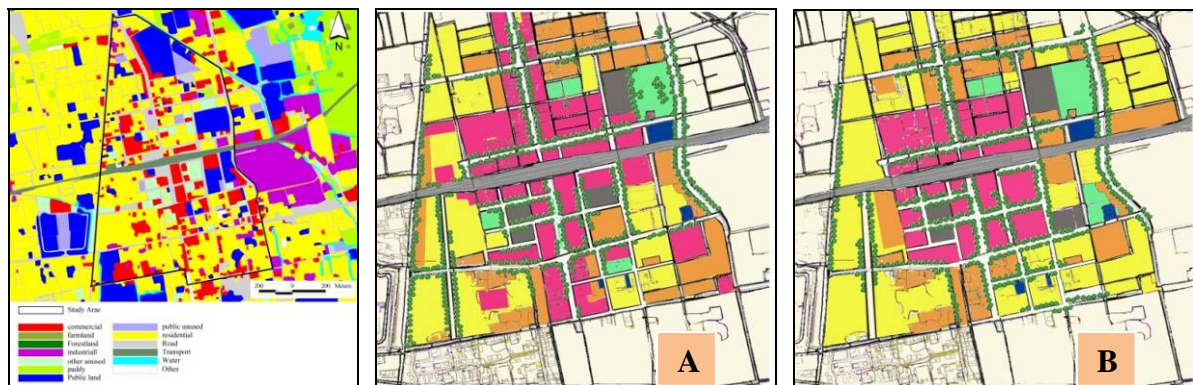


Figure 17. Conceptual plans for redevelopment

Table 1. Comparison conceptual assessment

Criterion Assessment	Existing conditions	Conceptual Plan A	Conceptual Plan B
Floor Area Ratio (FAR)	0.996	1.215	1.015
Max-use raise	0.029 sq.km	0.068 sq.km	0.055 sq.km
Commerce area	0.218 sq.km	0.254 sq.km	0.235 sq.km
Public open space	0.019 sq.km	0.32 sq.km	0.28 sq.km
Distribution value of pedestrian and bicycle friendly	2.511	2.785	2.658
Connectivity value	153.52	187.25	164.5
Total (weight-score assessment)	2.22	2.45	2.31

The Master plan for transit system can be applied for support land uses with 500 meter walkable distance of station. This land uses guideline is used to provide as a supportive tool for encourage transit use, transportation network efficiency, and discourage non transit-supportive land uses that are oriented primarily to the automobile and not the pedestrian, cyclist or transit user (as demonstrated in Figure 18). Each transit oriented development should maintain its own unique identity in terms of its mix of land uses, development intensity and the character relating to the surrounding development. To support the development of

the TOD, the detail of policies element can be elaborated as following;

- A mixture of land uses should be encouraged that are pedestrian oriented including a variety of housing, offices, retail, entertainment, hotels, restaurants, urban parks, day care, and public agencies and services.
- Buildings should be oriented to the sidewalk to provide a prominent pedestrian access and the development of public space along the street frontage should be encouraged

- The concept of “complete streets” should be promoted with travel lanes for transit, auto, and bikes along with on-street parking, landscaped parkways, sidewalks, and window shopping area.
- Shared driveways, access and parking between building parcels should be provided to limit street access points and to minimize conflicts between vehicles and pedestrians.
- Transit should be available and promoted with significant transit amenities, including park-and-ride, benches, passenger waiting shelters, bus turn-outs, trash containers, and safe pedestrian facilities.
- Safe, visually attractive, and well-defined pedestrian walkways from parking areas, park-and-ride areas, and transit stops to building entrances should be provided.
- Connectivity and access for pedestrians and bicycles should be provided and developed from the TOD to the surrounding area.

Integration of the public facilities should be encouraged to establish and promote a civic and public atmosphere in the area. The public spaces should be developed with various features including smaller amenities such as fountains, artwork and benches.

In conclusion, this paper presents the final conceptual land use plan by incorporates the existing of general features with the GIS-based land suitability analysis. Then, the conceptual plan and master plan can be used to guide for transit development by consider the proximity area of the transit station. To balance the high density with public space, it allocates a centralized park and trail system on the northeast and the southeast of the site for commercial development features. In conclusion, the result of this study finally provides the conceptual land use plan that could guide for sustaining of transit oriented development around the station area of Saga city. This information can serve as a guideline for other town as amend the comprehensive plan and zoning ordinances to reflect the goals and recommendations creating more efficient subcenters and minimizing sprawl. The enhance accessibility with TOD could enhance the overall economic efficiency of a city with more encouragement of transit ridership.

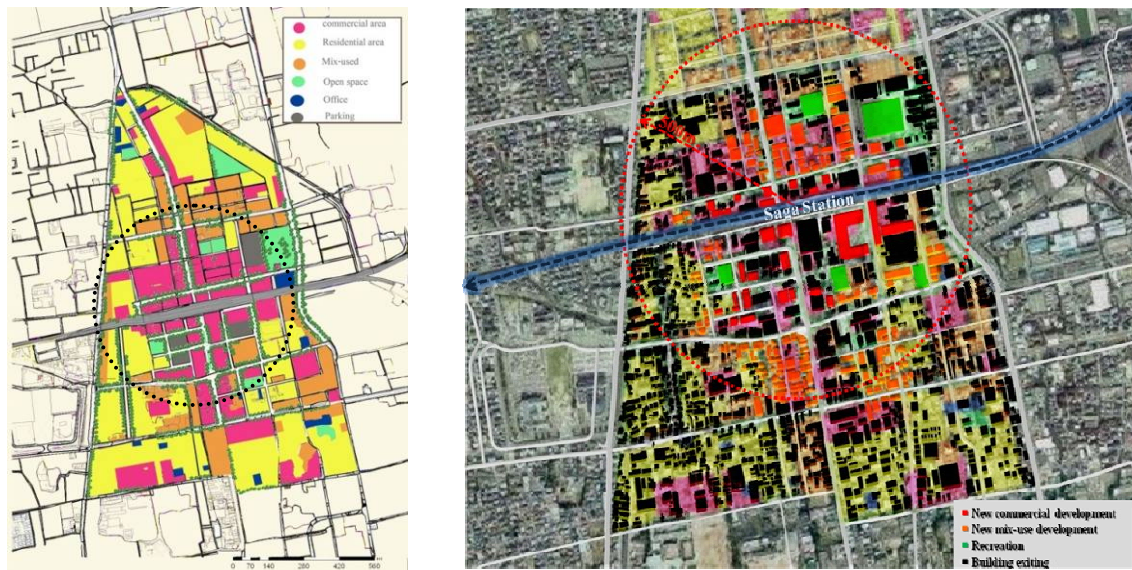


Figure 18. Conceptual plan and master plan

ACKNOWLEDGEMENT

The research was conducted during the Saga Collaborative Workshop between Saga University, Kitakyushu University and Faculty Architecture and Planning of Thummasat University under the theme of “Liveable community for Urban Development on 3-18 October, 2009.

REFERENCES

- Beimborn, E. and Rabinowitz, (1991) **Guidelines for Transit Sensitive Suburban Land-use Design**. Washington, D.C.: U.S. Department of Transportation, Federal Transit Administration.
- Calgary City Council. (1995) **Transit Friendly Design Guide**. Calgary Transit Division Transportation Department
- Coon Rapids, Cuningham Group. (2007) **Riverdale Station Area Transit Oriented Development Design Guidelines**, Minnesota.
- Dena Belzer and Gerald Autler. (2002) **Transit Oriented Development: Moving from Rhetoric to Reality**, The Brookings Institution Center on Urban and Metropolitan Policy and The Great American Station Foundation
- Ernest H. Forman and Saul I. Gass. (2005) **The Analytic Hierarchy Process – An Exposition**, Operations Research, <http://or.journal.informs.org>
- Federal Transit Administration. (2004) **Transit-Oriented Development in the United States: Experiences, Challenges, and Prospects**, Transportation Research Board.

- BROWARD COUNTY PLANNER'S WORKSHOP. (2008) **TRANSIT ORIENTED DEVELOPMENT DESIGN GUIDELINES**, Florida Department of Transportation and Florida Department of Affairs
- Goody Clancy and Byrne McKinney & Associates. (2002) **Density Myth and Reality**. Presentation, Boston, MA.
- Gwen Chisholm. (2002) **Transit-Oriented Development and Joint Development in the United States: A Literature Review**. Transit Cooperative Research Program. Sponsored by the Federal Transit Administration RESEARCH RESULTS DIGEST.
- John Wiley & Sons, Inc. (2006) **Planning and urban design standards**, American Planning Association , 450-452.
- Larry W. Pace, W.R. "Skip" Fischer, and Alice J. Nichol. (2007) **Transit Oriented Development and Rail Station Area Planning Guidelines**. Adams County.
- McHarg, I. L. (1971) **Design with Nature**. USA: Doubleday/Natural History Press.
- NC Department of Environment and Natural Resources. (2005) **Land Suitability Analysis User Guide**. Division of Coastal Management and the North Carolina Center for Geographic Information and Analysis. <http://dcm2.enr.state.nc.us/index.htm>
- Saaty, T. L. (1994) **How to Make a Decision: The Analytic Hierarchy Process**, Interfaces, 24, 19-43.
- San Francisco Bay Area Rapid Transit District. (2003) **BART Transit-Oriented development Guidelines**. San Francisco.
- The Urban Land Institute. (1994) **Transit Oriented Design**. Washington, DC: UCL.
- Wallace Roberts & Todd, LLC. (2006) **PATCO Transit-Oriented Development Master Plans Study**. Delaware River Port Authority and Port Authority Transit Corporation.

