Strategies for Integrated Transport and Urban Development in Asian Developing Countries

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Abstract

In many cities in developing countries, particularly in South East Asia, motorcycles play a critical role in urban transport system. The characteristics of the motorcycle make it well adapted to the urban form of many cities and hence, it is sufficient for meeting socio-economic needs of the citizens. Motorcycles offer flexible and door-to-door transport, which has been considered much more advantageous over other transport modes. During the last decade, the number of motorcycles has been significantly increasing in cities such as Taipei (Taiwan), Jakarta (Indonesia), Bangkok and Chiang Mai (Thailand), Hanoi and Ho Chi Minh City (Vietnam). Besides, due to increased income, citizens are leaning toward safer and more convenient modes of transport. Private cars are becoming preferable modes to those who can afford it. The use of individual transport modes is contributing to urban sprawl and challenging the development of new public transport system. This results in threats to urban health, safety, quality of life, economic growth, and especially the sustainability of the local and global ecology (Faiz, 1993; Nadis and MacKenzie, 1993). Considering the unsustainable development process of those cities, the concept of integrated transport and urban development – an approach that considers and connects transport system and urban form development – is promoted as a long-term solution.

Over the years, there have been many studies related to traffic management and urban planning in developing cities in Asia. The study of Barter (1999) addressed the urban transport and land-use situation of Surabaya (Indonesia) and Ho Chi Minh City (Vietnam). Khuat (2006) studied traffic management for cities dominated by motorcycles. Both Barter and Khuat generalised characteristics of cities having high degrees of motorcycle use and the associated problems. However, in both studies, as well as in other relevant studies, the interactions of transport system and urban form elements were not adequately addressed.

This study aims to understand the basic interactions of transport system and urban form elements in Asian developing cities. Going beyond the scope of past research, this study is not limited to infrastructure development. Instead, it includes the interactions of transport infrastructure development as well as operational traffic management measures (e.g. parking management and road pricing) with urban development. Based on the interactions, problems emerging due to the lack of coordination between transport and urban development are analysed. Then, a framework for integrated transport and urban development is established. To realise the concept of integrated development, strategies are developed. Finally, an example of a local case study illustrates the application of the developed strategies in practice, including impact estimation.

This study uses a literature review to identify the interactions between transport system and urban form elements and the problems of uncoordinated transport and urban development in Asian developing cities. Besides, data from a field survey in Ho Chi Minh City are used to illustrate the problems. The case study approach is employed to argue and pre-select candidate measures, which could potentially form strategies for integrated transport and urban development in Asian developing cities. Expert consultation is conducted to prioritise the measures, using multi-criteria assessment.

The study expects to contribute to the academic field with a detailed description of the interactions between transport system and urban form elements for the specific case of Asian developing cities. The practical contribution includes an analysis of problems, the establishment of the framework for integrated transport and urban development in Asian developing cities, the development of strategies and the proposal for the application. Those contributions can be useful for researchers and policy makers in Asian developing cities to develop policies for their city towards an integrated transport and urban development.

Kurzfassung

In einer Vielzahl von Entwicklungsländern, insbesondere in Süd-Ost-Asien, spielen Motorräder im städtischen Verkehrssystem eine entscheidende Rolle. Die Eigenschaften des Motorrads passen gut zur urbanen Form vieler Städte und sind ausreichend, um den sozioökonomischen Bedürfnissen der Bürger gerecht zu werden. Motorräder bieten die Möglichkeit eines flexiblen und Tür-zu-Tür Transports, welcher als vorteilhaft gegenüber anderen Verkehrsmitteln erachtet wird. Während des letzten Jahrzehnts stieg die Anzahl der Motorräder in Städten, beispielsweise in Taipeh (Taiwan), Jakarta (Indonesien), Bangkok und Chiang Mai (Thailand), Hanoi und Ho Chi Minh City (Vietnam), signifikant. Aufgrund des steigenden Einkommens neigen die Einwohner zu sicheren und bequemeren Beförderungsarten. Private Kraftfahrzeuge werden zu einem bevorzugten Verkehrsmittel für diejenigen, die es sich leisten können. Der Nutzen von individuellen Transportmitteln trägt zur Urbanisierung bei und erfordert die Entwicklung von neuen öffentlichen Verkehrsmitteln. Ein unausgeglichener Modal Split, inadäquate Bereitstellung für Verkehrsinfrastruktur, mangelnde öffentliche Verkehrsdienste und eine unkontrollierte Stadtentwicklung machen Städte anfällig für Verkehr und urbane Probleme. Daraus resultieren Gefahren für die menschliche Gesundheit, die Sicherheit, die Lebensqualität, das Wirtschaftswachstum und insbesondere die Nachhaltigkeit der lokalen und globalen Ökologie (Faiz, 1993; Nadis and MacKenzie, 1993). Unter Berücksichtigung des nicht nachhaltigen Entwicklungsprozesses dieser Städte wird das Konzept der integrierten Verkehrs- und Stadtentwicklung – ein Ansatz, der Verkehrssysteme und Stadtentwicklung einbezieht und verbindet – als langfristige Lösung vorangetrieben.

Während der letzten Jahre gab es eine Vielzahl von Studien zum Verkehrsmanagement und zur Stadtplanung in sich schnell entwickelnden asiatischen Städten. Die Studie von Barter (1999) befasst sich mit dem städtischen Verkehr und der Flächennutzung von Surabaya (Indonesien) und Ho Chi Minh City (Vietnam). Khuat (2006) erforschte das Verkehrsmanagement in Städten, die durch Motorräder dominiert werden. Sowohl Barter als auch Khuat erarbeiteten grundlegende Charakteristiken von Städten, die einen hohen Anteil an Motorrädern und den damit assoziierten Problemen haben. Dennoch wird in beiden Studien und weiteren relevanten Studien die Interaktion von Verkehrssystem und urbanen Elementen nicht genügend adressiert.

Diese Studie hat zum Ziel, die grundlegenden Interaktionen zwischen Verkehrssystem und urbanen Elementen in sich schnell entwickelnden asiatischen Städten zu verstehen. Sie ist nicht begrenzt auf infrastrukturelle Entwicklungen, sondern sie beinhaltet auch die Interaktionen von Verkehrsinfrastrukturentwicklung und operativen Verkehrsmanagementmaßnahmen (z.B. Parkraummanagement und Straßenbenutzungsgebühren). Basierend auf den Interaktionen werden Probleme, die durch die mangelnde Koordination von Verkehrsentwicklung und Stadtentwicklung hervorgerufen werden, analysiert. Dann wird ein Konzept für die integrierte Verkehrs-und Stadtentwicklung erarbeitet. Um das Konzept der integrierten Entwicklung zu realisieren, werden Strategien aufgestellt. Zum Schluss wird mit Hilfe des Beispiels einer lokalen Fallstudie die Anwendung der entwickelten Strategien in der Praxis illustriert, und die Auswirkungen werden abgeschätzt.

Diese Studie nutzt eine Literaturanalyse, um sowohl die Interaktionen zwischen Verkehrssystem und urbanen Elementen als auch die Probleme unkoordinierter Verkehrs-und Stadtentwicklung in sich schnell entwickelnden asiatischen Städten zu identifizieren. Außerdem werden Daten einer Fallstudie in Ho Chi Minh City verwendet, um das Problem zu illustrieren. Dabei werden geeignete Maßnahmen diskutiert und ausgewählt, mit denen Strategien für eine integrierte Verkehrs- und Stadtentwicklung in sich schnell entwickelnden asiatischen Städten gebildet werden können. Für die Priorisierung der Maßnahmen wurde eine multikriterielle Bewertung auf der Basis von Experteninterviews durchgeführt.

Die Studie leistet mit einer detaillierten Beschreibung der Interaktionen zwischen Transportsystem und urbanen Elementen in sich schnell entwickelnden asiatischen Städten einen Beitrag zur wissenschaftlichen Forschung. Sie umfasst die Analyse der Probleme, die Erarbeitung eines Rahmenkonzepts für die integrierte Verkehrs- und Stadtentwicklung in sich schnell entwickelnden asiatischen Städten, die Entwicklung von Strategien und einen Vorschlag für die Umsetzung. Diese Beiträge können hilfreich für Forscher, Praktiker und Politiker in sich schnell entwickelnden asiatischen Städten sein, um Richtlinien und Konzepte für ihre Städte zur integrierten Verkehrs- und Stadtentwicklung zu erarbeiten.

Glossary

Urban form	Urban form is characterised by the size, layout, density, and land-use of the built-up areas (Barter, 1999).
Urban size	The size of a city is defined by the natural area or the population living within the administrative boundary of the city (Pirozzi et al., 2012).
Urban layout	The overall urban layout may characterise such land-use phenomena as centralised vs decentralised, monocentric vs polycentric and continuous vs discontinuous developments (Tsai, 2005).
Urban density	Density refers to the number of persons, households or dwellings per unit of land. The more persons are living in an area, the higher the density is (Litman, 2012).
Urban land-use	The term land-use is used to describe the different functions of the environment. Within the urban context, the dominant land-use tends to be residential, but a functional urban area requires commercial, industrial, offices, infrastructure and other uses (Jenks et al., 2008).
Transit-oriented development	Transit-oriented development is defined as "a compact, mixed-use community within a walkable catchment of a transit place, blending housing, shopping, employment and public uses in a pedestrian-friendly environment that makes it convenient for residents and employees to travel by public transport" (Ashton-Graham et al., 2005).
Integrated transport and urban development	Integrated transport and urban development is the development process that takes into account and coordinates all planning of the transport system and urban form elements to archive sustainable urban development (New Zealand Transport Agency, 2011).

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1 Introduction

This chapter provides an overview of the whole study. In section 1.1, background of the study is presented. Research goal and objectives are introduced in section 1.2. The scope of the study is explained in section 1.3. Finally, the structure of the study is presented in section 1.4.

1.1 Background of the study

In many Asian developing cities, urbanisation is happening rapidly, creating changes in urban form patterns. Urban development calls for investments in the transport sector, which leads to the development of transport infrastructure and the increased number of transport vehicles. The process of transport development in Asian cities since the early 1940s can be briefly summarised as Barter (2000). During the period from 1940 to 1960, non-motorised transport in Asian cities, including walking and cycling, was mostly used for a trip of less than 5 kilometres. Buses and Jitneys were used for longer trips, but mostly in large cities with more than 500,000 inhabitants. Only a very small group of high-income people owned private cars. Tramways were used in many large Asian cities very early, such as in Hanoi (Vietnam) but they were mostly removed later in the early 1960's. In some Indian cities, primarily in Bombay, and in Japan, suburban rail services were operated. Since 1960s, the number of vehicles has been increasing quickly, and there was a motorisation explosion since 1970's (Barter, 2000).

Nowadays, in many cities, motorcycles are being used since they are flexible and well accessible to small alleys in dense cities. Motorcycles play a dominant role in urban transport, providing individual door-to-door transport and meeting most transport purposes, for example, going to schools, offices, markets, hospitals, etc. Due to the affordable price, motorcycles are owned and used by most of the citizens of both the low and high-income populace. The word "motorcycle city" were adopted first by Barter (1999) to address the urban transport and land-use situation of Surabaya (Indonesia) and Ho Chi Minh City (Vietnam). Khuat (2006) used the term "Motorcycle Dependent Cities" to describe the specific situation of high motorcycle ownership and intensive use in cities. He defined a Motorcycle Dependent City by examining three groups of indicators: (1) Vehicle ownership; (2) Availability of transport alternatives; and (3) The use of motorcycles in the city. In particular, the urban traffic in a typical Motorcycle Dependent City is manifested by the following characteristics:

- High motorcycle ownership (more than 350 motorcycles per 1,000 inhabitants);
- Lack of public transport alternatives (less than one bus per 1,000 inhabitants) and inadequate non-motorised trips compared with the motorcycle;
- High share of motorcycles in the traffic flow (more than 50%);
- High modal split of motorcycles (more than 40%) and extremely low modal split of public transport (less than 20%) while the percentage of non-motorised trips is still significant (about 20 to 40%).

Due to increased income, citizens have more opportunities and choices of residence location. High-income people tend to move their houses far away from the city centre for a more spacious living place and a cleaner environment, which causes a decrease in urban density. Besides, people demand safer and more convenient modes of transport. Consequently, private cars are becoming a preferable mode to those who can afford it. The proportion of citizens shifting from motorcycle to car is increasing.

Although public transport has been developed in many cities as an alternative to private transport modes, its proportion in the modal split is quite low due to the limited capacity and low service quality. The higher degree of car utilisation brings challenges to urban transport infrastructure since road occupancy of cars is many times greater than that of motorcycles. There is a high risk of collisions when cars and other transport modes, especially motorcycles, share the same road spaces. Besides, the use of individual motorised transport modes is contributing to urban sprawl and challenging the development of new public transport system (Ong, Sinha, & FWA, 2009). The situations of imbalanced mode use, inadequate transport infrastructure provision, insufficient public transport services, and uncontrolled urban development make cities vulnerable to transport and urban-related problems. The transport sector is significantly contributing to environmental degradation globally. Operation of vehicles releases enormous amounts of toxic emission to the environment, and people are negatively impacted. Besides, the transport sector also consumes a tremendous amount of fuel, which threatens global energy security. Transport problems are mostly attributed to private vehicle usage and impacts are a threat to urban health, safety, quality of life, economic development, and especially the sustainability of the local and global ecology (Faiz, 1993; Nadis and MacKenzie, 1993).

In developing countries, motorised two-wheelers account for a substantial proportion of the vehicle fleet, and their growth has been at even higher rates than cars. In 2013 alone an estimated 114 million two-wheelers have been added to the global fleet population (UN Habitat, 2013). Vietnam is a unique example, with 97% of vehicles made up of two-wheelers, while in India the figure is more than 70% (Kamakate & Gordon, 2009). This is an area requiring urgent policy attention, particularly due to the related health impacts on the urban population (Rode et al., 2014). Figure 1-1 and Figure 1-2 show the increase in motorcycle and car ownership as well as modal splits (as % of total motorised trips) in some Asian cities.

