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ATRANS
ASIAN TRANSPORTATION RESEARCH SOCIETY

Transportation Research Challenges In Thailand

Sub-Project on

Mobility and Accessibility

November 2008

ATRANS
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Abstract

This report is the output of a sub-project under ATRANS special research project entitled "Transport Research Challenges in Thailand". It is to identify the present status of mobility and accessibility and address the research challenges based on the findings. Case study is Bangkok. Mobility is expressed as travel time to a city center and illustrated on a travel hazard map. Accessibility to job is calculated and reveals that job accessibility on private mode is far larger than on public mode. Effect of mobility and accessibility to work trip pattern is examined through the location -associated travel preference curve. It is found that some areas exhibit characteristics of sub-center, in that it receives workforce from neighborhood. The future condition is evaluated with different railway network scenario. It is found that mobility and accessibility of the whole study area are improved with the railway network development. Some certain locations are greatly benefited such as the planed sub-urban sub-centers. The location-associated travel preference curves reveal that railway network improvement may produce adverse effects to some locations from the viewpoint of sub-center formation potential and attractiveness. The experience and findings provide guideline and recommend some challenging research topics such as mobility and accessibility definitions, property value impact of transport development, integrated land-use/transport analysis, and sustainability planning and evaluation.

Keywords: **Mobility, Accessibility, Travel Pattern, Land Use, Sustainability**

Acknowledgement

This study is a sub-project of the ATRANS special research project in 2008.

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ASIAN TRANSPORTATION RESEARCH SOCIETY

CHAPTER I INTRODUCTION

1. Introduction

Most of the cities in Thailand are now facing several urban problems such as traffic congestion, traffic safety, air pollution, social inequity, etc. Solutions to these are the policies that have goals to improve accessibility and the use of the space, increase the environment-friendly modes' share (public transport, cycling, walking), reduce congestion, improve safety, reduce air pollution, noise, and visual nuisance; while develop and maintain a wealthy and healthy urban economy, and ensure social equity and transport opportunities for all community sectors. Several projects are then planned and implemented such as highway construction, public transport improvement, etc.

Rapid population increase, suburbanization, economic growth, motorization, and car dependency are common urban problems experienced by many growing cities around the world. The situations are more severe in the developing countries. Most of their previous developments were undergone disorderly and unsatisfactorily. This resulted in terrible traffic congestion and critical level of urban air pollution. They are mainly stem from inefficient urban structure and suburbanization, which are caused by rapid population and high economic growth. In such a situation, residential areas are developed in the outer area, which reduces the inner density. Residents and households are moving out of the city, and some business firms will look for more accessible locations to serve them. This has often brought an urban sprawl that induces people to travel farther and longer in heavy traffic, to spend more money for transportation, and unavoidably to consume more fuels. This also caused other problems such as urban heat island, environmental degradation, low quality of living, etc. In order to alleviate these, the city growth must be properly controlled with a well developed urban plan. This requires a thorough understanding of the urban structure and characteristics, which are likely different for cities of different age, population, transport and development policies. Literature reviews found several theoretical and empirical studies to identify employment distribution pattern, sub-center formation mechanism in a metropolis, e.g., (Giuliano and Small 1999) and (Cervero and Wu 1998).

1.1 Objectives

This study has searched for directions of proper research and development regarding the mobility and accessibility in Thailand. The objectives are as follows:

- To review the state of the art and the state of practice on mobility and accessibility
- To identify the present status of mobility and accessibility in a case study city: Bangkok
- To recommend research topics that are challenging for Thailand

1.2 Methodology

The study has undergone a series of activities that can be described as follows.

1.2.1 Review of Academic Literatures

Literature reviews related with accessibility and mobility are conducted in order to select a set of accessibility and mobility indicators that are appropriate for Thailand by considering the theoretical consistency and the data availability concern.

1.2.2 Review of Practical Literatures

Literature reviews on local application and practices regarding accessibility and mobility in Thailand are conducted by reviewing the documents and reports of recent transportation projects.

1.2.3 Identify the Current Status of Bangkok

The study identifies the current status of mobility, accessibility by taking into account the urban activity locations as well as travel pattern. Mobility and accessibility index are determined and are represented the so-called travel hazard map and accessibility map respectively. The resulting travel patterns are determined in relation with activity locations by examining the so-called location-associated travel preference curves.

1.2.4 Case Study

Case study is conducted to determine the impact of rail transit on mobility, accessibility, and travel pattern. Three scenarios are defined with three phases of rail transit network. The reference year is 2005 and the future years are 2010 and 2025.

1.2.5 Research Recommendations

Based on the findings, the study recommends some research topics that are challenging for transportation related research and development in Thailand.

1.3 Analysis Tool

Thai government, by the Office of Transport Planning (OTP), has paid attention to transportation modeling for several cities over the past decades. All models are largely built upon the conventional 4-step model; while several model versions are being produced with various scopes, ranging from macroscopic to microscopic. In addition, extensive efforts are paid for the model maintenance in order to keep the data up to date, which is a result of large investment. For Bangkok, the latest version of the model is built upon Citilabs' proprietary software named CUBE, and so-called e-BUM (extended Bangkok Urban Model). There are in total 625 travel analysis zones with multi-modal transport network. Example of the model user interface is shown in Figure 1.

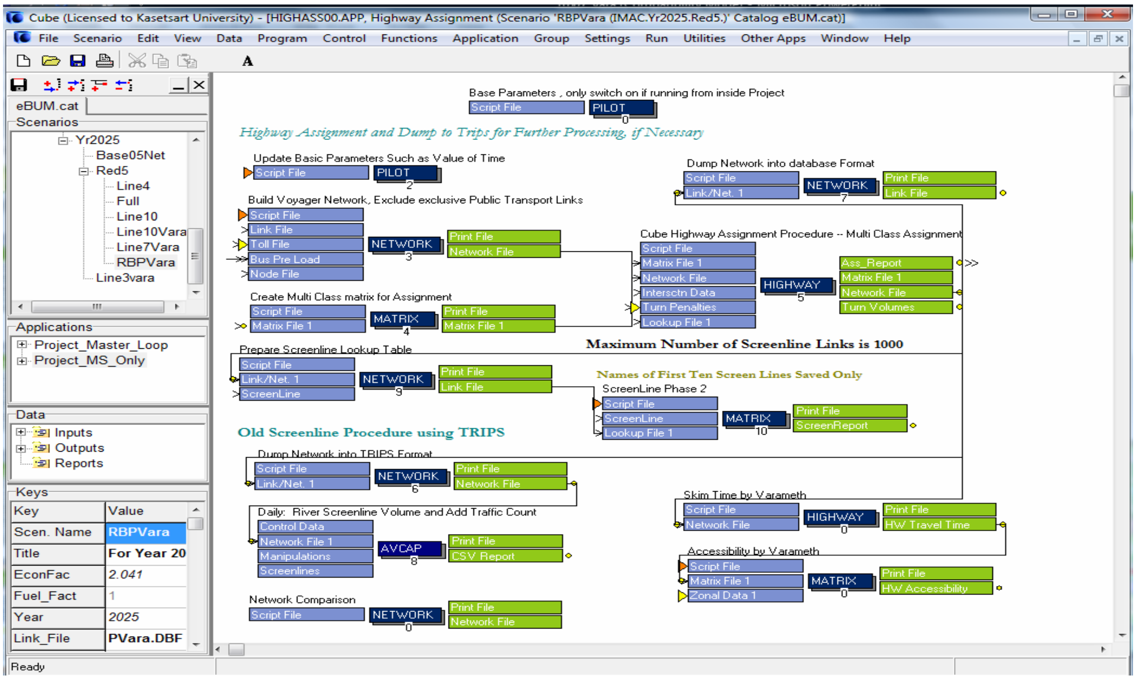


Figure 1 Bangkok Transportation Model

However, its land use assumption is a major drawback of the present system. That is, the future land use is considered exogenous or given in the transportation analysis. As a result, evaluation of transport alternatives is conducted by using the same set of future land use. It means the effect of transportation to land use is implicitly ignored; i.e., such effects as accessibility improvement, land development potential impact, and land value increase cannot be evaluated.

1.4 Organization of the Report

This report is organized as follows. This chapter has described the project background, scope and framework of the study. The next chapter presents literature reviews on transportation performance indicators emphasizing on mobility and accessibility. Chapter 3 determines the current situation of transportation in Bangkok in terms of mobility and accessibility with travel hazard map, accessibility map, cluster analysis of employment density, and location-associated travel preference. Chapter 4 presents a case study of impact of mass transit on mobility and accessibility of the city with scenario analysis. Finally, Chapter 5 concludes the report with recommendation on research challenges regarding mobility and accessibility that are essential for the local circumstances in Thailand.

2. Transportation Indicators

2.1 Transport System Performance

Several performance measures of transportation may be employed to evaluate the effectiveness of a transportation project. Examples of the measures are shown in Table 1.

Table 1 Transportation Performance Measures

Objectives	Type or Category	Performance Measures
Accessibility	Roadway	Percentage of population residing within 10 minutes or 5 miles of public roads
Mobility	Travel speed	Average speed Peak-hour speed
	Delay, congestion	Hours of delay Percentage of limited-access highways in urban areas not heavily congested during peak hours
	Amount of travel	Vehicle-miles of travel (VMT) on highways Percentage of VMT at specific road classes
Quality of life	Accessibility Mobility	Percentage of motorists satisfied with travel times for work and other trips

Source:

2.2 Mobility

Traditional measures of the effectiveness of the transportation system assess mobility. Performance measures associated with mobility may apply to passenger or freight transportation. These may include

- The travel time, level of service, travel speed, delay, congestion
- The average speed vs. peak-hour speed
- The transfer time at intermodal transfer terminals, hours of delay
- The percentage of a facility that is not heavily congested during peak hours

Data on travel time and congestion-related measures are typically estimated with existing analytical or simulation models, while mode shares and levels of service (inter-modal connecting times) can be ascertained using surveys of individual facility users or businesses.

2.3 Accessibility

An important function of any transportation system is to provide for people accessibility to residences; places for employment, recreation, shopping, and so on; and for goods and services, accessibility to points of production and distribution. Any performance measure for accessibility should reflect the ease with which passengers and goods reach their destinations. Performance measures for accessibility may include:

- The ability of a facility to handle specific types of passengers or freight
- The capacity of specific intermodal facilities for freight and passengers
- The ease of access to the transportation system
- The ease of connecting at transfer facilities
- The percentage of the population or freight-generating businesses located within a certain distance or travel time from a specific transportation facility

Accessibility is often discussed in contrast to mobility. Mobility emphasizes the transportation system, while accessibility also accounts for land use patterns. Accessibility is a way to characterize the ease of reaching activities. That ease is determined by a combination of the transportation system, which determines the physical connections between activities, and land use patterns, which determine the locations and intensity of activities. Most researchers agree that any accessibility measure should reflect changes in both the transportation system and land use patterns.

Many European nations are looking at accessibility as an indicator for sustainability in the transportation system. Efforts are being pursued in the Netherlands, the United Kingdom, and Spain to develop an accessibility measure to use in planning. Work in the Netherlands concentrates on three areas: reducing automobile use, access to needed activities (education, medical facilities, etc.), and the promotion of economic development.