EFFECT OF HIGH-SPEED RAIL DEVELOPMENT ON THE PROGRESS OF REGIONAL ECONOMY

Xuesong FENG
Research Fellow
Graduate School of Environmental Studies, Nagoya
University
Furo-cho, Chikusa-ku, Nagoya 464-8603, Japan
Fax: +81-52-789-1454
E-mail: charles.x.feng@gmail.com

Quan YUAN
Master Student
Graduate School of Environmental Studies, Nagoya
University
Furo-cho, Chikusa-ku, Nagoya 464-8603, Japan
Fax: +81-52-789-1454
E-mail: yuanquan0127@hotmail.com

Peng JIA
Research Fellow
Graduate School of Environmental Studies, Nagoya
University
Furo-cho, Chikusa-ku, Nagoya 464-8603, Japan
Fax: +81-52-789-1454
E-mail: jiapeng1979@gmail.com

Yoshitsugu HAYASHI
Professor
Graduate School of Environmental Studies, Nagoya
University
Furo-cho, Chikusa-ku, Nagoya 464-8603, Japan
Fax: +81-52-789-1454
E-mail: yhayashi@genv.nagoya-u.ac.jp

Abstract: Considering system efficiency and spatial interdependence, this study proposes an analysis approach to study the effect of High-Speed Rail (HSR) development on regional economy, by utilizing the development cases of the Japanese Shinkansen. The stochastic frontier analysis and spatial autoregressive study are applied in this research. It is confirmed that the proposed approach can make rationally accurate explorations of HSR development's impact on regional economy. It is found that HSR development will improve the economy of each city along HSR line, and the more the city's travel impedance to the nearest HSR station decreases, the more its economic progress is distinct. However, the proportions of the contributions to regional economy from the cities originally near to HSR stations decrease in comparison to the increase of the contribution shares of the cities which HSR lines newly extend to.

Key Words: High-Speed Rail, Regional Economy, Stochastic Frontier Analysis, Spatial Autoregressive, Shinkansen

1. INTRODUCTION

To date, much attention has been paid to the development of High-Speed Rail (HSR) as an efficient and sustainable transport mode (Arduin and Ni, 2005) with comprehensive spatial and social-economic impacts on regional development (Banister and Berechman, 2001; Blum, et al., 1997; Bonnafous, 1987; Froidh, 2005; Vickerman,

1997). However, though has been frequently being asked, it has never been fairly answered in theoretically precise manners that e.g. in what exact degree constructing some HSR line contributes to the economic growths of the cities in the region along the HSR line. It is argued that system efficiency study in support of convincing theories to analyze the HSR effect in spatial viewpoint is indispensable in the decision-making process of HSR

development especially for the benefit of regional economy (Banister and Berechman, 2001; Garmendia, *et al.*, 2008; Sasaki, *et al.*, 1997). Therefore, this paper proposes a study approach with system efficiency analysis in consideration of spatial effect to explore regional-wide economic impacts of HSR development, which is explained by utilizing the Shinkansen development cases in Japan, with its application accuracy computationally proved.

As for the analysis of system efficiency, Stochastic Frontier Analysis (SFA) (Kumbhakar and Lovell, 2000) and Data Envelopment Analysis (DEA) (Ray, 2004) are two dominating tools. The DEA can calculate the efficiency even in case of very small sample size, but the calculation results are very sensitive to the set of input variables; in contrast, SFA has an advantage of allowing for random shocks and measurement errors, also with the assumption of specific statistical distribution of both random shocks and error terms (Cullinane, 2006; Liao, *et al.*, 2007; Worthington, 2001). As a result, SFA is adopted in this research and integrated into the Spatial Auto-Regressive (SAR) study (Anselin, 1988; Getis, *et al.*, 2004) to investigate the effect of HSR development on both systematic and spatial perspectives of regional economy. The following parts of this paper are organized as follows. Section 2 explains the framework of the proposed analysis approach with the application of SFA and SAR study. Next, the SFA and SAR models established to be applied in the proposed approach is estimated with the software *Stata 9.0* in Section 3. Then, the effect of HSR development on regional economy is analyzed by making use of the cases of the Shinkansen development in Japan in Session 4,

with the application of the SFA and SAR models estimated in Section 3. Finally, Session 5 summarizes the findings and points out the future research issues.

2. PROPOSED ANALYSIS APPROACH

Despite the apparent multitude of factors influencing the performance of regional economy, the *Travel Impedance* to the nearest HSR station (Vickerman, 1998; Vickerman, *et al.*, 1999) is acknowledged to be one of the key elements to make a crucial effect on the economic prosperity of each city in a certain region with a HSR line passing through. Any change of such travel impedance of some city will first directly influence the frontier of this city's urban economic product which will systematically decide the product outcome, as explained by the SFA model shown in equation (1) from an *output-oriented* perspective (Kumbhakar and Lovell, 2000).

$$\ln y = \beta_0 + \beta_1 \ln TI + \sum_k \beta_k \ln x_k + v - u \quad (\text{Eq. 1})$$

Where,

y : output variable, i.e. outcome of urban economic product,

TI: travel impedance to the nearest HSR station,

x_k : the input variable, e.g. number of households,

v : the two-sided "noise" component,

u : the nonnegative technical inefficiency component, and

$\beta_0, \beta_1, \beta_k$: coefficients to be estimated

Moreover, $v \sim \text{iid } N(0, \sigma_v^2)$; $u \sim \text{iid exponential}$; v and u are distributed independently of each other, and of the regressors.

Because of the uncertainties of the random errors of the SFA model shown in equation (1), the value of urban economic outcome (y) based on the product frontier can be measured from the perspective of mathematical expectation, as shown in equation (2).

$$\ln y = \beta_0 + \beta_1 \ln TI + \sum_k \beta_k \ln x_k - E(u) \quad (\text{Eq. 2})$$

Any change of the outcome of any city's urban economic product will spatially affect the urban economic products of all the other cities within a certain region, according to the theory of spatial autocorrelation (Anselin, 1988; Getis, *et al.*, 2004). The outcomes of the urban economic products of all the cities within a certain region will make spatially interdependence on each other, which is explained here as the first-order SAR model (LeSage and Pace, 2009) shown in equation (3).

$$Y = \rho WY + \varepsilon \quad (\text{Eq. 3})$$

Where, Y is the $n \times 1$ vector of y in equation (2) (n is the number of the cities within the assumed region), and W is the spatial weight matrix composed of the standardized reciprocal values of the *Shortest Intercity Travel Time*. The parameter ρ is the SAR parameter on the dependent variables. Moreover, the error term ε follows the normal statistic distribution, i.e.

$$\varepsilon \sim N(0, \sigma^2 I) \quad (I \text{ is the identity matrix}).$$

Along with the changes of urban economic products because of the above-explained systematic and spatial effect, the contributions from each city within the decided regional area to the economy of regional wide will be accordingly changed, which can be simultaneously measured by equation (4), equation (5) and equation (6) in comprehensive viewpoints.

$$P^i = \frac{y^i}{\sum_{j=1}^m y^j} \times 100 \quad (\text{Eq. 4})$$

Where, P^i means the percentage of the contribution to the economy of region m from city i , and y^i represents the afore-explained outcome of urban economic product of city i .

$$P_{imp}^i = \frac{|y_{imp}^i - y_0^i|}{y_0^i} \times 100\% \quad (\text{Eq. 5})$$

Where, P_{imp}^i is the percentage of the improvement of urban economy of city i , y_{imp}^i represents the improved outcome of urban economic product of city i , and y_0^i means the original outcome of urban economic product of city i .

$$P_{imp}^m = \frac{\left| \sum_{i=1}^m y_{imp}^i - \sum_{i=1}^m y_0^i \right|}{\sum_{i=1}^m y_0^i} \times 100\% \quad (\text{Eq. 6})$$

Where, P_{imp}^m is the percentage of the improvement of the economy of region.

3. ESTIMATION TO THE SFA AND SAR MODELS

According to the data from the works of JTBF (2005) and SBMIAC (2007), the *Total Income of Urban Taxpayers (TIUT)* (here representing the outcome of urban economic product) of each city is firstly studied as the dependent variable of equation (1). The explaining variable of *Travel Impedance* takes the product of travel time and travel cost by public travel modes from each of

the more than 700 cities in Japan to the nearest stations of Shinkansen which is the longest-running HSR system in the world. Moreover, as another representation of economic prosperity, the *Number of Households* (Rivera-Batiz, 1988; Crampton, 1999; Luk, 1993) in each of these cities is also imported into the SFA model as another explanatory variable. Table 1 shows the results of the estimation to the SFA model and it can be seen that the statistical indices shown in this table are satisfactory.

Table 1. Estimation to the SFA model

Variable	Coefficients	Std. Err.	z-statistics	p > z
Constant	1.3909 (β_0)	0.0985	14.12	0.000
Travel Impedance	-0.0327 (β_1)	0.0030	-10.85	0.000
Number of Households	1.0317 (β_2)	0.0080	129.26	0.000
Model Log-Likelihood	196.3093			

Next, the expected outcomes of the *TIUT* of each city is able to be obtained according to equation (2) and further adjusted in accordance with the mechanism of the spatial interdependence explained as the first-order SAR model shown in equation (3) estimated

based on *the Shortest Intercity Travel Time* provided in the work of JTBF (2005). The estimation results of the SAR model described by equation (3) are reasonably and satisfactorily shown in Table 2.

Table 2. Estimation to the first-order SAR model

Parameter	Value	T-Score
ρ	3.8200e-0001	2.1939
Log-Likelihood	71.3922	R-Squared 0.8733

4. ANALYSIS OF HSR DEVELOPMENT EFFECT

With the SFA and SAR modes estimated, the effect of HSR development is able to be analyzed in systematic as well as spatial manners. By referring to the development case of the Sanyo Shinkansen Line in Japan in 1970s, the accuracy of the study of HSR development's impact on the general performance of regional economy is investigated in the first place. As the second

line of the HSR system in Japan, the Sanyo Line starts from Osaka, i.e. the terminal of the Tokaido Line which is the first Shinkansen line opened in 1964 from Tokyo to Osaka for the Tokyo Olympic Games (Hatheway, *et al.*, 2005). As shown in Figure 1, the Sanyo Line was initially put into operation in 1972 only between Osaka and Okayama (Richards, 1975) and fully opened with its extension to Fukuoka in 1975 (Kikuchi, 1988; Ohta, 1989).