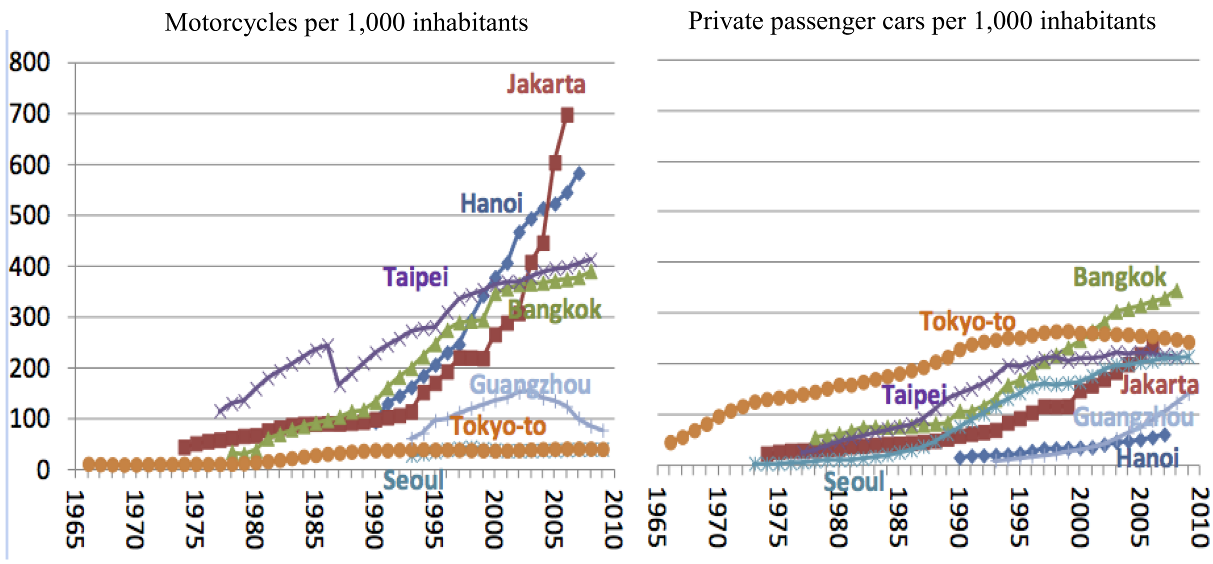


Figure 1-1: Development of private motorcycle and car ownership

Source: (Vu, 2012)

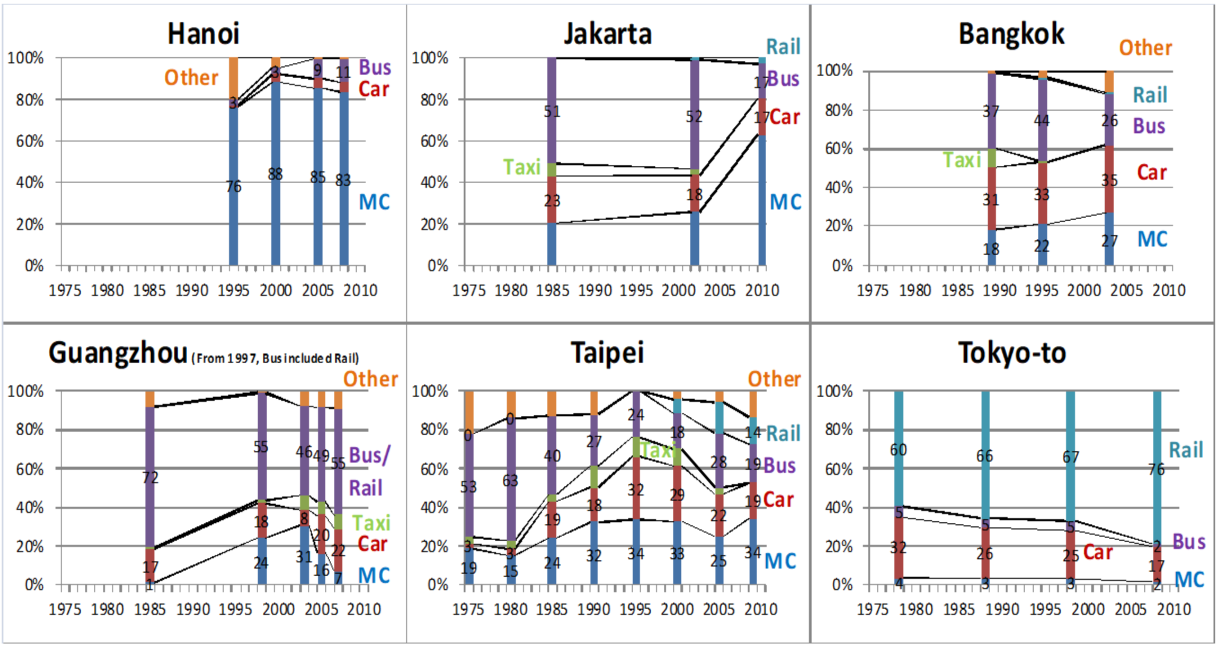


Figure 1-2: Trends in modal splits in some Asian cities

Source: (Vu, 2012)

There have been many studies on urban transport and urban development in Asia. Most of the studies focus on specific aspects of transport and urban development and recommend solutions for solving urban transport problems. Barter (1999) did a comprehensive study, focusing on comparing transport and urban conditions in different motorcycle cities. Barter argued the suitable transport modes for a certain urban condition. He also indicated the model for integrating land-use and transport in motorcycle cities and proposed that the long-term solution for a motorcycle city is a transit city. However, in his study, it is not clear which strategies can be used to achieve integrated development and how to assess the integrated transport and urban development. Sinha (2003) discussed strategies for achieving sustainability through integrated transport and urban development in the USA and Asia. His study compared development scenarios in several cities in the USA. He showed the relationships between urban density and sustainability parameters and proposed strategies for transport and urban planning. Significant lessons were also introduced as references for other similar cities. The study of Khuat (2006) described the characteristics of Motorcycle Dependent Cities and the associated transport and urban conditions. He proposed traffic management strategies for Motorcycle Dependent Cities. His study was quite comprehensive regarding introducing specific traffic management strategies for Motorcycle Dependent Cities. However, the study did not consider in detail the interactions between transport system and urban form in Motorcycle Dependent Cities.

In recent years, there has been much interest in a new approach, which integrates transport and urban planning. Since urban change within metropolitan areas in developing countries is so rapid and dramatic, the integration of transport planning and urban planning is essential to ensure sustainable development.

1.2 Goal and objectives

This study aims to develop strategies for integrated transport and urban development for Asian developing cities to reach sustainable development. This goal can be divided into the following objectives:

- Understand the interactions of transport system and urban form elements;
- Define specific problems emerging due to the lack of coordinated transport and urban development in Asian developing cities;
- Establish a framework for integrated transport and urban development in Asian developing cities;
- Develop strategies for achieving integrated transport and urban development in Asian developing cities;
- Propose the application of the developed strategies in a specific case study and estimate the impacts of such strategies.

1.3 Scope of the study

Urban development concerning demographic and economic growth, urban sprawl, density increase, land-use changing, etc., has various impacts on urban transport development. On the other hand, urban transport development influences many elements of urban development. The study focuses on critical interactions to find out deficiencies and problems in incoordination. Then, the strategies are developed for enhancing the interactions.

To form strategies, measures are selected, assessed and bundled. The selection of measures based on the review of relevant case studies. More measures can be taken into account in future studies, with a larger study scale. The assessment of measures is based on the developed method, although relevant assessment methods are reviewed.

The developed strategies are proposed for a specific case of Ho Chi Minh City Metro Line 1. This is an illustration of how the strategies can be applied in practice and what their impacts could be. The impact estimations are not adequate for all influenced areas. The comprehensive impact estimations, however, is recommended for further study.

1.4 Structure of the study

The study comprises seven chapters, which fulfil the research goal and objectives. The structure of this study is presented in Figure 1-3.

Chapter 1 explains the study background, goal and objectives, scope and the structure of the study.

The interactions of transport system and urban form elements are described in **Chapter 2**. Firstly, transport system are introduced, including transport modes, interactions of transport modes and traffic management. Secondly, urban form is presented, including urban form elements and urban planning. Then, the mutual impacts of transport system and urban form elements are analysed. There is the introduction of the integrated approach in transport and urban planning, as well as the basic strategies for achieving integrated development.

In **Chapter 3**, problems that emerge due to insufficient transport and urban development in Asian developing cities are analysed. The chapter uses specific conditions of several cities for the illustration. Besides, data from the field survey in Ho Chi Minh City is also presented.

Chapter 4 introduces a framework for effective integrated transport and urban development in Asian developing cities. The framework includes goal and objectives of sustainable transport and urban development and the goal and objectives of integration. Methods and indicators for impact assessment are also introduced.

In **Chapter 5**, strategies are formed. The process of strategy formation includes two steps of pre-selection of measures and qualitative assessment of measures. Then, the resulting strategies are introduced.

Chapter 6 is the proposal for applying the developed strategies in Ho Chi Minh City. Firstly, the city background is introduced. Secondly, the need for integrated transport and urban development in Ho Chi Minh City is analysed. The case study, which is the Metro Line 1 project is presented. Then, the developed strategies for integrated transport and urban development are applied in the case study.

The conclusions and recommendations of the study are given in **Chapter 7**. Major research results are summarised. The significance and limitations of the study are emphasised. Finally, the recommendations, as well as suggestions for further studies, are provided.

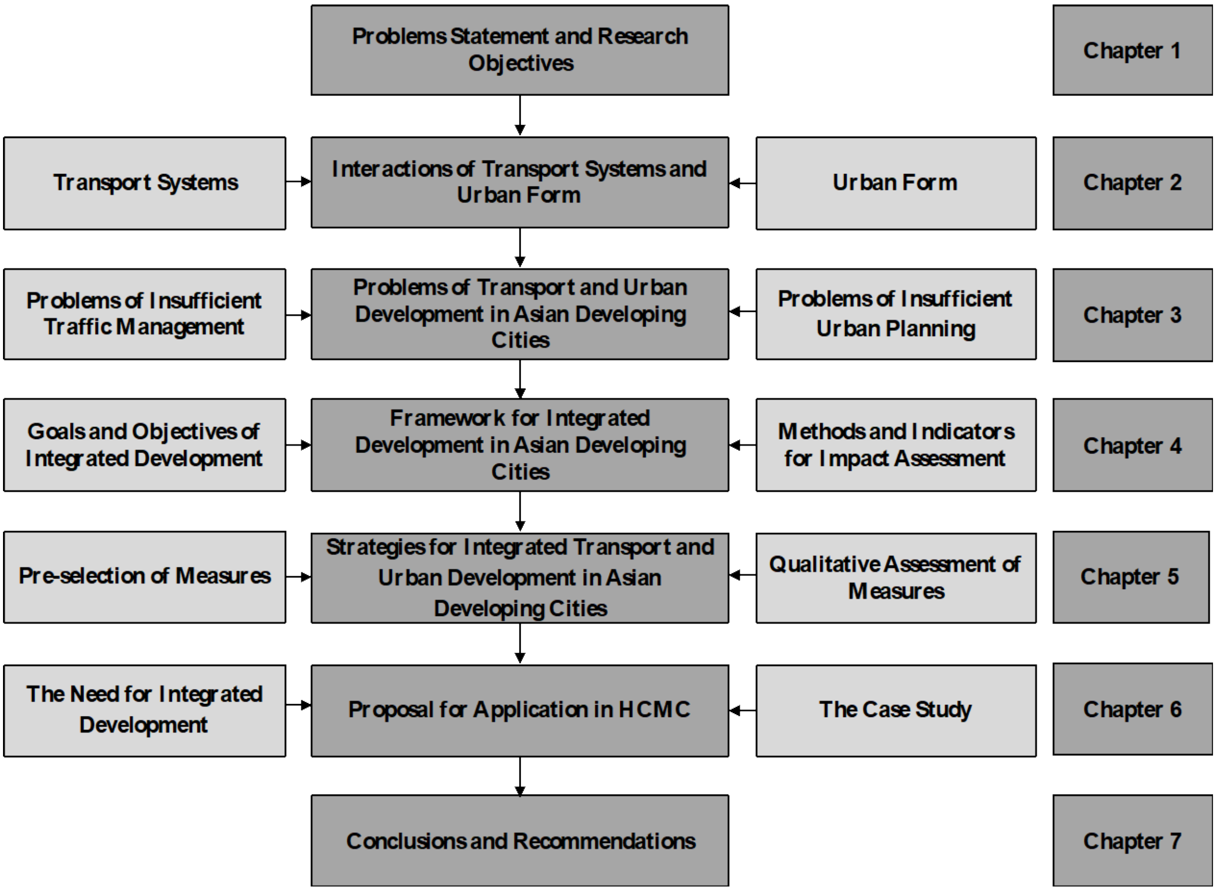


Figure 1-3: Structure of the study

Source: Author's representation

2 Interactions of Transport System and Urban Form

It is well known that transport development and urban development are highly correlated (Cao et al., 1998). Due to rapid urbanization, urban form patterns of cities have been changing through years, which change transport system. On the other hand, the development of transport system drives changes in urban form. Understanding the interactions of transport development and urban development is the basis for analysing transport- and urban-related problems and developing strategies for sustainable transport and urban development in Asian developing countries.

This chapter describes comprehensive interactions of transport and urban development. The first section introduces different transport system in general. Then, the mutual impacts of transport modes are presented. Traffic management packages, which are being implemented for the efficient operation of transport system, are reviewed. The second section indicates basic elements of urban form. Then, urban planning packages are discussed. The third part of the chapter looks at the interactions of transport system and urban form elements in Asian developing countries. Going beyond the scope of past research, this study is not limited to infrastructure development. Instead, it includes the interactions of transport infrastructure development as well as operational traffic management measures (e.g. parking management and road pricing) with urban development. Based on understandings of the comprehensive interactions, the integrated approach, which is essential for enhancing positive interactions, will be introduced. Finally, the basic strategies for achieving integrated transport and urban development are presented.

2.1 Transport system

According to Khuat (2006), transport system consists of two transport forms, called passenger and commercial transport (Boltze, 2003b and Khuat, 2006). For passenger transport, there are systems of non-motorised transport, individual motorised transport, and public transport. Each transport system is defined by transport modes with associated infrastructure networks and facilities. For the efficient operation of the transport system, appropriate traffic management measures are implemented. Different transport system function differently in providing mobility, accessibility and traffic safety for the users. The development of transport system in a city depends on the demographic and social-economic contexts as well as the technological level of that city.

Table 2-1: Structure of the passenger transport system

Passenger Transport Systems									
Non-motorised Transport (NMT)		Individual Motorised Transport (IMT)		Public Transport (PT)					
Walking (WAL)	Cycling (CYL)	Motorcycle (MCL)	Car (CAR)	Para-transit (PAR)	Taxi (TAX)	Bus (BUS)	BRT (BRT)	Light Rail Transit (LRT)	Mass Rapid Transit (MRT)

Source: Khuat (2006) adapted from Boltze (2003b)

2.1.1 Transport modes

Each kind of transport mode has its specific technical and operating characteristics, which influence the extent to which the mode is used. The basic characteristics include the size of the vehicle, capacity, required parking space, speed, flexibility in time and space, limitations to be used in specific roads/rails, distances between stops, etc. Table 2-2 shows basic characteristics of transport modes.

