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PREFACE

Dear Readers,

Welcome to the second issue of volume 3 of our online-peer-reviewed International Journal of the Thai Society of Transportation and Traffic Studies. Four issues of the journal are published annually.

This issue covers a key response to the challenge of climate change resulting from the impact of GHG from transport sector. It is the growing supply of mass transit which is being studies in many developing countries

The issue contains 4 papers on mass transport, and a special topic on carbon storage in urban area. The first deals with the feasibility of subway extension for Ilsan line by considering the improvement of connectivity and accessibility with Paju as well as the balanced regional development of the northwest in Seoul Metropolitan Area. The second paper presents the characteristics of Vietnam's railways, the orientation for sustainable and sufficient development towards a modern rail system to meet the travel demand of the country. The development of high speed railway system on north-south corridor was also described.

The third paper addresses the development of Thailand intercity passenger rail transport system. Overview of the rail transport system was described in terms of transport demand, current situation of the system with key issues in rail development plans of State Railways of Thailand highlighted. The fourth paper in this series of mass transport describes a research in the development of a public transport system – the Bus Rapid Transit system in HCMC and how to attract ridership to the system.

The special topic addresses the carbon issue in the green growth scenario. It describes a method for estimating carbon storage in urban area with the use of satellite image.

We trust you will once again find these papers informative and useful.

PichaiTaneerananon
Professor
Chair of Editorial Board

Journal of Society for Transportation and Traffic Studies (JSTS)

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A FEASIBILITY STUDY OF SUBWAY EXTENSION FOR ILSAN LINE IN SEOUL METROPOLITAN AREA

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ABSTRACT:

Paju, locating in the northwest of Seoul Metropolitan Area, is one of the most dynamic and rapidly growing cities in Korea. It has been provided huge amount of housing units by new towns development without subway system. However, the residents of Paju have asked regional government to extend the Ilsan subway line for better accessibility to Seoul. Thus, this paper aims to analyze the feasibility of subway extension for Ilsan line by considering the improvement of connectivity and accessibility with Paju as well as the balanced regional development of the northwest in Seoul Metropolitan Area. The extension of Ilsan subway line was evaluated by future travel demand, economic effect, and cost-benefit analysis. It has found that the modal split of car, bus, and taxi will decrease gradually and the passengers of subway will increase in comparison with the non-execution of subway extension. The benefit of subway extension was more economically advantageous than development costs and will contribute to the improvement of residential and environmental quality.

KEY WORDS: Subway Extension, Feasibility Study, Travel Demand, Economic Effect, Cost-Benefit Analysis

1. INTRODUCTION

Paju, locating in the northwest of Seoul Metropolitan Area and at the border region of North Korea, is one of dynamic cities in Korea. The urban structure of Paju has been changed rapidly due to the continual development of economy and the pressure of development from adjacent cities such as Seoul and Goyang. It is consisted of 2 villages, 5 towns, and 9 townships in 672.5 ㎢ living 341,203 persons. There is big different development demand between southern and northern part. The southern part of city developing rapidly as industrial and residential demand shows high population growth and improves not only residential but also environmental quality. However, many of manufacture factories, leisure facilities, and residential sites are scattered along the highways and major arterial streets. On the other hand, the northern part of the city does not have development demand by locating closely to demilitarized zone (DMZ). In 1996, Paju which was consisted of several rural townships and villages became an urban city. It has possessed gradually urban aspects and functions. The development of industrial and residential sites leads to make modern urbanforms. However, the city has lack of centripetal force and requires functional connection among the small CBD of towns and townships. Therefore, to identify stable city image and a balanced development, new towns of city should be developed as a focal town of the city. Since the year of 2000, annual population growth rate across the country appeared to be 0.60% over the last 9 years. However, the population of Paju increased 230,000 in 2001 to 330,000 in 2009, showing the high increase of 6.25%.In terms of the change in car ownership across the country, car ownership increased from 12,910,000 in 2001 to 17,330,000 in 2009, showing the average annual increase of 4.13%. However**,** the average annual increase of car ownership for Paju showed 9.58%, which exceeds 2 times more than that of adjacent cities.

Figure 1 Location of City of Paju

In addition, technology innovation network of high-tech knowledge-based industries in Paju has been established through the continual attraction of high-tech industry by geographical advantage and transportation accessibility in Seoul Metropolitan Area. The competitiveness of local enterprises in Paju has been strengthened through the technology development of joint industry-academy and technology exchange system. Due to the effective development and affordable supply of land as well as housing shortage in the Seoul Metropolitan Area, several new towns in Paju are developed to provide 78,454 households at EunJeoung new town and 10,412 households at Kyoha new town without subway system. Thus, the residents of new towns have insisted on providing convenient public transportation system to city of Seoul. The purpose of study is to examine the need to extend subway of Ilsan Line for the improvement of connectivity and accessibility to Paju

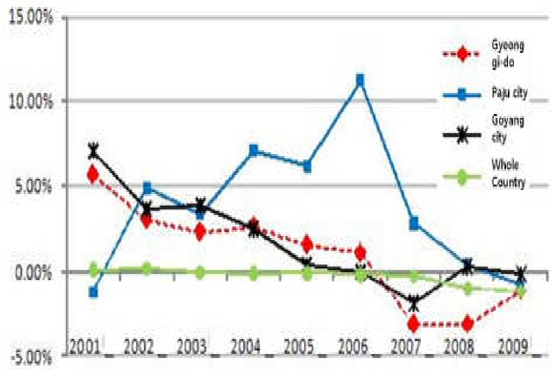

Figure 2 Changes in Population Growth

2. RESEARCH DESIGN AND METHODOLOGY

This study investigates the feasibility of the extension of Ilsan subway line according to the continual travel demand to the direction of Seoul from Paju. The feasibility is examined by future travel demand, economic effect, and cost benefit analysis. In terms of travel demand, traffic volume is estimated with the model of four-step travel demand forecasting by reflecting future social economy indicators after examining high-ordinate plans, the plans of relevant local government entity, the plans of city development, and land development plans based on the survey on current social and economic condition. The four-step travel forecasting model is divided into 4 steps: trip generation, trip distribution, mode choice, and trip assignment. These steps are the forecasting methods that are sequentially conducted. These methods estimate trip influx volume and trip inflow volume according to zones by the future indicators such as social and economic indicators or land using plans. Economic effect is examined by an Input-Output analysis (I-O Model) which can identify the correlation of inter-industry quantitatively. It starts with a drawing of input-output table, which is the statistical table that records transactional relations of all goods and services, produced in the country. Input-output table represents inter industry table targeting particular region for the analysis of interdependent relationships between regions and industries by reflecting different production technology structure of regions and transactional forms. For the cost and benefit analysis, the costs of subway construction were calculated by applying cost items presented by Korea Development Institute(KDI). The benefits of subway construction were calculated by the benefits of vehicle operating cost savings, benefits of travel time reduction, benefits of traffic accident reduction, and benefits of environmental cost reduction using appropriate equations. The extension of Ilsan subway line is reviewed by 2 different alternatives as shown Figure 3. An alternative 1 is to construct 4 stations with13km. extension from Daehwa station(Existed station) of Ilsan line to the Unification park station. An alternative 2 is to open the section from Kyoha station to the Unification park station as the second step in 2016 after the first step of total 5km extension from Ilsan line to Kyoha station. The 2 different alternatives were compared by future travel demand and cost benefit analysis.

3. FORECASTING TRAVEL DEMAND

3.1 Future Travel Demand

(1) Trip Generation

The trip generation of each traffic zone is forecasted based on future social and economical factors. Trip generations of both home-base trip and non-home-based trip were forecasted by the regression model of Seoul Development Research Institute. The whole linked trip volume in Seoul Metropolitan Area will increase by 26,744,000 trips in 2036 with the average annual increase of 0.31%. It is estimated that linked trip volume per person will decrease from 2.11 trips in 2011 to 1.98 trips in 2036.

(2) Trip Distribution

Fratar Model shown below is applied to forecast trip distribution among traffic zones. It repeats several times until the value of both Fi and Fj reaches 1.

$$T_{ij} = t_{ij} \times F_i \times F_j \times \frac{(L_i + L_j)}{2} \quad \text{(Eq.1)}$$

$$L_i = \frac{\sum_{j=1}^{2} t_{ij}}{\sum_{j=1}^{2} F_j \cdot t_{ij}}, \qquad L_j = \frac{\sum_{i=1}^{2} t_{ij}}{\sum_{i=1}^{2} F_i \cdot t_{ij}} \quad \text{(Eq.2)}$$

Investigating the distribution of total linked trip volume in Seoul Metropolitan Area, home-based commuting is estimated to gradually increase with 37.5% of the whole trip in 2011, and it is estimated that it will show the highest trip volume in 2036 with 38.7%. It appears that home-based attending school trip is the second trip volume with 16.7% of the whole trip in 2011. However, since population of students by ages shows a tendency of decrease due to the low-birth rate, home-based attending school trip will decrease with 11.4% of the whole trip even though home-based other trip will increase by 19.9%. It appears that shopping trip is on the gradual increase in both home-based trip and non-home based trip.

(3) Modal Split

(3.1) Forecasting of Trip Volume in the Non-Execution Project

It is estimated that total modal trip in Paju under the direct influence will increase from 1,289,000 in 2016 to 1,363,000 in 2036. In particular, it is estimated that the modal split of car will decrease from 51.77% in 2016 to 46.38% in 2036. It is forecasted that the modal split of car, bus, taxi, and railroad will increase 46.38%, 36.52%, 1.97%, and 15.13% respectively in 2036. It is estimated that the modal split of public transportation will gradually increase.

(3.2) Forecasting of Trip Volume inExecution of Project

① Alternative 1

An alternative 1, which extends Ilsan subway line for 13km from Daehwa station to Unification park station, is estimated that car, bus, taxi, and railroad will reach 538,762, 392,558, 22,755, and 408,500 trips/per day respectively in 2016. Examining the change of modal split, it is estimated that modal split of car, bus, and taxi in 2036 will decrease by 39.54%, 28.81%, and 1.67% respectively in comparison with the non-execution, while it is estimated that modal split of railroad will increase by 29.98% after the execution of the project in comparison with 15.13% in the non-execution as of 2036.

② Alternative 2

Alternative 2 extends Ilsan subway line for 5km from Daehwa station to Kyoha station as a first step until 2015 andaims at extending the subway from Kyoha station to Unification park stationafter 2016 as a second step. As a result of forecasting the trip volume according to modes, it is estimated that the modal split of car, bus, and taxi in 2016 will increase 46.50%, 29.47%, and 1.29% respectively. The modal split of car, bus, and taxi for Alternative 2 will increase slightly higher than those of alternative 1, while the split of the railroad will decrease from 25.62% in alternative 1 to 22.74% in alternative 2 as of 2016.

(3.3) Comparison of Trip Volume beforeand After the Execution of the Project

In terms of the modal split of alternative 1 in 2016, the modal split of car, bus, and taxi will decrease by 6.72%, 7.51%, and 0.33%, while the modal split of railroad will increase by 14.56%. In the case of alternative 2, the increase of railroad split in alternative 2 will be slightly lower than alternative 1, showing the increase of 11.68%. Investigating transference trip volume of modal trip before and after the execution of the project as of 2036, car, bus, and taxi will decrease by 93,210, 105,100, and 4,066 trip/per day respectively, while it is estimated that the modal split of car, bus, and taxi will decrease by 7.59%, 8.21%, and 0.44% respectively in comparison with the modal split of the non-execution.

3.2 Change of Subway Demand before and after the Execution of the Project

(1) Change in the Travel Demand of Ilsan Existed Line (Jichuk-Daehwa)

It is estimated that travel demand between Jichuk station and Daehwa station on Ilsan existed line will increase from 55,000 person/day in 2016 to 65,000 person/day in 2036 in the non-execution of project, with the average annual increase of 0.85%. In the case of executing the extension in the section from Daehwa station to Unification park station in alternative 1, it is estimated that Ilsan existed line (Jichuk-Daehwa) will increase from 92,000 person/day in 2016 to 97,000 person/day in 2036. In the case of executing only the extension between Daehwa station and Kyoha station as of 2016 in alternative 2, it is estimated that Ilsan line will be 79,000 person/day, showing a decrease of 12,000 person/day in comparison with alternative 1.

(2) Change of the Travel Demand in the Ilsan Extension Line (Daehwa-Unification Park)

As a result of travel demand forecasting in the extension section of Ilsan subway line, it is estimated that the demand from Daehwa station to Unification park station in alternative 1 will increase from 34,849 person/day in 2016 to 35,647 person/day in 2036, with the average annual increase of 0.11%. In terms of travel demand between Daehwa station and Kyoha station in alternative 2, it is estimated that travel demand will be 5,878 person/day as of 2016, but it is estimated that it will decrease by 29,001 person/day in comparison with alternative 2.

4. ANALYSIS OF ECONOMIC EFFECT FORSUBWAY EXTENSION

The economic effect, affecting each industry is analyzed by estimating expected construction amount around Gyeonggi Province after estimating production inducement coefficient, value added inducement coefficient, and employment inducement coefficient by using regional input & output table of 2005, announced in August, 2009 from the Bank of Korea. The cost of extending Ilsan line to Paju is estimated approximately 553.7 billion won.

(1) Analysis on Production Inducement Effect

It is calculated with multiplying investment costs that are invested to the extension of subway to values in which the production inducement coefficient of 19 business types is added. As a result of analyzing local industry inter table, presented by the Bank of Korea, production inducement coefficient in Gyeonggi Province, Seoul, and Incheon is calculated to be 1.35, 0.15, and 0.09 respectively as shown Table 1. The business type of the greatest production inducement effect is construction field, which is followed by non-metallic mineral production, metal production, real estate, and business service.