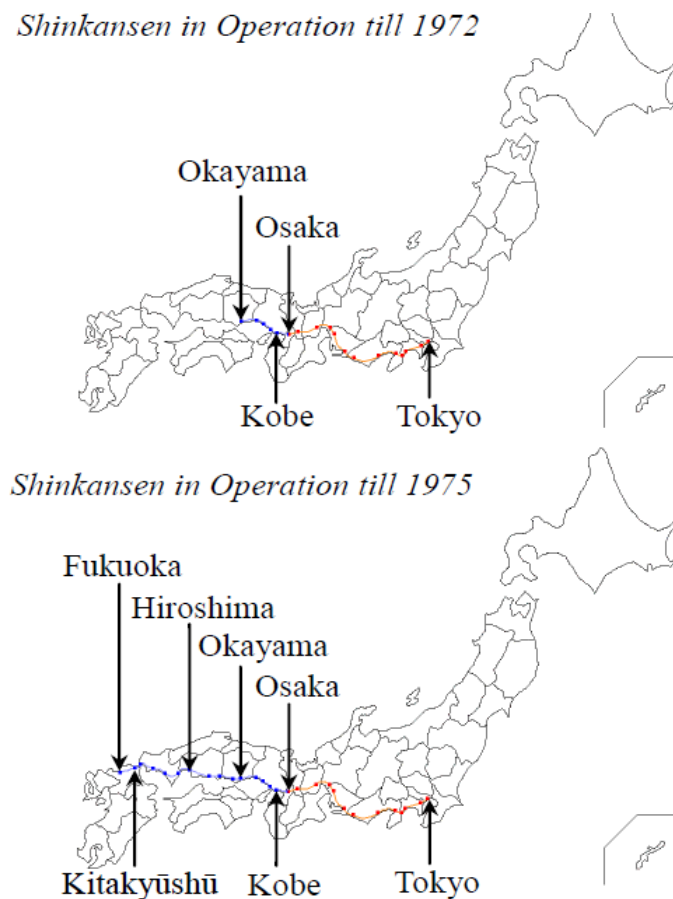


Figure 1. Development of the Sanyo Line of the Shinkansen in Japan

In order to reflect the economic improvement of the region along the Sanyo Line before and after its extension from Okayama to Fukuoka as introduced in Figure 1, the values of the indices decided by equation (4), equation (5)

and equation (6) for some main cities along this HSR line in 1970s are estimated according to the values of $TIUT$ studied successively by equation (1), equation (2) and equation (3) based on the afore-explained variables of

Travel Impedance, Number of Households and the Shortest Intercity Travel Time with their surveyed data supplied in the works of JACM (1974; 1976; 1977) and JTBF (1972; 1975). The estimation results are presented in Table 3, where the index values in parentheses are the actual results calculated directly base on the surveyed values of *TIUT* of these cities along the Sanyo Line in 1972 and 1975 (JACM, 1974; 1976; 1977). It is clearly shown in Table

3 that the maximum errors of the estimated values compared with their real values are smaller than 1.00%, which computationally confirms that the proposed analysis approach considering the efficiency of system frontier and the effect of spatial autocorrelation is able to roundly in reasonable accuracy explore the efficacies of HSR development to improve regional economy.

Table 3. Economic improvements of the region along the Sanyo Line from 1972 to 1975

City	P^i				P^i_{imp}	
	1972		1975			
Oosaka	40.3280%	(40.2470%)	36.1549%	(36.1538%)	39.6681%	(40.2853%)
Kobe	20.6361%	(20.5982%)	19.6978%	(19.6982%)	48.7058%	(49.3439%)
Okayama	6.1536%	(6.1832%)	6.6016%	(6.6017%)	67.1297%	(66.7378%)
Hiroshima	9.6509%	(9.6384%)	12.7218%	(12.7217%)	105.3610%	(106.1265%)
Kitakyushu	11.9060%	(11.9833%)	12.4175%	(12.4178%)	62.4818%	(61.8306%)
Fukuoka	11.3253%	(11.3500%)	12.4064%	(12.4068%)	70.6608%	(70.7084%)
P^m_{imp}		55.7892% (56.1677%)				

With the confirmation of the application accuracy of the proposed analysis approach, it is the time to study the effect of the HSR development. Figure 2 shows all the Japanese Shinkansen lines in operation now. As shown in this figure, the first section of the Hokuriku Line from Takasaki to Nagano was opened in 1997 (Nakagawa and Hatoko, 2007) and the whole line is going to be put into operation with its successive extensions to Jōetsu, Toyama, Kanazawa, etc., in 2014 (Muro, 2009). According to the afore-estimated SFA and SAR models based on the data in 2005 (JTBF, 2005; SBMIAC, 2007), the indices defined by equation (4), equation (5) and equation (6) are calculated to forecast the general performance of the economies of some main cities in the region along the Hokuriku Line in 2014, in only the consideration of the

changes of the travel impedances of these cities to the nearest Shinkansen stations. The prediction results about the development effect of the Hokuriku Shinkansen Line are shown in Table 4.

As can be concluded from the contents presented in both Table 2 and Table 4, the extensions of HSR Lines will first improve the economic performance of each city in the region along HSR lines. And the more a city's travel impedance to the nearest HSR station is decreased, the more its economic progress is distinct. Consequently, though all the cities' economic products increase, the shares of the contributions to the general development of regional economy from the cities originally near to HSR stations will decrease in comparison to the increases of the contributions

from the cities HSR lines newly extend to. In addition, simultaneously by referring to the illustrations in Figure 1 and Figure 2 about the changes of the transport accessibility of the cities to the nearest HSR stations, it is clearly

shown that the more the transport accessibility of a city to the nearest HSR station is improved, the more its economic weight in the regional economy is increased.

Table 4. Economic improvements of the region along the Hokuriku Line from 2005 to 2014

City	P^i		P_{imp}^i
	2005	2014	
Takasaki	17.6217%	17.1827%	3.9046%
Nagano	20.9102%	18.0130%	3.8009%
Joetsu	10.5425%	10.7698%	8.8568%
Toyama	23.9024%	24.6206%	9.7611%
Kanazawa	27.0232%	29.4138%	15.9863%
P_{imp}^m	6.5603%		

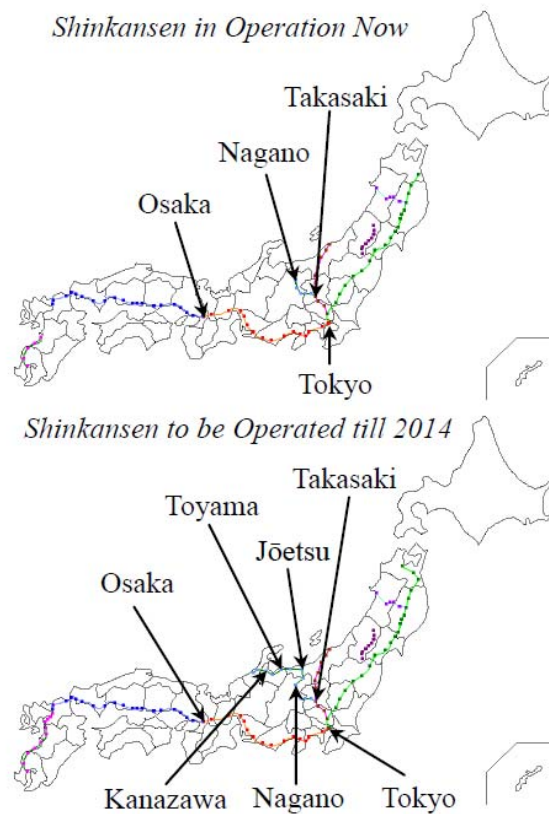


Figure 2. Development of the Hokuriku Line of Shinkansen in Japan

5. CONCLUSIONS AND FUTURE RESEARCH ISSUES

With the explanation by utilizing the development cases of the Shinkansen system in Japan, this paper proposes an analysis approach to study the effect of HSR development on regional economy, in consideration of the systematic change of urban economic frontier and spatial autocorrelation of urban economic interdependence. It is computationally proved that the proposed approach can truly explore in reasonable accuracy the comprehensive impact on the regional economy owing to HSR development. It is concluded that HSR development will improve the economic performance of each city along HSR line. The more the city's transport accessibility to the nearest HSR station is improved, the more its economic progress is able to be distinctly

found. As a result, in despite of the increases of all the cities' economic products, the shares of the contributions to the development of regional economy from the cities originally near to HSR stations will decrease in comparison to the increases of the contributions from the cities HSR lines newly passes through. Moreover, it is also able to be found that the more the accessibility is improved, the more its contribution to regional economy is increased. However, it is found that the spatial analysis in the proposed study approach applies only the basic spatial autocorrelation model which cannot fully explain the complicated spatial effect and need to be further improved in the future research. In addition, the proposed analysis approach should also be further applied to analyze the development effect of other HSR systems to check its applicability in general.

REFERENCES

- Arduin, J.P. and Ni, J. (2005) French TGV network development, **Japan Railway & Transport Review**, No.40, 22-28.
- Anselin, L. (1988) **Spatial Econometrics: Methods and Models**. Kluwer Academic Publisher, Dordrecht.
- Banister, D. and Berechman, Y. (2001) Transport investment and the promotion of economic growth, **Journal of Transport Geography**, Vol.9, No.3, 209-218.
- Blum, U. Haynes, K.E. and Karlsson, C.K. (1997) The regional and urban effects of high-speed trains, **The Annals of Regional Science**, Vol.31, No.1, 1-20.
- Bonnafoous, A. (1987) The regional impact of the TGV, **Transportation**, Vol.14, No.2, 127-137.
- Crampton, G. R. (1999) Urban labour markets. In P.C. Cheshire and E.S. Mills (eds.), **Handbook of Regional and Urban Economics, Volume 3: Applied Urban Economics**, North Holland, Amsterdam.
- Cullinane, K., Wang, T., Songc, D. and Ji, P. (2006) The technical efficiency of container ports: Comparing data envelopment analysis and stochastic frontier analysis, **Transportation Research Part A: Policy and Practice**, Vol.40, No.4, 354-374.
- Froidh, O. (2005) Market effects of regional high-speed trains on the Svealand line, **Journal of Transport Geography**, Vol.13, No.4, 352-361.