Table 2-2: Basic characteristics of transport modes

Size of the transport unit	Small Cabin	Large cabin	Composed unit	Infinite unit
Parking space	Mode specific			
Degree of freedom	Lane-bound	Lane-free	Carriageway-free	
Capacity	Mode specific			
Average travel speed	Mode specific			
Spatial and temporal availability	No spatial and temporal restriction	Limited spatial and temporal access		
Limitations to be used on road	Specific road/rail types	No specific road/rail types		
Distances between stops	Mode specific			
Travel distance	Short distance	Medium distance	Long distance	
Impacts from the environment	No impact from the environment	Impact from the environment		
Traffic safety	Low risk of accident	Medium risk of accident	High risk of accident	

Source: Adapted from Weigelt et al. (1973)

*** Non-motorised Transport**

Non-motorised transport includes mostly walking and cycling, which is very popular in many developing cities, especially in Asia and Africa. The urban poor, who cannot afford motorised transport, most often walk or cycle to reach work, school, and other services (Rode et al., 2014). Non-motorised transport does not have energy consumption, and from the users' perspective, it is healthy and affordable for everyone (Santos et al., 2010). It is also considered the most sustainable transport mode since there are no local environmental effects of noise or air pollution. Investment in infrastructure and facilities, as well as the space requirements for non-motorised transport, is low, compared to individual motorised transport and public transport. Despite its importance, non-motorised transport policy and its related infrastructure are often neglected in policy-making in developing cities (Pojani and Stead, 2015).

- **Walking (WAL)**

Walking comprises the majority of access and egress trips to other transport modes, or it can be used for the entire trip. Walking is a critical mode to facilitate public transport. Walking can contribute to human physical fitness and mental health. Average walking speed is about 5 km/h.

Major infrastructure and facilities for pedestrian include sidewalks, flyovers, zebra crossing, traffic signals, facilities for disabled people, etc. The provision of pedestrian infrastructure and facilities and the creation of urban landscapes and open spaces are major concerns in planning pedestrianised areas. In some cities, pedestrian-only streets or zones are organised for tourism, commercial and service purposes. However, adverse weather conditions, such as heat or rain, and the effects of carrying luggage may compromise walking performance.

- **Cycling (CYL)**

Similar to walking, cycling is an environmentally friendly transport mode that brings significant health benefits. The use of a bicycle is strongly related to trip distance and the physical condition of users. With the average travel speed of 15 km/h, a bicycle is an appropriate mode for trips lasting between 5 and 30 minutes. The cost of owning a bike is lower than that of any other mechanical transport modes. It is also easy to maintain and to park. Cycling is still likely to be extensively used in the future (Kenworthy & Hu, 2002). However, the bicycle is inconvenient on rainy or windy days. Cyclists also have the disadvantage of being exposed to the environment, especially to the air pollution in developing countries.

In developing countries, bicycles usually share the infrastructure with other road-based transport modes, which might lead to high numbers of bicycle accidents. A lack of facilities and comfort in cycling, compared to other transport modes, deter the greater use of this mode. Besides, the risk of bicycle theft is a factor, which could be addressed to improve safety and security for bicycle uses.

*** Individual motorised transport**

Individual motorised transport includes mostly motorcycles and cars, which are being drastically developed in cities around the world.

- **Motorcycle (MCL)**

Motorcycle ownership and use have been growing rapidly in many cities, especially in developing countries. The usual size of a typical motorcycle, which has the engine capacity from 100 cc to 125 cc, is 0.7 m x 1.9 m. Due to the relatively small size, the required parking space for a motorcycle is about 1.8 m^2. Therefore, using motorcycle is appropriate in the situation of limited parking spaces in the central urban areas. The small vehicle size also makes the motorcycle a flexible transport mode. It adapts readily to transport infrastructure network in crowded cities. However, the popularity of motorcycles contributes significantly to road congestion, accident, and pollution. Furthermore, motorcycle parking on sidewalks or streets creates obstacles to both non-motorised and motorised traffic, which exacerbates traffic congestion in central urban areas.

The average loading capacity of a motorcycle is 1.2 passengers. A motorcycle lane, with the lane width of 3.6 m, has the traffic volume of 6,660 motorcycles per hour. It means the passenger capacity of a motorcycle lane is 7,920 passengers per hour. A study of characteristics of motorcycle flows in Asian cities show that motorcycle traffic volume reaches a maximum velocity of 15 km/h (Hussian et al., 2005). This capacity is 5 to 6 times higher than that of private car lane in urban roads and two times higher than that of private car lane in the urban expressway.

Regarding traffic safety, a comparison of fatality rates among transport modes showed that motorcycles are the least safe transport mode. Approximately, 60% to 70% of road deaths are motorcyclists (WHO, 2009). In the United States of America, the United Kingdom and Australia, the risk of mortality to motorcyclists is 30-40 times higher than that of cars drivers and a hundred times higher than that of the bus and tramway users. In Western countries, most motorcycles have large capacity engines (more than 500 ccs) and travel on highways at an average speed of 80-150 km per hour. In Taiwan, as well as Vietnam and other Asian countries, motorcycles have smaller capacities (100-125 cc). The motorcyclists have lower risks of fatality than motorcyclists have in Western countries since they mainly travel with an average speed of 30-40 km/h on the city road. Experiments have shown that the risk of fatality occurs relative to the travel speed. For example, when the speed increases from 30 km/h to 80 km/h then the risk of fatality increases from 7 times to 300 times (Shibata and Fukuda, 1994). In the future, the dominance of motorcycles in traffic flow will negatively affect road safety in Asian countries.

- **Private car (CAR)**

Since their invention, cars have been significantly influencing the transport sector. They quickly became an integral part of the movement of people and personal goods and contributed to the economic development. Cars offer users comfort, flexibility, and conveniences. They protect the users from environmental impacts, such as the sunlight, heat, rain, noise and air pollution.

The length of a car ranges from 4.2 m to 5 m, and the width ranges from 1.7 m to 1.9 m, depending on the model of the car. Cars use an amount of road space for on road parking, about 14 m^2. The rapidly increased number of cars makes it difficult to meet the parking demand, especially in central urban areas. Besides, urban congestion is causing impacts on the utility of private cars in the main cities due to the lack of road space and parking restraints. The average loading capacity of a car is 1.2 – 1.3 persons per car. The average capacity of the car is about 2,600 persons/hour/direction. In practice, the capacity of the car lane could be higher when cars are fully occupied.

*** Public Transport**

Public transport varies from Para-transit to Transit and Mass Rapid Transit. Para-transit and Transit share infrastructure with other road-based motorised individual vehicles while Mass Rapid Transit requires separate infrastructure to be operated.

- **Para-transit (PAR)**

Para-transit is considered as an informal public transport service. Vehicles for Para-transit are diverse, include three-wheelers, motorcycle-taxi, Tuk-Tuk, Songtaew, Jeepney, etc. Para-transit is very prevalent in developing countries. Services provided by Para-transit are flexible and affordable for many people, particularly the poor. They provide on-demand access to schools, markets, hospitals, etc. in areas devoid of formal transit. Driving Para-transit modes offers jobs for low-skilled immigrants. Among Para-transit modes, motorcycle taxis are popular and used for short distances, such as picking up and dropping off passengers from inaccessible areas to public transport stations. Despite advantages, Para-transit modes are contributing to traffic congestion, air and noise pollution, and traffic accidents in cities (Cervero & Golub, 2007).

- **Taxi (TAX)**

Taxis are considered as a public transport mode, providing on-demand service. In recent years, due to the development of information technology, a new type of taxi-like transport mode appears, called “Uber/Grab”. Both traditional taxis and “Uber/Grab” operate on the road with other road-based transport modes, their speed ranges from 15 to 40 km/h, depending on the traffic condition. In some cities, there are arguments about the role of “Uber/Grab” due to their legal status and their competition with traditional taxis.

- **Bus (BUS)**

Buses can be used to cover the main journey or the access and egress trips for high capacity public transport modes. Due to their relative cost-effectiveness, buses can serve both high and low-density areas, collecting and delivering people closer to their homes and destinations. From a socio-economic perspective, bus users benefit from low fares and less exposure to the environment. In practice, most people who use buses belong to lower income groups, compared to the users of other public transport modes, particularly heavy rail. Average travel speed of the bus is 20 km/h. The average distance between bus stops ranges from 250 metres to 500 metres. A bus can carry up to 100 passengers.

- **Light Rail Transit (LRT)**

Light rail is best suited to inner city areas because the distance between stops is quite short, ranging from 500 metres to 1,000 metres. Vehicle capacity is about 370 passengers. The average travel speed of Light Rail Transit varies from 15 km/h to 25 km/h. The passenger capacity of a Light Rail Transit lane is about 13,200 passengers per hour.

Light rail systems tend to have the same alignment with streets and share the street spaces with individual transport modes such as cars, motorcycles, bicycles, etc. Newer systems tend to run in a separate grade and track alignment. Light Rail Transit vehicles can be developed on urban streets and run alongside urban traffic because they are fed electricity from overhead wires. This is an advantage of Light Rail Transit over Mass Rapid Transit, which require entirely segregated rights-of-way because they have an electrified third rail that increases speeds. Light Rail Transit is expanding rapidly in developed cities with low corridor volumes, sometimes feeding Mass Rapid Transit systems. Light Rail Transit advantages over the bus are the less local air pollution impact and possibly smoother rides for urban travellers. Light Rail Transit vehicles have higher carrying capacity than most buses.

- **Bus Rapid Transit (BRT)**

According to the Federal Transit Administration (2009), Bus Rapid Transit is “a high-performance rapid transit mode that combines a variety of physical, operating and system elements into a permanently integrated system with a quality image and unique identity”. The distance between stops ranges from 500 metres to 750 metres. With the average travel speed of 25 km/h, the capacity of Bus Rapid Transit lane is about 9,000 passengers per hour. The Bus Rapid Transit features the following characteristics:

Physically segregated exclusive bus lanes, which allow for a shorter travel time and higher reliability compared to local bus routes;

- Large, comfortable articulated or bi-articulated buses;

- Fully enclosed bus stops that feel like a metro station;

- Passengers pay to enter the Bus Rapid Transit station rather than pay for the bus driver;

- A bus station platform level with the bus floor;

- Convenient transfer between lines at transfer stations; and

- Priority signals at intersections.

Comparative assessments of Bus Rapid Transit systems throughout the world have found that most systems have significantly improved their local travel conditions and the quality and performance of public transport, especially in travel time savings and enhanced reliability (Pojani and Stead, 2015). Bus Rapid Transit systems have also reduced energy consumption and emissions.

- **Mass Rapid Transit (MRT)**

Mass Rapid Transit often forms the backbone of the transport system in major cities. This transport mode is particularly advantageous in commuting many people efficiently. The average passenger capacity of a Mass Rapid Transit line is 38,500 passengers per hour. It is not suitable as a mobility solution for low-density suburban residential areas. The average distance between stops is 500 metres to 1,500 metres. The average travel speed is 30 – 35 km/h. Vehicle capacity is 490 passengers. As presented in Currie (2009), heavy rail is characterised as follows:

- The relative simplicity of network;

- The relatively fast travel speed;

- The relative reliability of travel time;

- The volume of amenities offered at stations and the ease for passengers to identify the stations and understand the network.

Table 2-3: Basic characteristics of transport system

Characteristics	Non-motorised Transport		Public Transport						Individual motorised transport	
	Walking	Cycling	Para-transit	Taxi	Bus	Bus Rapid Transit	Light Rail Transit	Mass Rapid Transit	Motorcycle	Car
Size of the vehicle (L/W/H) (m)	-	0.6/1.9	-	4.2-5/1.7-1.9	12/2.5/3.5	18/2.6/2.9	-	-	0.7/1.9	4.2-5/1.7-1.9
Parking space (m^2)	-		-	25			-	-	2.5 – 3	25
Capacity (Pers/h/d)	4,500 (2m width)	3,500 (2m width)	-	-	10,000	9,000-13,000 5,000 – 40,000	13,200 10,000 – 30,000	30,000-40,000 20,000 – 70,000	7,920	2,200
Average travel speed (km/h)	5	15	15	30	20	25-30	15-25	30-35	15-20	35
Spatial and temporal availability	No spatial and temporal restriction	No spatial and temporal restriction	No spatial and temporal restriction	No spatial and temporal restriction	Stations to station	Stations to station	Stations to station	Stations to station	No spatial and temporal restriction	No spatial and temporal restriction
Limitations to be used on road	Road-based Non-fix route	Road-based Non-fix route	Road-based Non-fix route	Road-based Non-fix route	Road-based Fix route	Road-based, Separate lane Fix route	Rail based Separate lane Fix route	Rail based Separate lane Fix route	Road-based Non-fix route	Road-based Non-fix route
Distances between stops (m)	-	-	-	-	250 – 500	500-750	500– 1000	500 – 1.500	-	-
Travel distance	Short	Short	Short	Medium	Medium	Long	Medium	Long	Short to medium	Medium to long

Source: Rode et al. (2014)

2.1.2 Interactions of transport modes

Due to differences in technical and operating characteristics, each kind of transport mode functions differently in providing mobility, accessibility, and traffic safety to the users. Personal decision of using a transport mode for a trip depends on many elements, such as the trip purpose, trip length, costs, weather condition, etc. Figure 2-1 illustrates the linkage between factors affecting the generation and modal choice.