In the estimation of total business budget in the extension of subway line, production inducement effect within the region of Gyeonggi Province will be 746 billion won. Production inducement effect of Seoul and Incheon will be 83 billion won and 49.4 billion won respectively. If these costs are added, production inducement effect in Seoul Metropolitan Area is calculated to be 878.4 billion won.

(2) Analysis on Value-Added Inducement Effect

If subway extension amount is multiplied to the addition of value-added inducement coefficient in business types in accordance with the increase of final demand, value-added inducement amount would be calculated. Once total extension costs in the subway are estimated to be 553.7 billion won, the value-added inducement effect within the region of Gyeonggi Province will be 332.2 billion won. If value-added inducement effect costs of Seoul 44.8 billion won and Incheon 13.5 billion won are added, value-added inducement effect in Seoul Metropolitan Area is estimated to be 390.5 billion won.

Table 1 Region Production Inducement Coefficient

Coefficient	Gyeonggi	Seoul	Incheon
production inducement coefficient	1.35	0.15	0.09

Table 2 Region Added Value InducementCoefficient

Coefficient	Gyeonggi	Seoul	Incheon
production inducement coefficient	0.58	0.08	0.02

(3) Analysis on the Employment Inducement Effect

Employment inducement scale will be estimated if extension investment amount in the subway is multiplied to the addition of employment inducement coefficient in business types according to the increase of final demand. The business type of the greatest employment inducement effects is construction field, which is followed by metal production, and non metal mineral production. If subway extension costs are estimated to be 553.7 billion won, employment inducement scale within the region of Gyeonggi Province will be 7,305 persons, and if employment numbers of Seoul 814 persons and Incheon 203 persons are added, employment inducement scale in the metropolitan areas is calculated to be 8,322 persons.

5. ANALYSIS ON THE COST AND BENEFIT

5.1 Estimation of Cost

(1)Alternative 1

In terms of investment costs in alternative 1, construction costs and annual operating expenses are estimated to be 553.7 billion won and 12 billion won.

By the investment plan, investigation and basic design are performed in 2011~2012, and construction will be executed in 2013~2015, and subway will open in 2016. It is planned that construction costs will be input annually by 30%, 40%, and 30% from 2013 to 2015. The costs of basic design, execution drawing, supervision, investigation, surveying, system engineering are included in incidental expenses. 45% of incidental costs will be used in 2011 and 55% will be used in 2012. 40% of the land acquisition cost will be paid in 2013, which is the closing point of investigation and basic design about the extension line, and other 60% will be paid in 2014. 10% of the total cost for construction, incidental, and land acquisition in each business year is set as a reserve fund. Labor costs, power costs, maintenance costs, and general management costs are included in operating expenses. These costs are input from 2016 when extension line is constructed.

Table 3 Region Employment Inducement Coefficient (Unit: Person/10 hundred million won)

Coefficient	Gyeonggi	Seoul	Incheon
production inducement coefficient	0.58	0.08	0.02

Table 4 Cost Calculation Alternative 1 (Unit: hundred million won)

Division	Construction Cost
A.Construction Cost	4,019.0
A-1.Civil	2,581.2
A-2.Railroad	273
A-3.Architecture	292.4
A-4.System	507
Total(A1~A5)	3,653.6
A-6.Added value tax	365.4
B. Incidental cost	339.9
C. Site compensation cost	674.5
D. Preparatory cost	503.3
Total Project Cost	5,536.7

Table 5 Manage Cost Calculation Alternative 1 (Unit: hundred million won/year)

Division	Cost
A. Personnel cost	29.6
B. Electric power cost	10.6
C. Maintain management	69.2
D. General management	10.9
Annual manage Cost	120.3

(2) Alternative 2

(2.1) Propulsion of the First Step (Sectionfrom Daehwa station to Kyoha station)

The costs of the first step are estimated with construction costs, 265.4 billion won, and annual operating costs 5.1 billion won.

In terms of the investment plan of the first step, investigation and basic design will be performed in 2011~2012, and construction will be executed in 2013~2015 for opening in 2016. It is planned that annual construction costs are input by 30%, 40%, and 30% every year from 2013 to 2015. The costs of basic design, execution drawing, supervision, investigation, surveying, system engineering are included in incidental expenses. 45% of incidental costs will be used in 2011 and 55% will be used in 2012. 40% of the land acquisition cost will be paid in 2013, which is the closing point of investigation and basic design about the extension line, and other 60% will be paid in 2014. 10% of the total cost for construction, incidental, and land acquisition in each business year is set as a reserve fund. Labor costs, power costs, maintenance costs, and general management costs are included in operating expenses. These costs are input from 2016 when extension line is constructed.

(2) The Propulsion of the Second Step (From Kyoha Newtown to Unification Park)

The costs of the second step are estimated with business costs, 288.3 billion won, and annual operating costs 12 billion won. In terms of the annual investment plan of the second step, investigation and basic design will be performed in 2016~2017, and construction will be executed in 2018~2020 for opening in 2021. It is planned that annual construction costs are input by 30%, 40%, and 30% every year from 2018 to 2020. The costs of basic design, execution drawing, supervision, investigation, surveying, system engineering, which are performed for 2 years at the early period of the project, are included in incidental expenses. 45% of incidental costs will be used in 2016 and remaining 55% will be used in 2017. 40% of the land acquisition cost will be paid in 2018, which is the closing point of investigation and basic design about the extension line, and other 60 % will be paid in 2019. 10% of the total cost for construction, incidental, and land acquisitionin each business year is set as a reserve fund. Labor costs, power costs, maintenance- costs, and general management costs are included in operating expenses. These costs are input from 2021 when extension line is constructed.

Table 6 Cost Calculation Alternative 2
(Unit: hundred million won)

Division	Construction cost
A.Construction Cost	2,083.1
A-1.Civil	1,383.7
A-2.Railroad	105
A-3.Architecture	210
A-4.System	195
Total(A1~A5)	1,893.7
A-6.Added value tax	189.4
B. Incidental cost	172.4
C. Site compensation cost	157.4
D. Preparatory cost	241.3
Total Project Cost	2,654.2

Table 7 Manage Cost Calculation Alternative 1
(Unit:hundred million won/year)

Division	Cost
A. Personnel cost	15.9
B. Electric power cost	4.3
C. Maintain management	26.6
D. General management	4.46
Annual manage Cost	51.3

5.2 Estimation of Benefits

1) Benefits of Vehicle Operating Cost Savings

It is realistic that travel speed can be different from different types of vehicles, but it is difficult to reflect it in current trip assignment model. Therefore, the premise that there would be no division in the speed of different vehicles was set in order to calculate vehicle benefit. The vehicle operating cost savings (VOCS) of each year is calculated as following:

$$VOCS=VOC_{\text{Execution of Project}}- VOC_{\text{Non-execution of Project}} \quad \text{(Eq.3)}$$

Where

$$VOC=\sum_{l}\sum_{k=1}^{3}(D_{kl}\times VT_{k}\times 365)$$

D_{kl} = Link(l), Vehicle(k) a car·km

VT_k = Vehicle(k) Speed of the link road vehicle cost per km

k = Vehicle(1: Passenger Cars, 2: Bus, 3: Luggage car)

According to the extension of Ilsan line, benefit of vehicle operating cost savings is estimated to be about 6.5 billion won in 2016 alternative 1. Meanwhile, in the case of alternative 2, benefits of vehicle operating cost savings are estimated to be about 4.1 billion won. However, since benefits will continually increase until 2036, it is expected that benefits will be about 8 billion won in both alternative 1 and alternative 2.

Table 8 Benefits of Vehicle Operating CostSavings (unit: 100 million won/year)

Years	2016	2021	2026	2031	2036
Alternative1	65.05	69.01	87.71	66.58	80.20
Alternative2	40.95	69.01	87.71	66.58	80.20

(2) Benefits of Travel Time Savings

In terms of benefits of travel time savings, total travel time is calculated by using the multiplication of link travel time and traffic volume of vehicles under the direct influence, calculated as a result of trip assignment. Travel time savings are calculated by comparing differences after the calculation of total travel time costs by applying time value to total travel time, calculated according to modes in non-execution and execution of the subway extension. The value of travel time savings (VOTS) are as follows:

$$VOTS=VOT_{\text{Execution of Project}}-VOT_{\text{Non-execution of Project}} \quad \text{(Eq.4)}$$

Where

$$VOT=\{\sum_{l}\sum_{k=1}^{3}(T_{kl}\times P_{k}\times Q_{kl})\}\times 365$$

T_{kl} = Link(l)trael time of the vehicle

P_k = Vehicle(k) time value

Q_{kl} = Link(l) of the vehicle traffic

k = Vehicle(1: Passenger Cars, 2: Bus, 3: Luggage car)

In the case of alternative 1 in 2016, benefit of travel time savings according to the extension of Ilsan subway line is estimated to be about 42.8 billion won. In the case of alternative 2, benefit is estimated to be about 31.5 billion won. However, since benefit continually increases, about 55.9 billion won is estimated to be generated in both alternative 1 and alternative 2 by the year of 2036.

Table 9 Benefits of Travel Time savings (Unit: 100 million won/year)

Years	2016	2021	2026	2031	2036
Alternative1	428.2	594.6	582.8	620.2	559.2
Alternative2	315.2	594.6	582.8	620.2	559.2

(3) Cost Reduction Benefit of Traffic Accident

The cost reduction of traffic accident is calculated by multiplying the length of link to link traffic volume as a result of trip assignment to calculate road types of express highway, national road and local road. Traffic accident costs are calculated in regard to non-execution and execution of the project by multiplying basic unit of traffic accident costs and casualty number of traffic accidents according to road types, and then cost reduction benefit of traffic accident is calculated by using differences. The formula of VACS for the cost reduction benefit of traffic accident is calculated as following:

$$VACS_{Road}=VAC_{Execution\ of\ Project}-VAC_{Non\text{-}execution\ of\ Project} \quad \text{(Eq.5)}$$

Where

$$VAC_{Road}=\sum_{t=1}^{3}\sum_{s=1}^{2}(A_{ts}\times P_s\times VL_t)$$

A_{ts} = Types of road accidents sector one hundred million- Number of traffic wonded per km

P_s = Accident types accident costs

VL_t= Annual road types one hundred million a car – km

t = Road types (1: High way, 2: National road, 3: local road)

s = Accident types(1:Death, 2:Wounded)

It is estimated that cost reduction benefit of traffic accident will be about 300 million won in the case of alternative 1 in 2016, while the benefit of 200 million won will be generated in the case of alternative 2. However, since cost reduction will continually increase, cost reduction benefit about 400 million won in both alternative 1 and alternative 2 will be generated by the year of 2036.

Table 10 Cost reduction Benefit of TrafficAccident (Unit:100 million won/year)

Years	2016	2021	2026	2031	2036
Alternative 1	2.74	3.26	3.12	3.39	3.54
Alternative 2	1.90	3.26	3.12	3.39	3.54

(4) Benefits of Environmental Cost Reduction

(4.1) Estimation on the Benefit of Air Pollution Reduction

Air pollution costs are calculated by applying basic unity of air pollution costs according to running speed by using running speed and traffic volume, calculated as a result of trip assignment, targeting links under the direct and indirect influence of the subway project. Put simply, air pollution costs in individual link is calculated by multiplying link with the results of multiplication of each link traffic volume according to car types and lengths, loaded in analysis road network with the basic unit of air pollution costs in car types based on average link speed. The benefit of air pollution reduction is calculated with differences in non-execution and execution of the project.VOPCS formula in regard to the benefit of air pollution reduction of each year is as following:

$$VOPCS=VOPC_{Execution\ of\ Project}-VOPC_{Non\text{-}execution\ of\ Project} \quad \text{(eq.6)}$$

Where

$$VOPC=\sum_{l}\sum_{k=1}^{3}(D_{lk}\times VT_k\times 365)$$

D_{kl} = Link(l), Vehicle(k) a car·km VT_k=Vehicle(k) Rate p air pollution costs

k = Vehicle (1: Passenger Cars, 2: Bus, 3: Luggage car)

(2) Calculation on the Benefit of Noise Reduction

Benefit of noise reduction, EVN of each analysis year is represented as follows:

$$EVN = EVN^{o} - EVN^{c} \quad \text{(Eq.7)}$$

Where
EVN = Noise Costs(Benefit)
EVN^{o} = Noise Costs in the Execution of Project
EVN^{c} = Noise costs in the Non-execution of Project

$$EVN^{k} = \sum_{i}\sum_{j} Pl_{ij}L_{ij} \quad \text{(Eq.8)}$$

Where
P = the basic unit of Noise Values
l_{ij} = the extension of subject line
L_{ij} = Noise Prediction
I = Classification of Road and Railway (Road, Highway, Railway, High-Speed Rail)
k = (o = in the non- execution of Project, c = in the execution of project

It is expected that about 1.3 billion won will be generated in 2016 in the case of alternative 1 with the benefits of environmental cost reduction that add reduction costs of air pollution and noise according to the extension of Ilsan subway line, while about 700 million won will be generated in the case of alternative 2. However, it is expected that the benefit of about 1.5 billion won will be generated in both alternative 1 and alternative 2 with the continual increase of reduction benefits by the year of 2036.