- Garmendia, M., Ureña, J.M., Ribalaygua, C., Leal, J. and Coronado, J.M. (2008) Urban residential development in isolated small cities that are partially integrated in metropolitan areas by high-speed train, **European Urban and Regional Studies**, Vol.15, No.3, 249-264.
- Getis, A., Mur, J. and Zoller, H.G. (2004) **Spatial Econometrics and Spatial Statistics**. Palgrave Macmillan, New York.
- Hatheway, A. W., Kanaori, Y., Cheema, T., Griffiths, J. and Promma, K. (2005) 10th annual report on the international status of engineering geology--year 2004-2005; encompassing hydrogeology, environmental geology and the applied geosciences, **Engineering Geology**, Vol.81, No.2, 99-130.
- JACM (Japan Association of City Mayors) (1974). **Municipal Year Book of Japan**, Vol.32. Jitinipposya Company, Tokyo.
- JACM (Japan Association of City Mayors) (1976). **Municipal Year Book of Japan**, Vol.34. Jitinipposya Company, Tokyo.
- JACM (Japan Association of City Mayors) (1977). **Municipal Year Book of Japan**, Vol.35. Jitinipposya Company, Tokyo.
- JTBF (Japan Travel Bureau Foundation) (1972) **JTB Timetable 1972**. JTB Publishing, Tokyo.
- JTBF (Japan Travel Bureau Foundation) (1975) **JTB Timetable 1975**. JTB Publishing, Tokyo
- JTBF (Japan Travel Bureau Foundation) (2005) **JTB Timetable 2005**. JTB Publishing, Tokyo
- Kumbhakar, S. C. and Lovell, C. A. K. (2000). **Stochastic Frontier Analysis**. Cambridge University Press, Cambridge.
- Kikuchi, I. (1988) Shinkansen noise: Research and achievements in countermeasures for Shinkansen noise, **Journal of Sound and Vibration**, Vol.120, No.2, 381-389.
- Liao, H., Wang, B. and Weyman-Jones, T. (2007) Neural network based models for efficiency frontier analysis: An application to east Asian economies' growth decomposition, **Global Economic Review**, Vol.36, No.4, 361-384.
- LeSage, J. and Pace, R. K. (2009) **Introduction to Spatial Econometrics**. CRC Press, Boca Raton.
- Luk, F. K. (1993) A general equilibrium simulation model of housing markets with indivisibility, **Regional Science and Urban Economics**, Vol.23, No.2, 153-169.
- Muro, T. (2009) Compact city development using public transport, **Japan Railway & Transport Review**, No.52, 24-31.
- Nakagawa, D. and Hatoko, M. (2007) Reevaluation of Japanese high-speed rail construction: Recent situation of the north corridor Shinkansen and its way to completion, **Transport Policy**, Vol.14, No.2, 150-164.

- Ohta, K. (1989) The development of Japanese transportation policies in the context of regional development, **Transportation Research Part A: Policy and Practice**, Vol.23, No.1, 91-101.
- Ray, S. C. (2004) **Data envelopment analysis: Theory and techniques for economics and operations**. Cambridge University Press, Cambridge.
- Richards, E. J. (1975) A method of assessing the noise nuisance arising from the channel tunnel high speed rail system, **Journal of Sound and Vibration**, Vol.43, No.4, 633-657.
- Rivera-Batiz, F. L. (1988) Increasing returns, monopolistic competition, and agglomeration economies in consumption and production, **Regional Science and Urban Economics**, Vol.18, No.1, 125-153.
- Sasaki, K., Ohashi, T. and Ando, A. (1997) High-speed rail transit impact on regional systems: Does the Shinkansen contribute to dispersion?, **The Annals of Regional Science**, Vol.31, No.1, 77-98.
- SBMIAC (Statistics Bureau, Ministry of Internal Affairs and Communications (Japan)) (2007) **Statistical Observations of Shi, Ku, Machi, Mura**. Statistics Bureau, Tokyo.
- Vickerman, R. (1997) High-speed rail in Europe: Experience and issues for future development, **The Annual of Regional Science**, Vol.31, No.1, 21-38.
- Vickerman, R. (1998) Accessibility, peripherality and spatial development: The question of choice. In A. Reggiani (ed.), **Accessibility Trade and Locational Behaviour**, Ashgate, Aldershot.
- Vickerman, R., Spiekerman, K. and Wegener, M. (1999) **Accessibility and economic development in Europe**, **Regional Studies**, Vol.33, No.1, 1-15.
- Worthington, A. (2001) An empirical survey of frontier efficiency measurement techniques in education, **Education Economics**, Vol.9, No.3, 245-268.

APPLICATION OF PUBLIC-USE BIKE SYSTEM IN KASETSART UNIVERSITY, BANGKHEN CAMPUS: RESEARCH AND REALITY

Supaporn Kaewko LEOPAIRONJANA
Lecturer
Division of Urban and Environmental
Planning, Faculty of Architecture,
Kasetsart University
50 Phaholyothin Rd., Jatujak, Bangkok
10900 Thailand
Fax: +662-9428960-3 ext. 202
E-mail: supaporn_k@hotmail.com,
supaporn.ka@ku.ac.th

Salila TRAKULVECH
Research Associate
Division of Urban and Environmental
Planning, Faculty of Architecture,
Kasetsart University
50 Phaholyothin Rd., Jatujak, Bangkok
10900 Thailand
Fax: +662-9428960-3 ext. 202
E-mail: punnavech@hotmail.com

Abstract: Research into the application of a public-use bike system in Kasetsart University (KU) was conducted in 2008 to study user needs and provide guidelines for the application. The KU bike project was implemented in August 2009 to let staff and students borrow bikes free of charge to encourage the staff and students to use bikes to create a green campus and a healthy community. This study aims to examine student feedbacks on the KU bike project and to provide suggestions to improve the project based on the research. The authors found that the project is not popular. Half of the bikes at KU main gates are not borrowed because the borrowing process is inconvenient and the KU environment is unsafe. Different scenarios were provided to increase the number of bike users. Improvements of both the public-use bike system and safety were recommended when KU has available budget. Otherwise, improvements of safety have priority.

Key Words: public-use bike system, KU bike project, user needs, non-motorized transportation

1. INTRODUCTION

A public-use bike (PUB) system is a non-motorized transportation system provided for people who want to travel by bikes but cannot afford or do not want to buy bikes. The system allows users to rent or share bikes with the others and lets the users change their modes without worrying about losing their bikes. Demaio and Gifford (2004) explain that the system provides more transportation choices for public transport users and pedestrians. It also helps to retain public transport users and draw new users. The public transport users

choose the system to save time when they have to transfer or walk to complete their trips. However, the car users do not select the system since they can reach their destinations directly by car. At present, the system is applied in many countries in Europe, the United States, Japan and Singapore.

In 2008, the authors conducted research to apply a PUB system in Kasetsart University (KU), Bangkheng Campus. KU is selected as a case study area because KU is well known as a bike campus and traveling by bike is a tradition of KU. However, the number of bike users has

declined due to increasing numbers of cars in the campus which cause traffic congestion and make bike trips unsafe. Problems from thefts also discourage staff and students from using bikes.

To promote traveling by bikes in KU, to reduce energy consumption, and to promote an environmental friendly and safe campus, “KU bike project - green campus healthy community” or KU bike project was introduced in late August 2009 (Vehicle, Building and Physical Plant Division [VBPD] 2009). At present, 870 bikes are provided for staff and students to borrow free of charge in Bangkhen campus. KU intends to allocate a budget of 8.55 million baht to supply 4500 bikes to its four campuses, and Bangkhen campus will receive a total of 1200 bikes in the future (Manager 2008). Along with the project, a budget of 10.8 million baht is available to improve bike facilities such as bike lanes to promote safe and pleasant riding.

After implementation of the KU bike project, feedback from students was examined to indicate improvements to the project. This study reports the results and provides suggestions to improve the project based on results from the research. Improving the KU bike project by considering user needs will make the project more acceptable and encourage staff and students to travel by bikes in the campus. Riding bikes will be popular in Bangkhen campus again.

2. PUBLIC-USE BIKE STSTEM

DiDonato et al. (2002) and DeMaio and Gifford (2004) describe that the first generation of the PUB system originated in Amsterdam, the Netherlands in 1968. This program provided normal white bikes, which were donated, for public use. However, the bikes were stolen and taken apart for spares. The program subsequently failed.

In 1995, the second generation of the PUB system was introduced in Copenhagen, Denmark (DiDonato et al. 2002 and DeMaio and Gifford 2004). The bikes were designed for very frequent use to reduce maintenance costs and were manufactured using nonstandard parts to prevent bike parts from stealing. To use the bikes, people pay a small deposit using coins. This could not safeguard the bikes from theft since borrower information was not recorded. To overcome this problem, a magnetic strip card was provided for the PUB system in Rennes, France in 1998 (DiDonato et al. 2002). Borrowers are required to insert the cards to release the bikes. The card has the borrower information, so the city can track the use of the bikes and address the problem of theft. However, the technology makes the system more expensive. Recently, a smart card contains a chip storing personal data and relevant information has replaced the magnetic strip card (DiDonato et al. 2002). This system allows people, who hold smart cards of other systems such as the subway system, to use the same cards for borrowing the bikes. The smart cards help to reduce the costs of the PUB.

Figure 1 presents “Vélib” a PUB system in Paris. Betts (2007) explains that this system was introduced in July 2007. About 20,600 bikes are provided at 1,450 rental bike stations around the city (Erlanger 2008). Borrowers can subscribe and return the bikes to any station. The subscription rate is based on half-hour periods at 1 euro for the first half hour and 2 euros for the second half hour, while the annual subscription rate is 29 euros (Betts 2007). Erlanger (2008) clarifies that a borrower’s credit card is required to sign up for the system and to rent the bike. A 150 euros deposit is

taken from the borrower’s credit card if the bike is not returned. The rental fee is cheap because the system is subsidized by advertising. At present, the system is very popular. It accommodates 120,000 trips per day. However, the system has been facing problems from traffic congestion and safety, vandalism and theft. At least 3,000 bikes have been stolen and three people have died on their borrowed bikes. Therefore, the city started a new safety advertising campaign in September 2008 to encourage vélib users to follow road rules.