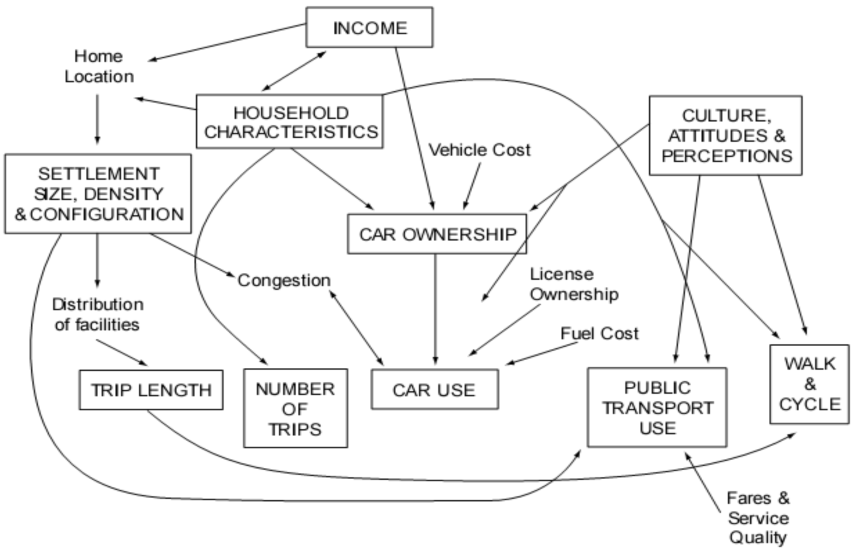


Figure 2-1: Linkage Between Factors Affecting Generation and Modal Choice

Source: (Potter et al., 1997)

With very short travel distances, trips can be covered by walking. The acceptance walking distance depends on many elements, such as the availability of sidewalks, walking environment or weather conditions. For longer travel distances, bicycles can be used. Motorised transport vehicles are preferred for long travel distances. The available, affordable and convenient transport modes, which meet the travel purposes, will be used to fulfil the trip. Figure 2-2 illustrates the correlation of trip length and the choice of transport modes.

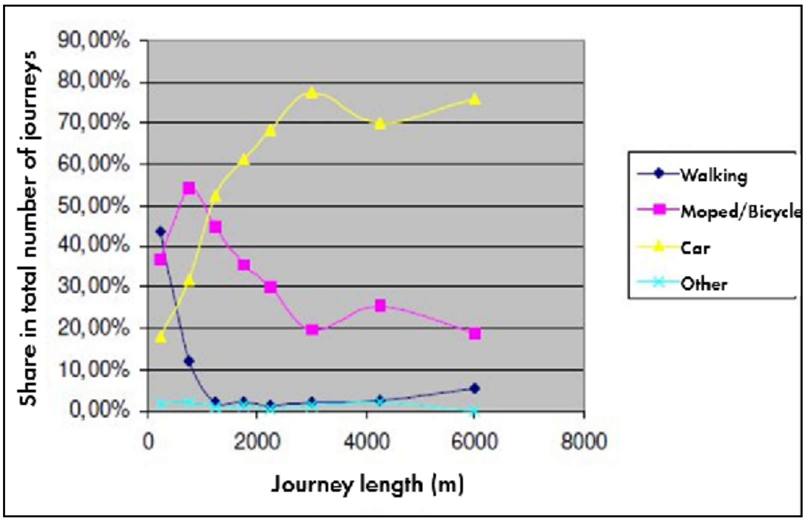


Figure 2-2: Correlation journey length and transport mode choice

Source: https://www.q-park.com/blogs/newsitem/10301/correlation-journey-length-and-transport-mode-choice

Transport modes interact with each other due to differences in speed, capacity, flexibility, and bundling effects, etc. The intermodal interactions are complicated to be addressed. In general, there are three types of interactions among transport modes, including:

- Type S - The modes can be used alternatively for the same trip - Potential substitute for the full trip.
- Type I - The modes can be combined to use in a trip - Intermodal combination use within one trip.
- Type C - The modes compete against each other; the increased use of a mode decreases the use of the other - Competitive use for the trip.

Interaction of walking and cycling

Walking and cycling can potentially substitute for a trip. Within a short travel distance, a person can choose either to walk or to cycle. Walking and cycling compete since the increased use of a bicycle for short travel distance decrease walking. The transport infrastructure and facilities for walking and cycling can be developed together, for example, the crossing facilities or the traffic signal.

Interaction of walking and motorcycle

Walking and motorcycle can potentially substitute for a short trip. Due to the increased number of motorcycles, walking becomes less attractive to people, even with very short travel distances. The two modes are competitive. However, walking and motorcycle can be combined in the pedestrianised areas, with the support of parking places. Motorcyclists could park their motorcycle and walk for shopping and entertainment. However, the case is not popular. In developing cities, the use of sidewalks for vendors and parking deters the number of walking trips. Besides, the use of motorcycles in the sidewalks, especially in the intersection areas or in the one-way roads, creates dangers for pedestrians.

Interaction of walking and car

Walking and car cannot substitute for a trip since they are significantly different. They might combine in a journey with the support of parking facilities. In central urban areas where the access of cars might be controlled, car users might park their car in public parking places and walk to the destinations.

Interaction of walking and taxi/Para-transit

Walking and Para-transit, especially motorcycle taxi, can potentially substitute for a trip. Walking and motorcycle taxi can also be competitors in short trips. In Bangkok, there is an increase in the number of high-rises residential buildings near transit stations and people living there prefer to use the transit systems. They are expected to walk to transit stations and use rail services for daily commuting. However, due to the increasing number of motorcycle taxis, walking trips are becoming less attractive (Pongprasert & Kubota, 2016). Since motorcycle taxis are available and they can quickly move even through narrow spaces during traffic jams, they become a preferred transport mode, especially in public transport stations. The motorcycle taxi drivers use sidewalks to park their vehicles, which occupy walking spaces. Motorcycle taxi riders also ride their vehicle on the sidewalks, which is very dangerous to the pedestrians and bicyclists. The study of Pongprasert and Kubota (2016) also indicate an increasing number of pedestrian accidents related to the growing number of motorcycle taxis in Bangkok. Since walking is not safe, people do not want to walk to the public stations, and the number of public transport users is decreased.

Interaction of walking and public transport

Walking is a critical mode to supplement public transport. In developed countries, thanks to excellent facilities and infrastructure for pedestrian, the number of walking trips to access/ egress to/from the station is high. The use of public transport will be increased if walking safe, secure, comfortable and pleasant. In developing countries, especially in Asian developing cities, the lack of facilities and infrastructure for non-motorised transport limit the number of public transport users. Street connectivity around railway stations is another factor, which influences the choice to walk to/from transit stations. Many studies confirmed that transit-oriented policies are better supported by urban development policies and zoning and subdivision regulations that encourage transit-friendly urban forms. Findings also argued the knowledge base that supports transit-oriented development by emphasising the contribution of the spatial structure of the street network, over and above the impact of sidewalk provision and design and pedestrian safety. Poor integration of station designs with the surrounding development has produced chaotic pedestrian circulation patterns and long passenger queues at suburban stations (Ozbil & Peponis, 2012).

Interaction of cycling and motorcycle

Cycling and motorcycle can potentially substitute for a trip, depending on the trip length. They also compete. In central urban areas where travel speed by motorcycles is slow due to traffic congestion, riding a bicycle can be also preferred. However, in many developing countries, the lack of separate lanes for bicycle increases the risk of cycling.

Interaction of cycling and car

Depending on the trip length, cycling and car can be competitive. However, the alternative use of bicycle and car is not popular. It is also unusual to use both modes within a trip.

Interaction of cycling and taxi/Para-transit

Cycling and Taxi/Para-transit can potentially substitute for a trip with a short distance. When bicycles are used as the feeder mode for public transport, parking places for bicycle need to be considered.

Interaction of cycling and public transport

Cycling and bus can potentially substitute for a trip. The two modes are competitive since the improvement of the cycling infrastructure and facilities might affect the number of public transport use. Cycling and public transport can also be combined in a trip, offering competitive performance over motorcycles and private cars for trips. Better facilities such as bicycle - transit exchange hubs around transport stations in association with commercial services could attract more people to transit, convert long-distance bicycle commuters, improve transport efficiency, and relieve road traffic pressure (Kenworthy and Hu 2002).

Interaction of motorcycle and car

Motorcycle and car can potentially substitute in a trip. In developing countries, due to economic development, more people can afford cars, which increases the number of car ownership and use. More people are shifting from using motorcycles to cars which makes cities more congested. Besides, since motorcycle and car share road spaces, there are increased numbers of traffic accidents between the two modes.

Interaction of motorcycle and tax/Para-transit

Motorcycle and taxi/Para-transit can potentially substitute for a trip. When motorcycles are used as the feeder mode for public transport, parking places for motorcycle need to be considered.

Interaction of motorcycle and public transport

Motorcycle and public transport can be used alternatively for a trip, depending on the travel distance and the availability of bus routes. In Asian developing cities where public transport system are limited, and the service quality is still weak, motorcycles are popular transport modes. Motorcycles are competing with public transport. Motorcycle brings benefits regarding low operational cost, high flexibility and door-to-door service. Motorcycles are also convenient for commuting within the city area, especially during traffic congestion. Due to small vehicle size and high manoeuvrability, motorcycles appropriate to use in narrow roads in Asian developing cities. The majority of the lower to medium income groups also prefer to use motorcycles as their primary mode of transport to reduce the living cost. Moreover, the parking space requirement for a motorcycle is also small, which makes it easy to park in any convenient place, including the sidewalk. The advantageous characteristics of motorcycles over buses make them more attractive to passengers. Hence, the number of bus users is not high in Asian developing cities. Due to the traffic conditions in many developing cities, it is common to see buses caught in congestion of cars and motorcycles. With signal priority, buses can run faster and more efficiently, which makes them more reliable and therefore more attractive. Then, motorcycles can supplement public transport system with the support of well-organised and convenient parking places in the stations.

Interaction of car and taxi/Para-transit

In many congested cities, it is hard to drive a car in the central urban areas. Besides, it is difficult and costly to park a car there. Therefore, car users need to consider many options, including the option of using taxi or Para-transit. Car and taxi/Para-transit can potentially substitute for a trip. In recent years, due to the rapid development of ride-sharing services, many people use “Uber” or “Grab” for their trips. They can enjoy paying the low fee and less stress from driving. The two modes are competitive, but not very much.

Interaction of car and public transport

Car and public transport can potentially substitute for a trip. They can compete, like in the case of cars and buses. However, they can be combined for a trip, for example, the combination of car and Bus Rapid Transit or Mass Rapid Transit with the support of the Park & Ride facilities. People can drive their car from the suburban areas or even from the rural areas to the Park &Ride and then, use the Bus Rapid Transit or Mass Rapid Transit.

Interaction of taxi/Para-transit and public transport

Taxi/Para-transit and public transport can potentially substitute for a trip, considering travel cost and distance. They can also combine in a trip. From the public transport stations, taxis and Para-transit can support individual trips to the final destinations. The combination of Para-transit as a feeder mode to public transport becomes one of the typical travel choices for commuters, and this will continue to increase in the future (Tagphaisankunn, 2010).

Interaction of bus/Light Rail Transit and Bus Rapid Transit/Mass Rapid Transit

Bus/Light Rail Transit and Bus Rapid Transit or Mass Rapid Transit can potentially substitute for a trip. Since the networks of Bus Rapid Transit or Mass Rapid Transit are normally limited in the trunk roads only, Bus/Light Rail Transit can directly serve the travel demand without route changing. To reduce the competition among public transport modes, a well-connected network and fare systems can enhance the efficiency. Intermodal connections between high-capacity public transport system and secondary systems, like bus/Light Rail Transit, serve to extend the spatial reach of backbone systems. The strong city-shaping influences of metros in Paris (France), London (UK) and Tokyo (Japan) are, to a large extent, a result of such network effects, wherein railways serve shares of origin-destination combinations that are comparable to freeway and motorway networks. The addition of a new railway or Bus Rapid Transit line creates spill overs and synergies, benefiting not only the newly served corridors but existing ones as well. For metro lines, newly opened lines increase the number of regional origin-destination combinations that can be served. Buses can be the feeder service for the Metro or Light Rail Transit systems. The bus fleet could be relatively easily increased in the early stages of public transport development when high capital investment for rail systems is still difficult. However, limited bus capacity is one of the reasons for inadequate service provision.

Due to differences in speed, capacity, flexibility, bundling effects, etc., each kind of transport mode is appropriate to function in a specific infrastructure network. Different transport mode provides a different possibility of mobility, accessibility, and safety to the users. Transport modes interact with each other, and the intermodal interactions are complicated to be addressed. Transport modes can be used alternatively for the same trip, or they can be combined to use in a trip. Transport modes can also compete, the increased use of a mode decreases the use of the other.

For short trip, the main competitor of walking is cycling. However, the use of cycling instead of walking is not negative for the traffic and the provision of non-motorised transport infrastructure and facilities are essential for both transport modes. For medium length trips and longer trips, in general, motorcycles, cars and buses are main competitors. In Asian developing cities, the use of motorcycles is dominant, with an increasing use of cars. However, the use of motorcycles for long travel distances is dangerous. The use of cars is facing increased traffic congestion. When bus service is improved with wider network coverage and effective service provision, buses can become a strong competitor against motorcycles and cars. At the same time, the networks of high-capacity public transport such as Bus Rapid Transit or Mass Rapid Transit are constructed to shoulder the main load in the trunk roads. Then, bus, Light Rail Transit, car and motorcycle could be the feeder modes. Integrating public transport with other transport modes is important. This will allow a greater variety of connections to be made and greater flexibility for the non-motorised transport user (Kenworthy & Hu, 2002). The choice of feeder modes depends on the length of the feeder sections and the provision of the feeder services.

Table 2-4: Interactions among transport modes

MODE	WAL	CYL	MCL	CAR	PAR/TAX	BUS/LRT	BRT/MRT
WAL							
CYL	S C						
MCL	S I	S C					
CAR	I	C	S C				
TAX/PAR	S C	S C	S C	S C			
BUS/LRT	I	S C I	S C I	S C I	S I		
BTR/MRT	I	S C I	S C I	S C I	S I	S C I	

Source: Author's representation

Note: S: Potential substitute for the full trip

I: Intermodal combination use within one trip

C: Competitive use for the trip

2.1.3 Traffic management

Traffic management has been implemented in many cities for managing and controlling traffic. Khuat (2006) reviewed traffic management in many countries in the world. Then, traffic management strategies for cities dominated by motorcycles are proposed. There are three groups of strategy, named (1) Traffic Avoiding Strategy; (2) Traffic Shifting Strategy and (3) Traffic Controlling Strategy. Each strategy comprises several selective measures. The Traffic Avoiding Strategy consists of two traffic management measures - Land Use Change and City Logistic, which are defined as the Basic Measures of the strategy. The Traffic Shifting Strategy includes ten Basic Measures, which are five Public Transport Measures (Public Transport Routing, Public Transport Scheduling, Public Transport User Incentives, Public Transport Information, Management Centre), three Non-motorised Transport measures (Pedestrian Facilities, Non-motorised Transport Zone, Non-motorised Transport Information), and two Individual Motorised Vehicle measures (Taxes and Duties, Registration Control). The Traffic Controlling Strategy includes five Basic Measures, which are one Non-motorised Transport measure (Pedestrian Facilities), one measure for Individual Motorised Vehicles

(Registration Control), and other three Multimodal measures (Signalisation, Traffic Calming, Traffic Information) (Khuat, 2006).