It is agreed on several characteristics of accessibility measures; a basic set of criteria were first put forth by Weibull in 1976 as follows:

- The order of opportunities should not affect the value of the measure;
- The measure should not increase with increasing distances or decrease with increasing attractions
- Opportunities with zero value should not contribute to the measure.

It is also generally agreed that accessibility measures should have a behavioral basis, although there is not always agreement on exactly what this basis must be. More sophisticated measures are structurally consistent with travel choice theory, but even the simplest measures can be calibrated to observed patterns of travel. However, some researchers raise the question of the appropriateness of relying on revealed travel behavior as a basis for accessibility measures, given that such behavior is constrained by the available choices and may not be indicative of preferences and desires. Practical considerations often come into play in the resolution of these alternative approaches; technical feasibility and the need for ease of interpretation, for example, may necessitate the use of measures less directly reflective of travel behavior theory.

Differences among the accessibility measures used by researchers derive at least partly from differences in the purposes for which the measures are used. Many researchers have studied the influence of accessibility on individual and household transportation patterns and agree that accessibility is an important variable in transportation modeling. Accessibility measures also have been used frequently in models that predict the impact of transportation investments on development and in industrial and residential location choice models. Accessibility measures have been (and are increasingly) used to study equity of access to jobs and basic services between different segments of the population. Although the concept of accessibility employed in different studies may be essentially the same, the operationalization of the accessibility measure may vary in ways appropriate to the specific application. Some expressions of accessibility are summarized in the following sub-sections. These are summarized and adapted from (Bhat et al. 2000), that has discussed the appropriateness of different accessibility expression in relation to land use.

2.3.1 Spatial Separation Measure

The simplest accessibility measure is the distance or separation measure. The only dimension used is distance. Because these measures do not consider attraction level (e.g., land use), strictly speaking they do not fit the general definition of an accessibility measure discussed above. But, they are more than a mobility measure because they discount distances. The most general network accessibility measure computes the weighted average of the travel times to all the other zones under consideration.

$$A_i = \frac{\sum_j d_{ij}}{b} \qquad (1.1)$$

In this general formulation of this version of an accessibility measure, d_{ij} is the distance between zones i and j, and b is a general parameter. Early work in the graph theory area used a completely abstract version of the road network. There were two reasons for this: one was the cost of analysis at that time, and the other was the argument that the measure should be compared to the ideal of the Euclidean distance between two areas. Alternative formulations of this measure include the addition of weighting factors to the distance. These weighting factors may be the number of zones in an area or an attractive factor determined by importance in the household budget. These factors are not based on land use in the area

If accessibility is an indication of the combination of land use and the transportation system, then criticism of the spatial separation measure's lack of land use information is well-founded. Another criticism of such measures is their reflexive nature. Accessibility from point A to point B is the same as from point B to point A, which indicates independence from land use information and behavioral data.

2.3.2 Cumulative Opportunities Measure

The simplest accessibility measure that takes account of both distance and the objective of a trip is the cumulative-opportunities measure. This measure defines a travel time or distance threshold and uses the number of potential activities within that threshold as the accessibility for that spatial unit.

$$A_i = \sum_t O_t \qquad (1.2)$$

Here *t* is the threshold, and O_t is an opportunity that can be reached within that threshold. Often, several time or distance increments are used to create an isochronic map. The only information needed for this measure is the location of all the destinations within the desired threshold (e.g., jobs or hospitals). In this case, there is no distinction between attractions near to and far from the origin under consideration. To address this shortcoming, researchers have made refinements in a variety of ways. (Black and Conroy 1977) use the area under the cumulative-opportunities curve as the accessibility measure. Many researchers find cumulative opportunities an effective measure for evaluating accessibility for a particular trip purpose or for a particular population subgroup. Advantages of such forms include ease of interpretation and limited data requirements; disadvantages include the lack of an explicit behavioral basis.

2.3.3 Gravity Measure

The gravity measure includes an attraction factor as well as a separation factor. While the cumulative-opportunities measure uses a discrete measure of time or distance and then counts up attractions, gravity-based measures use a continuous measure that is then used to discount opportunities with increasing time or distance from the origin. The general form of the model has an attraction factor weighted by the travel time or distance raised to some exponent.

$$A_i = \sum_j \frac{O_j}{t_{ij}^{\alpha}} \tag{1.3}$$

The cumulative-opportunities model is criticized for treating opportunities equally, whether they are right at the origin of study or just inside the isochronic line determined by the time or distance parameter. Including the time or distance in the denominator of the equation, gravity-type measures provide a dampening effect that devalues attractions far from the origin.

Many researchers have explored the appropriate nature of the impedance factor of the gravity equation. As discussed in the next section, some argue for a Gaussian form that values nearby attractions highly and then falls off more quickly with distance or time. Searching for an appropriate form and value of the impedance function, many researchers find it appropriate to have different parameters for different kinds of attraction. An example often cited is that many individuals are willing to travel farther for work than for other activities.

There are three main components of the gravity model that researchers model differently. These are the characterization of a zone's attractiveness, impedance measure between zones (e.g., time or distance), and the form of the impedance function.

The attractiveness of a zone can be modeled in several different ways. When assessing accessibility to employment, the number of jobs in a zone is often used (Tagore and Sikdar 1996; Zhang et al. 1998). For accessibility to shopping, the number of retail positions (Bhat et al. 1999; Kockelman 1997) or the square footage devoted to retail sales might be used.

Regarding spatial separation, there may be several methods to characterize spatial separation such as using

- Euclidean distances
- Actual network distances
- Travel time

- Combined measure
- Perceived distance or cost

(Bhat et al. 1999) argue that the travel impedance factors used should be policy sensitive in order for the model results to be useful in policy analysis and, consequently, to construct a multimodal impedance factor for their analysis. (Levinson and Kumar 1994) create a multimodal measure because they are particularly interested in mode split as a result of the addition of high occupancy vehicle lanes (in eight potential configurations).

It is intuitive that the form of distance impedance should be Gaussian-centered on the origin. The flatness near the origin is intuitive in that nearby activities are more attractive than those farther away. The function gradually drops off, approaching zero at infinite distance. An important parameter in the Gaussian model is the distance (from the origin) at which the function has the steepest slope. Behaviorally, this is where distance-normalized attraction decreases fastest.

Researchers use various methods to determine the value of the parameter in the impedance function. The most common form used is the exponential form. The cumulative-opportunities measure can be thought of as the case where this factor, alpha, equals zero. Many researchers set alpha equal to one (Linneker and Spence 1992). Others use empirical data to determine a value that best describes the area under consideration (Bhat et al. 1999; Cervero et al. 1999).

Gravity-type accessibility measures have been used to measure access to medical facilities, grocery stores, railway stations, shopping, and employment. In addition to using accessibility measures to evaluate access to particular types of activities, researchers have used gravity measures to compare different transportation configurations. (Zhang et al. 1998) compare an existing urban situation with the situation following the addition of a proposed light-rail system. Graphical presentations of their findings show wide variations in accessibility across study areas. Other researchers also find gravity-based accessibility measures to be an effective way to track changes over time (Cervero et al. 1999).

A variation on accessibility to employment was used (Cervero et al. 1999). Instead of using the number of all jobs as the attraction, they investigate whether or not citizens have access to jobs in their income bracket. Their work also considers the local area jobs/housing mix and their changes over time.

Gravity-type accessibility measures are also used as inputs to other modeling projects. (Kockelman 1997) uses such a measure as one of three new variables she introduces to travel behavior models to explain vehicle kilometers traveled, automobile ownership, and mode choice. The introduction of accessibility is found to significantly improve performance of the models.

Several researchers criticize the ability of gravity-based accessibility measures to accurately reflect accessibility. One criticism is that many measures assign the same level of accessibility to all individuals in a zone, but this applies to all measures that aggregate at the zonal level. Another difficulty is highlighted in (Handy and Niemeier 1997), where the difficulty of constructing a measure that accounts for the possibility that two people in the same place may face different levels of accessibility is discussed.

Another point of criticism is the method that some researchers use to calibrate gravity-based accessibility measures. As mentioned earlier, several researchers found local data useful in calibrating their measures. This technique is not uncommon in other transportation-modeling situations. (Agyemang-Duah and Hall 1997) were successful in transferring an ordered-response model to other areas that needed limited changes to the model parameters. Their model includes a gravity-based accessibility measure as one of the variables. They found this method works reasonably well.

A final criticism is that the general form of the gravity model implies a trade-off between attraction and distance. One unit of attraction is equal to one unit of distance. However, this criticism is specific to simple forms of the gravity measure and is not relevant to general forms of the measure.

An alternative to these measures is a utility or logsum accessibility value. Based on microeconomic theory, these measures evaluate accessibility at the individual (or household) level and assume that individuals will choose options to maximize their well-being. This approach offers a more sophisticated and theoretically sound treatment of travel behavior by using observed travel choices to accurately value impedance and attractiveness factors. In addition, these models easily incorporate socioeconomic variables to reflect differences between individuals in the valuation of these factors.

2.4 Local Practices of Mobility and Accessibility

This study has reviewed several transport-related projects conducted in Thailand during the past ten years. Some of them are listed below:

- **Transport Data and Model Center, TDMC (Office of the Commission for the Management of Land Traffic 2000b)**
- **Transport Data and Model Center V: TDMC V (Office of Transport and Traffic Policy and Planning 2006b)**
- **Urban Rail Transportation Master Plan in BMA and Surrounding areas (URMAP) (Office of the Commission for the Management of Land Traffic 2001)**
- **BMTA Route Planning and Scheduling Project (Office of the Commission for the Management of Land Traffic 2003)**
- **The Intermodal Service Integration for the Improvement of Mobility, Accessibility, Sustainability and Livelihood for Bangkok Metropolitan Region (BMR) and Surrounding Area (Office of Transport and Traffic Policy and Planning 2006a)**
- **The Study on Holistic Plan for Traffic System Development - Holistic Development Plan for Transportation and Traffic 2006 - 2011**
- **Bangkok Transit System Extension (BTS Extension) 2005**
- **Transport and Traffic Data Collection for the Prachuapkirikan Regional Master Plan (Hua Hin District) 2006 (OTP)**
- **Urgent Traffic Action Plan on the Major Traffic Corridor 2005 (OTP)**

As summarized in Table, it is found that all projects employed similar mobility and accessibility indicators. Mobility is usually expressed in terms of speed of travel, either average travel speed or running speed, as well as travel time. Accessibility is recognized only in terms of development output such as kilometer of highway construction. In some projects, the captured or influenced area is used as an accessibility measure to express the development contribution of the project. However, none has considered the impact to urban development explicitly.