Table 11 Benefits of Environmental Cost Reduction (Unit: 100 million won/year)

Years	2016	2021	2026	2031	2036
Alternative 1	13.3	8.98	12.5	8.96	14.82
Alternative 2	6.54	8.98	12.5	8.96	14.82

Table 12 Results of Cost-Benefit Analysis

Division	B/C	NPV (100 million won)	IRR (%)
Alternative 1	1.07	397	6.3
Alternative 2	1.18	883	8.0

6. CONCLUSION

The feasibility on the extension of Ilsan subway line was verified by forecasting future traffic volume, economic effect, and cost benefit analysis in view of rapidly increasing population and the condition of surrounding development. It is estimated that the modal split of car, bus, and taxi will decrease gradually and the passengers of subway will increase in comparison with the non-execution of extension.It is estimated that the economic benefits of residents in Paju will increase from 50.9 billion won in 2016 to 65.8 billion won in 2036. Regarding the methods of cost benefit analysis, Benefit/Cost Ratio(B/C), Net Present Value(NPV), Internal Rate of Return(IRR) by applying the discount rate of 5.5% are calculated to be 1.07, 39,7 billion won, and 6.3% for alternative 1. Meanwhile, B/C, NPV, and IRR in alternative 2 are estimated to be 1.18, 88.3 billion won, and 8.0% respectively. Therefore, economic efficiency is shown in both alternative 1 and alternative 2, and economic efficiency is estimated to be high when each subway section is open by phases rather than opening the whole section. The benefit of extension line was more economically advantageous than development costs. Therefore, the extension line of Ilsan line will contribute to the improvement of urban life quality and environmental quality.

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THE ORIENTATION FOR SUSTAINABLE AND SUFFICIENT DEVELOPMENT OF RAILWAYS IN VIET NAM

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ABSTRACT:

This paper presents the characteristics of Vietnam's railway with existing weakness, the orientation for sustainable and sufficient development, towards a modern rail system, to meet the travel demand of the country. It includes the development of high speed railway system on north-south corridor.

KEY WORDS: Transport planning, Railways development, Sufficiency transport, Sustainable development

1. GENARAL ABOUT VIET NAM RAILWAY

At present day, the rail network of Viet Nam is approximately 2,600km of single &non – electrified track. Vietnam Railways network connects residential area to cultural, agricultural and industrial center, except the Mekong river delta area and Highland area.

The former national railway network was put in disrepair as a result of the war and neglect during that time. Since then much of the focus has been in the rehabilitation of the network.

However, track infrastructure remains unsatisfactory with problems of weak bridges and bottlenecks, i.e. restricted speed sections, as well as numerous at – grade crossings with the roads.

The system utilizes mainly single track and narrow gauge with maximum passing capability of 25 up and down trains per day. Signal and communication systems are outdated.

Typical operating train speeds are as follows:
(1) Hanoi – HCMC Line: 90% at 70 – 80km/h;
(2) Hanoi – HaiPhong Line: 94% at 70km/h;
(3) Hanoi – Lao Cai line: 63% at 45 – 55km/h, 14% at 70km/h; and
(4) Hanoi – Lang Son Line: 47% at 40km/h and 34% at 70km/h.

Rail condition between Hanoi and HCMC: manually managed at – grade crossings.

Rolling Stock of rail network: 346 diesel locomotives, of which 291 are operational. About 75% are greater than 15 years old; most of them are more than 20 years old.

There are 842 passenger cars and 4,856 wagons (Source: Vitranss 2, May 2010).

Table 1 The length of Vietnam railway network

Main routes	Length (km)	Track gauge
1) Ha Noi - Ho Chi Minh city	1726	1000 mm
2) Ha Noi - HaiPhong	102	1000 mm
3) Ha Noi - Lao Cai	296	1000 mm
4) Ha Noi - Dong Dang	163	dual gauge (1435 &1000 mm)
5) Ha Noi - QuanTrieu	75	dual gauge (1435 &1000 mm)
6) Kep – Uong Bi - Ha Long	106	1435 mm
7) Kep - LuuXa	57	1435 mm

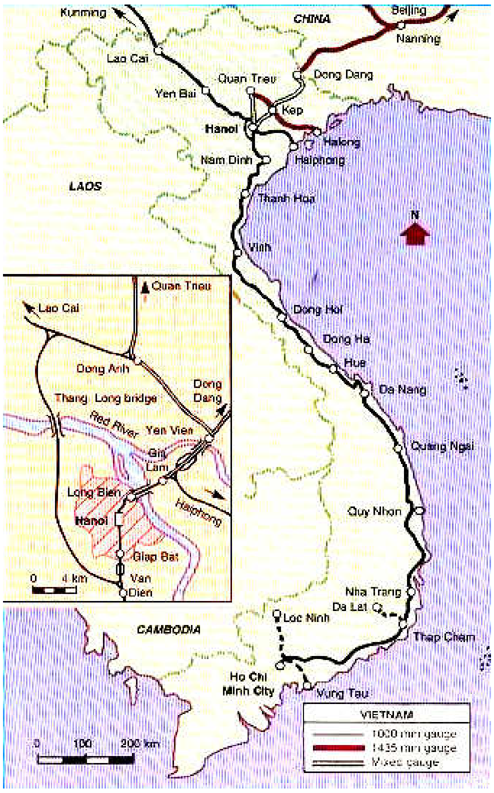

Figure 1 Existing railway system

General service: in the main corridor North – South alongside the country: 7 couple trains run every day on Ha Noi– Ho Chi Minh city railway line, with the travel time from 29.5 to 40.8 hours. Beside main corridor railway, there are some regional passenger trains for other rail lines: Yen Vien – Ha Long, Ha Noi – HaiPhong, Ha Noi – Lao Cai, Ha Noi – Dong Dang, Ha Noi – QuanTrieu etc. The safety issues: in 2010, happened 482 accidents, with 230 fatalities, increased 7.5 % in comparison with 2009.

2. ORIENTATION OF RAILWAY DEVELOPMENT

According to The Overall Strategy for Transport Development to 2020 and Vision to 2030, by the Prime Minister’s Decision no. 35/2009/QD–TTg dated 03/03/2009, in relation to intercity passenger transport, some main contents are described below:

For railway development**:** complete renovation and upgrading of existing railway lines to reach the technical standards for the national railway and the region to achieve speeds of 120km/h; building new high speed railway (HSR) lines; give priority to building north - south high - speed rail line with a speed of 350 km/h. Rapidly develop rail transport in urban area, internal suburbs railway, play an important role of public passenger transport, in the first time, give priority to deploy in the capital of Hanoi and Ho Chi Minh City.

Development goals of transport by 2020:To develop appropriate all modes of transport. Railway transport mainly take on long – distance with cargo and passenger transport; and on medium distance, which also has a large volume of passenger transport between cities, urban zones and public passenger transport in the big citiesVision to 2030**:** to2030 will be fundamentally perfects transport network in the country as well as external traffic corridors. Ensure the quality of transport to reach the international standard:

quiet convenient, fast, safe and reasonable connection between transport modes, especially among long - distance passengers transfer point with passenger transportation in cities. Basically complete construction of North - South expressways and high speed railways (HSR). System of roads, railways of Vietnam is sync with technical standards, facilitate connection with a road system in ASEAN, and expand the Mekong sub-region and Trans-Asia railway.

The Development Strategy for Vietnam Railways to 2020 and Vision to 2050, no 1686/TTg dated 20/11/2008 and The Adjusted Master Plan for Vietnam Railways Development 2020, vision to 2030, no 1436/QD-TTg dated 10/09/2009, are other most important documents, approved by the Prime Minister. By this document, railway infrastructure needs to focus its investment priorities to be one step ahead, quick, synchronous, reasonable, combining firm development steps, to break through to go straight on modern, to motive for promoting the socio – economic development of country; to develop international railway network to link with foreign ports and countries with the same common border, to promote international integration, to fast develop urban rail network for core of public transport in big cities, with immediate priority for Hanoi capital and Ho Chi Minh.

Railway transport development towards a modern, high quality, reasonable cost, fast, safe, energy saving, environmental protection, saving society cost; associates with major centers of commodities distribution, with land ports (ICD) and other transport modes; undertakes long-distance transporting, high volume, urban public passenger transport , focuses to services for inner city - suburban passenger, meets the needs of socio - economic development .

Specific objectives

- **to 2020 year** Railway transport shall take a share the demand at least 13% on passengers turnover and 14% on goods turnover of the whole transport volume; in which urban passenger transported by rail at least 20% of public passenger transport demand in Hanoi capital and in Ho Chi Minh

- **Period to 2030** the proportion will reach 20% of the transport needs on passengers & goods; will reach 25% of the needs on public passenger transport in urban areas.

To formulate and promulgate mechanisms to encourage all economic sectors to participate in the railway transport investment & business, striving to attract non – government budget capital for infrastructure construction at least 10% (to 2020) and 20% (to 2030) of total investment.

Figure 2 Conventional Railways planning to 2003

The railway development Planning are defined as follows:

• **By 2020** to complete construction works:

- Renovation and upgrading the existing railways.
- Some first sections of North - South high speed Railway,
- Some railways: Yen Vien - Pha Lai - Ha Long - CaiLan, Bien Hoa - Vung Tau, Lao Cai - Hanoi - HaiPhong, Dong Dang - Hanoi, Railway for servicing bauxite exploit (DakNong - BinhThuan)
- Railways connecting to ports, industrial parks, economic zones, mines zone etc

• **By 2030** complete construction:

- The rest of high speed north - South railways
- Highlands railway network, consisted of main axes: Da Nang - Kon Tum - DakLak - Buon Ma Thuot - Chon Thanh - Ho Chi Minh City and the branch railways: Buon Ma Thuot - TuyHoa, DakNong - BinhThuanetc

3. THE HIGH SPEED RAILWAY IN THE NORTH – SOUTH CORRIDOR

Methodology

- Base on the social-economic development needs of country and the national target in period of 2020-2030
- Forecast the travel demand in the most important corridor of the country, with the characteristics of the urban areas stretching across this corridor. To develop the scenarios and to choose development options
- Analyze and evaluate the impact of the route uninterrupted HSR for travel demand and urban development, industrial parks, tourism and services in the future.
- Learn the experience from other countries in the construction of HSR.
- Analysis the economic - financial efficiency and environmental impact of projects.
- Develop the necessary mechanisms and policies, focusing more funding resources to mobilize

The first pre-feasibility study with four options have made by The Transport Investment & Construction Consultant Joint Stock Company (TRICC JSC) of Viet Nam Railways. It was submitted to the Prime Minister to prepare the project of north-south high speed railway. The study present the explanation of the research and selection, specifying the four options for transporting passengers and goods by rail on the North - South corridor.

In 2030, passenger demand on North -South corridor in both directions will be 195 million pax/year for inter-provincial trips. By 2030, if not build high speed rail, the total capacity of all modes of transport on the North - South corridor will be only about 138 million pax/year; Thus, lack of 57 million pax/years. With HSR, the high capacity is about 100-140 million pax/year in both directions.

Option 1 is to expand the existing railway line (single track, 1000 mm gauge) into the 1435 mm gauges railway and build one more 1435 mm line for double track line.

Option 2 is the removal of existing rail line to build the modern double 1435 track lines with the speed of 200km/h, using only a part of existing railway.

Option 3 is to upgrade the existing rail line for short term demand and concurrently to build new second double track line of 1435 mm gauge for both cargo and passenger transport, with operating speed of 200 km/h.

Option 4 is to upgrade the existing railway lines to meet the local needs, and also to build double track of high speed rail from Hanoi to Ho Chi Minh City, with 300 km/h speed of exploitation. Design speed of 350 km/h.

After carefully analyzing the optionsmentioned above, the Government proposed selection option 4.

About the elimination of option 1 and 2, reported that, these two options for actual construction of the 1435 mm gauge railway are based on the current basis of 1000 mm railway. So the construction would not be feasible due to the expansion of at least 15m, the resettlement work is great for clearance, the land acquisition in urban areas is not feasible. In addition, the construction will disrupt traffic on the railway between Hanoi and Ho Chi Minh City.

For Option 3, the transportation of both passengers and cargoes on the new double track of 1435 mm gauge railway will increase the volume of transport goods, but will limit passenger transport, because it can not run fast passenger trains. Meanwhile, in the natural conditions of Viet Nam, for transporting cargoes in north - south corridor, can use the sea and road transport for share.

By this study for HSR, accordingly, in the period of 2020-2025, expected to put the Hanoi-Da Nang and NhaTrang-HCMC routes in exploitation.... By 2030, will put the Vinh - Danang route to exploit and in 2035 will explore the entire line of HSR.

Expected total cost of project implementation is about 56 billion USD.A part of project cost will be invested by the State, a part by debt and a part by funding of businesses. To mobilize capital from all economic sectors. State capital will be available at a reasonable level for "stimulus" to the project in the early stages.
Regarding funding, the first phase of construction (expected before 2025) will need about average 3-4 billion USD/year.

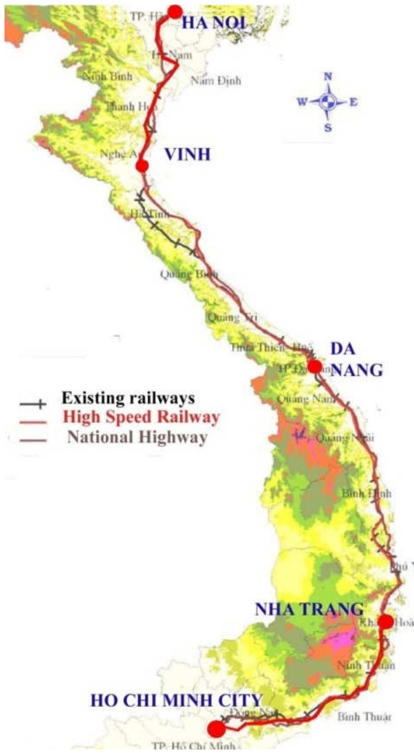

Figure 3 High speed railways planning

In our country today, the fares of North-South route railway are between 40 -60% of economy class airfare. So in the assumption fare by scenario of the project, the using the fare for high speed rail by 50% - 75% of economy class airfare is acceptable.

In the Analysis Report, the total investment in transportation at present is only 7% of the total social investment. Counting the project ofhigh-speed railway with capital mobilized above-mentioned, the investment for transportation is in the range of 10 to 15% of the total social investment.