A Vélib stand with bikes at a plaza in front of the Pompidou Center



Instructions for borrowers to keep the system “user-friendly”



A borrower has to use a swipe and chip card or a general credit card to release the bike from a bike attach point



A self-service pay station

Figure 1. A PUB System in Paris: Vélib

3. OVERVIEW OF KASETSART UNIVERSITY, BANGKHEN CAMPUS

Kasetsart University (KU), Bangkhen Campus was established in 1943 to provide agricultural education in the country. When there were a few roads in the campus and a small number of buildings located close to each other, bikes were the most popular and convenient mode for traveling inside the campus (Kasetsart

University Archives [KUA] 2009). At present, the number of bike users has fallen due to a higher number of cars that makes bike travel unsafe. Staff and students also have more choices of traveling since KU provides internal shuttle buses free of charge. Moreover, motorcycle taxis with affordable prices and fast services are available at the university main gates. Figure 2 presents the old and present KU internal transportation modes.



Figure 2. KU Mode Choices in the Old Days (VBPD 2009) and Today

Figure 3 shows that KU is surrounded by three arterial congested roads, Phaholyothin, Vibhavadi Rangsit and Ngamwongwan roads, and Bangkhen canal. The distance between Vibhavadi Rangsit and Phaholyothin is around 1.7 km which makes the KU area a “superblock”, and the KU internal roads are used as shortcuts by many car users. Although cars without KU stickers are not allowed to enter the university area, enforcement is lacking, and this rule is impossible to

implement in the case of taxis. Furthermore, Bangkok Metropolitan Administration (BMA) is going to construct a new road along Bangkhen canal. This will attract more cars to use the KU internal roads as shortcuts. However, two mass transit lines, the “Green” and “Red” lines, are planned to be constructed along Phaholyothin and Vibhavadi Rangsit roads, and are expected to reduce the number of cars commuting to the campus.

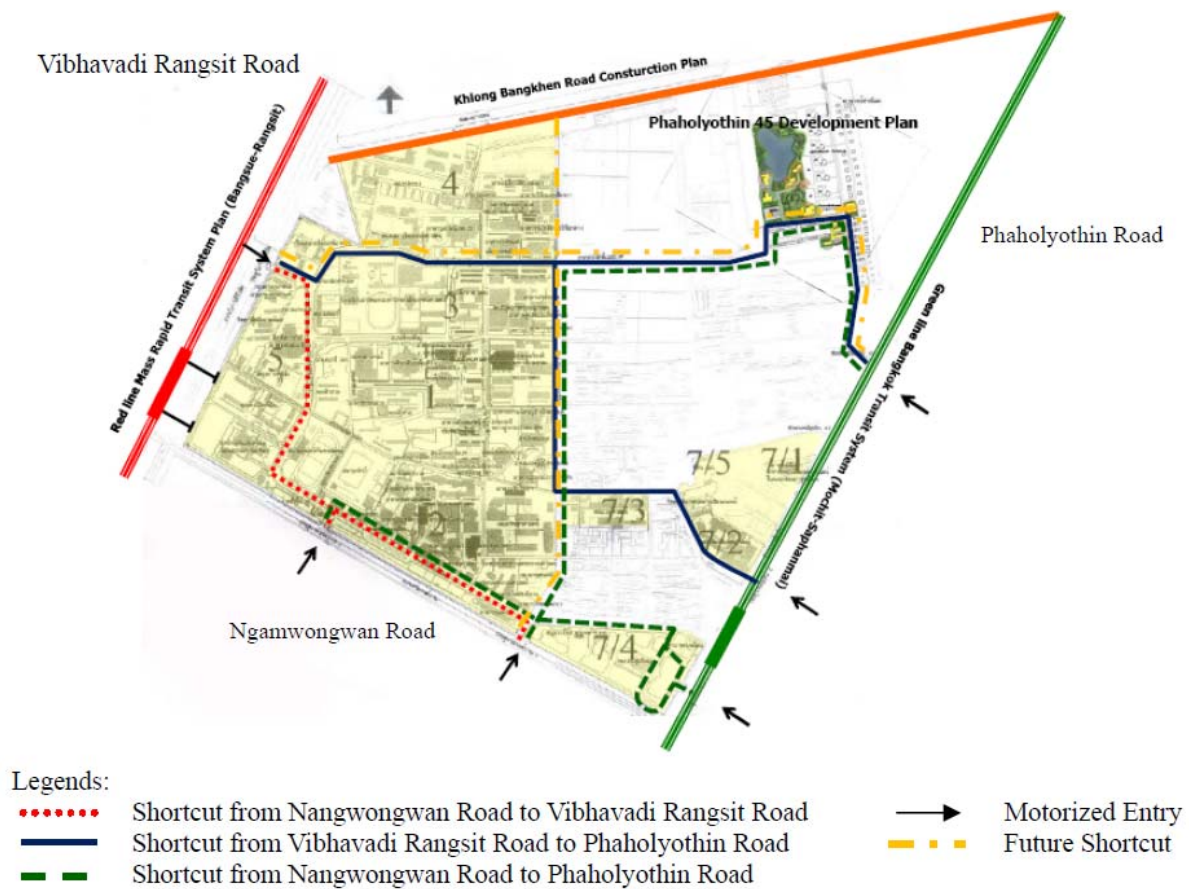


Figure 3. A KU Superblock

The KU campus lay-out adopted existing design concepts for government centers (Sunakorn et al. 2002). It has enclosed space that clearly separates it from surrounding areas. The KU superblock is separated into two main areas, the university area and the Ministry of Agriculture and Cooperative area, by an internal main road. The university area includes faculties, administrative and service buildings and student dormitories. The dormitories accommodate 1,800 students or around 5% of students. KU zoning is presented in Figure 4. The road network in the university area can be classified into 5 levels - main internal roads, collector roads, local roads, bikeways, and pedestrian walkway. The main roads are constructed as a four-lane ring road

surrounding the education area and linking to the three arterial roads. Inside the ring road, collector roads are arranged as a four-lane and two-lane grid-like road network linking different faculties and university administrative buildings together. The collector roads divide the education area into several small blocks. Inside the blocks, local roads with one-way systems and pedestrian walkways are provided. Sunakorn et al. (2002) revealed that with good traffic management, the small block areas can be converted to bike and pedestrian zones. In 2008, there was only one bikeway sharing road space with cars on a one-way system collector road. KU internal road network is presented in Figure 4.

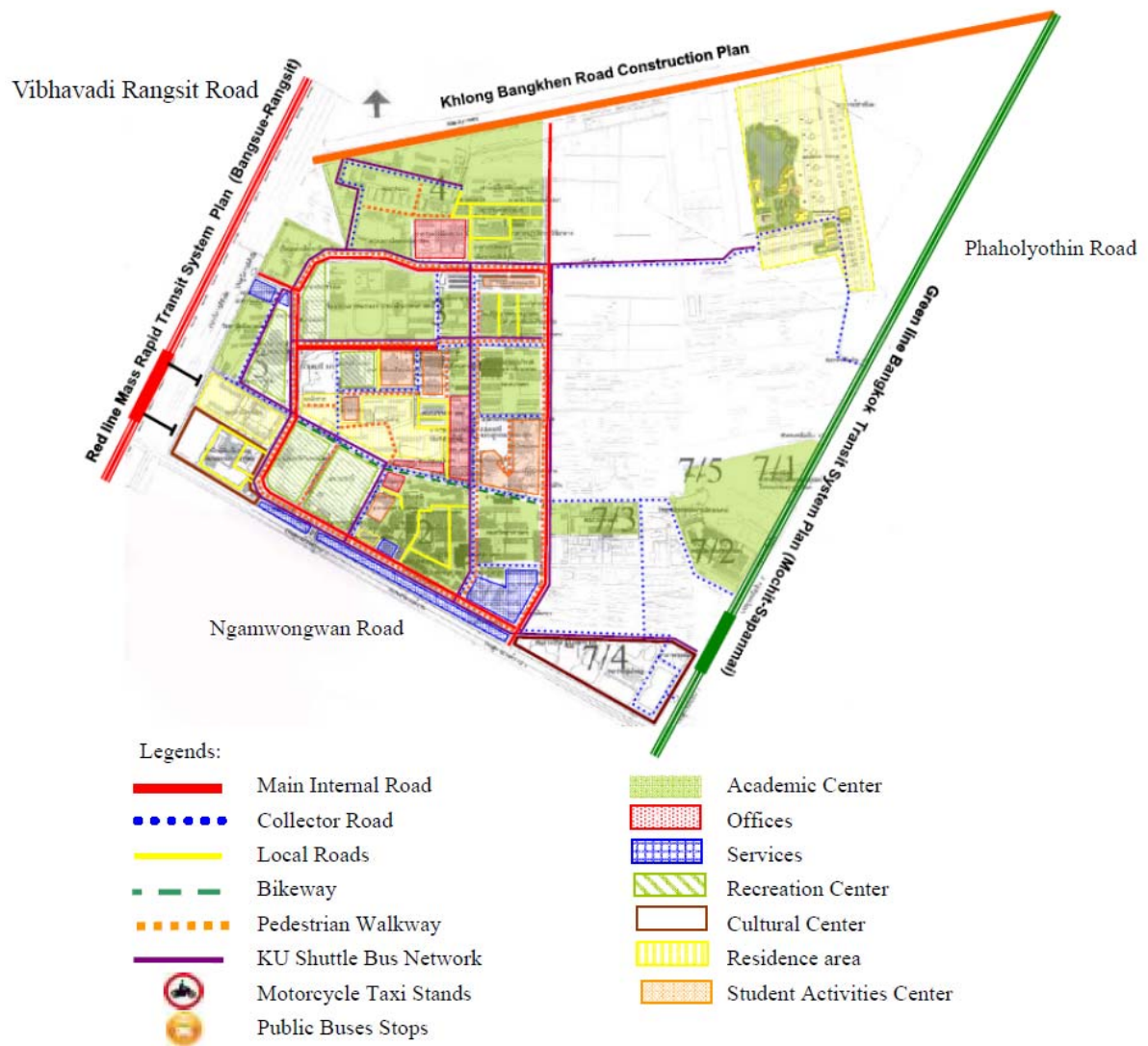


Figure 4. KU Zoning and Transportation Network

4. RESEARCH: A STUDY ON THE APPLICATION OF PUBLIC-USE BIKE SYSTEM IN KASETSART UNIVERSITY, BANGKEN CAMPUS

Trakulvech and Leopairojna (2008, 2009) conducted a research to apply a PUB system in KU. Questionnaire surveys were carried out to find user needs and opinions. Field surveys were performed to design a proper network for the PUB system.