Table 2 Mobility and Accessibility Measures in Local Practice

Project	Mobility			Accessibility	
	Average Speed	Running Speed	Travel Time	Physical Length	Area Captured
Transport Data and Model Center: TDMC	/	/	/	/	/
Transport Data and Model Center V : TDMC V	/	/	/	/	
Urban Rail Transportation Master Plan in BMA and Surrounding Areas (URMAP)			/	/	
BMTA Route Planning and Scheduling Project	/			/	
The Intermodal Service Integration for the Improvement of Mobility, Accessibility, Sustainability and Livelihood for Bangkok Metropolitan Region (BMR) and Surrounding Area (IMAC)	/				/
The Study on Holistic Plan for Traffic System Development - Holistic Development Plan for Transportation and Traffic	/				
Bangkok Transit System Extension (BTS Extension)	/			/	/
Transport and Traffic Data Collection for the Prachuapkirikan Regional Master Plan (Hua Hin District) 2006 (OTP)	/		/	/	
Urgent Traffic Action Plan on the Major Traffic Corridor 2005 (OTP)	/				

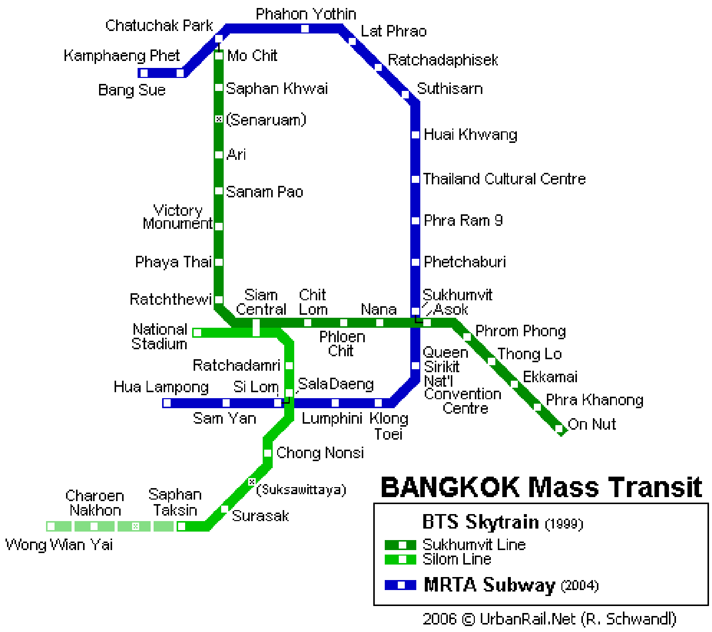
CHAPTER 3 CURRENT SITUATION IN BANGKOK

3. Current Situation in Bangkok

Covering 7,758 square kilometers, Bangkok Metropolitan Region (BMR) consists of a large core so-called Bangkok Metropolitan Area (BMA) and five surrounding areas, namely Nonthaburi, Pathumthani, Samut Prakarn, Samut Sakorn, and Nakorn Pathom. BMR has undergone rapid urbanization and industrialization since 1960. Population growth is so dramatically rapid due to extensive investment in road network and the rapidly growth of real estates. However, from 1987 to 2000, population of the inner area has declined, but the outer area increased. The inner area population density decreased from 15.27 to 11.09 thousand/sq.km. (3.25 to 2.36 million people) while the outer increased from 0.77 to 1.28 thousand/sq.km. (0.67 to 1.12 million people). Recently in 2005, the total population in BMR accounts for 16.8% of the country population and produces 44.2% of the country's GDP. This shows that BMR is a major economic center of the country, where every economic activity can be found in various areas such as high-density business districts, high-density residential areas, heavy industrial estates, etc.

3.1 Urban Transportation

Regarding the transportation, major travels in Bangkok are based on road transport; mostly by private vehicles. In 2005, private mode share is approximately 53%; while public mode is only 44%. The fact is that private mode is far superior to public transports, mostly are public bus. Although there are over 404 bus routes, they are not enough to accommodate travel demand, especially from/to the suburban areas. For the rail transport, the urban rail transit has been introduced recently. In 1999, 23-kilometer elevated urban railway so-called BTS, standing for Bangkok Transit System, started its service in two lines. BTS is presently receiving over 400,000 daily passengers. Five years after BTS opened, a 20-kilometer urban subway line (called MRT) operated by Mass Rapid Transit Authority has started its service in 2004. There are three transfer points between the two systems. The network of BTS and MRT is shown in



Source http://www.urbanrail.net/as/bang/bangkok.htm

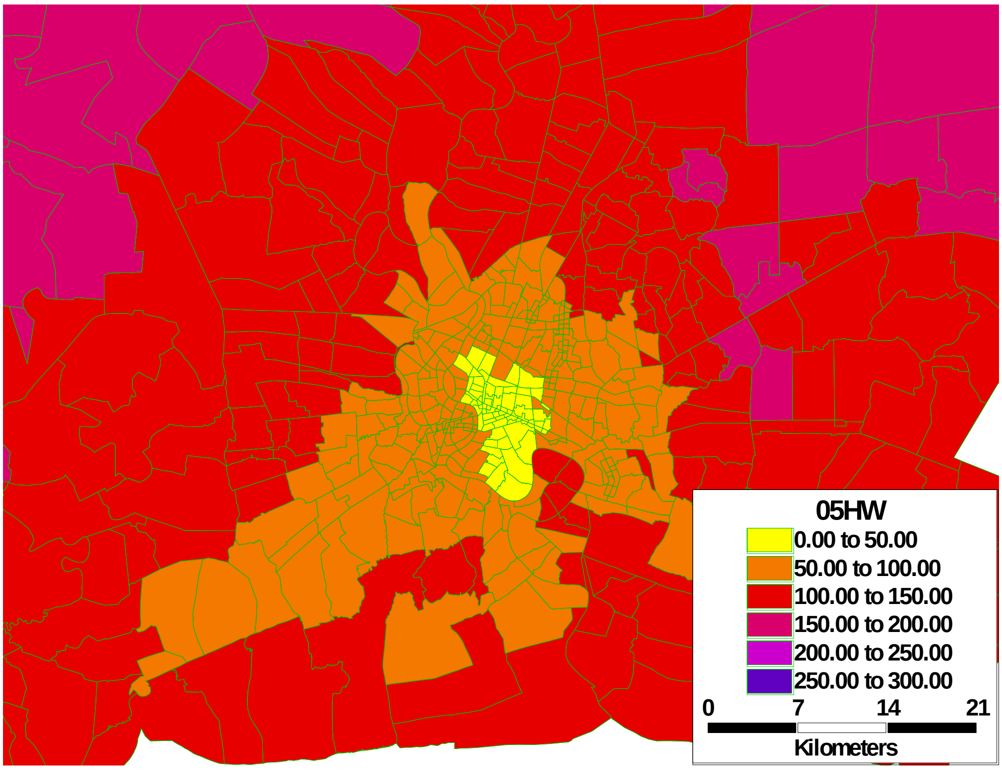
Figure 2 Urban Rail Transit in Bangkok

In addition, there are sub-urban railway lines of SRT, standing for State Railway of Thailand, mainly on sub-urban and inter-city routes. Although the rail services of BTS, MRT, and SRT have accommodated some portions of urban travel demand, but still not enough.

3.2 Urban Mobility

Mobility measures how ease travelers can move from a certain place to their final destination, which may be represented by travel time, travel speed, average delay, or level of service, etc. This paper presents a so-called *Travel Hazard Map* as shown in Figure a and b for private and public transports, respectively. It is the travel time in minutes to the city center, named Silom (zone 131), computed by the travel demand model as mentioned in Chapter 1. It is shown that travelling to the center from the outer residential area like Don Muang, Nonthaburi, Phutthamonthon, or Bang-Na (the red areas in Figurea), would take about two hours on private cars; but would take longer on public transport (becoming pink in Figureb). Recalling that residents are sprawling (Figure a) but employment are concentrating at the center (Figure b), those people living in the outer area have poor mobility on public transport comparing with private cars, so they will never choose to take public transport but prefer to drive into the center. This generated a lot of travel demand on private mode and causes severe traffic congestion, particularly during rush hours.

a) Private Transport



b) Public Transport

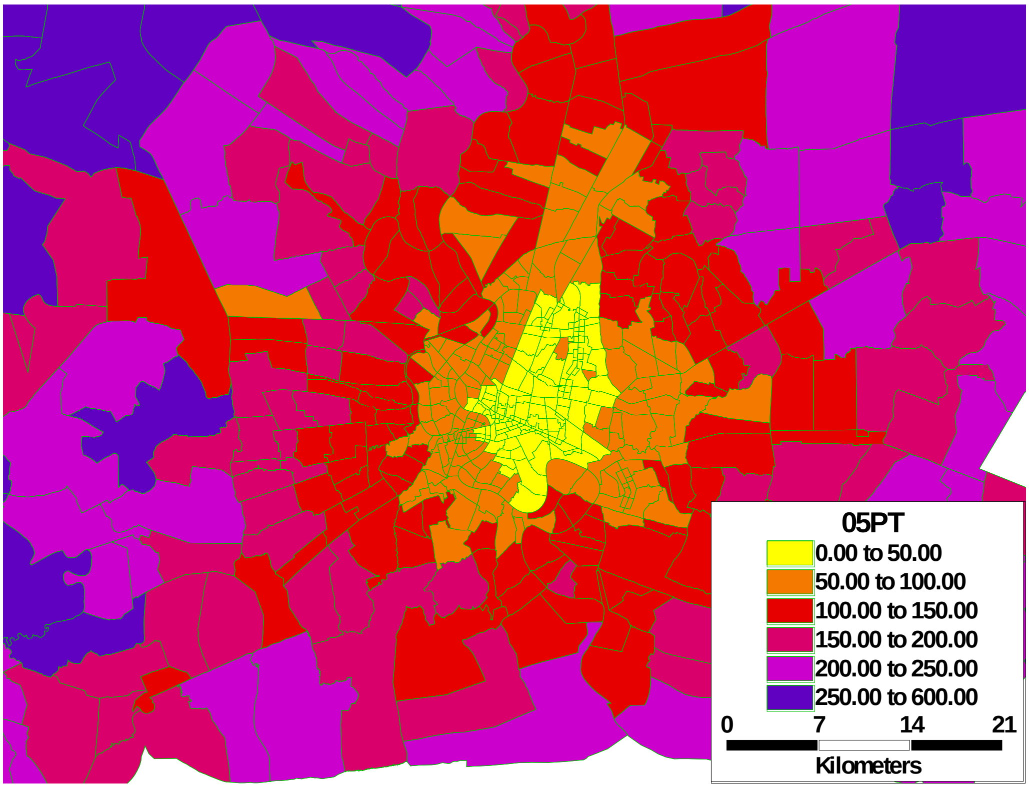
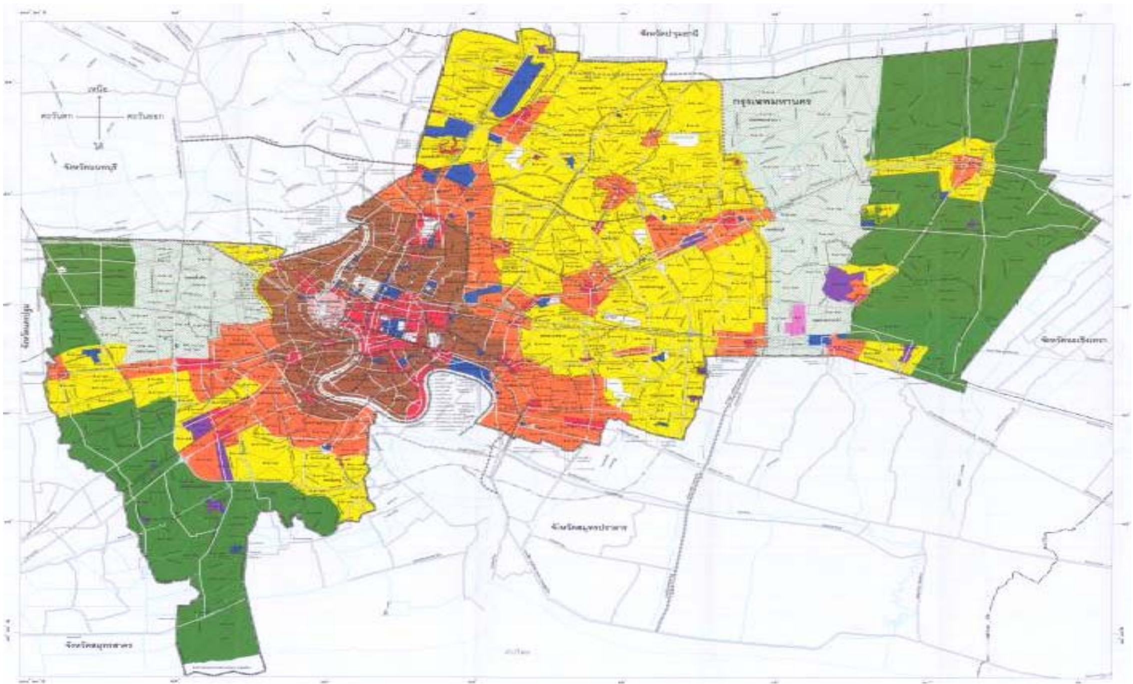