The Basic Plan for The North-South High-Speed Railway was presented in The Comprehensive Study on the Sustainable Development of Transport System in Vietnam (VITRANSS 2). Travel Time Hanoi – HCMC is estimated with Max. speed of 300km/h as: 6 hours 50 minutes when stopping at all 26 stations; 5 hours 40 minuteswhen stopping at 6 priority stations only. The total length of the completely new alignment would be 1,570km.

4. CONCLUSION

The Government is expected to ensure arrangements the state budget for infrastructure components (about 31 billion USD), while the transport rolling stock component will mobilize investment of enterprises (about 10 billion USD), based on the kinds of PublicPrivate Partnership (PPP) and Private Sector Participant (PSP). Element to change the preliminary total investment is mainly the compensation for site clearance, estimated about 1.8-2.5 Bill.USD.

Although the preliminary financial analysis is not so high, but must take into account the general efficiency of economic development - social as well as the joint interdisciplinary pervasive effect of the project, and reduction in road traffic accidents.

The opinion of the Ministry of Transport is still to continue to study more, to give the efforts in some next years to be able to keep the land demarcation for the project. The land use planning will avoid huge clearance work later. Construction projects required by Congress, while planning of the land is the authority of the Government.

To further scrutinize the economic - technical solutions and policy mechanisms, to ensure the feasibility of the project

Learning more experience, exchange and cooperation with other countries, including the Asian countries construction and exploitation of HSR

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THE FUTURE OF INTERCITY PASSENGER RAIL TRANSPORT SYSTEM IN THAILAND

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ABSTRACT:

This paper describes development of Thailand intercity passenger rail transport system. Overview of the rail transport system is described in terms of transport demand, current situation of the system. Important issues in rail development plans of State Railway of Thailand are highlighted. The paper discusses issues and challenges facing the rail development which include high speed rail issue, OD survey between Bangkok and eight provinces show intercity bus and private car dominate short and medium distance and air transport the long distance. Rail is not popular for travel due to problems and limitations: time delay, rail accidents, lack of signaling equipment at junctions, insufficient number of locomotives, and low service quality. The constraints on government budget for investment in the high-speed train project, the PPP approach is deemed most appropriate. The private sector is to develop the project on a Build-Transfer-Operate (BTO) basis.

KEY WORDS: Intercity rail system, Rail transport development

1. INTRODUCTION

1.1 History of Railways in Thailand

The development of rail infrastructure started in the reign of King Rama V (1868 – 1910). The first railway in Thailand was a private line connecting Bangkok with Paknam, a distance of 21 kms on meter gauge track. Originally the Northern and Eastern Railways were controlled by the Northern Railway Authority, whereas services west of the Chao Phraya River operated by the Southern Railway Authority. The Northern Railway used Standard Gauge (1.435m) but The Southern Railway adopted Narrow Gauge (1 meter). In 1920 Narrow Gauge was adopted as the national standard. Conversion of the network was completed in 1930. The Royal State Railways of Siam was first established under the Ministry of Public Works in October 1890, and was divided into two departments, namely Northern and Southern Railways, which were finally merged into one and became the Department of the Royal State Railways of

Siam June 5th, 1917. On July 1st, 1951, RSR changed its name to the present State Railway of Thailand (SRT), which gained control of the whole system, and by which time most of the present network had been constructed.

1.2 Objectives

The objectives of this paper are to review the rail transport system in Thailand and to propose the policies for the system enhancement in the future.

2. OVERVIEW OF RAIL TRANSPORT SYSTEM

2.1 Rail transport demand

Currently, government is implementing the development of infrastructure of both urban and intercity projects. However, most investment projects are in road infrastructure development.

Road is the dominant mode in passenger intercity transport and in 2006, the modal shares of the passengers were 85% of all modes. Although road transport has capacity constraint for large amount of passengers and freight as compared to rail mode, rail transport is not popular in Thailand due to the lack of system development, service and operation improvement, and poor maintenance. Thus, the modal shares of rail transport are only 6% for passengers. (TDRI, 2009)

Travel volumes on public transport during the five-year period (2005– 2009) showed an average of 460 million passenger-trips/year. The proportion of passengers choosing to travel by intercity buses was a predominant 87%, followed by the rail and air modes, at 10 % and 3% respectively. Intercity bus and airline riderships showed average increases of increased 7.9% and 5.8 % per year respectively, while the rail ridership showed an average drop of 2.1% per year. (Figure 1 and 2)

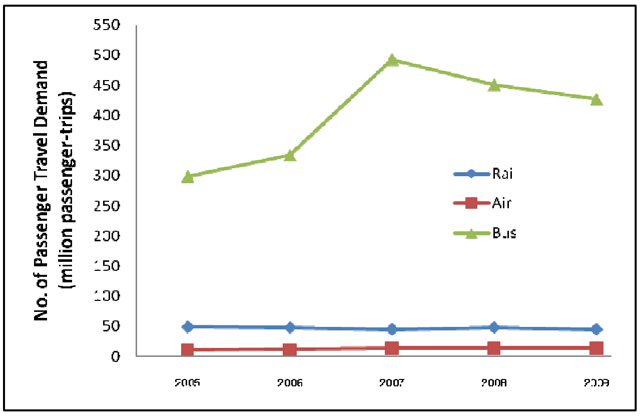

Figure 1 Intercity passenger travel demand by mode, during 2005-2009

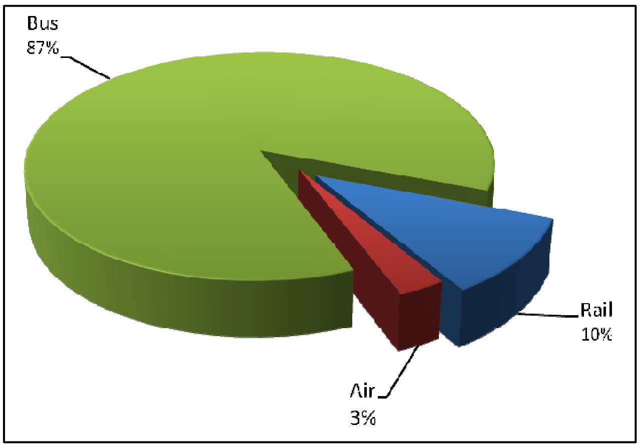

Figure 2 Mode share of intercity transport for ridership

2.2 Performance of RailTransport System

The State Railway of Thailand (SRT) is in charge of rail network and system development, operation, and maintenance. As shown in Figures 6 - 9, railway infrastructure of the SRT (TDRI, 2009) consists of: (Figure 3)

- railway network which covers 47 provinces (from the total of 76 provinces),
- total length of 4,129 km. which includes 3,881 km. (94%) of single track 165 km. (4%) of double track, and 83 km. (2%) of triple track,

- track gauge is one meter standard gauge,
- rolling stock totals 209 units (only 136 units or 65% are in operation),
- sleepers: main route - wooden sleeper 1,381 km. (31%) and concrete sleeper 3,047 km. (69%).
  : Mae Klong junction - wooden sleeper 34 km. (53%) and concrete sleeper 31 km. (47%),
- 442 railway stations,
- 260 railway bridges and tunnels,
- 7 inland container depots (ICDs) = (2 ICDs are under SRT and other 5 ICDs are owned by private companies), and.
- 11 container yards (CY).

3. RAIL TRANSPORT DEVELOPMENT PLANS

3.1 Potential Role of Railway in Intercity Transport

Trend in total number of passengers by intercity rail mode continues to decrease until in 2007, when the total number of passengers gradually increases, this is due to the government's policy on free 3rd class trains. Most of intercity passengers travel between Bangkok and the provinces. Figure 4 shows the city size distribution in selected provinces.

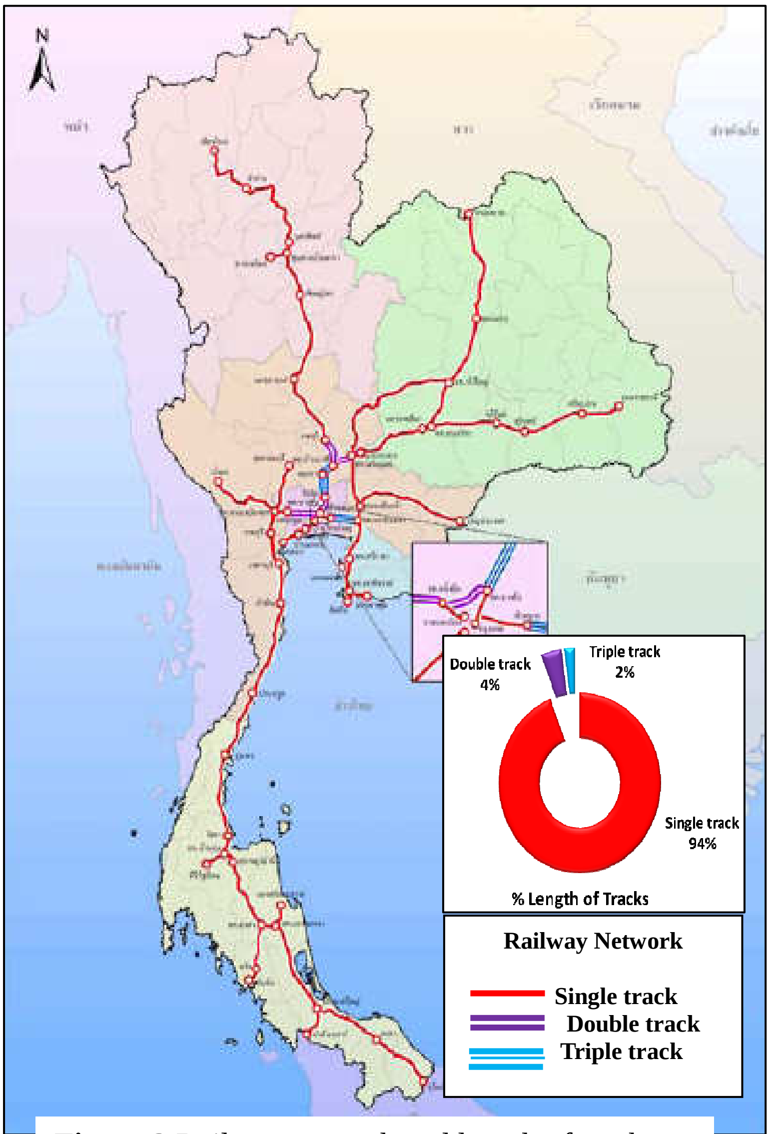

Figure 3 Railway network and length of tracks
Source: SRT

The first rank city is Bangkok compared to other regional cities. Bangkok, the capital of Thailand has a population of some 7 million, about 15 times the size of the next largest regional city. Provincial people migrate from to Bangkok to find jobs and improve quality of their life. Over the long weekends of New Year and Songkran (Thai New Year in Mid-April) festivals, people go back to their hometowns and thus creating huge intercity transport demand. Intercity bus is the dominant mode for passenger travel, making up about 39.1% of all demands, followed by private car (32.2%) and other modes (37.7%) including van, train, air (NSO, 2009).

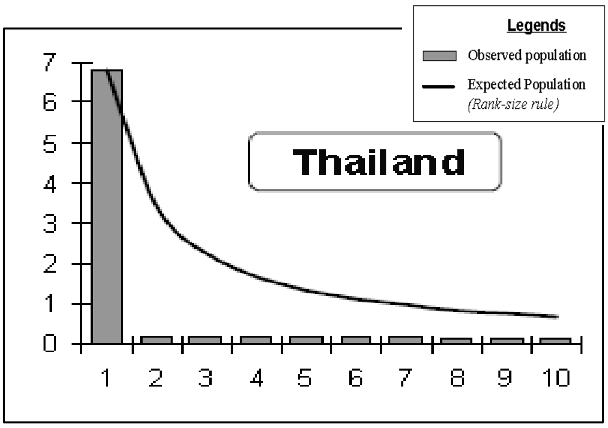

Figure 4 City-size distributions in selected provinces
Source: Adapted from UN, 2003

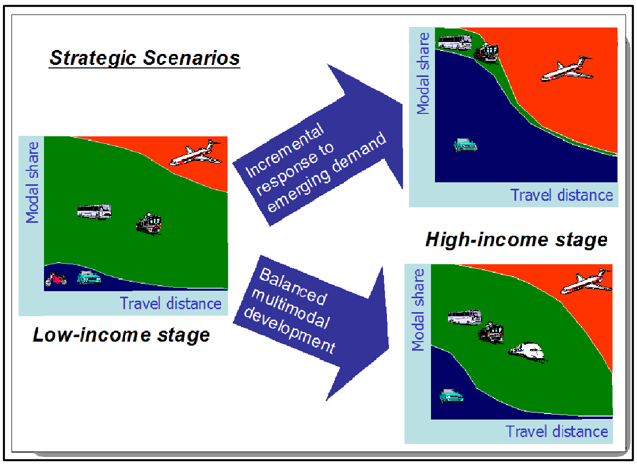

Figure 5 Dynamics of model share for intercity transport
Source: ITPS, 2010

Figure 5 shows the dynamics of modal share for intercity transport with dynamics of mode choice behavior between modal share and travel distance. The figure illustrates the relations between travel distance and modal share of the low-income and high-income people. For the long trip, the low-income people use intercity bus and rail. On the other hand, the travel behavior of the high-income people can be classified into two cases:

1) If existing policy of incremental is continued, private car dominates short distance while air dominates medium and long distance intercity transport,

2) If proactive policy of promoting multi modal transport, modal shares and travel demand are adjusted to balance multimodal development (Morichi, 2005). It is clear from the figure that rail transport can play an important role for an average citizen wishing to travel medium to long distance.