The study of Ong (2010) reviewed transport measures, which were implemented in the USA and Asian countries. He classified measures into three groups of (1) Transport supply measures; (2) Transport demand management measures; and (3) Targets and standards measures. These measures primarily aim to relieve congestion and to promote the use of alternative transport modes. Some of these measures are listed in Table 2-5.

Table 2-5: Traffic management measures

Transport Supply Measure	Transport Demand Management	Targets and Standards
Road construction	Road pricing	Air pollution standards
Rail investment/construction	Toll charges	Noise level standards
Improved public transport	Parking control	Road safety standards
Provision of Park and ride	Auto restricted zones	Fuel consumption controls
Bicycle and walk ways	Goods traffic restraint	Emission standards
	Pedestrian areas	Carpooling policy
	Pedestrian/Bicycle/Bus priority	Public transit use policy
	Traffic calming	
	Carpooling/Carsharing	

Source: (Ong, 2010)

Several packages of measures are utilised to analyse impacts of traffic management on modal splits. Each package includes several measures, which have similar direction in influencing the modal splits. Although there are many measures, the analysis focuses on twenty traffic management measures, which are considered as the most popular and important measures. Measures cover both supply and demand sides, as well as the operational side. Packages include (1) Promote Non-motorised Transport (TM1); (2) Control Individual Motorised Vehicles (TM2); (3) Promote Public Transport (TM3); and (4) Promote Intermodal and Multimodal transport (TM4).

*** TM1 – Promote Non-motorised Transport**

The package aims to improve walking and cycling conditions. Measures focus on enhancing the comfort and safety of pedestrians and cyclists. Popular measures include (1) Providing Facilities for Pedestrians; (2) Organising Pedestrian Zones; (3) Organising Bikeway Networks; and (4) Bicycle-sharing Schemes.

*** TM2 – Control Individual Motorised Vehicles**

The package aims to control the ownership and use of individual motorised vehicles, including cars and motorcycles. Popular measures include (1) Vehicle Registration Control; (2) Taxes and Duties for Individual Motorised Vehicles; (3) Road Pricing for Private Car; (4) Access Control; (5) Traffic Calming and Speed Reduction; (6) Parking Pricing; and (7) Parking Restriction.

*** TM3 – Promote Public Transport**

The package aims to facilitate the operation and improve service quality of public transport system. Popular measures include (1) Public Transport Service Improvement; (2) Public Transit Priority Lanes; (3) Public Transport Signal Prioritisation; (4) Public Transport Feeder Services; (5) Pricing Mechanism; and (6) Public Transport Authorities.

*** TM4 – Promote Intermodal and Multimodal Transport**

The package aims to facilitate the connectivity among transport modes and transport system. Popular measures include (1) Intersectional Traffic Control Systems; (2) Park & Ride Systems; (3) Intelligent Transport System.

2.2 Urban form

The definition of "urban" varies from country to country and can be different in one country over time. An urban area can be defined by one or more of the following characteristics (1) Administrative or political boundaries; (2) A threshold population size; (3) Population density; (4) Economic function; or (5) the presence of urban characteristics (Pirozzi et al., 2012). In 2016, an estimated 54.5% of the world's population lived in urban settlements. By 2030, urban areas are projected to house 60% of people globally, and one in every three people will live in cities with at least half a million inhabitants (United Nations, 2016).

The term "urban form" is used broadly to refer to the various patterns of location, function, and intensity of land-uses and activities in an area (Barter, 1999). Urban form is characterised by the size, layout, density, and land-use of the built-up areas. The urban form of a city has been created since the beginning of human settlement and is evolving continually in response to social, environmental, economic and technological developments (Williams, 2014).

The urban form can be viewed from various geographical scales - from a strategic scale (metropolitan area, city), to local scale (districts, zones, corridors) and neighbourhood scale (blocks, streets, transport nodes, public transport stations) (Tsai, 2005). At the strategic scale, urban form concerns the location of new developments in relation to the existing urban area and the transport infrastructure connections. At the local scale, urban form concerns the size and shape of new developments and the type of land-use (residential, commercial, industrial purposes or a mixture of these purposes). At the neighbourhood scale, urban form concerns the level of land-use mixing and the extent to which development is clustered or concentrated into nodes (Stead & Marshall, 2001).

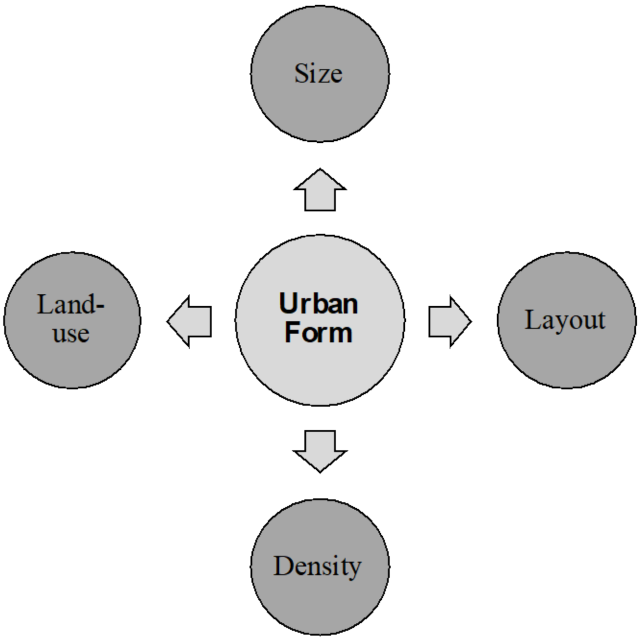


Figure 2-3: Elements of urban form

Source: (Williams, 2014)

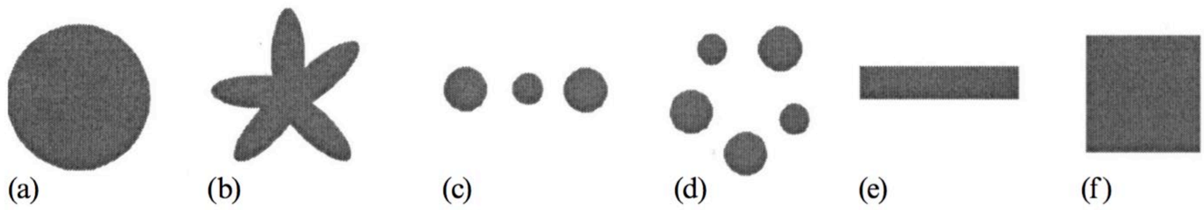
2.2.1 Urban from elements

*** Urban size**

The size of a city is defined by the natural area or the population living within the administrative boundary of the city. There are megacities, large-sized cities, medium-sized cities, and small-sized cities. The size of an urban area is more complicated to be defined, due to the unclear fringe between urban-rural areas. Urbanisation expands urban areas, which means an increase in the urban size. A megacity is defined as an urban agglomeration with a population of 10 million or more. In 2009, there were 21 urban agglomerations qualified as megacities, accounting for 9.4 % of the world's urban population (Pirozzi et al., 2012).

*** Urban layout**

The overall urban layout may characterise such land-use phenomena as centralised/ decentralised, monocentric/polycentric and continuous/discontinuous developments (Tsai, 2005). Urban layout elements (consolidation zones, urban corridors, urban activity nodes, activity spines) are defined to create a 'skeleton' on which urban development/redevelopment takes place over time (Department: Road and Transport, Gauteng Province, 2012). The urban layout is guided by the network of the high-volume transport system. Different transport network has different efficiency and adaptability to various transport system. Therefore, they have different influences on travel patterns. The hierarchy of the road network – arterial, primary and secondary, as well as bike paths and footpaths – constitutes the essential elements of the connectivity matrix for the city (UN-Habitat 2014). The suitable allocation of transport modes in the network is vital for urban mobility, accessibility, and traffic safety. Basic transport networks include the ring network, the radial network, the linear network and the grid network (Snellen et al., 2002). Based on the road network, the urban layout is developed relatively, including six types of urban layout.



(a) The concentric layout; (b) The lobe layout; (c) The linear layout; (d) The polycentric layout; (e) The linear layout; and (f) The grid layout.

Figure 2-4: Types of urban layout

Source: (Snellen et al., 2002)

The concentric layout represents the most common morphological layout in cities around the world. It is the typical layout of a city which has grown from a small centre along with some radial roads. Over the years, the areas along the radial roads have been filled, and the urban area has received its concentric layout. This urban layout is often associated with a radial road network, based on the historic routes, but combinations with ring or grid networks also exist. Often these urban layouts are quite compact and have a strong centre with a mixed supply of facilities (Snellen et al. 2002).

The lobe layout has developed between some radial roads and not among others. The lobe layout can result from roads stretching out in some directions or from intentional urban planning.

The linear polycentric and polycentric layouts have some common things. These urban areas can be developed either from some smaller settlements, located close to each other, start to function as one urban area, or an urban area is designed as a polycentric layout.

The linear layout is developed from the gradual expansion of residential development, business activities and services to the outlying suburbs in a linear pattern along the main road network (Zifou and Serraos 2005). All major urban functions are arranged along that axis. The layout consisted of large blocks with residential buildings surrounded by vegetation with commercial and public structures situated at intersections (Memisevic and Stachura 2015).

The grid layout is more or less rectangular. These urban areas often have a grid-type transport network (Newton et al. 2000).

*** Density**

Density refers to the number of persons, households or dwellings per unit of land. The more persons are living in an area, the higher the density is (Litman, 2012). Density affects sustainability through differences in the consumption of energy, materials, and land for housing, transport, and urban infrastructure (Walker and Rees, 1997).

Urban density plays a critical role in creating the urban form since it is closely associated with elements such as land-use and access to services. For example, for a service or facility to be viable, it needs to serve a population of a particular size. Density, on the one hand, can be seen as an outcome of the competition between land-uses within a given urban transport infrastructure and its associated pattern of accessibility. On the other hand, it is a policy goal as it is also input into the quality of urban life through the viability of services provision and availability of public and private space. High density and integrated land-use conserve not only resources but also provide compactness that encourages social interaction. Density has therefore been used as a tool to measure the viability of public transport infrastructure and other service provision, the feasibility of certain land uses, mainly commercial and service, in urban design and construction (Jenks et al., 2008).

*** Land-use**

The term land-use is used to describe the different functions of the environment. Within the urban context, the dominant land-use tends to be residential, but a functional urban area requires commercial, industrial, offices, infrastructure and other uses. Land-use patterns are crucial to the efficiency of a city and potential sustainable urban form since they influence urban travel patterns and the quality of life, for example through the existence of green space (Jenks et al., 2008).

2.2.2 Urban planning

The key to achieving sustainable urban development lies in the implementation of effective urban planning (Ong et al., 2010). Table 2-6 shows some of the planning measures that have been implemented in various urban areas in the USA and abroad.

Table 2-6: Urban planning measures

No.	Planning Measures
1	Zoning ordinances (single use, mixed use, densities etc.)
2	Emphasis on economic growth of principal city centres
3	Designated cities or areas for growth/control over the pattern of development
4	Relocation of particular employment groups/sectors
5	Use of preferred locations for travel generating activities (i.e. town centres)
6	Fiscal inducements to relocate in designated areas
7	Growth boundaries around urban areas
8	Regeneration of brownfields and other decaying areas (inner city centres)
9	Improvement to housing and neighbourhood quality/facilities
10	Parking standards for new developments
11	Environmental impact assessment
12	Smart growth provisions

Source: Adapted from Levy (2006)

From the review of urban planning measures, which are being applied in cities in the world, several urban planning packages are considered for the analysis of impacts of urban planning on urban form elements. The basic packages include (1) Promote Compact Development in the Central City Area (UP1); (2) Control Suburban Areas (UP2); (3) Promote Transit-oriented Development (UP3), and (4) Develop New Sub-centres (UP4). Although these are urban planning packages, transport transport-related measures, which are regulated by urban planning, might also be included. Figure 2-5 illustrates the idea of urban planning covered by the four packages.

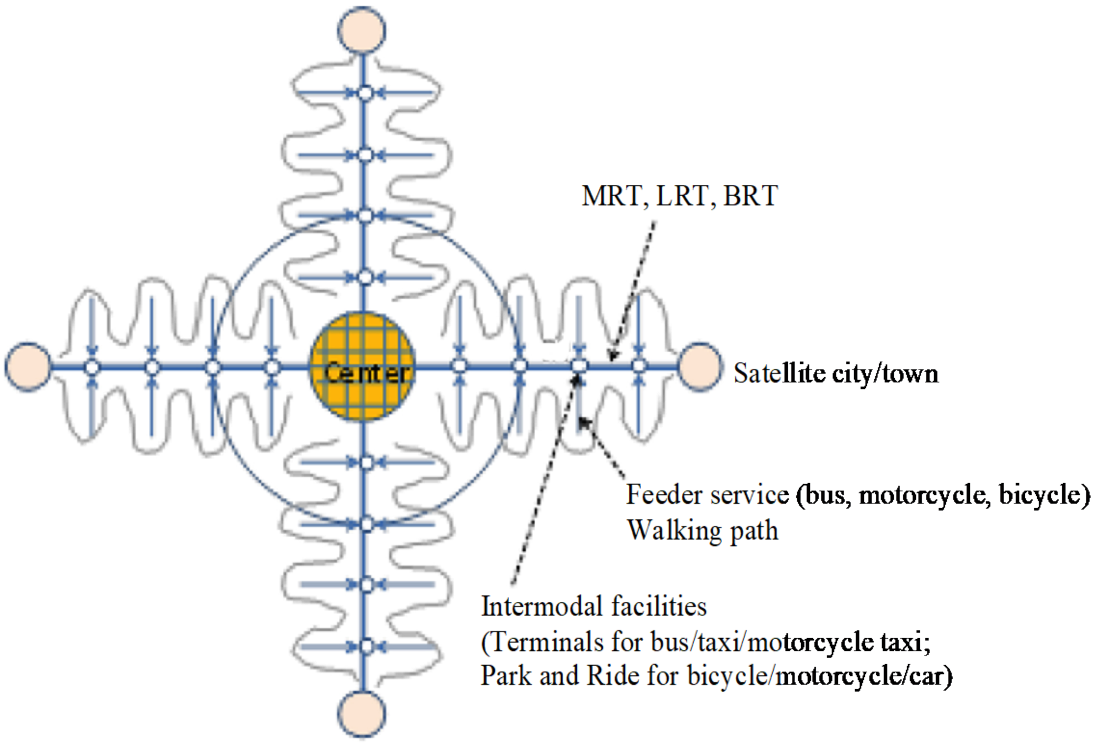


Figure 2-5: Illustration of Transport and Urban Development

Source: (Vu, 2012)

*** UP1 – Promote Compact Development in Central City Area**

The creation of compact central urban areas is a critical element of efforts to arrest urban sprawl and to protect the climate (Ong et al., 2010). Compact developments can be achieved by urban expansion management, land-use policies, transport planning and management measures. The package includes measures of (1) Density Increase in the Central City Areas; (2) Mixed-use Development in the Central City Areas; (3) Layout and Landscape Design in the Central City Areas; (4) Urban Growth Boundaries; and (5) Maximum Parking Space Regulations.