Figure 3 Mobility in 2005

3.3 Urban Activities

Previous studies (Rujopakarn 2003) indicated that traffic problems in Bangkok were originated from inefficient master plan, inefficient planning and design standards, ineffective land-use control, unstructured hierarchy of road network, as well as inefficient public transport system. In a bigger picture, Thailand has become automobile-dependent during the past transportation plans and policies. Road-based transports had obtained top priority, taking almost all of the budgets available for transport infrastructure development. However, less attention is given to land use regulation or land use control to structure the city in accordance with the master plan. The first revision of Bangkok City Planning, or so-called Comprehensive Plan, was devised in 1999. Recently, the plan was revised by adding changes in the circumstances since the first revision. Now, the second revision is now active; so called the Ministerial Regulation on Bangkok Comprehensive Plan BE. 2549 (Bangkok Metropolitan Administration 2006) as shown in Figure .



Legend

- Low Density Residential Zone
- Medium Density Residential Zone
- High Density Residential Zone
- Commercial Zone
- Industrail and Warehouses Zone
- Warehouses Zone
- Special Industrial Zone
- Rural and Agricultural Zone
- Educational Institution Zone
- Rural and Agricultural Conservation Zone
- National Identity and Cultural Conservation Zone
- Religious Institution Zone
- Government Institution Zone

Figure 4 Land Use Plan

Comparing with the previous plan, land designation was changed in some parts of the city; reflecting increased development. Many of the changes are due to transportation development. Transportation demand is forecasted from 2002 to the next 20 years. Congestion in the inner area, i.e., the area surrounded by Ratchadapisek middle ring road, is reportedly becoming more severe. The average speed reduces from 18 km/hr in 2002 to 14 km/hr in 2009, and 12 km/hr in 2022. Although roads are becoming more congested, people still prefer traveling by private cars. Share of public transport reduces from 45% in 2002 to 40% in 2009, and 38% in 2022. It is, therefore obvious that Bangkok needs a proper set of countermeasures to alleviate the traffic congestion problems. Land use regulation and the related measures must be carefully considered and applied. The measure may be to provide transport infrastructure such as urban rail transit. In this case, understanding its impact to urban development will provide good information for the other policy measures.

Population, household, employment, land use, and transportation data used in this study are the same set as the official transportation planning data, which are responsible by the Office of Transportation Policy, (Office of the Commission for the Management of Land Traffic 2000a). In 2005, total population is 10,661,047 and total employment is 5,962,497. The distribution of population and employment are shown in Figure . It is clear that population and employment are mostly concentrated in the inner core; only some portions are scattered to the northern and eastern parts.

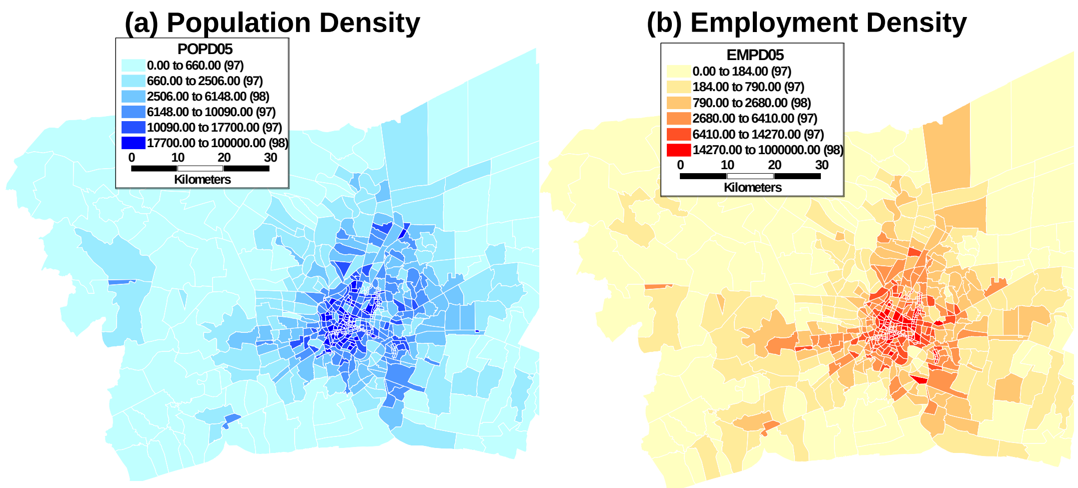


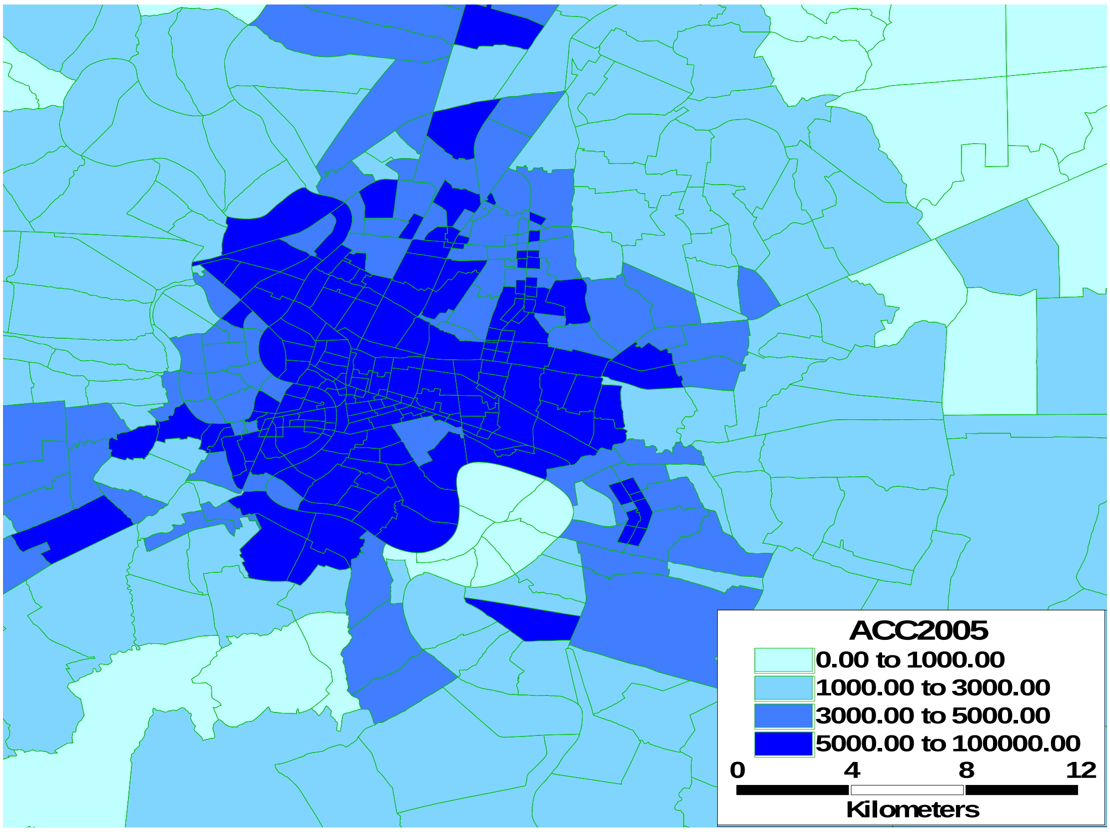
Figure 5 Population and Employment Distribution

3.4 Accessibility to Employment

Accessibility measures the opportunity to complete certain activity at other locations at a distance away. Regions with well-developed transportation networks generally have high degrees of accessibility. A typical accessibility measure has two components. One is related to the destinations and is commonly called the attractions portion of the measure. For example, attractions measures for shopping may be number of employees, amount of sales, or square feet of space. The second component describes the ease of reaching those attractions. Since difficulty increases over distance, this component is commonly called the impedance factor. Typical impedance factors include distance to the attraction, the amount of time it takes to reach the attraction, or cost of traveling to the attraction. Expression of accessibility measures vary from simply minimum-travel-time indices, cumulative opportunities within specified time thresholds (Srour et al. 2002b), to more complicated measures of various forms (Kim and Kwan 2003). This study employed an exponential expression $A_i = \sum_j Emp_j \exp(-0.001 t_{ij})$ to determine job accessibility from each area in the city: where A_i is the employment accessibility of zone i, E_j is the number of employment or workforce available in zone j, and t_{ij} is the inter-zonal travel times on private and public modes. The resulting job accessibility on private and public modes are shown in Figure a and b respectively. It is obvious that job accessibility on the private mode is far larger than on the public mode. This confirms that public transport service is inadequate, considering that people are living around the city and most of them are commuting to work in the city center. Again, the large numbers of people living outside with low job accessibility on public transport would have no choice other than using private modes of transport for their commuting trips.