3.2 SRT Development Plans

Recently, the SRT proposed the railway infrastructure development master plan. The plan comprises of three phases: 1) the restoration phase 2010-2014, 2) the improvement phase 2015-2019, and 3) the efficiency enhancement phase 2020-2024. On 21st November 2009, the Thai government approved a total budget of USD 5.3 billion for the first phase of the development plan.

The first phase of the plan aims to construct dual-track for the east coast railway, and the Maptabao-Pakchong-Nakhonratchasima route.

Policy development of SRT has four key issues as follow:

1) Improving existing system in five years plan.
2) Track doubling in fifteen years plan.
3) Connecting to the region.
4) Constructing high speed train system.

3.3 Problems in Rail Transport System Development

Interview with SRT senior staff revealed 3 majors issues facing the rail system development:

1) Old SRT work force:Due togovernment's constraint on recruitment of new officials, the present system is overloaded. The old staff work in old style which is inefficient and also present an obstacle to organization development.
2) Internal organization problems: there are conflicts between officials and presence of political interference.
3) High speed rail issue: many disagreed with the HSR project citing very high cost, lack of discipline of Thai people to use HSR, instead they suggest investment should be used to improve existing track to support a higher speed of 120 km/hr.

The Cabinet has recently approved a framework for negotiations between the government and China on a high-speed-train project. The project will have two phases: from NongKhai in the Northeast to Bangkok and from Bangkok to Padang Besar, on the border with Malaysia. The whole project, from NongKhai to Bangkok, and from Bangkok to Padang Besar, will cost about USD 11 billion. The railway tracks will be built in parallel with existing tracks, but with a wider gauge of 1.435 m. The high-speed train will travel at max. speed 250 km/hr. It will be electrically powered, and studies have shown that existing power supplies will be sufficient (The Nation, 8/09/2011). Nonetheless, finalization of the project is halted awaiting further decisions from the new government which will be formed subsequent to the general elections on July 3rd in this year.

4. SURVEY OF O-D DATA

Origin-Destination Surveys were conducted in order to analyze the behaviors of intercity passengers. Key destinations were selected for trips originating from Bangkok. The eight O-D pairs chosen are: (Fig.6 and Table 1)

1) Bangkok – Chiang Mai (CHM), 693 km.
2) Bangkok–NakornRatchasima (NRS), 252 km.
3) Bangkok – NongKhai (NK), 617 km.
4) Bangkok – UbonRatchathani (UBON), 585 km.
5) Bangkok – Rayong (RY), 220 km.
6) Bangkok – SuratThani (SRT), 615 km.
7) Bangkok – Nakhon Si Thammarat (NST), 746 km.
8) Bangkok – Hatyai city (HTY) 887 km.

The intercity travel modes under investigation include: Automobile, Bus, Train and Airline. The bus mode is categorized into class 1 and class 2 (Aircon. with meal/beverage). For the train mode class 2 seatings and seating classes of domestic airlines were selected. Travel behaviors are grouped according travel distances, as described below.

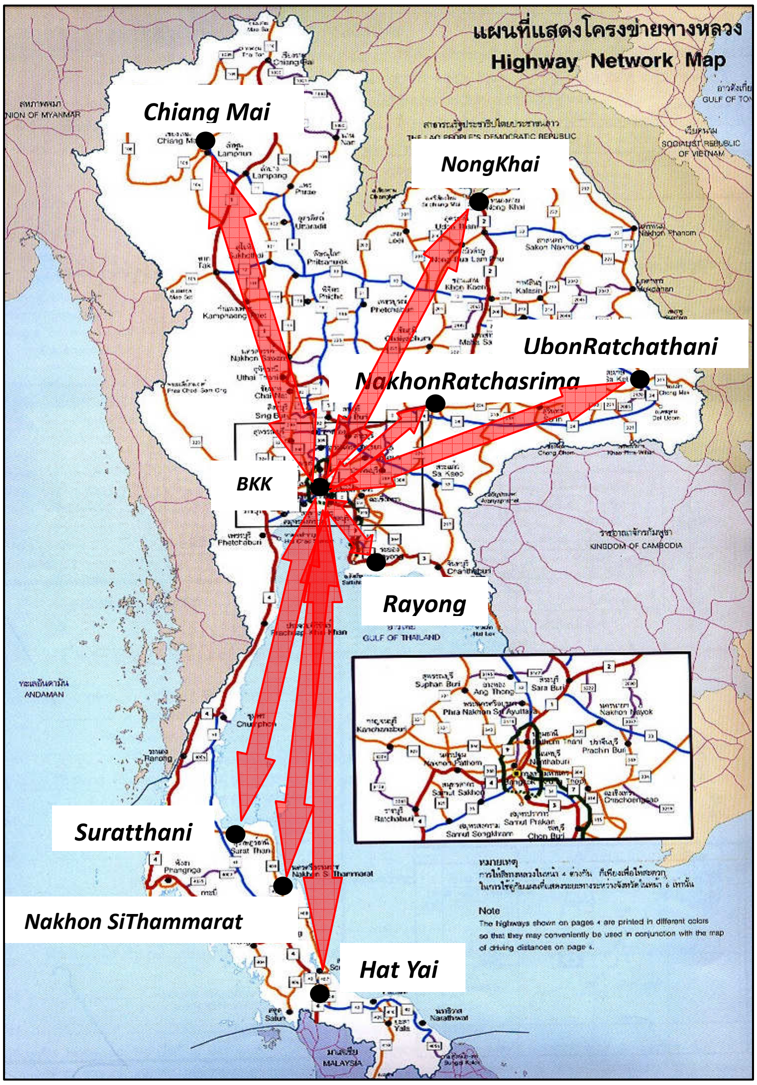

Figure 6 O-D surveys between Bangkok with 8 regional cities

Table 1 Example of O-D survey data

O-D pair		Trunk service							
Origin	**Destination**	**Mode**	**Class**	**Distance (km.)**	**Fare (USD)**	**Time (hrs.)**	**One-way Trip (Pax/day)**	**Frequency (Dep./day)**
Bangkok	**Chiang Mai**	Bus	AC/Luxury	720	18.90	10.00	2544	84
			Ordinary		16.18	12.00	344	13
		Rail	1st Class	751	45.41	14.45	36	6
			2nd Class		26.28		651	
			3rd Class*		8.47		399	
		Air	Normal Fare	580	78.12	1.10	2260	12
			Low Cost Fare		62.50	1.10	1576	13
		Automobile		720	51.43	8.30	1477	-

1.City pair separated by distances under 300 km(Short distance). This includesBKK-NRS andBKK-RY(rail mode not available for RY). The bulk of passengers for these O-D pairs settle for the bus and automobile modes (Automobile is classified as private car with max 7 seatings, or van, or pick-up truck or SUV). The number of passengers choosing the Bus mode is highest.

2. For travel distances of over 500 km (Medium & Long distance). More than 60% of the passengers opt for a public mode from available choices of bus, train and airline. More than 30% of passengers prefer to travel by private Automobile, except for trips to farther-lying destinations such as CHM and UBON. Passengers to CHM or HTY predominantly choose flying for its convenience and shorter travel times. However, the pattern for NST, which lies farthest from Bangkok, shows a different scenario from the two previous destinations. Most passengers traveling to NST prefer to take the Bus mode. The next preference is the Automobile. This is because NST, being a secondary city, is sited on a secondary road which leads directly to the town's bus terminal, thereby offering convenient access to travelers arriving by Bus or private car. The train line to NST does not serve the city centre; train passengers will have to transfer to a secondary train in order to reach the township. And the very high cost of a plane ticket to NST tends to discourage air travel to the province. In the case of UBON, cost is the deciding factor, and the Train is the most preferred option. Train fares are the lowest among the various transport choices, not to mention the fare-exempt Class 3 coaches that attract large volumes of low-income passengers. A sizable proportion of Ubon residents live below the poverty line. Data compiled by NESDB in 2007 indicated 13.69% of the city's population is classified as "poor" while NK's corresponding portion is only 3.37%. (Average country-wide percentage of the "poor" is around 8.48%).

3. Train travel is not as popular as it should be despite its lower fare scale. This is due to the much longer traveling time when compared with other modes on the same distance traveled. Air travel is often out of reach due to its relatively high prices. All of this makes the intercity bus the most popular travel option. Figure 8 shows the relationship between O-D pairs and Travel Time. Two service gaps are indicated; the first gap lies between the Train and the Bus modes, and the second one between the air and other travel modes. The first gap widens with travel distance, an indication that travel time on the train mode expands disproportionately with the time required for the bus mode on the same distance traveled. This reflects the inefficiency of train services which need upgrading. The gap between the air and other modes indicates the need for innovative options in order to fill it; for example, high-speed rail with service speeds of 250 kph or higher.

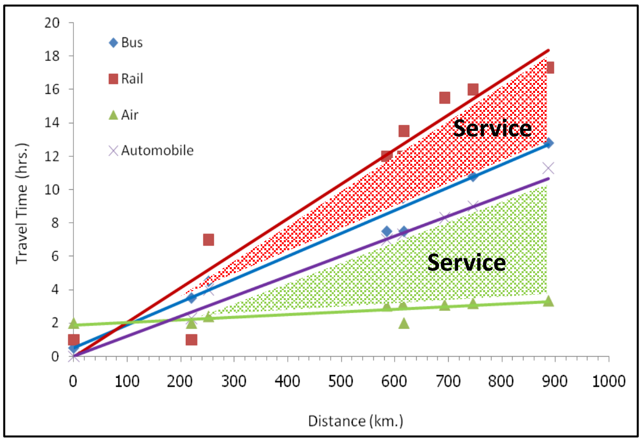

Figure 8 Travel time vs. O-D Distance by mode
Remark: Flight time add 2 hours for access and egress time

5. IMPROVEMENT OF RAILWAY SERVICES

5.1 Improvement of Existing Rail and HSR in The Future

A US$ 2.8 billion budget has been approved by the Thai government for development efforts in the rail sector over the period 2010-2012. Notable among the planned projects are:upgrades of existing rail infrastructure, procurement of new locomotives, and the installation of double-track lines. The latter development initiative involves the construction of a 106 km East Coast Line. In addition, a Railway Development Master Plans (RMAP) has been drawn up as guidelines for the development of the 120 kph Express Train which is a double-track system on narrow-gauge (1.00m) running alongside the existing SRT tracks. And for the introduction of High-Speed Rail (HSR) with service speeds up to 250 kph. The HSR will run on new dedicated standard-gauge track of 1.435 m. This medium-haul option is expected to fill the service gap between existing road-rail modes. From the O-D surveys, the average service speed of existing train is found to be as low as 50 kph. For a distance of 900km, an outdated SRT train requires 18 hours to cover it. In contrast, an Express Train running at 120 kph will be able to cover it in 8 hours, thereby cutting current travel time by 10 hours. Even greater travel time reductions will be possible where an HSR is employed, as shown in Figure 9.

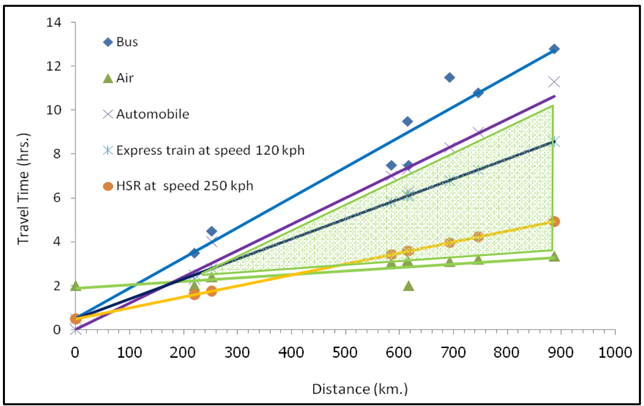

Figure 9 Expected Express Train and HSR to fulfill in service gap between travel time and O-D distance.

SRT's Double-Track rail project is planned for nationwide service coverage with a combined route length of 3,039 km, and to be implemented over 15 years. Development is staged in three phases Phase I: From 2010 to 2014, or a duration of 5 years; total route length 767 km; project investment US$2.5 billion.Phase II: From 2015 to 2019, or a duration of 5 years; total route length 1,025 km; project investment US$2.5 billion. Phase III: From 2020 to 2024, or a duration of 5 years; total route length 1,247 km; project investment US$3.3 billion

The previous government had agreed in principal to sign MOU with the Chinese government. The MOU marked the commencement of negotiations for an appropriate investment framework for the first HSR line for BKK-NK. Subsequent expansion was planned for additional HSR lines to Padang Besar at the Malaysian border and to RY. However, the new government has unveiled a revised plan for HSR network. The plan differs from that of the previous government. The first line will be to NakhonRatchasima, 260 km. northeast of BKK, CHM (north) and HuaHin (200 km. south)

Studies, however, have been carried out for the HSR project. Implementation and financing plans over the project duration from 2015 to 2032 are shown in below.

- BKK-CHM Line, 745 km; Project investment:US$6.54 billion
- BKK-NK Line, 615km. Project investment:US$5.64 billion
- BKK-UBON Line,570 km. Project investment:US$5.2 billion
- BKK-Padang Besar Line, 982 km. Project investment:US$7.8 billion
- BKK-Aranyaprathet Line,250 km. Project investment:US$2.1 billion
- BKK-ChantaBuri Line, 330 km. Project investmentUS$2.7 billion

A range of upgrades are necessary to accommodate the planned Express Train and HSR. Either new or upgraded rail systems as well as E&M will be required to support train operations at higher speeds. A portion of existing rolling stock may be upgraded for use on the new express track. Existing trackwork (1.00 m gauge) can be altered to support speeds up to 120 kph. Likewise, existing signaling system may be upgraded for compatibility with the express system. For the high-speed train operating at 250 kph on single track, all-new rolling stock will have to be procured. The track required for HSR will be standard gauge (1.435m) dedicated track which cannot be linked with SRT's narrow-gauge lines, the Airport Rail Link being an exception. Elevated rail will be necessary where a line crosses a traffic intersection.