Questionnaire surveys of 364 respondents were conducted during 18-28 January 2008. The respondents were representatives from all 14 faculties in KU. Revealed and stated preference approaches were applied to find characteristics of the respondents, their opinions about traveling in KU, and application of the PUB system including an appropriate PUB network. Information of the PUB system was also introduced to the respondents. A map of KU was provided to let the respondents identify an appropriate PUB network. Details of questionnaire items are presented in Box 1.

Box 1. Questionnaire Items

Part 1. Respondent characteristics: - Age - Gender - Status (staff or student) - Average monthly income - Mode selection for commuting - Approximate commuting expenditure	Part 3. Opinions about application of the PUB system: - Usage of PUB in KU - Appropriate PUB network - Responsible agencies - Appropriate locations for PUB stands - PUB fee - Rental fee system - Rental fee rate
Part 2. Opinions about traveling in KU: - Mode selection for traveling in KU - Ability to ride a bike - Usage of bike in KU - Obstacles in riding a bike in KU	

Results from the questionnaire surveys show that 114 respondents (32%) were male and 248 respondents (68%) were female while 2 respondents were not clarified. There were 337 students (93%) and 27 staff (7%) who answered the questionnaire surveys. Most of the respondents were undergraduate students (90%) aged between 21-30 years old (58%). Most of them had average monthly income of around 5,000-10,000 baht (49%) and 57% of them spent less than 1,000 baht per month for commuting between their accommodations and

KU. Their chosen travel modes were mainly public buses, walking, cars, and bikes for commuting between their accommodation and KU. Table 1 shows comparison between the respondent average monthly incomes and their mode selections. Most of the respondents travelled by public buses and had monthly income less than 5,000 baht. However, some of their monthly incomes (5,000-10,000 baht) did not corresponding with their mode selections (cars) since many students were taken to university by parents.

Table 1. Comparison between Monthly Incomes (Baht) and Mode Selections (Persons)

Mode selections	Average Monthly Incomes (Bath)						Total (Person)
	<5,000	5-10,000	10-15,000	15-20,000	>20,000	Not answer	
Cars	13	23	5	6	2	0	50
Motorcycle	0	6	1	0	0	0	7
Motorcycle taxi	6	14	7	0	0	0	26
Taxi	3	8	1	0	1	0	13
Public buses	71	50	8	1	1	1	132
Passenger vans	6	7	1	0	0	0	14
Bikes	16	16	2	0	0	0	34
Walking	16	34	3	0	0	1	54
KU shuttle buses	1	3	0	0	0	0	4
BTS	0	1	0	0	0	0	1
>one mode	13	15	1	0	1	0	30
Total	144	177	29	7	5	2	364

The respondents were asked to rank transportation modes for traveling inside KU. The most popular modes were KU shuttle buses, walking, motorcycle taxis, bikes and KU electric cars respectively. It found that 319 respondents (88%) could ride bikes but only 94 respondents (26%) traveled by bikes in KU. Reasons for traveling by bikes were convenience (67%) and to save travel costs (14%). The respondents who did not use bikes gave reasons that they did not own bikes (42%), riding bikes was inconvenient (10%) and bikes were stolen (6%).

Regarding obstacles to bike usage in KU, the respondents were asked to select and rank those that were most important to them. Table 2 shows that high numbers of cars and motorcycles, speed of cars and motorcycles,

thefts, female student uniforms that are unsuitable for riding bikes, and narrow bike lanes were selected as the important obstacles in that order. This table also shows that the respondents considered safety and convenience as the main obstacles while costs were not important.

Regarding usage of the PUB in KU, 57% of the respondents said they would use the PUB system, as presented in Table 3. In addition, 56% of the non-bike users and 60% of the existing bike users would use the PUB system. The PUB system would increase number of bike users in KU by 41% (150 respondents). The respondents gave the reason that the PUB system would make traveling by bikes in KU more convenient.

Table 2. Obstacles in Riding Bikes in KU

Obstacles in Riding Bikes in KU		Scores	Rank
Safety	High number of cars and motorcycles	223	1
	Speed of cars and motorcycles	192	2
	Thefts (Bikes were stolen)	135	3
	Bike lane is narrow	91	5
	Parked cars along roads	74	6
	Road surface is rough	49	7
Convenience	Female student uniforms are not suitable for riding bikes	95	4
	Bike racks and facilities	44	8
	Weather	33	9
	Broken link of the bike lane	26	10
	Travel time	23	11
	Shade along the bike lane	22	12
	Linkage between bikes and other public transportation	13	14
Costs	Bikes are expensive	14	13
	Maintenance costs	11	15

Table 3. Comparison between Present Bike Users and Proposed PUB Users

	Usage of the PUB system							
	Using bikes in KU		Will not use		Will use		Not answer	
	persons	%	persons	%	persons	%	persons	%
No	269	74%	116	(43%)	150	(56%)	3	(1%)
Yes	94	26%	35	(37%)	56	(60%)	3	(3%)
Not answer	1	0%	0	(0%)	1	(0%)	0	(0%)
Total	364	100%	151	41%	207	57%	6	2%

Most of the respondents (80%) agreed that the university should be the organization that operates the PUB system. Regarding rental fee, 38% of the respondents preferred to pay the fee based on a daily basis. Most of them (74%) agreed that the rental fee should be collected to cover costs of security guards and bike insurance. Regarding rental fee system, 21% of the respondents considered that a coin system was the most suitable system. However, the coin system cannot prevent the PUB bikes from being stolen (DeMaio and Gifford 2004) and therefore, a card system was recommended. The card can be integrated with staff and student ID cards similar to a library card system. The two most appropriate PUB stands were at KU main gates and in front of the academic and administrative buildings.

Table 4 presents a comparison between respondent characteristics and opinions about usage of the PUB system and shows that gender and status had no effect on whether a respondent “will not use” or “will use” the PUB system. Factors that influence the respondents to use or not use the PUB system were age, monthly income and selected commuting modes. Respondents who were older than 50 years, had a high income (>20,000 baht per month) and traveled between their accommodation and KU by car, answered that they would not use the PUB system. The respondents who will use the PUB system were younger than 50 years, had a middle income (<15,000 baht per month) and traveled by public transport or walking.

Table 4. Respondent Characteristics and Opinions about Usage of the PUB System

Respondent Characteristics		Opinions about usage of the PUB system			Total (persons)
		Will not use (persons)	Will use (persons)	Not answer (persons)	
Gender	Female	47	65	2	113
	Male	102	142	4	248
Age	< 20	54	81	2	137
	21-30	91	117	3	211
	31-40	1	3	0	4
	41-50	3	4	1	8
	>50	2	1	1	4
Status	Staff	13	13	1	27
	Student	138	194	5	337
Monthly income (Bath)	< 5,000	65	78	1	144
	5,000-10,000	67	108	2	177
	10,000-15,000	12	16	1	29
	15,000-20,000	3	3	1	7
	> 20,000	4	1	0	5
Mode selection for commuting to and from KU	Cars	25	20	1	46
	Private motorcycles	4	3	0	7
	Motorcycles taxi	9	16	1	26
	Taxi	3	10	0	13
	Public buses	50	80	2	132
	Passenger vans	5	9	0	14
	Bikes	16	18	0	34
	Walking	21	32	1	54
	KU shuttle buses	2	1	0	3
	BTS	0	4	0	4
	> one mode	1	0	0	1

The PUB routes and stand locations were determined using opinions from the respondents. Since it was found that the respondents, who commuted by public transport, would use the PUB system, the PUB routes were designed to link with existing and future transportation projects. The KU land

development project on Soi Phaholyothin 45 was also taken into account. Development of the PUB network is separated into 5 phases, as presented in Figure 5. In each phase, road environments should be improved to accommodate the bikes and allow the bike users to travel safely and conveniently.