It is noticed that the areas with high accessibility (the dark areas in Figure b) are on the corridors of the two urban railway lines and have very rapid increase in land value as well. This shows that the impact of transport on land development potential is quite strong.

a) Private Transport



b) Public Transport

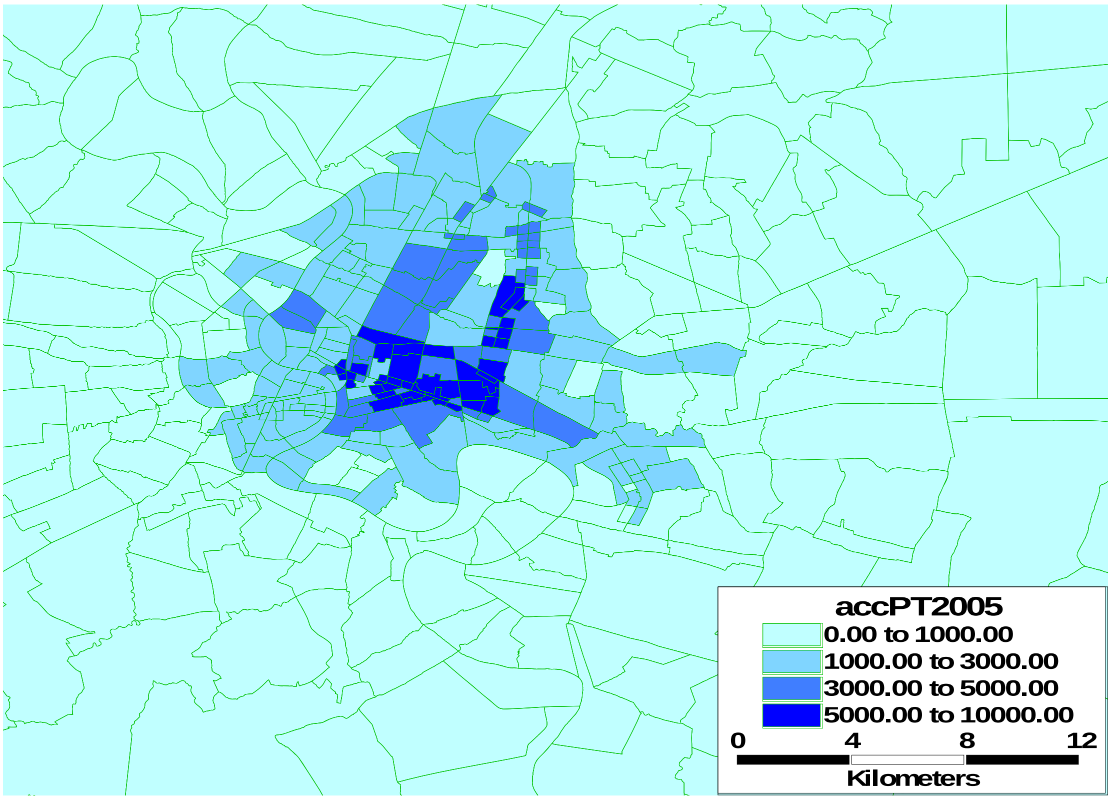


Figure 6 Job Accessibility

3.5 Location-Associated Travel Pattern

Although it is understood that Bangkok is rather mono-centric where most of urban activities are concentrated at the center, it is still growing in which many activities have been moving out to agglomerate at some certain location and will form sub-centers at the end. This study analytically shows the residential location preferences for a given employment center is to plot the destination-specific employment preference curve, based on a form of the intervening opportunity model (Black et al. 1993; Vichiensan 2007). It presents the capability that an employment area is able to capture its employee from the surrounding residential places. Steep gradients imply a nearby choice of residential location while shallow gradients around an area imply a broader, metropolitan-wide, spatial labor market. The curves of some employment zones in Bangkok are presented in Figure .

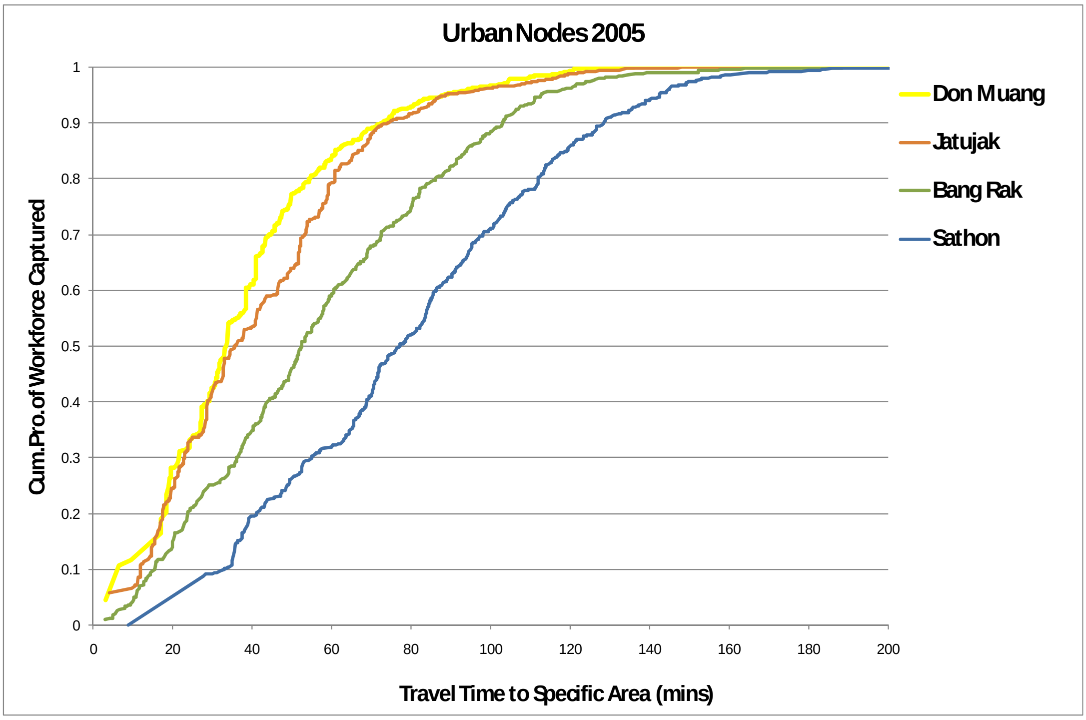


Figure 7 Location Associated Travel Preference Curves

From the graph, it is clear that people who work in the central area such as Sathon and Bangrak are coming from various parts of Bangkok, which is interpreted and obvious by the relative flat curve; while people working in the outer employment nodes such as Jatujak or Don Muang are coming from shorter distance, showing by a steeper curve. This can be explained shortly as follows: only about 50 percent of Sathon workers are coming from the area within 80 minutes travel time to Sathon; while almost 90 percent of Don Muang workers are coming from the area within 80 minutes travel time to Don Muang. As a result, Sathon is seemingly more

accessible due to its large activity size while Don Muang is more accessible due to its travel ease. This made clear that accessibility and mobility are the two dimensions that are of interest, so several measures of accessibility and mobility have been proposed and employed.

CHAPTER 4 THE FUTURES IMPACT OF RAIL TRANSIT

This chapter presents a case study on impact of mass transit network from viewpoint of mobility and accessibility by comparing the three following scenarios.

4.1 The Scenarios

4.1.1 Reference (Scenario A)

In the reference scenario, called Scenario A, the future mass transit network is the same as the existing network comprising of three urban railway lines: two elevated BTS lines and a subway MRT line, as shown in Figure 8.

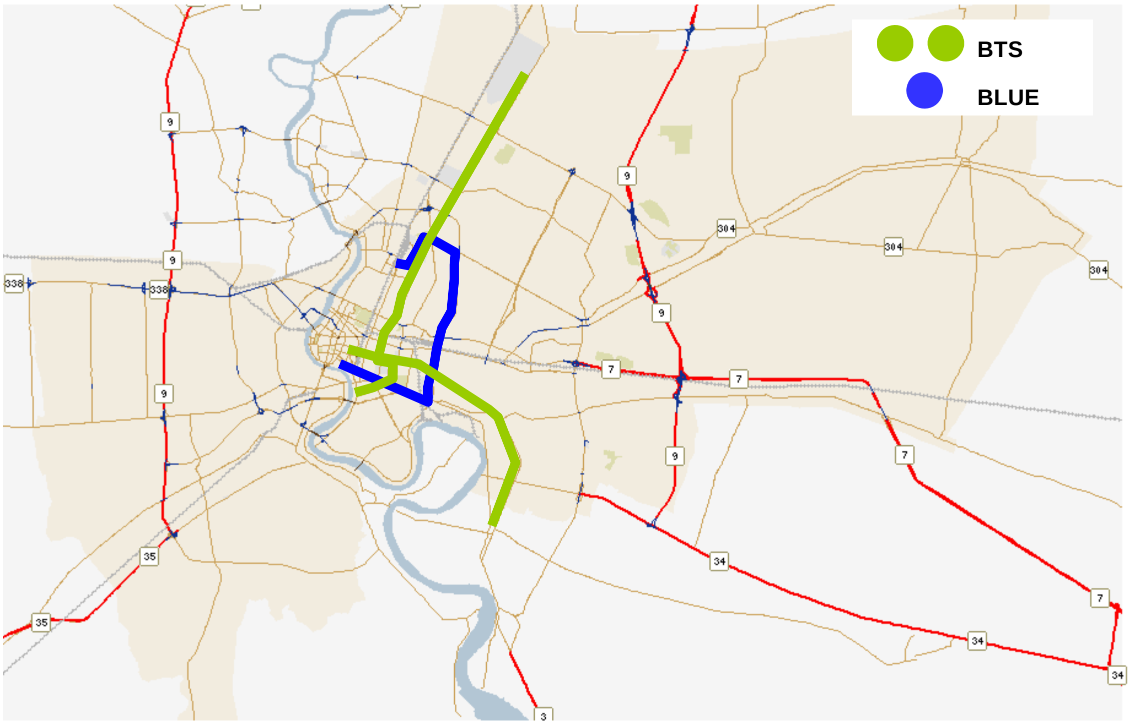


Figure 8 Present Mass Transit Network (Reference Scenario A)

4.1.2 Priority Transit Network (Scenario B)

The government has realized that the existing 42-kilometer BTS and MRT lines of mass transit service are inadequate to relieve the traffic problem in Bangkok. Despite of the expensive mass transit master plan, the medium-term action plan of mass transit is more likely to achieve, which consists of six highly prioritized lines, as shown in Figure . This is considered in the analysis as Scenario B.

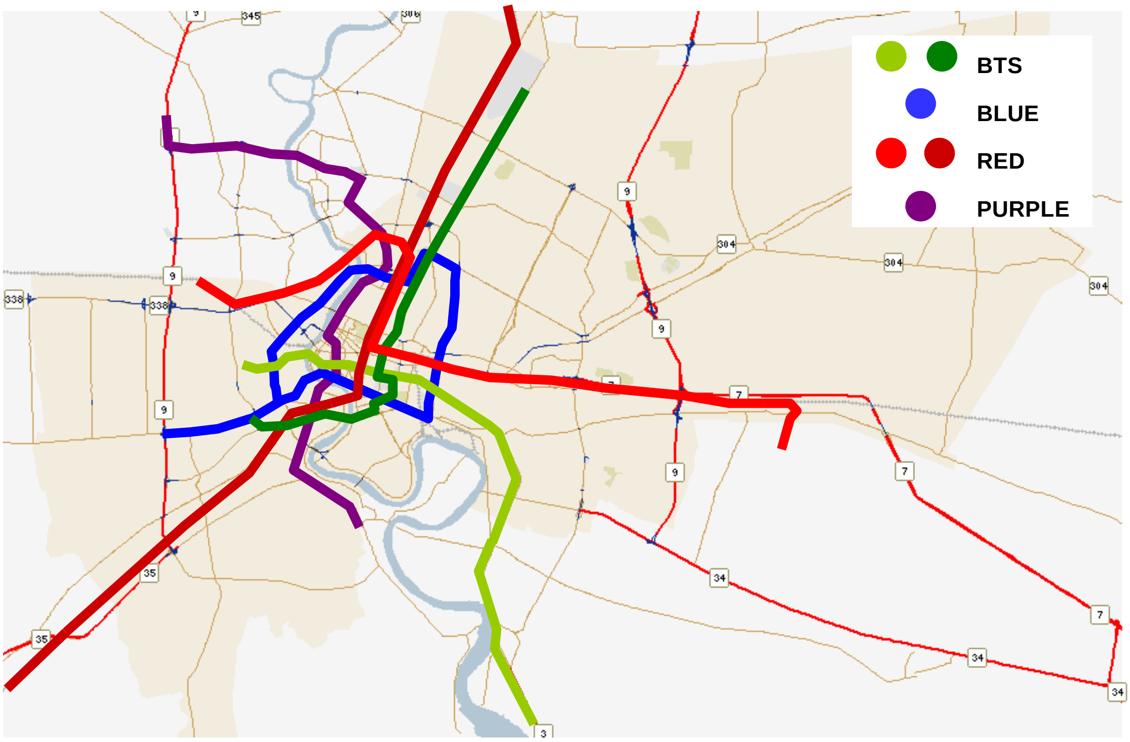


Figure 9 Medium-Term Mass Transit Network (Scenario B)