A special organizational body, with autonomy from SRT, is to be established to manage and supervise the operations of the HSR system. Such an organization must be staffed with specialists with experience in operating high-speed trains, and training for its general staff must be conducted before commencement of the system's revenue operations. Nonetheless, finalization of the project is halted awaiting further decisions from the new government which will be formed subsequent to the general elections in July this year.

5.2 Funding and financing: PPP

Development of the high-speed train for intercity transport will require a project investment as high as US$3.0 trillion. If financing of the project was to be undertaken entirely by the government, a huge public debt would be incurred that would exceed the 50% GDP limit imposed by the Cabinet. Thailand's public debt situation as of 2009 and 2010 already showed a debt level at 43% of GDP – almost reaching the debt ceiling -- which was accounted for by extensive government borrowing for the TKK program and other required expenditure items.

The constraints on government budget for investment in mega-projects such as the high-speed trains, the PPP approach is deemed most appropriate. The private sector is to develop the project on a Build-Transfer-Operate (BTO) basis. Issues relating to project yields and government assistance or subsidies to the private investor must be clearly defined and transparently specified. Care should be exercised so as to design a scheme of public transport that is viable and fair and non-monopolistic. This type of investment undertaking must comply with the provisions of relevant laws, in particular, the 1992 Private Sector Participation in State Undertakings Act. Funds for development may be raised by way of a Special Purpose Vehicle (SPV) which is to be established for this particular purpose. SPV is to undertake the public listing of SRT assets or securitize them and offer the securities to market investors and/or onshore/offshore institutional investors. The revenue stream from commercial operations of the project will be used to repay the loans. This method of funds mobilization will require either a government guarantee or a measure of support in the form of capital funds or tax deductions in order to bolster investor's confidence in the project.

6. CONCLUSIONS

The paper described the intercity transport in Thailand with the focus on the potential development of rail transport. O-D study between BKK and eight regional cities were carried out which show opportunity to develop railway transport. Government has approved a budget of US$ 2.8 billion for development efforts in the rail sector over the period 2010-2012. SRT is the agency responsible for rail system in Thailand. The slow pace of rail transport development is due to organization's problems and limitations including lack of investment budget.

However, the new government has unveiled a revised plan for HSR network. The plan differs from that of the previous government. The first line will be to NakhonRatchasima, 260 km. northeast of BKK, CHM (north) and HuaHin (200 km. south).

Development of the high-speed train for intercity transport will require a project investment as high as US$3.0 trillion. The constraints on government budget for investment in the high-speed train project, the PPP approach is deemed most appropriate. The private sector is to develop the project on a Build-Transfer-Operate (BTO) basis.

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RESEARCH IN BUILDING PASSENGER PUBLIC BUS TRANSPORT LINE IN LARGE QUANTITY (BRT- BUS RAPID TRANSIT) THE CORRIDOR OF AN SUONG-SUOI TIEN, HO CHI MINH CITY

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ABSTRACT:

This paper mentions the research in developing the public transport system – Bus Rapid Transit in HCMC, attracting people to use it and developing oriental substance.

KEY WORDS: Public transport, Bus Rapid Transit

1. THE NEED OF THE RESEARCH

Presently, the situation of traffic jam, accident, pollution of environment ... ever are problems that most nations in the world have to care about. In Vietnam, there are Hanoi City and Ho Chi Minh City (HCMC) - the two big cities of alarming traffic jam. While individual means are increasing quickly, especially motorcycles are commonly used, traffic infrastructure is not yet developed in time

In Vietnam, there is situation of imbalance in network of city streets concerning mechanical means, along with rate of increase of motorcycles up to 30% per year, increase in automobile over 10%/year, while rate of development of street only reached 5-7%, streets roads are narrow and of poor quality. Surface for transportation is only 7-8% city land surface figure is about 20-25% in the modern cities. Presently the HCM City has over 4 million motorcycles 2-wheelers (that is over 79% road surface) and about 400,000 individual automobile that are used. Moreover, public passenger transportation has not yet been developed in time, even though the City already hadefforts to consolidate and develop thepublic passenger transportation – the bus.

Following planning for development oftransportation in Ho Chi Minh City, wewill have 6 metro lines. However,because of very high expenditure, the timeneeded to work and to clear land surfaceprolonged, now it is possible to preparetwo lines. With these first two lines, wecan increase capacity of transportation ofpublic transportation system to max of3%-4% of the requirement.

HCMC, with fast rate of economicdevelopmen t then it has along the facingwith problem of to o fast populationincrease. Concentrated industr ial zones areformed very quickly in quite a sho rt timealready attracted a large rate of youngw orkers, of low technical level (about70%) from elsewhere who come. This ispopulation migrat ion in large number fromrural into Ho Chi Min h City. Presentlyimbalances concerning housing, electricity, water, transportation infrastruc ture social, etc. New concentrated industrial zo nes and urbanization of nearby rural areas cont ributed to movement of workers between inner city and external of HCMC along with the near by provinces that cause traffic jam at rush h ours especially at gates of the City. While the c apacity of streets and roads cannot respond in t ime, roads are over loaded and traffic jams are frequent, city transportation is alarming

Because of the traffic jam situation and pollution of the environment, city must hasa more effective public transport system in the nearest future. With the aim to develop the bus system concerning quality and quantity, it is necessary to study to develop the - Bus Rapid Transit (BRT). Around 2006-2007, there are some research about BRT, but it is not implemeted. Until now, there is not yet any line of BRT in HCMC.

In 2010, public transport system by bus just has satisfied about 7.3% travel demand of HCMC's people. Following the new planning, HCMC will have strong solutions to increase this rate up to 15% in 2015 and 30% in 2020, with some newtypes of public transport system as: Bus rapid transit BRT, Underground mass rapid (metro), electric rai.

The subject matter: Research on building passenger public bus transport line with large quantity (BRT) for the corridor of An Suong-SuoiTien, Ho Chi Minh City, along with the goal to contribute in applying modern means of transport, of large loading capacity by way of renovating and building main roads of Ho Chi Minh City of great traffic requirement, and on that arrange the fast bus line (BRT) in order to respond to in order to respond to requirement but on the basis of limitation of city infrastructures, to build a mode of public passenger transportation that is of high speed, cost effective, passenger transportation in large number, attracting people to use to limit pollution of the environment.

Following results of statistics in the year 2010, Bus route No. 33 from AnSuong to SuoiTienhas large figure of passengers: 8,919,768 Passengers and the number is increasing quickly, and number of trips of each week day 300, on Sunday: 450 trips, category of bus 8-seater, average use coefficient is 1,01 and inter-time is about 5- 10 minutes/trip.

2. RESEARCH METHOD

- Traffic survey, survey on demand of the people in transportation
- Analysis of transportation statistics from real sites from results of related research, later generalize
- Using forecast modules of requirement of transportation of the route.
- Imitation modules of various nations, proposing application.

Method of investigation survey of transportation as: survey on traffic flow; survey on speed of the route; interview of passengers.

The forecast methods of transportation demand are: method of travelling coefficient, method of elasticity forecast and the forecast of 4 steps, consisting of: defining transportation requirement; share of mode of transportation and division of flow over network.

3. THE PARTICULAR OF AN SUONG – SUOI TIEN BRT LINE

BRT An Suong – SuoiTien is proposed to start at the An Suong Bus Station (there already are the Bus line 27 and 85), the line almost is running along National Road QL1A, of the City belt 2, connected to northern gate next to Dong Nai and to the North West toward TayNinh Province; the line cuts National Road QL13; National Road QL22; National Road QL1K; Provincial Road 12; 14; 15; 16, linking Binh Duong to HCMC.

It passes LinhTrung Export Processing Zone, important Industrial Zone of the City with large number of workers, passes Nong Lam

University. The final point is at SuoiTien Bus Station, transportation requirement here is great, next to theStation isSuoiTien Tourist Zone, Saigon High Techno Zone, National University Campus, Security University, SportUniversity, in the future is the corridor of BenThanh- SuoiTien Metro and the extended Eastern Bus Station of 20 ha.

Length of the line is 25 km. especially the lane already has available width and requirements concerning surface in order to arrange corridor of BRT, in order to minimize the expenditure concerning land surface clearance.

SUBJECT OF RESEARCH:

- Research of assessment of present trafficsituation the corridor An Suong – SuoiTien and forecasts concerning travelingrequirements.
- Research on design in applying the lineBRT AnSuong – SuoiTien suitability tocorridor of National Road QL1A.
- Research on arrangement of parking space, intermediate transit station, stop/waiting station. Selection of suitable bus,from that designing the route and structureof road surface for the busses.
- Designing operation and assessment ofeco-social effectiveness of the BRT route.

From the experiences from the othercountries, this category of publictransportation is more efficient because of large capacity (average of 15,000passengers/hour/direction, and even in Bogota (Colombia) and Curitiba (Brazil), it reaches 35-45 thousand passengers/ hour/ direction when compared to normal bus 1,000 passengers/hour/direction), and there is not the use of fixed rails like railroad.

The speed is high (about 20-30km/h), convenience, good passenger service, separate bus lane, using exclusive signs at crossroad and is operated via managing center, bus stop is of the type of rail road the waiting stations have roof above, the bus has many doors and there is ticket checking before entering on board at stop station allowing fast entry and exit of vehicle.

Therefore when it is in operation, BRT does not cause interference chaos to system of transportation. BRT also can overcome main disadvantages of present bus system that it does not run the zigzag way, to get the passengers at stop place.

Construction expenditure is approximately 1-2 million USD/km, only about 5-10% compared to underground train, (expenditure for electric - tramway is about 15-20 million USD/km, for Metro is 60- 100 million USD/km) and time of construction is very fast (1-2 years).

Expenditure in exploiting the system is low and absolutely can refund investment capital of purchasing means. This cannot happen in the investment of light railway or underground railway. BRT construction technology is not so complicated and expensive so can easily mobilized economic resources within the nation to invest suitable to eco-social situation of Vietnam.

It is clear, the flexibility of BRT is much more compared to iron wheel public passenger transportation. BRT can combine along with other public transportation types such as tramway, taxi, bus frequently seen at transit stations. Maintenance for BRT is simple compared to light railroad, underground. Moreover, BRT requirement of land surface is not high.

From above mentioned benefits which will attract people to use BRT and this contribute to reduction in the use of individual vehicles.

4. CONCLUSION

The development of bus rapid transit BRT system in HCMC, including An Suong – SuoiTien line is very urgent and neccessary, responding to practical need of the City, along with, regulated, civilized and modern facilities, suitable to eco-tech capability of Ho Chi Minh City.

Therefore it is neccessary to continue to research, learn study cases of the other countries in the world, especially the study cases from Southest Area, and make planning attract investment in future time, concentrate on Public Private Partnership to get higher effect.

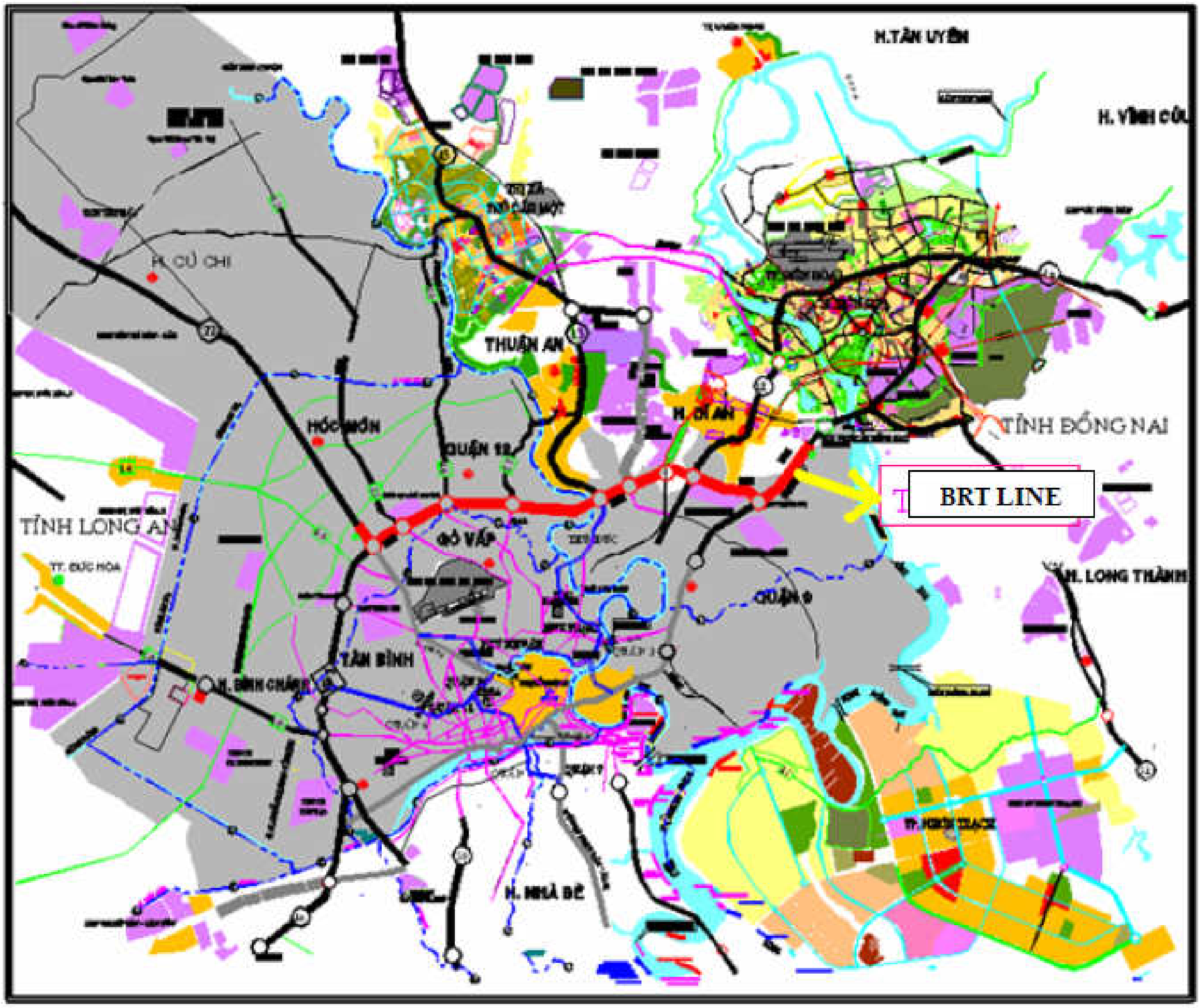

Figure 1 Map of the AunSuong – SuoiTien bus line

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CARBON STORAGE ESTIMATION OF URBAN AREA USING SATELLITE IMAGERY

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ABSTRACT:

The Korean government is pushing ahead with diverse policies in order to realize Low Carbon Green Growth. To realize low carbon green growth, the urban management planning needs to be established that can effectively manage this with estimating carbon emission and storage. This study extracted the vegetation area by calculating NDVI(Normalized Difference Vegetation Index) using KOMPSAT-2 satellite image of Jinju city, and suggested a method of assuming carbon storage from this. Especially, even a method was suggested that estimates carbon storage by dividing a broadleaf tree and a needle-leaf tree with the use of satellite image, which was shot in summer and winter. The carbon storage by land use zoning in downtown area was also guessed. The estimation of carbon storage with the use of satellite image in this way is judged to be likely used as important data in establishing a plan for low carbon green growth.