*** UP2 – Control Suburban Areas**

Suburban areas are controlled to remain low density. Land-use functions are also strictly controlled. For example, the areas of water surfaces are reserved to ensure the natural drainage of the city. The package of compact development includes measures of (1) Height and Density Controls and (2) Land-use Control.

*** UP3 – Promote Transit-oriented Development**

Transit-oriented development is defined as “a compact, mixed-use community within a walkable catchment of a transit place, blending housing, shopping, employment and public uses in a pedestrian-friendly environment that makes it convenient for residents and employees to travel by public transport” (Ashton-Graham et al., 2003). Transit-oriented developments are characterised as places offering both land-use and transport variety and choice. It is therefore essential that a balanced transport system is available within and around Transit-oriented developments. For Transit-oriented development, measures include (1) Sufficient Spaces for Mass Rapid Transit Lines and Stations and (2) Mixed-use and Compact Development in the Neighbourhoods of Mass Rapid Transit Stations.

*** UP4 - Develop New Sub-centres**

The development of new sub-centres aims to reduce the over-concentration of traffic in the existing central city areas, as well as to decrease traffic pressure on the roads leading to the centre. Development activities in sub-centres will lead to a more homogenous distribution of activities, thus reducing average trip distances and mitigating traffic increases. Land-use plans and public investments can lead the development, in close coordination with the modernisation of public transport networks. Such development is a necessary step to maintain a compact urban form (Petersen, 2006). For sub-centre development, major measures include (1) New Urban Zones Development and (2) Provision of Facilities and Services in Sub-centres.

2.3 Mutual impacts of transport system and urban form elements

In a city, patterns of urban development are inseparable from the evolution of urban transport. Likewise, urban transport development cannot be considered independently from urban development (Newman and Kenworthy 1989; Newman and Kenworthy 1996; Rode et al. 2008; UN Habitat 2013). On the other hand, urban form elements have various effects on the modal splits of non-motorised transport, individual motorised transport and public transport (Rodrigue et al., 2007). Urban planning, which is designed to influence urban form elements, has certain impacts on the modal splits. The interactions of transport system and urban form elements are complicated by the fact that changes in any one aspect will also result in changes in the others. The interactions of transport system and urban form elements are considered comprehensively. As shown in Figure 2-6, interactions include (1) The impacts of traffic management on modal splits; (2) The impacts of urban planning on urban form elements; and (3) The interactions of modal splits and urban form elements. Interactions are illustrated in Appendix A.

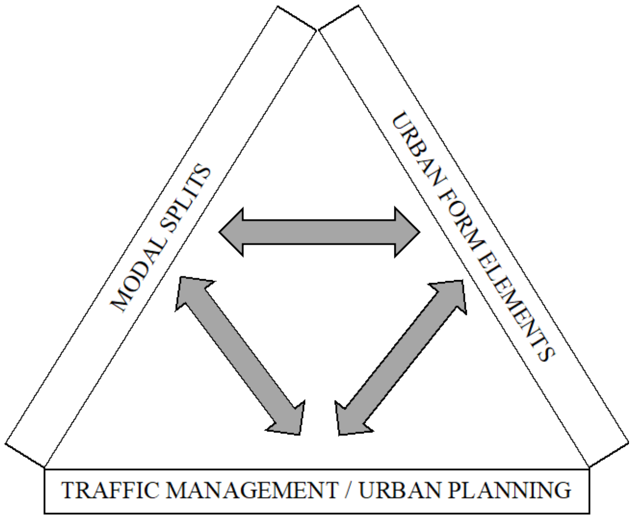


Figure 2-6: Interactions of transport system and urban form

Source: Author's representation

2.3.1 Impacts of traffic management on modal split

Traffic management packages, which are implemented for effectively managing and controlling traffic, influence modal split. Traffic management packages might have indirect impacts on the urban form elements.

*** Promote Non-motorised Transport (TM1)**

- **Impacts of TM1 on walking/cycling**

By managing sidewalks, preserving the sidewalks for pedestrian use only, people have more space to walk without being interrupted by boards, installations, street vendors or vehicles. The provision of crossing facilities, such as the zebra crossings, flyovers and the pedestrian signals, support the safe walking and cycling, which encourages more walking and cycling. Pedestrian/cyclist-friendly urban form makes non-motorised transport feasible and supports the reduction of motorised transport dependence (Pan et al., 2009).

- **Impacts of TM1 on motorcycle**

The management of non-motorised transport might have influences on the use of motorcycles. When sidewalks are not strictly managed, in some one-way streets or at the intersections, motorcyclists prefer to ride their motorcycles on the sidewalks for fast and convenient access to destinations. However, when sidewalks are managed, and crossing facilities are provided for pedestrians, motorcyclists must respect the right of pedestrians, which might reduce the flexibility of using motorcycles. The organisation of non-motorised transport zones in the central urban areas might also limit the use of motorcycles in the areas.

- **Impacts of TM1 on car**

When organising non-motorised transport zones in the central urban areas, all motorised transport modes, including the cars, are prohibited to use in the areas. Car traffic might be reduced in the areas. With the facilitation of parking places in the suitable position, car users can park their vehicles and access the areas.

- **Impacts of TM1 on taxi/Para-transit**

The package does not have a significant influence on the use of the taxi. However, with Para-transit modes, especially with motorcycle taxis, the management of sidewalk might face objection from motorcycle taxi drivers since they mostly park their motorbike on the sidewalks. The improvement of walking conditions attracts more people to walk. Then, taxi/Para-transit can be used to continue the trip, and the modal split of taxi/Para-transit might increase.

- **Impacts of TM1 on bus/Light Rail Transit/Bus Rapid Transit/Mass Rapid Transit**

The improvement of non-motorised transport conditions significantly supports public transport. When people can walk or cycle to public transport stations, the modal split of public transport is increased. The package for non-motorised transport management has positive impacts on the use of public transport modes.

*** Control Individual Motorised Transport (TM2)**

- **Impacts of TM2 on walking/cycling**

The implementation of the package makes travelling by individual motorised vehicles, particularly by cars and motorcycles, less attractive. Then, people might consider walking or cycling for short trips. For longer trips, the measures promote walking and cycling as feeder modes for public transport modes.

Parking management supports the shift from individual motorised transport to public transport and non-motorised transport. Parking spaces for bicycles might be provided at the public transport stations so that people can park their bicycle and continue their trip with public transport modes. In the central urban areas where pedestrian zones are organised, the provision of parking places facilitates the modal shift from individual motorised transport use to walking. The provision of parking facilities in the central urban areas needs to be considered carefully to promote intermodal transport of walking/cycling and public transport, not to attract more motorcycle and car traffic to the central urban areas.

- **Impacts of TM2 on motorcycle**

The package influences the use of motorcycles. Access control limits the freedom of motorcycle use, which might contribute to decrease traffic congestion. The imposing of taxes and fees on motorcycle increases cost for vehicle operation. Therefore, motorcyclists might consider shifting to public transport modes. Since motorcycle parking does not require much space, people prefer to park their motorcycle in front of offices, shops, etc., with little to no payment. The parking pricing increases the price of motorcycle parking, which might decrease the number of trips by motorcycle in the central urban areas.

- **Impacts of TM2 on car**

The package has significant influences on car ownership and use. A private car, which moves around and parks in a city, needs at least about 40 m^2 of land space (Bertaud, 2004). The more cars are introduced in the Central Business Districts of dense cities, the more they compete for space with people, not only with pedestrians but also with commerce, open space and all sorts of amenities. By implementing road pricing, car users have more financial burdens. They might choose to own a car and pay a high cost for operation, or they consider using alternative affordable transport modes. Like road pricing, the limitation of new car registration makes car ownership difficult and costly. The control of access and speed also make car traffic less attractive. The implementation of the tax for individual motorised transport ownership and use decreases the likelihood to own and use the modes. In general, the package has impacts on the likelihood to own and use individual motorised transport modes. Therefore, it reduces the modal split of cars.

The parking pricing is implemented to decrease the number of car use, especially in the central urban areas. The increased parking price makes car driving less attractive. Therefore, people will consider whether they want to drive cars with high operating expenses or use other transport modes, such as public transport modes. Like parking pricing, the regulations on the maximum parking spaces in buildings or parking duration and parking right for a user group have influences on the parking supply. The measures help to control the number of parking places, limit parking time and user group, hence, affect the likelihood to use cars in the central urban areas. The package negatively influences the use of cars. Car users might consider using alternative modes, such as taxi, bus or Mass Rapid Transit for their trips.

- **Impacts of TM2 on taxi/Para-transit**

The implementation of the package discourages the use of individual transport modes and might increase the use of taxi and Para-transit modes. When the total cost of owning and operating a car increases, combined with the difficulties in finding parking places in central urban areas, people will consider using other transport modes instead of using cars. Parking management facilitates modal shifting from motorcycle and car to other transport modes, including taxi and Para-transit. In recent years, many people are using “Uber” or “Grab”, a taxi-like service, for their daily trips due to their convenience and cost-effectiveness.

- **Impacts of TM2 on bus/Light Rail Transit/Bus Rapid Transit/Mass Rapid Transit**

The package has significant contributions in reducing the use of private transport modes. Then, public transport modes are alternatives due to their cost-effective and sufficient network coverage. Road pricing in the corridors having Mass Rapid Transit lines contributes to increase the number of passengers for Mass Rapid Transit and reduce congestion in the road network. The package is implemented at the same time with public transport development to facilitate the modal shift from individual motorised transport to public transport.

Parking management is essential to facilitate the efficient operation of public transport modes. In the central urban areas having very high density and mixed land-use, the demand for public transport is high. However, if individual motorised transport is not managed and controlled, it is hard for public transport modes to compete with individual motorised transport modes. Parking management makes individual motorised transport look less attractive, and the provision of sufficient public transport modes will increase the number of public transport mode users.

*** Promoting public transport (TM3)**

- **Impacts of TM3 on walking/cycling**

The package focuses on improving public transport conditions so that public transport is more attractive to people. Then, walking and cycling are fundamental modes in providing access to public transport stations. The implementation of measures in the package increases the modal split of walking/cycling.

- **Impacts of TM3 on motorcycle**

The implementation of measures in the package improves service quality regarding speed, reliability and cost-effectiveness. Then, public transport can attract more users. Motorcyclists might consider shifting from using motorcycles to using public transport modes. The modal split of motorcycles is decreased. When public transport modes are operated in the separate lanes, conflicts between public transport modes and individual motorised transport modes, especially motorcycles, are reduced.

- **Impacts of TM3 on car**

Similar to the decreased modal split of motorcycles, the modal split of cars might also be reduced due to the implementation of measures to promote public transport. When people have more favourable conditions to use public transport, they will consider shifting from car use to public transport use. However, the number of shifting cases will not be high if the public transport services are not significantly improved. At the same time, other packages for managing individual vehicles need to be implemented.

- **Impacts of TM3 on taxi/Para-transit**

Taxi and Para-transit are efficient feeder modes for public transport. Therefore, the promotion of public transport increases the modal split of taxi and Para-transit.

- **Impacts of TM3 on bus/Light Rail Transit/Bus Rapid Transit/Mass Rapid Transit**

The implementation of measures in the package has direct impacts on public transport system. When public transport is well managed, non-public transport users might consider shifting from their current mode to public transport. The separation of road spaces for organising separate bus lanes reduces the spaces of other individual motorised vehicles. Hence, travelling by cars and motorcycles might be more congested. Passengers of road-based public transport modes are safer when boarding and alighting. However, in some developing cities, the organisation of separate lanes for bus faces objections from motorcyclists and car drivers due to the limited road spaces for them. Besides, the low demand for some bus systems renders the separation of lanes ineffective. The prioritisation of traffic signals for public transport modes makes travel time by buses fast. Subsidisation for low price and incentives are also vital contributors to the increase in the number of public transport users.

*** Promote Intermodal and Multimodal Transport (TM4)**

The promotion of intermodal and multimodal transport facilitates the increased use of non-motorised transport and public transport modes. Buses, Taxis/Para-transit modes and motorcycles can be used as feeder modes for public transport. The convenience of public transport decreases the use of motorcycles and cars as main modes of transport.

2.3.2 Impacts of urban planning on urban form elements

Urban planning packages are designed to influence the urban form elements. They also have indirect impacts on the modal split.

*** Promote Compact Development in the Central City Areas (UP1)**

The package positive influences the urban size since it helps to decrease urban sprawl. In the compact development areas, the layout is differentiated. The compact development creates high urban density, which is important for the development of non-motorised transport and public transport. The compact development requires mixed land-use so that diverse services can be reached within a close distance. Cities that grow compactly with high-density development, concentrated on nodes, can support a more significant share of public transport than cities growing in a leapfrogging manner along radial highway corridors.

*** Control Sub-urban Areas (UP2)**

The controlling of sub-urban areas supports compact development in the central city areas. The measure is essential for land-use management in avoiding urban sprawl. In suburban areas, the land is controlled for balanced development. The changes of land-use functions, for example, from agricultural areas to residential areas, are strictly managed. Some sub-urban areas play the role of drainage basins, preventing the central urban areas out of severe flooding.

*** Transit-oriented Development (UP3)**

Transit-oriented development positively contributes to land and density development in the areas surrounding Mass Rapid Transit corridors. In the Mass Rapid Transit nodes, high density and mix land-use development are promoted to ensure the efficiency of the systems. Transit-oriented Development takes the Mass Rapid Transit as the trunk networks of development, from that, other public transport networks are connected as feeder networks. Hence, the urban layout is differentiated.

*** Develop New Sub-centres (UP4)**

Sub-centre development plays important role in changing the urban layout from monocentric layout to polycentric layout. It is vital to keep the central urban areas compact. The development of new urban zones, as well as providing facilities and services, decreases the transport needs to the central urban areas. The development of new urban zones positively influences land-use and density of the areas.