4.1.3 Complete Transit Network (Scenario C)

As the ultimate goal, the mass transit master plan of Bangkok is realized in Scenario C in the analysis. It consists of nine urban and sub-urban railway lines in 291 kilometers, as shown in Figure

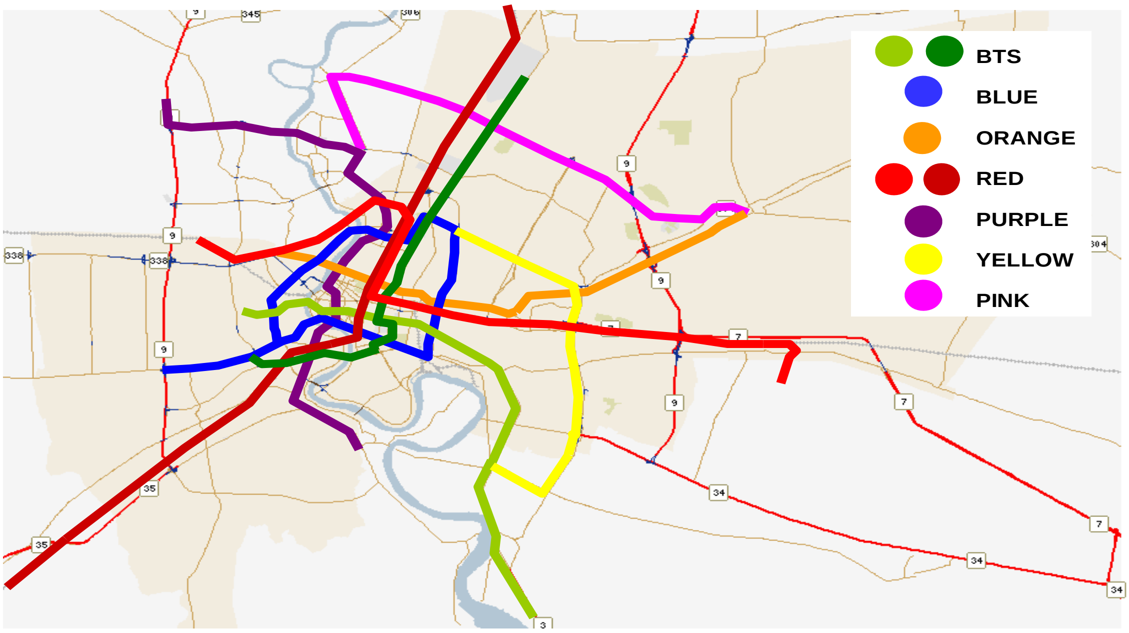


Figure 10 Complete Railway Network (Scenario C)

The base year is 2005, which presents the present condition, so only the reference scenario is run. The future years are 2010 and 2025, where the three scenarios are compared in terms of mobility and accessibility. For convenience, the scenarios to be analyzed are shortly called as shown in Table 3 and the results are presented next.

Table 3 Analysis Scenarios

	2005	2010	2025
A - Present Lines	Base	10A	25A
B - High Priority Lines		10B	25B
C - Full Network		10C	25C

4.2 Sample Locations

Specific locations are arbitrarily selected for more detail discussion. Their locations are shown in Figure . Apparently, Chatu Chak, Asoke, Hua Mak are high density areas with intensive employment opportunity. Taling Chan and Wong Wian Yai are the areas expected to be transit centers where the railway lines cross. Rangsit and Minburi are the sub-urban nodes and expected to be self contained.

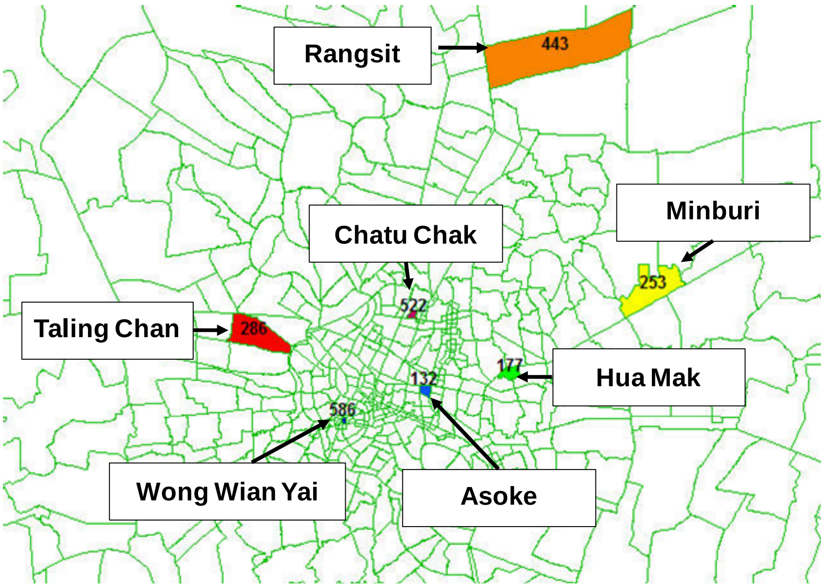


Figure 11 Location of the Selected Areas

4.3 Impact on Mobility

Mobility level of Bangkok in each scenario is illustrated by travel hazard maps in Figure 12

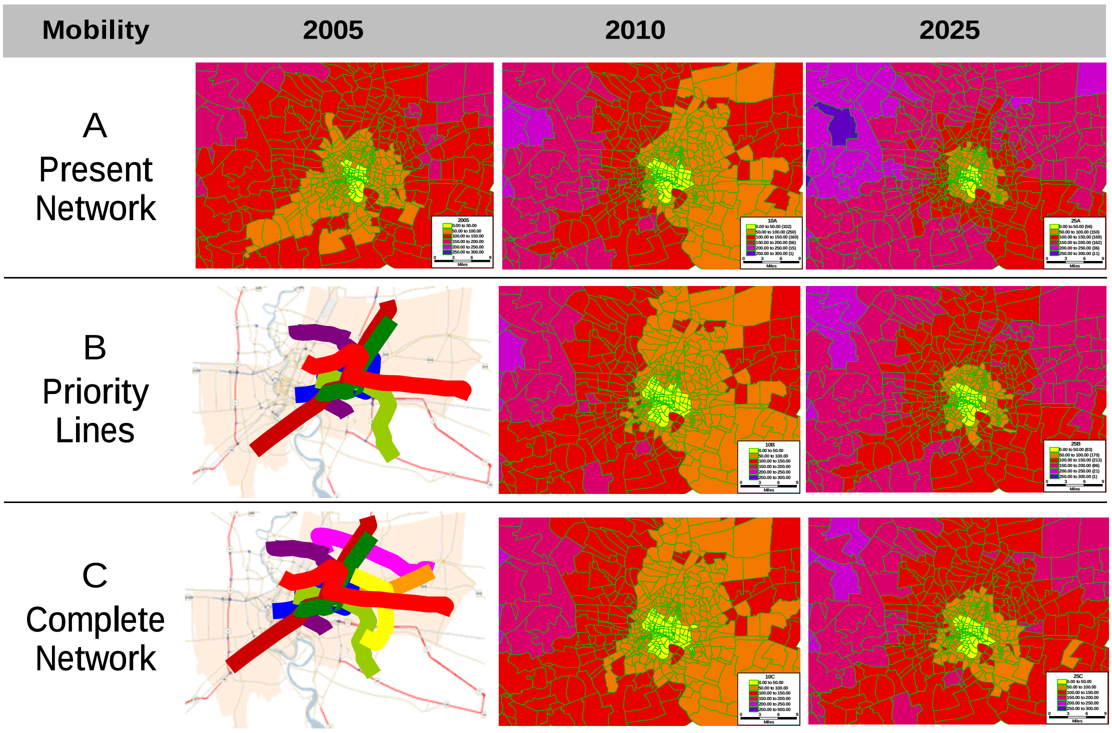


Figure 12 Impact on Mobility

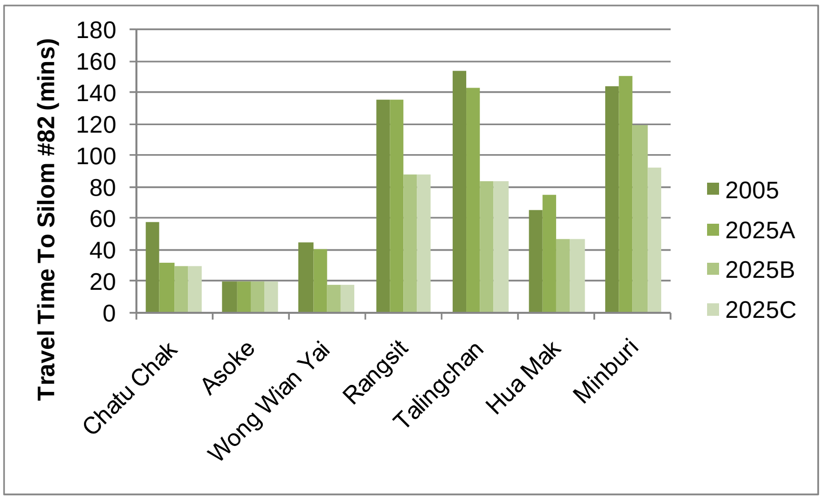


Figure 13 Mobility at Selected Locations

It is obvious that the full network (Case C) has significantly changed the mobility and accessibility, comparing to the case with only the three lines of BTS & MRT (Case A). Unless the network is improved, the city will be severely congested, i.e., it will possibly take very long time to travel into the city center, as shown by the widely spread pink area. Further examining the selected locations, shown in Figure , found that the network improvement has improved the mobility level of each location differently. The locations that presently have railway service such as Chatu Chak and Asoke will not get benefit from the network improvement. But the potential sub-center such as Wong Wian Yai, Rangsit, Talingchan, and Hua Mak will greatly get benefit from the new railway lines in Scenario B. The potential sub-urban sub-center such as Minburi still get further mobility benefit from the improved railway network in Scenario C.

4.4 Impact on Accessibility

Job accessibility level of Bangkok in each scenario is shown in Figure . It can be observed that the network improvement gives higher job opportunity compared to the reference network.