KEY WORDS: Low Carbon Green Growth, NDVI, KOMPSAT-2 satellite image, Carbon Storage, Carbon Emission

1. INTRODUCTION

In the middle of which many efforts are being attempted recently for reducing carbon emission domestically and internationally, a driving strategy or an international treaty is being made. A carbon trade market is being formed, too. Even the Korean government suggested a policy-based plan for realizing low carbon green growth, and established a goal of reducing carbon emissions up to 30% until 2020. This carbon-emission target value is what exceeds largely more than the carbon emission reduction target value, which was suggested by IPCC(Intergovernmental Panelon Climate Change). Thus, thinking thatKorea's recent carbon emissions tend to grow, it can be said to be very shocking level (IPCC, 1996). Korea arranged a strategy for realizing low carbon green growth through 'The 1st National Energy Master Plan (2008~2030)' and 'The 3rdBasic Plan for Technology Development, Application, and Deployment of New &Renewable Energy (2009~2030).' America has attempted an effort to secure again the leadership of green industry such as carbon market and renewable energy market since rejecting ratification on the Kyoto Protocol. Even Japan is making an effort to develop into green power by positively driving the green growth policy, reinforcing energy efficiency, and developing technology. A research for estimating carbon emission and storage depending on this trend at home and abroad is being carried out multi-dimensionally. A forest has influence upon carbon storage and global-warming reduction. Thus, a research on assuming carbon storage in the forested area can be said to be important element available for analyzing global warming (Eun-Jin Park, 2009). Estimation of carbon storage in the forested area is guessing carbon storage in the forested area by applying forest biomasscoefficient(Birdsey, 1992; Jae-Hoon et al., 2010). In case of Korea, the carbon storage in the forested area is being calculated by utilizing the forest information, which was surveyed periodically. In case of built-up district that has relatively small area, there is no sample point for the national forest resource survey. Thus, there is limitation of calculating the accurate forest biomass and carbon storage. As for the estimation of forest biomass and carbon storage in smalls calearea in order to supplement this limitation, the estimation methods are under development, which use satellite image, aerial photo, and digital elevation model(Nowak et al., 2002).

Especially, a research of validity was progressed on carbon storage in large forested area by using Landsat TM satellite image and kNN algorism. However, development in the estimated technique of carbon storage on small-scale area like urban area is still in a weak condition (Ki- Tae et al., 2010). However, resolution in satellite image is being developed gradually into high resolution. Thus, an interest is being attracted even in developing carbon storage estimation technique on small-scale area. Accordingly, the purpose of this study is to implement the foundation available for reflecting a change in carbon emission and storage in establishing urban management planning, through assuming carbon emissions targeting Jinju city in Korea and through estimating carbon storage by administrative unit and by land use zoning with the application of KOMPSAT-2satellite image.

2. EXTRACTION OF VEGETATIONZONE AREA AND ESTIMATION OF CARBON STORAGE

2.1 Extraction of Vegetation Zone Area

KOMPSAT-2(Korea,Multi-Purpose satellite- 2), which was launched on July 28, 2006, is providing users with Panchromatic image(1m resolution) and Multi-spectral image (4m resolution), and can extract vegetation zone by calculating NDVI(Normalized Difference Vegetation Index)with the use of Multi-spectral image. Inother words, NDVI can be calculated byusing Band 3, 4 value in KOMPSAT-2image.

$$NDVI= \frac{\text{band 4-band 3}}{\text{band 4+band 3}} \quad \text{(Eq. 1)}$$

NDVI comes to have value from -1 to 1. Snow, cloud, or plant comes to generally have value in 0~1. Also, even in the area with plants, the region where there are lots of plants or healthy plants comes to have the higher value compared to plants with disease and insects or senility, and is divided into vegetation zone and non-vegetation zone after establishing threshold by analyzing distribution of the calculated NDVI.

2.2 Estimation of CarbonStorage

In the estimation formula of carbon storage, which guesses carbon storage in single tree, the biomass and carbon transformed coefficient are used. The estimation formula in biomass was calculated DBH (Diameter at Breast Height) and was used a method of guessing carbon storage. DBH implies diameter in height of 1.3m in a tree.

Biomass implies the renewable organic matter, which was extracted from a tree. Weight(W) in a tree necessary for calculating total biomass is calculated by using the coefficient by tree species and the DBH(McHale, 2007). Amount of total biomass is calculated by multiplying W and biomass transformed coefficient (coniferous tree: 1.6512, broadleaf tree: 1.7202). And, multiplying here by 0.5, which is the carbon transformed coefficient decided by IPCC, the carbon storage on vegetation (kg/tree) is obtained (Eun-Jin Park, 2009).

$$W = a + bDBH = c \times DBH^2 \quad \text{(Eq. 2)}$$

Table 1 Tree weight coefficient depending on species of trees

Species of trees	Coefficients $W = a + b*DBH + c*DBH^2$		
	a	b	c
Nigida	12.17400	-3.28612	0.36354
Koraiensis	31.60970	-5.44588	0.42022
Leptolepis	1.42534	-1.98035	0.40005
Acutissima	-3.66166	-0.51529	0.35117

Source: Korea Forest Research Institute

3. ANALYSIS OF RESULTS

3.1 Research Subject Region

The research subject region is Jinju citywhere is located in the southland of Korea and where has about 340,000 people in population and is monsoon season region with four distinct seasons. To extract vegetation area by administrative unit and land use zoning in Jinju city and to estimate carbon storage, KOMPSAT-2 satellite image was used. The satellite-image observation period was used the image that was shot in June 13, 2008 (summer) and January 3, 2009 (winter). The satellite image, which was hot in summer, was excellent in vitality of vegetation, thereby having been used in extracting the whole vegetation area. The image, which was shot in winter, was used in extracting only coniferous trees. In other words, a method of improving the estimation accuracy in carbon storage was suggested by comparing the shot images in summer and winter, by dividing it into broadleaf tree and coniferous tree, and by applying the carbon transformed coefficient, respectively, depending on species of trees when estimating carbon storage. KOMPSAT-2 offers panchromatic image in 1m of resolution and multispectral image in 4m of resolution, thereby having created true color image in 1m of resolution by applying image fusion technique. Fig. 1 and 2 are showing the location in the research subject region and the satellite images in administrative units (6 pieces) in Jinju city, which was selected.

Figure 1 Research subject region (Jinju City)

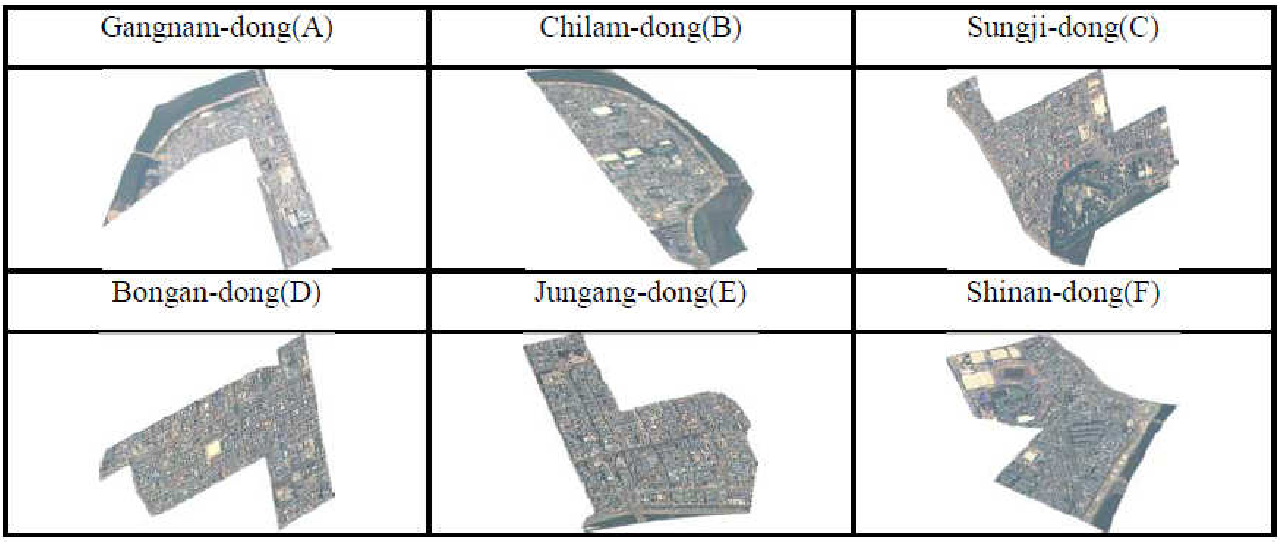

Figure 2 Administrative units in Jinju city

3.2 Calculation of Carbon Emission

The calculation of carbon emissions was made the emission depending on a method that was suggested in IPCC guideline (1996). The elements, which were considered in calculating carbon emission, were population number, electricity utility amount, tap-water utility amount, waste discharge amount, and gas utility amount. The reference year was based on 2008 when is same at the point of time of collecting relevant data and acquiring satellite images.

Table 1 is the result that estimated the carbon emission by administrative unit, which was selected as research subject out of administrative units in Jinju city. The carbon emission was analyzed to be much in the densely populated area. The order was indicated to be Shinan-dong, Chilam -dong, and Bongan-dong. Especially, Shinan-dong is the region that was rapidly formed a rise in population because large-scale land development was made. As Chilam-dong is old built-up area, the concentration of population is being steadily maintained.

Table 2 Estimation of carbon emissions by carbon emission element (Based on data in 2008 for Jinju city)

Administrative units	Carbon emission factors used to estimate				
	Power consumption (ton)	Water consumption (ton)	Garbage emission (ton)	Gas consumption (ton)	Total carbon emission (ton)
Gangnam-dong	35,798	53	8	35,751	71,610
Chilam-dong	63,003	94	13	62,922	126,032
Sunji-dong	35,879	54	5	35,832	71,770
Bongan-dong	36,687	57	8	36,552	73,304
Jungang-dong	24,410	36	5	24,378	48,830
Shinan-dong	168,642	252	36	168,425	337,355
total	364,419	546	75	363,860	2,873,937

3.3 Estimation of Carbon Storage by Administrative Unit

To estimate carbon storage, 6 pieces among administrative units in Jinju city were selected. NDVI value was calculated by using satellite images in 2008. The calculated NDVI value is the one that is distributed from -1 to 1, and was indicated as Fig. 3 by changing it into 256 gray valuein order to express in the form of image data. In Fig. 3, the part, which shows bright color, is the region that is excellent in vegetation status. Dark color is the part that has no vegetation characteristic.

Accordingly, it decided on the threshold, which shows the boundary in vegetation and non-vegetation, by analyzing distribution of NDVI value. Binary image was generated by dividing it into vegetation region (green) and non-vegetation region (black color) (Figure 4). As a result, the vegetation area by administrative units could be calculated. The result value was indicated in Table 3.

In Table 3, a reason that the ratio of vegetation area in Bongan-dong and Jungang-dong is lower compared to other administrative units is because of being the region with high-density development as commercial region in charge of commercial function in Jinju city. However, Gangnamdong, Chilam-dong, and Shinan-dong are residential area, are formed a park adjacent to residential area, and are formed diverse open spaces along the side of NamgangRiver, thereby having been indicated to be higher in vegetation area compared to other administrative units. Also, Seongji-dong is situated a traditional park called Chokseokruthat is very famous in Korea, thereby Having been indicated to be high in vegetation area.