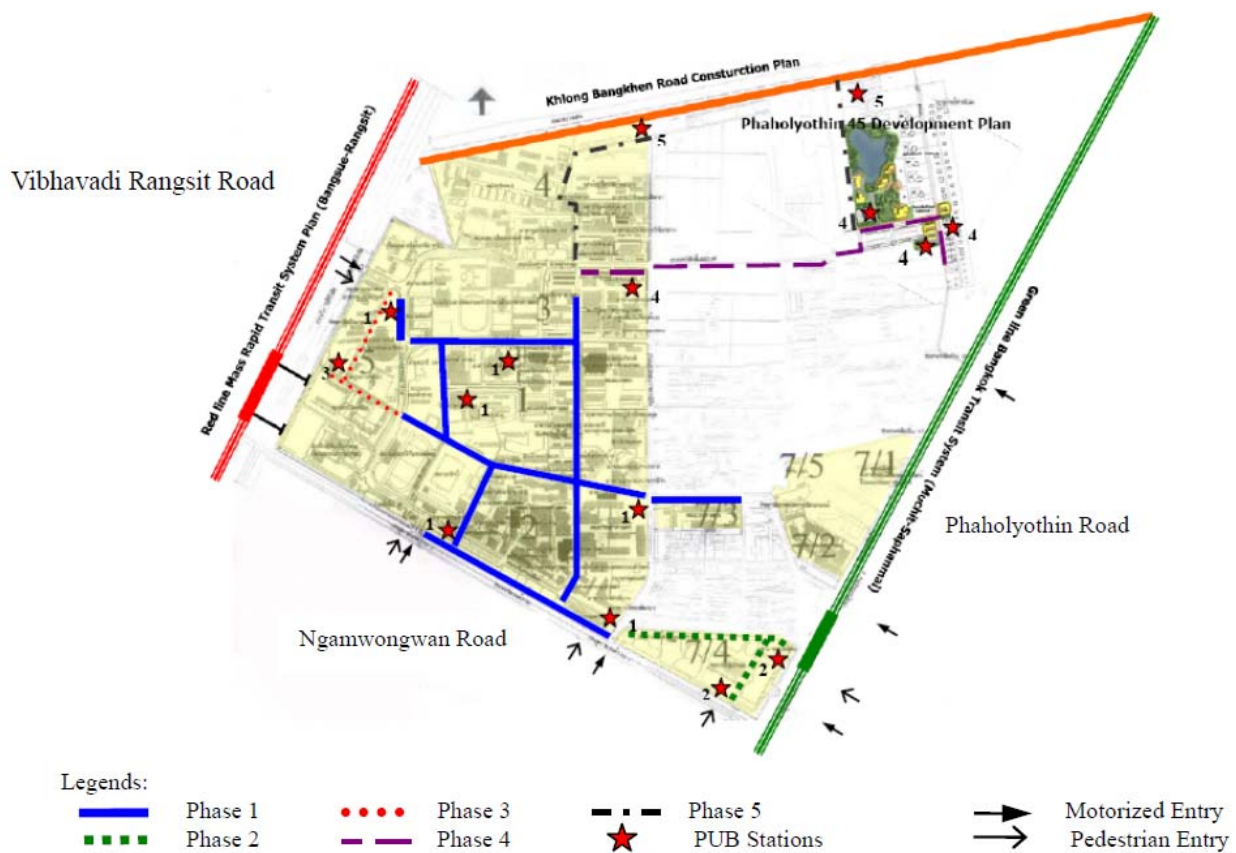


Figure 5. Development of the PUB Network

The Phase 1 PUB route was selected by the respondents as the most suitable route. It links KU activity nodes with public transportation outside KU. Figure 6 shows an existing of a road in KU and an example of its improvement

to accommodate bikes in the PUB program. In this phase, 6 PUB stands should be located at Ngamwongwan 1 and 2 and Vibhavadi Rangsit gates, KU post office, Learning Center 4 building and KU main cafeteria 1.

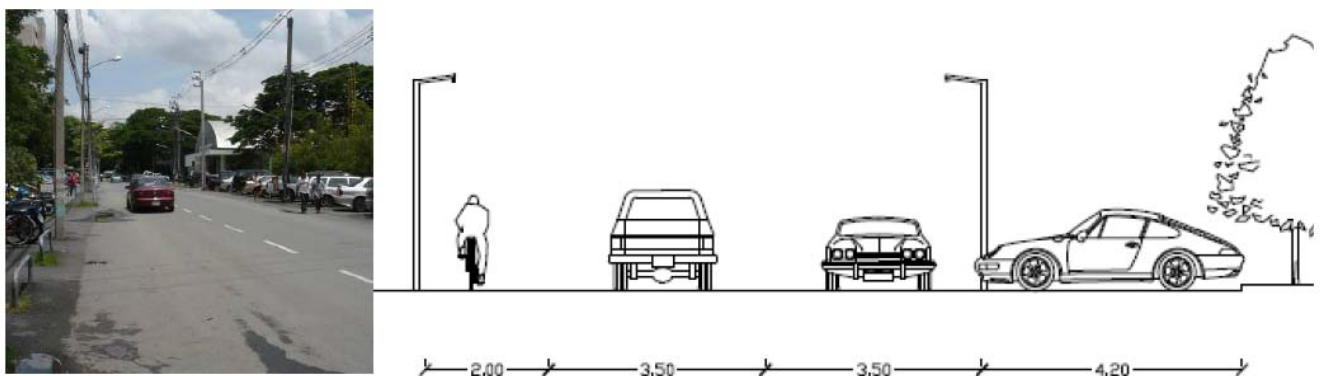


Figure 6. An Existing of a Road in KU and its Improvement

In the second phase, the PUB network would be extended to link with the Green Line mass transit project on Phaholyothin road. The Green Line is scheduled to start operation in 2013 (Office of Transport and Traffic Policy and Planning [OTP] 2007a). In this phase, 2 PUB stands should be added at a KU shuttle bus terminal near Phaholyothin road and a car park near a pedestrian access on Ngamwongwan road.

For the third phase, the PUB network would be extended to link with the Red Line mass transit project along Vibhavadi Rangsit road. The red line is scheduled to open in 2016 (OTP 2007b). KU should open a new pedestrian access close to the Red Line station. At the new access, a PUB stand should be provided.

The fourth phase should be in place when KU land development project on Soi Phaholyothin 45 is complete. The project was expected to be finished in 2018 (Sunakorn et al. 2006). The PUB network should be expanded to serve staff and students who live in the development project. The PUB stands should be located in front of a staff apartment, dormitories for male and female students, and at KU main cafeteria 2.

In the last phase, the PUB network should be linked to the proposed BMA road along Bangkhen canal. VBPD (2007) revealed that an opening date for this road cannot be determined since land acquisition is not complete. PUB stands were proposed at two future gates in front of the Faculty of Fisheries and the Phaholyothin 45 development project.

The research shows that most of the respondents revealed that they would use the PUB system in KU. However, it was found that the respondents were concerned about their safety in using bikes. Improvement of the road environment together with a bike safety policy and campaign are therefore necessary. In order to improve the road environment, a traffic calming concept should be applied to reduce the number and speed of cars and motorcycles. In the case of the bike safety policy and campaign, students should be encouraged to participate.

5. REALITY: THE KU BIKE PROJECT

“KU Bike Project -Green Campus Healthy Community” or the KU bike project was initiated by the KU in August 2009 to promote traveling by bikes in Bangkhen campus, to reduce energy consumption, and to promote an environmental friendly and safe campus. At present, 870 bikes are provided for staff and students to borrow free of charge. In the beginning, 70 bikes were provided at Vibhavadi Rangsit gate. In September 2009, an additional 100 bikes were supplied at Ngamwongwan 2 gate and a further 100 bikes were supplied at Ngamwongwan 1 gate afterwards. 300 bikes were provided to students living in the male dormitories while another 300 bikes were provided to students in female dormitories. Three offices inside KU are responsible for the bike project. VBPD is in charge for establishing rules, borrowing processes and providing bikes. The Student Affairs Division operates the bike project for students who live in KU dormitories. The Security Division provides security guards to operate the PUB system for staff and students at the main gates.

The PUB bikes are white. ID code is shown on each bike, as shown in Figure 7. The bikes for male and female students in the dormitories have ID codes ending with a letter “M” and “W” respectively. These students are allowed to borrow the bike for the whole semester. To borrow the bikes, they have to fill a form and submit a copy of their student ID cards. At the end of the semester, they must return the bikes in good condition and reapply if they want to continue using the bikes.

Staff and students are allowed to borrow the bikes from PUB stands at the three main gates, as shown in Figure 7. Their ID cards must be presented to a security guard who operates the PUB system. The bikes can be borrowed between 5am to midnight. The borrowers must borrow and return the bikes only at the same

stand. To prevent the bikes from theft, the borrowers have to bring their own bike locks to lock the bikes at provided bike racks. Before taking the bikes, the borrowers have to supply the following information: name, family name, student or staff ID code, division, faculty or office, year of study, borrowing date and time, bike ID code, and telephone number or cell phone number; in the borrowing record books. Condition of the bike should be checked before taking possession. On returning the bikes, the security officers check whether the bikes are in good condition and check that the ID codes match the records. The borrowers have to sign and write the time of return time in the record books and park the bikes in the PUB stands. Broken bikes must be fixed at the borrowers’ expense at the KU bike clinic which provides a cheaper service than external bike shops.



The white PUB bikes with ID codes



An advertisement shows that the PUB bikes are free of charge at the PUB stand at Ngamwongwan 2 gate



A security guard operates the PUB system at Vibhavadi gate



Rules are posted at the stand at Ngamwongwan 1 gate



Bike locks at the stand at Ngamwongwan 2 gate

Figure 7. The PUB System in KU

VBPD (2009) determines the rules and regulations for borrowing the PUB bikes. The borrowers are responsible for any damage or loss of the PUB bikes. In case of loss, the borrowers have to pay for the bike cost or buy new bikes that are similar to or as expensive as the PUB bikes. The borrowers are not allowed to modify the bikes, take the bikes outside the university area, park the bikes without locking or outside the bike racks provided, and must lock the bikes in the PUB stands. Borrowers who do not return the bikes before midnight, are put on probation or fined. Borrowers who do not return the bikes within 24 hours, are reported to their divisions and penalized afterwards. Borrowers, who fail to follow these rules are not be allowed to borrow the PUB bikes again.

6. FEEDBACK ON THE KU BIKE PROJECT

An interview with the Head of Student Services and Welfares, Student Affairs Division shows that there are problems in operating the PUB system. Filling borrower's information in the borrowing record book means that the borrowing process is slow. Separated PUB parking areas at the main gates are required. Some students and security guards do not know the rules. Some PUB bikes were taken outside the university area or parked at wrong locations. As a result of this, PUB rules are now posted at the PUB stands, as presented in Figure 7. In the future, KU plans to increase the number of PUB bikes and PUB stands. KU messengers will travel by bikes inside the campus. However, a budget is lacking, and KU has introduced a Bike Donation project to recruit bikes from alumni and donors. In addition, KU has a policy to limit parking

spaces. Car users will be allowed to park their cars only in car park buildings.