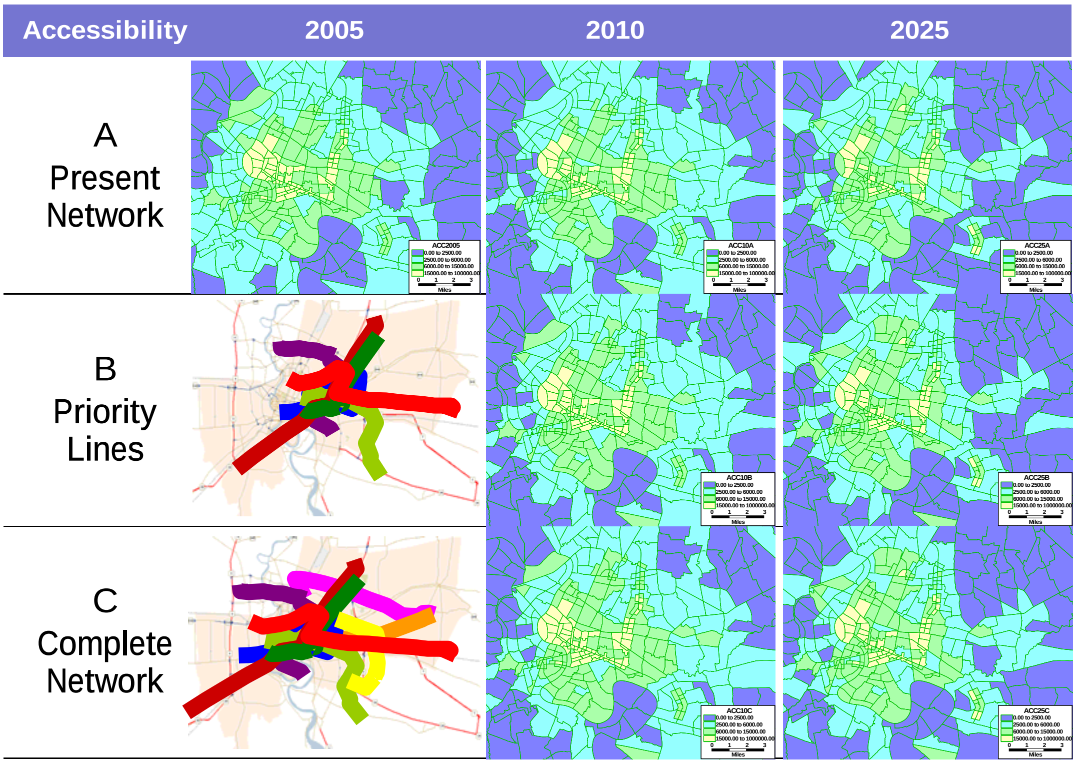


Figure 14 Impact on Accessibility

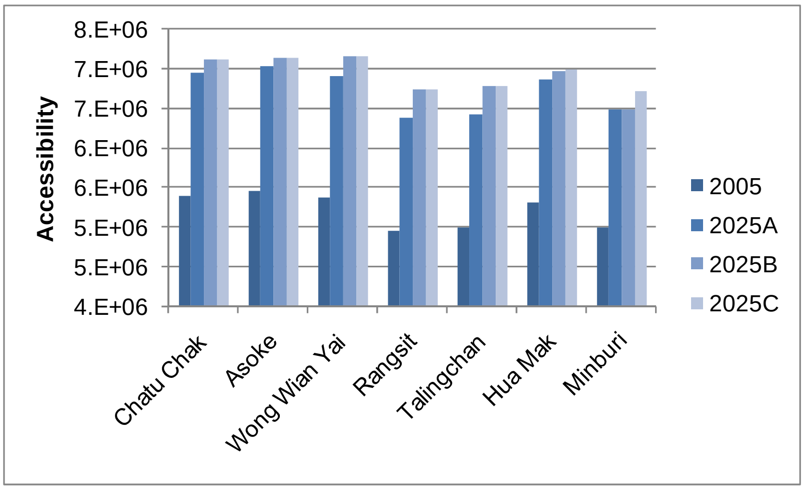
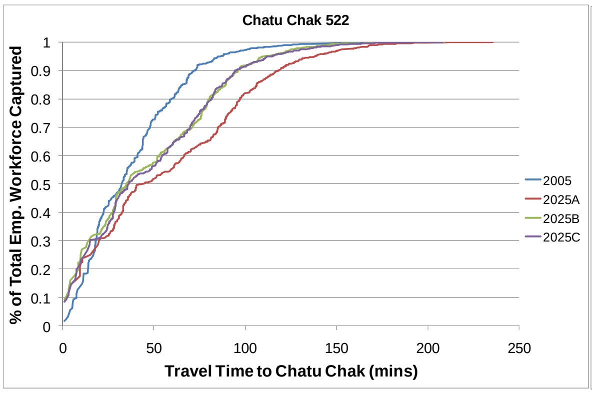


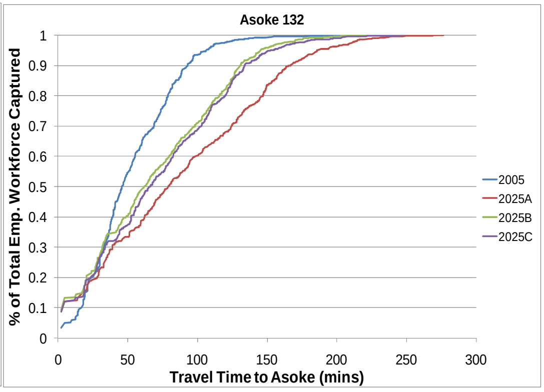
Figure 15 Accessibility at Selected Locations

Closer looking in Figure found that every selected location has improvement in job accessibility level as the railway service is improved in 2025 but at slightly different extent. That is, job accessibility of all locations are increased in Scenario B and almost no longer increased in Scenario C. However, Minburi still obtain larger job accessibility in Scenario C, the benefit brought by the orange and yellow lines, as shown in Figure c.

4.5 Impact on Location-Associated Travel Pattern

Examining the location-associated travel preference curves in Figure let us found that different locations have different response to railway network configuration in terms of sub-center formation potential. Taken 2005 as reference, Asoke may be considered as a city center comparing to the others, i.e., at 50-minute boundary it has received only 50% of its workers while Chatu Chak 70%, Wong Wian Yai 80%, Talingchan 80%, Hua Mak 70%, and Min buri 50%.





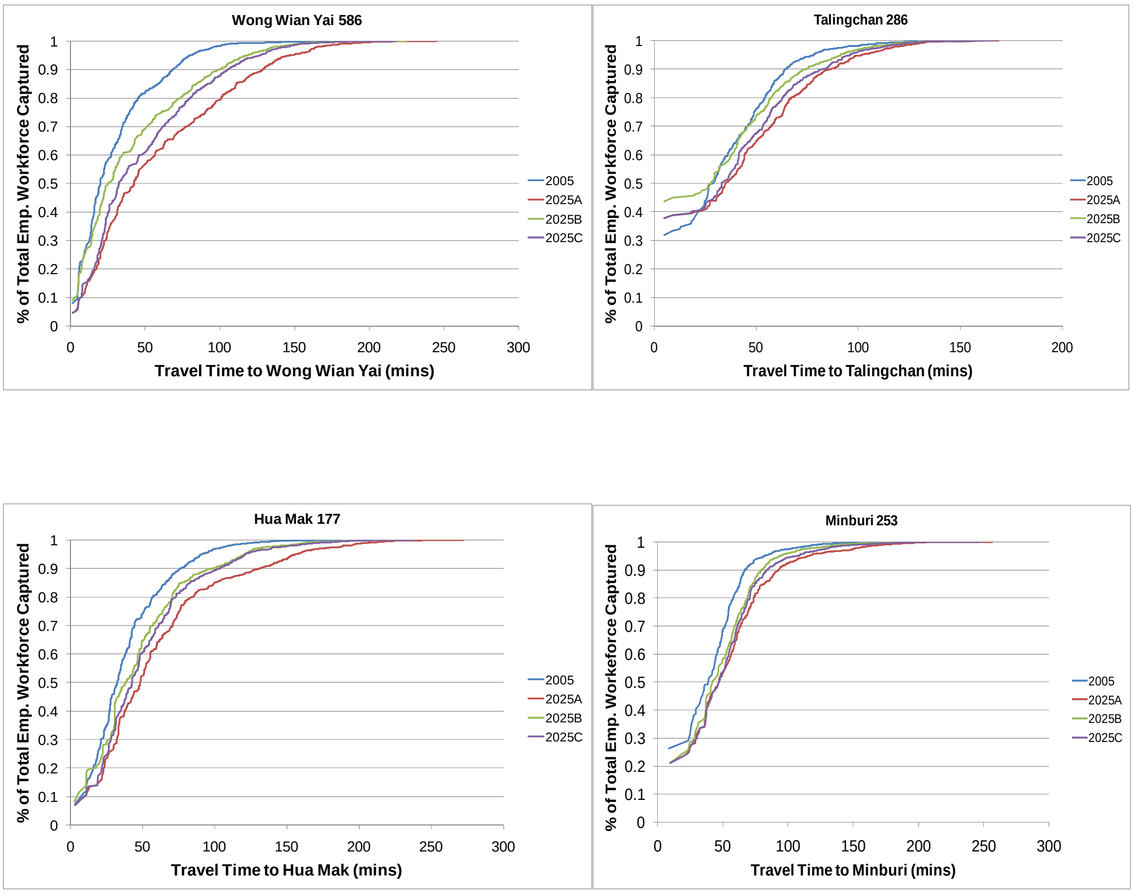


Figure 16 Location-Associated Travel Pattern at Selected Locations

In the future year 2025, Scenario 25A indicates that it takes much longer for each area to capture the same proportion of workers as in 2005. When the network is improved by adding more railway lines to the network, it is intuitive that the time to attain the same proportion is reduced than in the reference case. However, the extent of improvement is different for each location. Locating in the inner core, Chatu Chak, Asoke, and Hua Mak gain substantial portion of workers when railway service is expanded. But adding the yellow and orange lines does not help much, as shown that the curves in Scenario 25B and 25C are coincide. In contrast, the railway development does not affect Minburi locating in the suburb. But it is interesting in Wong Wian Yai and Talingchan on the west side of Bangkok, see Figure , that Scenario 25B exhibit steeper curves than Scenario 25C, meaning that it would take longer to attain the same worker proportion although the network is improved. This implies that adding more service on the east may cause adverse effect on the west side when considering the potential to form sub-center or employment node. The framework illustrated here let us understand the impact of accessibility on the urban form based on travel pattern. It allows transport

policy such as transit oriented development (TOD) be evaluated to what extent it has capability to capture or attract activity within certain travel range.

The above analysis results have confirmed that the rail transit development is very worthy to improve the transportation in Bangkok. However, the analysis had an inherent assumption that land use in the future is a given condition and not different in each scenario. In the other words, the feedback effect of transportation to land development is implicitly neglected. This definitely limits the discussion and will be discussed in the next chapter.

CHAPTER 5 RESEARCH CHALLENGES

5. Research Challenges

This study has reviewed several literatures, both academic and practical oriented; both international and local perspectives, regarding mobility and accessibility. It has come up with some indicators that are used to identify the present status of mobility and accessibility in Bangkok. The idea is, however, applicable for the other cities in Thailand as well. The case study has shown that mass transit plays important role in improving mobility and accessibility as well as influencing the potential for development of an area.

Evaluation of the present and future status of the city presented earlier provides insight on the remaining, lacking, and challenging research themes that are essential and substantial to be conducted in Thailand.