Table 3 Vegetation area by administrative units according to KOMPSAT-2 image analysis

Administrative units	Administrative units area (km^2)	Ratio of vegetation area (%)	Vegetation area (km^2)
Gangnam-dong	0.55	11.70	6.435
Chilam-dong	1.32	5.34	7.049
Sunji-dong	0.68	9.91	6.739
Bongan-dong	0.48	0.64	0.310
Jungang-dong	0.46	0.44	0.294
Shinan-dong	1.07	7.19	7.693

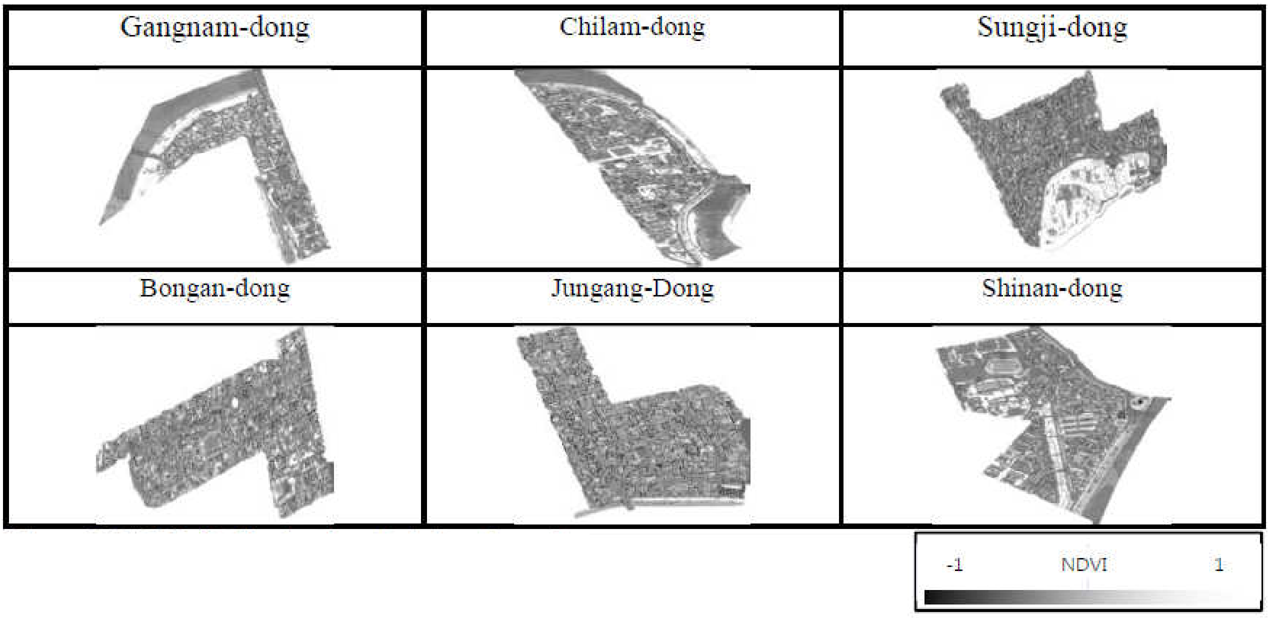

Figure 3 NDVI distributions by administrative units

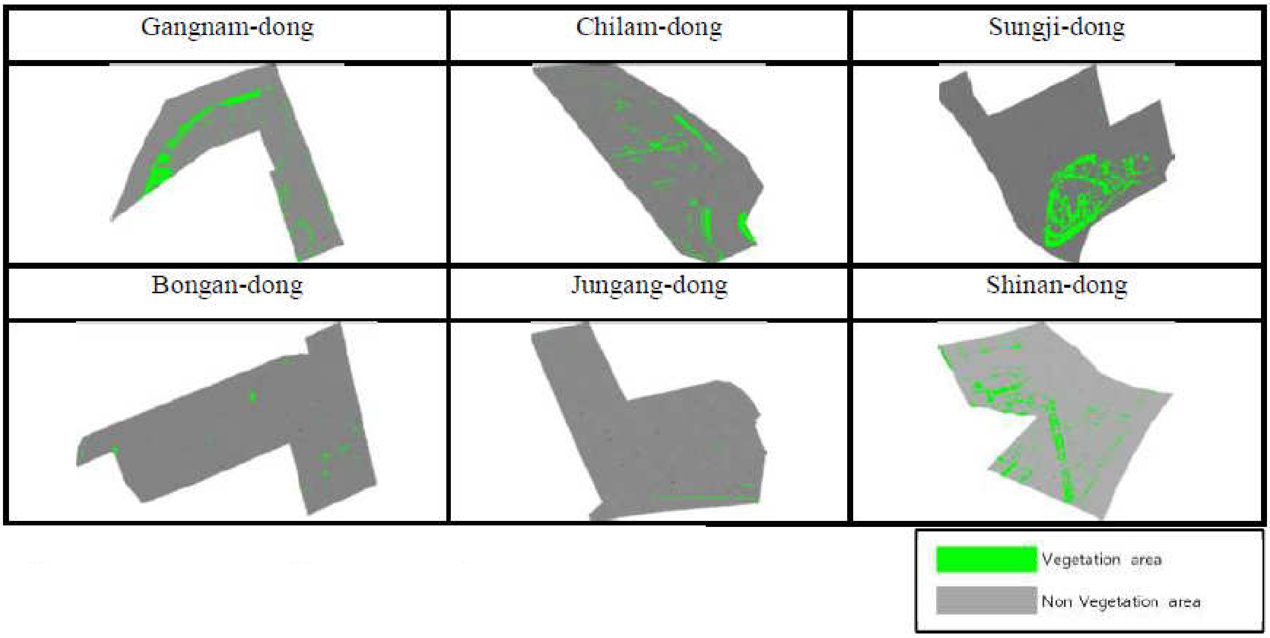

Figure 4 Extraction of vegetation are by administrative units

Carbon storage was estimated by using vegetation area by administrative units, which was calculated from KOMPSA-2 satellite image. At this time, the species of trees, which are distributed in vegetation area, can be divided into coniferous tree and broad-leaf tree. However, the carbon storage was calculated by applying carbon storage coefficient (7.7) on broad-leaf tree in consideration of characteristics that the vegetation area in downtown region is relatively very little and is possessed by many broad-leaf trees (Table 4). Table 4 is the calculated carbon storage by administrative units. It is the real situation that is very small compared to carbon emission. Accordingly, lots of carbon is being emitted due to the concentration of population in downtown space. Thus, there is a need of arranging a plan forcontinuously managing vegetation space,which is surrounding the vicinity of a city, along with an effort of broadening green space like downtown space when establishing urban management planning.

Table 4 Comparison of carbon storage and emission by administrative units

Administrative units	Vegetation are (km^2)	Carbon emission (ton)	Carbon storage (ton)
Gangnam-dong	6.435	71,610.258	49.550
Chilam-dong	7.049	126,032.879	54.276
Sunji-dong	6.739	71,770.602	51.889
Bongan-dong	0.310	73,304.410	2.387
Jungang-dong	0.294	48,830.618	2.264
Shinan-dong	7.693	337,355.924	61.317

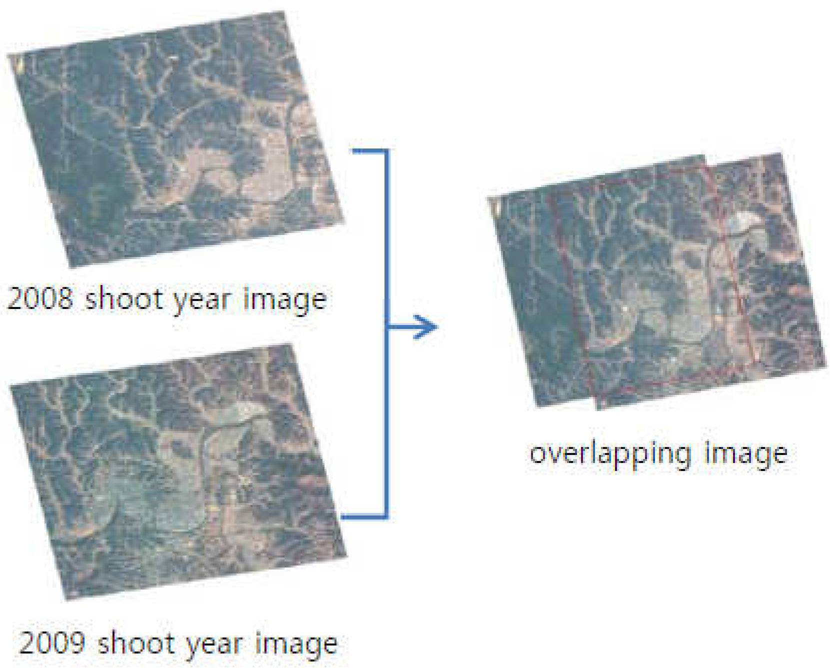

Figure 5 Extraction of the overlapping shooting region for estimation carbon storage in Jinju city

3.4 Estimation of Carbon Storage in Jinju City

In the paragraph 3.3, the carbon storage was estimated by selecting the administrative units where is located in Jinju city. However, in the paragraph 3.4, the carbon storage was estimated on the whole area of Jinju city by using merits that the satellite image can shoot the extensive area. Given extracting vegetation area from the image in 2009(winter) by reflecting seasonal characteristic with the use of the image in 2008(summer) and the image in 2009(winter) at this time, the seasonal characteristic is reflected, thereby being extracted only a coniferous tree as vegetation area. Given comparing this with vegetation area, which was extracted from the image in 2008(summer), the whole vegetation area can be divided into broad-leaf tree and coniferous tree regions. When reflecting the carbon storage coefficients in coniferous tree and broad-leaf tree of each area, which was divided, the carbon storage is calculated by being divided by tree species. Thus, the more accurate carbon storage can be estimated.

As Fig. 5 is the one that shows the process of extracting the overlapping shooting region for assuming carbon storage over the whole area of Jinju city, the vegetation region was extracted by using the overlapping shooting region. The overlapping region is existed simultaneously the images, which were shot in summer and winter. Thus, comparison of two images can lead to dividing into coniferous tree and broad-leaf tree regions.

Fig. 6 is showing the results, which obtained NDVI by using satellite images in 2008(summer) and 2009 (winter) and extracted the vegetation area by applying threshold here.

The whole area of the target region is 16,521.8 ha. The vegetation area, which was extracted in the winter image for 2009, is 29% of the whole area, thereby corresponding to 4,791.3 ha. The region, which was extracted as vegetation area in the winter image for 2009, can be defined as the region that coniferous trees are distributed. Also, the vegetation area, which was extracted from the summer image in 2008, is 67% (11,069.6 ha), thereby being the area of including both broad-leaf tree and coniferous tree. Accordingly, the region that is distributed only coniferous trees can be obtained given subtracting the vegetation area, which was extracted in 2009, from the vegetation area, which was extracted in 2008. With this method, total carbon storage can be calculated. Table 5 was indicated the area by tree species, the carbon storage by tree species, and total carbon storage.

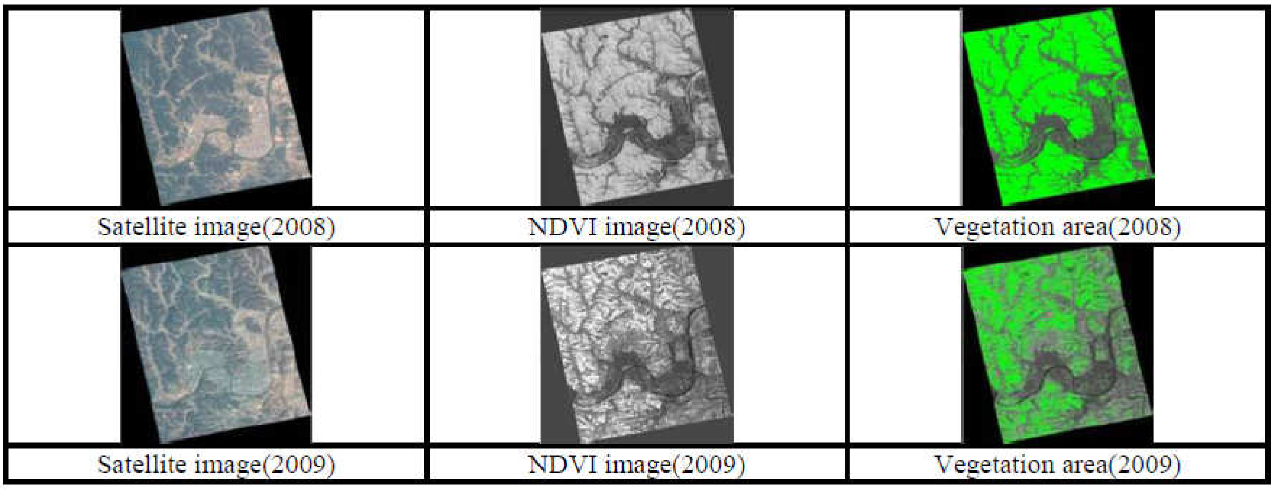

Figure 6 Extraction of vegetation area with the use of images in 2008 and 2009

Table 5 Calculation of carbon storage with the use of satellite images in 2008 and 2009

Total area (ha)	Area by species of trees (ha)		Carbon storage for species of trees (ton)	Total carbon storage (ton)
16,521.8	Broad-leaved tree	6,278.3	48,342.91	71,820.28
	Coniferous tree	4,791.3	23,477.37	

4. CONCLUSION

To realize low carbon green growth, the carbon emission and storage need to be estimated. Thus, the urban management planning needs to be established by using this. This study extracted the vegetation area by using KOMPSAT-2 satellite image targeting Jinju city, and suggested a method of estimating carbon storage from this. Especially, it divided into the coniferous tree and broad-leaf tree distribution regions by using satellite images, which were shot in summer and winter, thereby having suggested even a method available for improving the estimation accuracy of carbon storage by applying carbon storage, respectively, by tree species. As a result of analyzing carbon storage by administrative units and by land using zoning targeting Jinju city, a case of urban area was shown the large carbon emission in the densely populated residential area. In the commercial area where is located in downtown, the vegetation area is small, thereby having been indicated to be the lowest in carbon storage. In other words, a carbon management plan needs to be established that can increase carbon storage by effectively managing the park region where is located in the outskirts of a city, as well as increasing vegetation area by forming a park even within urban area.

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