2.3.3 Interactions of modal splits and urban form elements

The implementation of packages of traffic management and urban planning influence the modal splits and urban form elements. Then, there are interactions of modal splits and urban form elements.

*** Modal splits and urban size**

The size of an urban area or a settlement affects the range of local jobs and services that can be provided within the area. Hence, urban size influences the choice of mode to access the area. Urban size also influences the ability to provide transport infrastructure and services. On the other hand, the use of different transport modes has impacts of the urban size in different urban scales.

- **Walking/cycling and urban size**

  Walking and cycling can be conducted within a short travel distance, in the neighbourhoods. The promotion of walking and cycling do not influence the urban size very much. However, the size of the urban area has certain influences on walking and cycling. According to the study of Pojani and Stead (2015), the smaller the urban size, the higher the percentage of non-motorised transport use. Small settlements or blocks can encourage foot travel since trips made by foot are likely to be less circuitous. The acceptable walking distance was different, depending on the geographical conditions, climate, land-use characteristics, and walking preferences. Moreover, developing public spaces and pedestrian network connectivity can encourage people to walk longer (Pongprasert & Kubota, 2016). In megacities and large-sized cities, non-motorised transport plays a vital role in supporting public transport system.

- **Motorcycle and urban size**

  A motorcycle has a limited travelling speed, and it is quite dangerous for travelling long distances. Therefore, motorcycles are suitable to use in the local area, within the radius of 15 km. In small-sized and medium-sized cities in developing countries, the use of motorcycles as the main transport mode is appropriate. However, the rapid growth of motorcycles in small-sized and medium-sized cities leads to traffic congestion due to the limited road capacity. In megacities and large-sized cities, the use of motorcycles for long trips is very dangerous and time-consuming. Motorcycle use might contribute to the urban sprawl, which makes public transport inefficient and requires more investment in road infrastructures.

- **Car and urban size**

  Since small settlements are unable to support a broad range of services and facilities, residents may travel long distances to access their required services and facilities, which increase the urban size. Megacities and large-sized cities have significantly higher average urban densities than medium-sized and small-sized cities and thus higher traffic densities. Very large, centralised settlements may lead to longer travel distances as the separation between homes and the urban centre becomes large. Megacities and large-sized cities with a huge range of jobs and services may also attract people living long distances away to travel to them. Along with the increased urban size is the increased total distance travelled per person by car (Hillman and Whalley 1983). Due to the differentiation of trip distances created by the urban size, the investment and operation of transport system are considered accordingly. In megacities and large-sized cities, the construction of a road network to meet the demand of individual motorised transport is infeasible due to the high cost of construction and land acquisition. Besides, the construction of new roads, which is supposed to solve the shortage of road infrastructure and contribute to reducing traffic congestion, might exacerbate transport problems in the long term. The theory is that new road infrastructure will increase the capacity and hence, improve traffic flows and reduce travel time. However, a more dynamic approach shows that increased road capacity in such situations will enhance the attractiveness and competitiveness of the private car, and result in modal shifts from public transport, walking and bicycling to private cars (Tennøy 2007). The increased road capacity and reduced travel time results in growth in urban car traffic volumes in the longer term. As travel time is reduced, people can move further away from the central urban areas, and they can choose living areas and workplaces demanding longer trips, making their travels dependent on the private car. This allows an urban land-use development, which results in urban sprawl and a more car-dependent city. Urban sprawl burdens municipal budgets, imposing high costs for extending infrastructure and public services to suburbs. Despite this, most cities, particularly in developing countries and emerging economies, continue to prioritise motorised transport and related transport infrastructure. Many cities both in the developing and developed countries are experiencing fast and uncontrolled growth in their peripheries. In developed countries, suburban living, associated with the lowering of population and employment densities, has contributed to rising motorisation rates and the environmental problems related to car dependency.

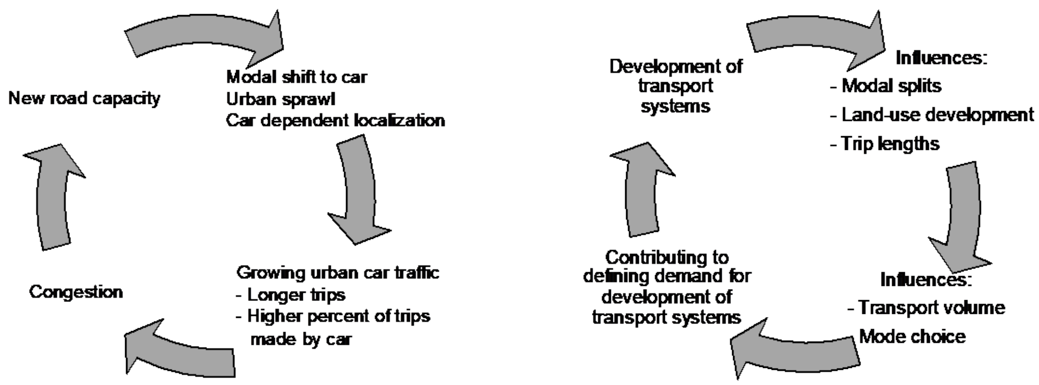


Figure 2-7: Cause-effect relations in spatial development, development of infrastructure systems and development of urban car traffic volumes

Source: (Tennøy, 2007)

- **Taxi/Para-transit and urban size**

In small-sized and medium-sized cities, the operation of taxi and Para-transit is not popular due to the low demand. In megacities and large-sized cities, especially in developing countries, taxi and Para-transit are very popular and play the role as supportive modes for buses, Light Rail Transit, Bus Rapid Transit and Mass Rapid Transit. Para-transit services, such as motorcycle taxis, provide on-demand mobility for the commuters in areas lacking formal public transport supply. Para-transit modes are operated both in large-sized cities and medium-sized cities. In Bangkok, due to the severe congestion in the central urban areas, the use of "Tuk-Tuk" or motorcycle taxis is very popular to access public transport stations. In the suburban areas of the city, "Song Thaew" is being used as an effective informal mini-bus service. In Ho Chi Minh City or Hanoi, motorcycle taxis are also a popular mode to access public transport stations. However, Para-transit modes facing problems of unclear travel costs, which may annoy passengers.

- **Bus/Light Rail Transit and urban size**

Bus and Light Rail Transit are essential transport modes in medium-sized cities. Although the investment in the Light Rail Transit system in medium-sized cities, especially in developing countries, may have limited economic and practical value. Due to their high costs, developing cities often can only construct such systems over a few kilometres in a few limited corridors, which do not meet the broader transport needs of the population. In megacities and large-sized cities, due to their limited passenger capacity, buses and Light Rail Transit cannot take the main load. They can just play the role as the feeder modes for the Bus Rapid Transit and Mass Rapid Transit systems. However, in suburban areas of megacities and large-sized cities, buses are major public transport modes to access employment, education, and public services since such destinations are beyond viable walking and cycling distances and the people there have limited access to automobiles.

- **Bus Rapid Transit/Mass Rapid Transit and urban size**

In megacities, due to the large city size and high population density, public transport investments in rail-based transport services exert the strongest spatial influence and significantly contribute to reducing traffic congestion. Mass Rapid Transit systems are usually the most expensive form of public transport regarding construction and operation but, as fully segregated systems, have the best performance. Underground metro systems cannot be easily integrated into existing urban physical structures without disrupting existing buildings and utility lines (Flyvbjerg et al., 2008). In addition to high capital costs, metro systems have high operating costs and usually require operating subsidies; otherwise, the price of the tickets would be prohibitive even in developed cities. While in principle public transport operations do not need to be profitable, given the valuable service that they provide to society, the high capital and operation cost of Mass Rapid Transit makes them less economically viable in medium-sized developing cities than in megacities. Since most Mass Rapid Transit systems are usually designed for capacities of around 30,000 to 40,000 passengers per hour in the peak direction, only cities with a population of more than 2 million have at least one corridor (UN-Habitat 1993). In some large cities in the developing countries, such as Beijing, Ho Chi Minh City, Hanoi, Bangkok, Jakarta, there are systems of metro or suburban rail systems.

Bus Rapid Transit systems have been developed in some large-sized and medium-sized cities. Bus Rapid Transit might use segregated busways in the trunk roads or major corridors of the city. Bus Rapid Transit can be complemented by existing conventional bus, taxi and Para-transit systems, which can provide feeder connections to the remote areas.

*** Modal split and urban layout**

Major transport networks of a city, together with the intensity of land-use create the urban layout. The urban layout of a city is very resilient, and it changes very slowly (Bertaud, 2004). The hierarchy of the road network – arterial, primary and secondary, as well as bike paths and footpaths – constitutes the essential elements of the connectivity network for the city and it guides the development of urban layout (UN-Habitat 2014). Each kind of urban layout is suitable to a specific transport mode. The monocentric layout has a direct impact on the trip length and the feasibility of transit systems or private cars. In a concentric city, trips are usually shorter as many trips are from the periphery to the Central Business Districts. In a polycentric city, each sub-centre generates trips from all over the built-up area of the city. Trips in a polycentric city tend to be longer than in a concentric city (Bertaud, 2004).

- **Walking/cycling and urban layout**

  Since walking and cycling are only feasible in the short travel distance, the interactions of urban layout and walking/cycling are within the neighbourhood areas. The layout of the neighbourhoods influences the likelihood to walk or to cycle. Normally, the pedestrianised areas have concentric or grid layout to facilitate the quick and smooth movement of pedestrians. Other urban layouts, such as the polycentric or the linear layout are not favourable to walk or to cycle.

- **Motorcycle and urban layout**

  In many cities in developing countries, the number of motorcycle ownership and use is increasing significantly, and the reason for that development is closely linked to the urban layout of the city. Urbanization creates job opportunities and the need for living places calls for the development of residential areas, mostly in the urban fringe and suburban areas. Cities are expanded in size, so are the road networks. However, due to the lack of transport and urban planning in the early stage, roads have been constructed quickly in responding to the immediate travel needs, mostly by motorcycle, of the residents. The construction of those roads mostly bases on the convenience, not considering the connectivity of roads as a network. The consequence is the establishment of small alleys with undifferentiated structure, poor connectivity, and "zig-zag" layout. Motorcycles, with the advantages of small vehicle size and high flexibility, are easily able to access the areas. Therefore, the number of motorcycle use is increasing, and the city becomes more and more dependent on the motorcycle.

  Du (2012) studied the relationship between the road network layout and the width of roads with the development of motorcycle in Ho Chi Minh City. He concluded that the increase in the number of registered motorcycles in Ho Chi Minh City during the period 2005-2010 correlated to the increase of the total length of alleys. When the travel demand in the city increases, motorcycles cannot meet the travel demand and the city is congested, the ability to re-structure or increase the capacity of the road network is costly.

- **Car and urban layout**

  The expansion of the urban areas and changes in land-use characteristics influence the urban layout and hence, affect transport patterns and the use of transport modes. According to the study of Bertaud (2002), it has become apparent over the years that the layout of many cities departed from the concentric. When many trip-generating activities were spread in clusters over a wide area outside the traditional Central Business District, the city grows and the original mono-centric layout tends with time to dissolve progressively into a polycentric layout. The Central Business District of the city lose its primacy, and clusters of activities generating trips are spreading within the built-up area. Some cities are dominantly monocentric, others are dominantly polycentric, and many are in between. Urban sprawl and sub-centres development outside the Central Business District have contributed to lengthening average trip distance and made trips possible by the car (Wegener and Fürst, 1999). The study of Snellen (2002) found that the number of trips per year conducted by car tends to be higher in cities with a radial network as compared with cities with a grid network. The concentric urban layout, which is associated with the radial road network, is suitable for the use of motorised transport modes, including motorcycle and car. Many cities in the world have the concentric shape, and the transport system are concentrated in the city centre. However, this kind of road network offers direct access to the city centre from all directions, which might lead to the over-concentration in the central urban areas.

- **Taxi/Para-transit and urban layout**

Taxi and Para-transit are suitable to serve travel demand in the local and neighbourhood areas. When being used in the local areas, they do not have significant influences on the urban layout and vice versa; the urban layout does not have significant influences on the use or taxi and Para-transit modes. However, in some cities in Africa and South America, the direct route-based Para-transit services enhance the concentric urban layouts (Cervero 2013). Middle- and lower-income inhabitants living in peripheral areas use affordable Para-transit services to go to their workplaces in the central city areas (Ferro & Behrens, 2015).

- **Bus/Light Rail Transit and urban layout**

Bus and Light Rail Transit can be operated on local roads due to the suitable vehicle size. The operational speed of bus and Light Rail Transit is not so high, which makes them appropriate to serve as feeder modes for high capacity public transport modes. Within dense urban areas, buses are efficient at serving the accessibility needs of the Central Business Districts. Bus and Light Rail Transit are appropriate to serve the urban areas having the concentric, lobe or grid layout, which do not have very much differentiated structure.

- **Bus Rapid Transit/Mass Rapid Transit and urban layout**

The urban layout and the high capacity public transport modes strongly interact. The high capacity public transport networks form the basis of the movement system and guide the development of urban layout. Rail-based public transport investments often a strong force toward decentralisation. From the trunk network, other public transport networks, such as bus, Light Rail Transit, are connected to create the "skeleton" of the urban areas. A clear hierarchical structure with trunk network and feeder network facilitate a differentiated urban layout. As cities continue to develop toward multiple centres, Mass Rapid Transit systems that link the Central Business Districts with sub-centres will be especially cost-effective. Mass Rapid Transit offers opportunities for two directional flows at all times of the day and supporting urban layout developing from concentric layout to polycentric layout (Parsons Brinckerhoff Quade & Douglas, 1996).

*** Modal split and urban density**

Urban density is one of the most critical factors in determining the level of use of a transport mode. Urban density influences the patronage of the transport modes and hence affects the modal splits. On the other hand, the use of a specific transport mode might lead to the increase or decrease of urban density. Figure 2-8 indicates the relationship between urban density and cost-effective transport modes. According to the study of UN-Habitat (2014), in very low-density cities, cars are effective transport modes. In spread-out cities, public transport modes are difficult to compete with private cars. Cost-effective public transport can only be achieved through high urban densities, having a significant share of jobs and retail activities concentrated in the urban core (such as in Shanghai, China), or in polycentric cities with multi-directional travel patterns (such as Stockholm, Sweden) (UN-Habitat 2014).