5.1 Mobility

It is shown earlier that transport network gives rise to improvement in mobility differently. This study has expressed mobility level in the form of travel time to city center. It is one representation among the other indicators: travel time to certain location at different time of day, month, and year; hourly, daily average speed; total delay, average delay, and approach delay at major intersection; trip length; vehicle kilometer travel, in-vehicle time, waiting time transfer time, and number transfer per trip on public transport, etc. It will be greatly useful to define a set of mobility measures that is possible in terms of data availability. Some raw data need to be collected from household interview or roadside survey and should be conducted periodically. These data will keep the travel demand model always up-to-date. (Rodier and Johnston 2002) has shown that inaccurate data will significantly mislead the analysis and make MPO (metropolitan planning organization) incompliant with the air quality standard. In addition, it is interesting to research on mobility management for different groups of decision makers, travelers, income classes, trip purposes, vehicle ownership levels, etc. For example, (Cervero and Wu 1998) found that VMT (vehicle miles traveled) per employee has increased in the San Francisco Bay Area and it is attributed to a lengthening of commutes and reduced transit and ridesharing market shares.

5.2 Accessibility

The accessibility expression employed this study is among several ways of expressing the opportunity to approach the activities in a city. It will be useful to develop an accessibility measure that is able to characterize, in a meaningful way, the overall system represented by the interaction between land use and transportation facilities. (Srour et al. 2002a) proposed accessibility indices that consider access to job, open space, shopping opportunities. It is interesting to examine how accessibility has influence on travel in Thailand. (Kockelman 1997) found that the travel behavior is the result of composite effects of accessibility, land use mixing, and land use balance. (Zhang et al. 1998) measured the accessibility in order to quantify the social benefit of a rail line in Puerto Rico and found that different income groups have different demand for accessibility to job. In longer range, it is also interesting to research how urban form is influenced by accessibility. (Alpokin et al. 2007) examined Tokyo, Sydney, Bangkok, Shanghai, and Istanbul and found that they are at different stage of polycentric development as a result of accessibility to job has improved.

5.3 Property Value Impact

Having shown that mobility and accessibility will be drastically improved as a result of transport development, its impact to nearby property value is yet to be explored. Empirical studies have shown that transport accessibility has large influence on land and real estate development and result in higher property value.

Classical hedonic approach has been long employed in various ways. (Pan and Zhang 2008) employed a simple hedonic regression to show the land value premium of proximity to train station in Shanghai. (Vichiensan et al. 2007) showed that after the BTS railway in Bangkok has opened, the land price along the corridor has remarkably increased especially around the stations. Figure shows the contour of the change of appraised land value between 1992 and 2006. It is obvious that the change is strong around Asoke station: a transfer point between two railway lines BTS and MRT.

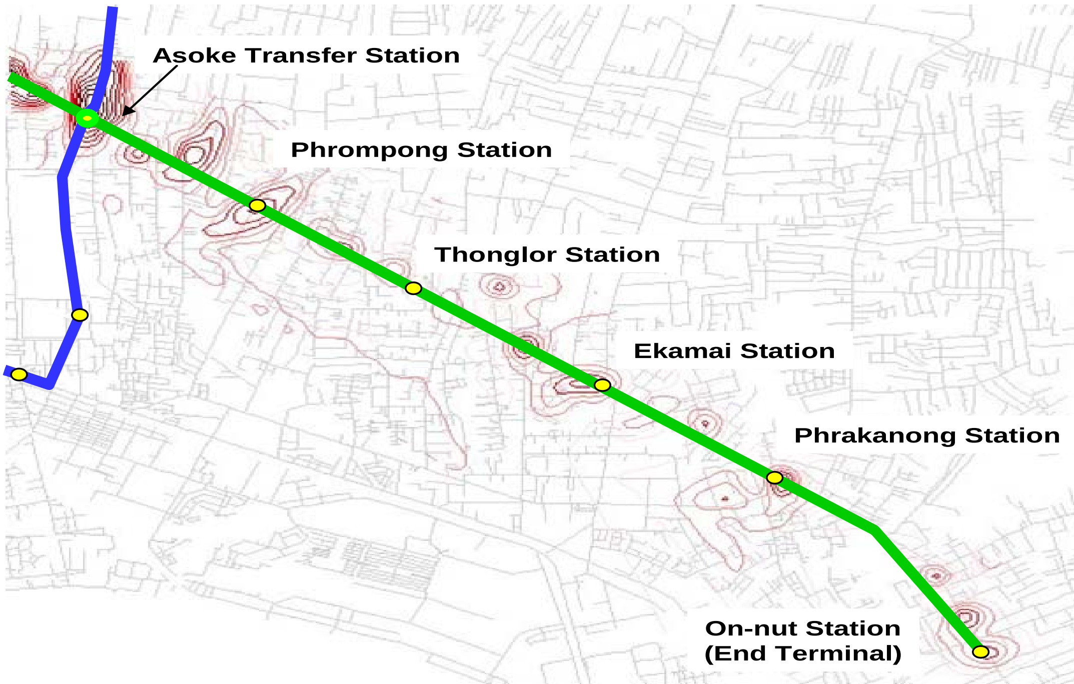


Figure 17 Increase of Land Value on the BTS Corridor

(Ryan 2005) also employed a simple hedonic model in San Diego showed that access to highway is significant effect to office rent while access to LRT is not. (Munoz-Raskin 2007) found that walk access to BRT in Bogota has great impact on property value. Alternatively, some studies have taken into account the neighborhood effects. (Cervero and Duncan 2004) showed that composition of neighborhood has great influence on land value. (Bae et al. 2003) proved that distance to the line-5 subway station in Seoul has less impact than other factors such as quality of school district, proximity to high-status sub-center, and accessibility to recreational resource. (Chalermpong 2007) examined the impact of BTS urban railway on property price in Bangkok with spatial autoregressive regression model. (Shin et al. 2007) observed the impact of transportation accessibility on residential property value with a spatial lag model. (Hess and Almeida 2007) examined the impact of the LRT in New York on station-area property value with individual regression models for each of the light rail system's 14 stations. It was found that effects are not felt evenly throughout the system. Proximity effects are positive in high-income station areas and negative in low-income station areas.

Alternatively, some studies focus on local variation of the impact by incorporating nonstationarity. A study in Tyne and Wear Region, UK has employed the Geographically Weighted Regression (GWR) approach and revealed that nonstationarity existing in the relationship between transport accessibility and land value (Du and Mulley 2006). GWR allows variation in model coefficient in space to capture the fact that the relationship may not be stable or stationary over the study area. It is showed that transport accessibility may have a positive effect on land value in some areas but in others a negative or no effect, suggesting that a uniform land value capture would be inappropriate. (Paez and Suzuki 2001) also examined the impact of transportation on land use change by looking at local effect by using GWR. In addition, property value expectation after transport project completion has also obtained some research interests. (Yiu and Wong 2005) showed that there were positive price expectation effects well before the completion of the tunnel in Hong Kong. The expectation effects allow the government to finance infrastructure projects by selling land in the affected districts in advance. This situation is very similar in Bangkok where land speculation is occurring on the future railway corridor. Therefore, it is recommended that land development impact be studied in more elaborated ways that is suitable and plausible within the context of Thailand.

From technical perspective, it is challenging to explore the transport impact to property value while taking these factors into consideration: neighborhood, nonstationarity, benefit expectation, land value capture such that the estimated impact can be quantified accurately and appropriately. This will greatly contribute the transport project planning and evaluation practice in Thailand.

5.4 Land Use/Transport Interaction

The scenario analysis in 0 has an inherent assumption that the future land use is predetermined and not sensitive to the changing transport condition. In the other words, land use effect on transport has been considered but transport feedback to land use is neglected. This definitely limits the policy discussion and contradicts the long-recognized land use/transport interaction. (Gilat and Sussman 2003) demonstrates a coordinated transportation and land use planning such as station area development, downtown redevelopment, real estate development along transit line in Mexico City. (Pan and Zhang 2008) has shown empirically that higher development intensity and more capital-intensive land uses occur in more accessible areas near train stations in Shanghai.

Technically, the interaction of land use and transportation may be modeled within an integrated framework. To date, many urban models exist and are applied in many cities and regions around the world such as MEPLAN (Abraham and Hunt 1999), (Johnston et al. 2005), UrbanSim (Waddell et al. 2007), ILUTE (Hatzopoulou and Miller), PECAS (Hunt et al. 2004), (Abraham and Hunt 2007), TRANUS (De la Barra 1989). Several application to Asian cities are reported such as (Vichiensan et al. 2003), (Lefvre), (Hunt et al. 2008), etc. For Bangkok, several attempts have been made to develop an integrated land-use transportation model in Thailand. BALUTAS was developed as a simplified land use model to represent the particular land market in Bangkok, (Ratchapolsitte et al. 1986). Its computing efficiency was judged very satisfactory with respect to the computer technology at that time. Later a Bangkok version of RURBAN was developed with graphic user interface under Windows 3.1 environment, (Udomsri 1993). MARS project was conducted for regional cities in Thailand and concluded that direct transfer of the model to local application in Asian cities was not possible because many modifications are required at the calibration stage such that it is able to represent local characteristics (Emberger et al. 2005). Recently, (Vichiensan et al. 2005) attempted to develop a TRANUS model of Bangkok but sacrificed with data issues.

Therefore, it is recommended to research on land use/transport interaction where the mobility and accessibility affects the future land use. Development of an integrated land use/transport model will allow planner to evaluate the mutual impact of land use and transportation in a consistent manner. To do this, an extensive research is required to model the location behavior such as (Miyamoto et al. 2004b). The data availability may be problematic in Thailand. Several necessary data is not presently available. Special data estimation technique may be required such as spatial interpolation (Vichiensan et al. 2006). Data synthesis technique may be necessary to get the real number of zonal population and employment. (Tiglao et al. 2003) produced synthetic household data in Manila to be used in the land-use microsimulation model. (Abraham et al. 2005) synthesized the building stock by type, age, density, and other variables. (Hunt et al. 2008) used synthesized dataset for the PECAS model application to Mumbai. Most importantly, the land price or floor rent data must be consistently collected. In Thailand, appraised price data is available but market price data is still questionable. (Lewis 2007) shown that the use of market prices in Jakarta instead of appraised prices does not have much effect on the estimated land value gradient, although it does have major consequences for the estimated influence on land price. This is yet to be explored in Thailand.

5.5 Sustainability

Sustainability of a city may be achieved through fully understanding the interaction between the several activities developed in the cities and its impacts in the environment, in the society and in the urban economy. Transportation system plays important role to preserve the resident's well-being by providing mobility and accessibility within the city but need to minimize its impact to the environment. It is worthwhile to research on proper definition of sustainability within the developing country context such as Thailand. Then evaluation of transport and other urban policy with respect to sustainability is indispensable. Example of sustainability analysis and evaluation framework are SPARTACUS project (Lautso and Toivanen 1999) and PROPOLIS project in European countries (Lautso et al. 2004). Finally pushing the sustainability concern into implementation is essential and still challenging for the developed countries. (Cheng et al. 2007) measures the sustainable accessibility in order to push sustainability into planning practice. In Thailand, the planning agencies under different bodies such as OTP, BMA, MRTA, or EXAT must work more closely in order to achieve at the desirable and integrated planning policy especially in terms of sustainability.

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