A small questionnaire survey with students in Faculty of Architecture and at KU Learning Center 3 building was conducted to find student feedbacks on the KU bike project. A total of 97 respondents were randomly requested to answer the questionnaire. There were 46 respondents from the Faculty of Architecture and 51 students from other 10 faculties such as the Faculty of Humanities, Faculty of Business Administration, Faculty of Engineering and Faculty of Social Sciences. The numbers of male and female respondents were 46 and 51 students respectively. Most of the respondents (93%) were able to ride bikes. However, 88% of them did not ride bikes in KU because riding bikes was inconvenient (42%), unnecessary (29%), and unsafe (10%), and they did not have bikes (11%). Regarding awareness of the KU bike project, 75% of them knew about the KU bike project from KU advertising boards, as shown in Figure 3, and had been told by their friends or teachers. However, only one respondent used to travel by the PUB system since she stays in a KU dormitory. The respondents did not use the PUB bikes due to the slow and complicated borrowing processes that requires students to fill in their information and bring their own bike locks (23%). Some students leave their bike locks at the PUB stands, as shown in Figure 7. Other negative reasons were that students have to pay when the bikes are lost or broken (13%), there are too many rules and regulations for borrowing the bikes (12%) and riding bikes was unsafe (12%). The respondents suggested providing the PUB stands in front of academic and administration buildings and at KU shuttle bus stops. Suggestions to improve the PUB system

were as follows: simplification of the borrowing process, provision of bike shelters at the PUB stands, promotion and advertisement of the PUB system, ability to return borrowed bikes to any PUB stand, and improvements in terms of road safety and safety from thefts.

Interviews with security guards, who operate the PUB system at the three main gates, show similar results to the questionnaire surveys. The bike project is not popular among staff and students. Seventy bikes have been provided at the PUB stand near Vibhavadi Rangsit gate since 25 August 2009 but only around 30 bikes are borrowed daily. Similarly, one hundred bikes have been provided at the PUB stand near Ngamwongwan 2 gate since 4 September 2009 but only around 40 bikes are borrowed daily. For the PUB stand near Ngamwongwan 1 gate, 100 bikes have been provided since 12 September 2009 but only around 30 bikes are borrowed daily. This means less than 50% of the bikes are borrowed. The rest of the bikes are left at the PUB stands that provide no shelter for the bikes from sunlight and rain. The security guards revealed that students complained about the slow and complicated borrowing process. In addition, some students were unhappy when they could not borrow the bikes since they did not bring their own bike locks. Regarding the PUB bike system in the dormitories, an interview with a staff in Student Affairs Division shows that the PUB system is popular among the students in male and female dormitories. In the last semester, all 300 bikes were borrowed in the female dormitories while around 250 bikes were borrowed in the male dormitories. At present, it is the university term break and all bikes are being checked and prepared for the borrowers in the next semester.

It is expected that the number of the borrowers will increase.

Although the research showed that 42% of the respondents did not use bikes because they did not own bikes and 57% of them would use the PUB system but the reality shows that the PUB system at the main gate is not popular while the PUB system in the dormitories is welcome by students. The main reason is the system at the gates is inconvenient. In addition, the free PUB bikes are not sufficiently motivating since the research shows that costs of buying bikes are not important to them. Furthermore, the research and the feedback show that the respondents are most concerned about safety: both road safety and security against theft.

To address these complaints, four scenarios based on convenience and safety issues are presented in Figure 8. For convenience, KU can choose to continue using the manual system or to invest in upgrading the PUB system as an automated system. In the case of safety, two conditions: improvement of safety and no improvement of safety, are indicated in the diagram. Scenario 4 shows that even if KU invests in changing the PUB system from manual to automated, the number of PUB bike users may or may not increase because the PUB system will be more convenient but still unsafe. Scenario 3 shows that with no improvement of the system and safety, the number of PUB and private bike users will not increase. Therefore, scenarios 3 and 4 are not recommended. Scenario 2 is recommended when KU has sufficient budget to change the PUB system from manual to automated system and to improve safety. Otherwise, scenario 1 is recommended since the research shows that the students were more concerned about safety

than convenience. The plan to provide 1,200 PUB bikes in this campus should be delayed and the budget for this should be re-allocated to improve bike safety. The inconvenient borrowing process but safe environment may or may not increase the number of PUB bike users

at the main gates, but the PUB bikes that are not borrowed at the main gates can be relocated to the dormitories. With a safe environment, the number of bike users of both private and PUB bikes should increase.

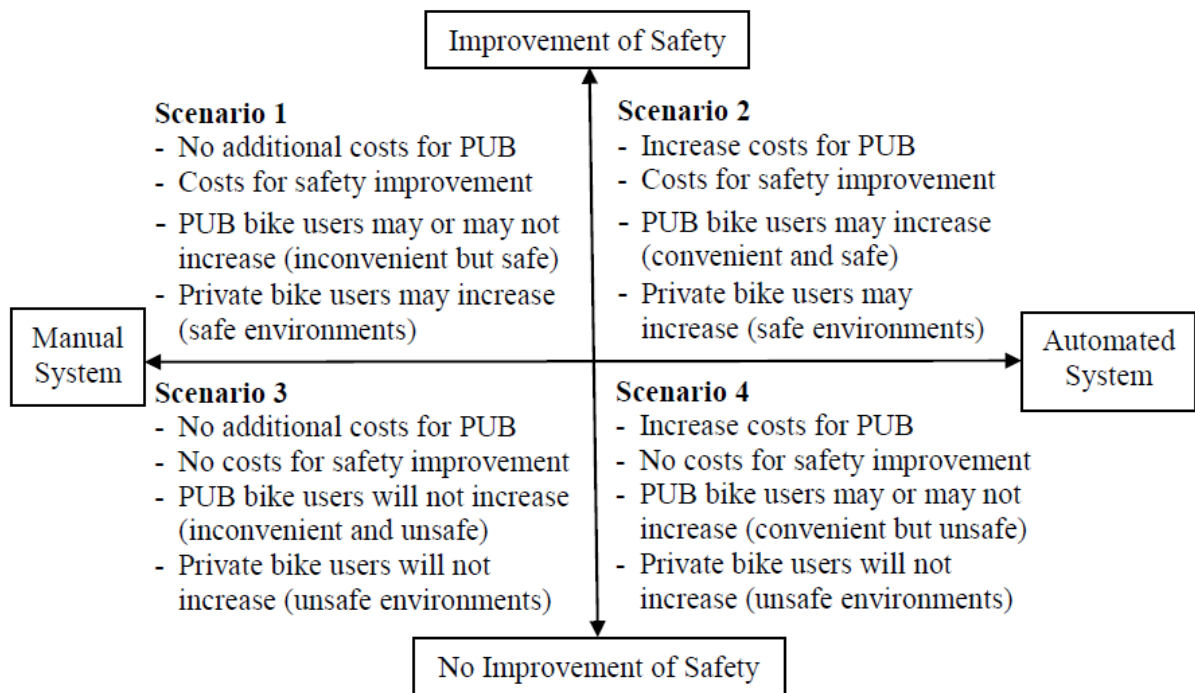


Figure 8. Four Scenarios for PUB System Improvement

7. CONCLUSIONS AND RECOMMENDATIONS

Bangkhen campus, KU is well known as a bike campus. At present, the number of bike users is in decline. KU has a policy to bring bikes back to this campus. Therefore, a public-use bike system (PUB) entitled the “KU bike project” was introduced to allow staff and students to borrow bikes free of charge. At present, a total of 270 PUB bikes were provided at three main gates and 600 PUB bikes were provided to students in dormitories. Although the research showed that the PUB system would increase

number of bike users for 41% but it was found that more than 50% of the PUB bikes at the main gates were not borrowed while 90% of the PUB bikes at the dormitories were borrowed. The main reasons that students did not borrow the bikes were that the borrowing processes at the main gates were inconvenient and the KU environment was unsafe in terms of road safety and security from theft. Upgrading the PUB system from a manual to an automated system and improvement of safety is recommended when KU has sufficient budget. Otherwise, improvement of safety should be given priority because the research shows that

the students were more concerned about safety than convenience. In addition, the research also shows that students considered that the costs of bikes were not an important factor since they can afford to have their own bikes. Therefore,

the budgets for providing additional PUB bikes should instead be re-allocated to safety improvements. With a safe environment, the aim of bringing bikes back to KU looks promising.

REFERENCES

- ASTV Manager Online. (2008) KU invested a budget of 18.5 million baht to bring bikes to the university. Manager. (Online). www.manager.co.th, September 8, 2009
- Betts, K. (2007) Paris's bicycle days. Time Magazine. (Online). www.time.com, October 8, 2009.
- Demaio, P. and Gifford, J. (2004) Will smart bikes succeed as public transport in the United States?, **Journal of Public Transportation, Vol. 7, No. 2**, 1-15.
- DiDonato, M., Herbert, S. and Vachhani, D. (2002) City-bike maintenance and availability. Bachelor of Science, Worcester Polytechnic Institute. (Online). www.hfcyclists.org.uk/cityBike.pdf, October 7, 2009.
- Erlanger, S. (2008) A new fashion catches on in Paris: cheap bike rentals. The New York Times. July 13, 2008. (Online). www.nytimes.com, October 8, 2009.
- Kasetsart University Archives. (2009) KU bikes. (Online). <http://archives.psd.ku.ac.th/kuout/p9021.html>
- Office of Transport and Traffic Policy and Planning. (2007a) Detailed design of the Green line extension (Mo chit – Saphan Mai). (Mimeographed)
- Office of Transport and Traffic Policy and Planning. (2007b) Detailed design of the Red line extension (Bang Sue-Rangsit). (Mimeographed)
- Sunakorn, P., et al. (2002) Physical impact due to organization growth, case study: Kasetsart University, Bangkhaen Campus. Kasetsart University. (Mimeographed)
- Sunakorn, P., et al. (2006) The research and development for master plan of Kasetsart University, Soi Paholyothin 45. Kasetsart University. (Mimeographed)
- Trakulvech, S. and Leopairojna, S. (2008) An application of public-use bike system in Kasetsart University, Bangkhen Campus. **Proceeding 13th National Convention on Civil Engineering**, Jomtien Palm Beach Hotel, Pattaya, Thailand, 14-16 May 2008.
- Trakulvech, S. and Leopairojna, S. (2009) Guidelines on applying public-use bike system in Kasetsart University, Bangkhen Campus. **Proceeding 47th Kasetsart University Annual Conference**, Kasetsart University, Bangkhen Campus, Thailand, 17-20 March 2009.

Vehicle, Building and Physical Plant Division. (2009) KU-bike KU-green campus healthy community. (Online). www.vehicle.ku.ac.th, October 1, 2009.

Vehicle, Building and Physical Plant Division. (2007) Information of the road project along Bangkok canal (additional) and a parking lot at KU post office. (Online). www.vehicle.ku.ac.th, June 9, 2008.