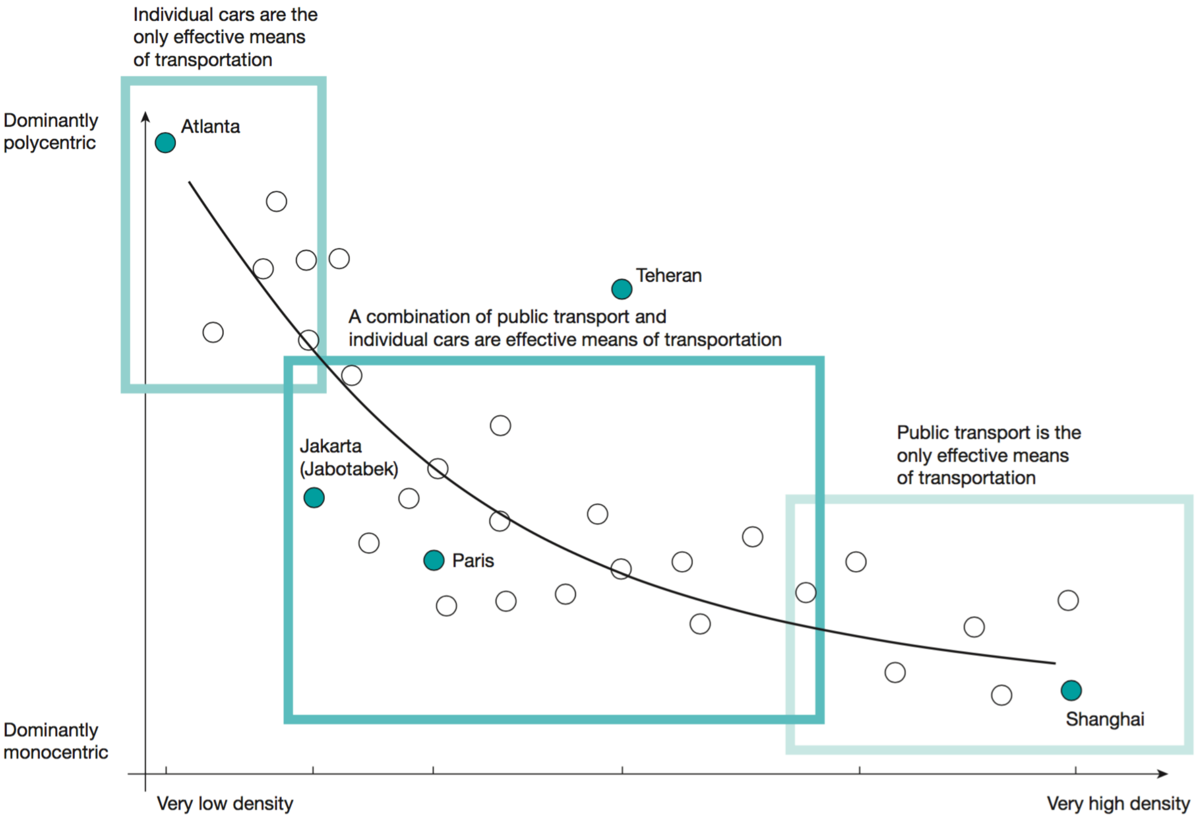


Figure 2-8: Relationship between density and cost-effective transport modes

Source: The UN-Habitat (2014)

- **Walking/cycling and urban density**

Many recent studies have suggested that compact developments with high densities encourage non-motorised transport (Cervero and Kockelman, 1997; Krizek, 2003, 1994). Studies on commute mode choice provide some evidence that the probability of walking increases at higher population densities and higher employment densities (Frank and Pivo, 1994; Reilly and Landis, 2002; Chatman, 2003). Dense settlements commonly have mixed uses, small city blocks, and central locations, all of which shorten distances between homes, services, employment and other opportunities, which reduce travel distance and encourage walking.

- **Motorcycle and urban density**

The use of motorcycle and urban density closely interact. As mentioned above, motorcycles adapt to the small, "zig-zag" structure of roads in the high-density urban areas. However, in high-density areas, the over-utilisation of motorcycles in the limited road spaces makes cities vulnerable to traffic congestion and accidents.

- **Car and urban density**

There is a negative influence of car use on the urban density. When infrastructure for cars - for example, a highway - is built, people move out from high-density central city locations to low-density suburban areas, and population density declines (Coleman, 2010). More sprawling cities require rapid transport modes to reduce travel time and often rely on individual motorised vehicles, for example, cars. These car-based transport system need substantially more space than any other urban transport system. As a result, the space requirements of private vehicular traffic not only imply further de-densification of cities, but they are also a significant contributor to congestion and parking pressures on public space, as road infrastructure provision is frequently unable to keep up with rising levels of vehicular traffic (Kersys 2011; World Bank 2014b).

According to Morichi (2005), the over-concentration in capital city continues as the growing income disparity forces people from rural areas to migrate to metropolitan areas, but without secure jobs and housing. This increase squatter settlement in urbanised areas. In the case of weak institutional capacity to manage rapid urbanisation, there will be a mismatch between infrastructure and land-use patterns, such as high floor-area ratio in downtown areas without adequate road infrastructure. On the other hand, high-income residents may prefer suburban residential areas, which accelerates low-density sprawl in suburban areas. Such a pattern of low-density suburbanisation further increases usage of private transport modes, such as motorcycles and cars. The long-term dynamic interaction between the urban transport system and urban form finally takes the city an irreversible path of automobile-dependent and unplanned low-density urbanisation. The incompatible land-use makes it very difficult to provide adequate infrastructure, and as a result, the overall quality of life in the city would decline.

- **Taxi/Para-transit and urban density**

Taxi and Para-transit serve the demand in the high-density urban areas. In the low-density areas, the demand for taxi and Para-transit is not high. The use of taxi and Para-transit does not have significant influences on the urban density.

- **Bus/Light Rail Transit and urban density**

Buses can serve low to high-density areas. In the low-density areas, frequencies of bus service are low, compared to the frequency in the high-density areas. Similarly, the number of stops in the low-density areas is limited. The organisation of bus service in the low-density suburban or rural areas might be ineffective due to the low travel demand.

However, since buses play an important role in connecting the suburban areas to the urban areas and the high price might help to remain the service.

- **Bus Rapid Transit/Mass Rapid Transit and urban density**

There are close relationships between urban density and public transport system. Bus Rapid Transit and Mass Rapid Transit are incompatible with low densities (Bertaud, 2004). Very dense cities must rely on the space-efficient and low-impact transport modes to avoid congestion (Barter & Kenworthy, 1997). High density offers the opportunity for average trip lengths to be short and to foster successful, economically viable public transport (Pushkarev and Zupan, 1977). Further, within dense urban regions, transit service is attractive and competitive. According to the study of UN-Habitat (2014), high densities are essential for sustaining cost-effective public transport services. Experience shows that when densities increase, so does public transport ridership (Meyer, 1965).

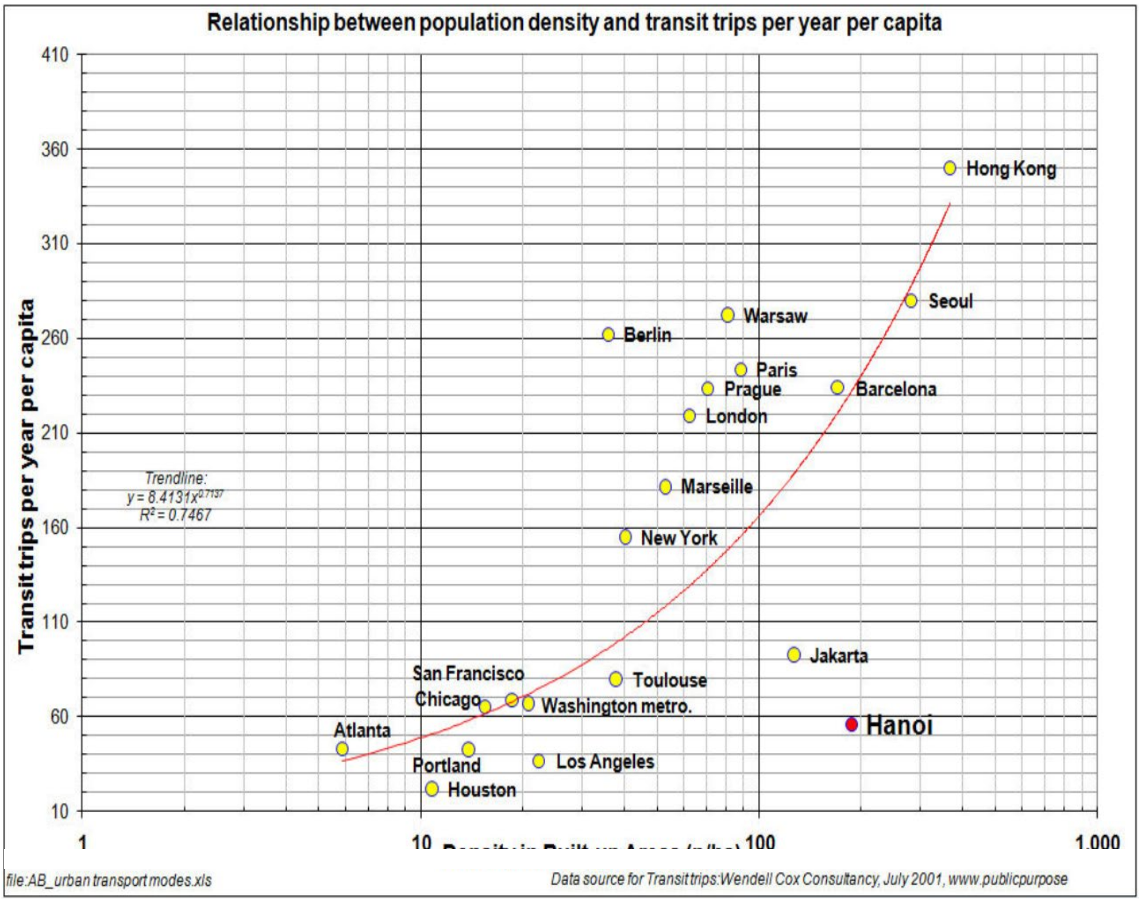


Figure 2-9: Correlation between density and transit use

Source: (Bertaud, 2011)

*** Modal split and urban land-use**

Land-use patterns influence the need for transport infrastructure and mobility behaviour of the inhabitants. Recent studies verify that the high level of mix land-use at the trip origins and destinations is the primary driver of mode choice (Bhat and Pozsgay, 2002; Rodriguez and Joo, 2004; Schwanen and Mokhtarian, 2005).

- **Walking/cycling and urban land-use**

Land-use patterns significantly relate to the likelihood to walk or to cycle in an area. The diversity of land-use functions is especially essential to the areas around public transport stations since it influences the choice to walk to or from transit stations of riders. Studies regarding the impacts of land-use characteristics on travel have shown that the proportion of public transport and walking trips increase as the intensity and mixing of land-uses is higher (Cervero, 1996; Cervero, 2002; Cervero and Kockelman, 1997). Thus, it is argued that improving the diversity of land-uses in neighbourhoods can reduce automobile dependence and encourage walking (Rajamani et al., 2003). Higher densities and mixed land-uses support good access to transit services and provide opportunities for pedestrian and bicycle trips to a diverse mix of desired destinations. Combining housing, employment, and retail opportunities with other functions allows residents to make necessary trips without using private transport modes. When neighbourhoods are compact, and many of daily needs of people can be found within walking distance, the number of vehicle trips per household declines rapidly.

- **Motorcycle and urban land-use**

The use of motorcycle influence land-use patterns and vice versa. Due to the high flexibility and accessibility, motorcycles are used to access many places in the city, which make the urban land-use more diverse. In many developing cities, it is popular to see markets along roads where having high motorcycle use. With the motorcycle, people can easily conduct trips for combined purposes such as go to work and shopping. The ability to park the motorcycle almost everywhere also supports mixed land-use developments.

Bertaud (2011) conducted a study in Hanoi on the relationship between land-use and motorcycle use. In Hanoi, areas of retail, office buildings, and small manufacturing are spreading throughout the metropolitan area. This dispersion has been made possible by the dominant use of the motorcycle. The land-use of Hanoi was strongly influenced by the easy accessibility provided by motorcycles.

- **Car and urban land-use**

Urban land-use has significant influences on the use of cars. In many cities, the development of residential areas, mostly in newly developed areas, and the construction of roads connecting the areas to the city centre, facilitate the development of cars. When high-income people move to the suburban areas for more spacious living places, using cars are more favourable due to their safety and comfort. Consequence is the increased congestion in the gateway sections and the main contributors are cars. Similarly, the construction of large-scale shopping malls in the suburban areas promotes the use of cars. Cars use an incompressible amount of road space for both on road parking and circulation. The percentage of land devoted to road space in the existing built-up area is practically fixed, and it is difficult to increase it on a large scale to accommodate an increase in car traffic (Bertaud, 2011). Figure 2-10 illustrates the "Land-use transport feedback cycle". It can be recognised that travel time, distance and cost influence car ownership. At the same time, car ownership is affected by the activities, which are generated from the location decisions of users.

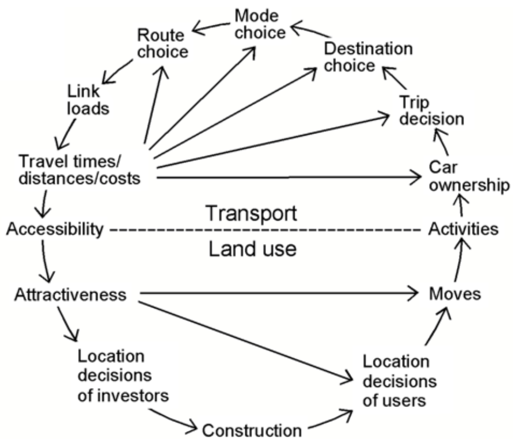


Figure 2-10: The "Land-use transport feedback cycle"

Source: (Wegener, 2004)

- **Taxi/Para-transit and urban land-use**

Taxi and Para-transit are appropriate for transporting in neighbourhoods. The use of taxi and Para-transit do not have significant influences on the urban land-use.

- **Bus/Light Rail Transit and urban land-use**

Bus and Light Rail Transit have influences on the use of land in the neighbourhoods of the bus/Light Rail Transit stations. Convenient shops selling foods, beverages, books, groceries, etc., are allocated at the stations to facilitate bus passengers. These kinds of land-use attract the use of bus systems.

- **Bus Rapid Transit/Mass Rapid Transit and urban land-use**

The construction of Mass Rapid Transit lines significantly influences land-use patterns, especially in the areas surrounding the stations. On the other hand, the diversity of land-uses in transit corridors contributes to the attractiveness of transit systems since it influences the way in which people travel to and from transits. The walkability and land-use mixture of the areas surrounding stations are vital to viable public transport services (UN-Habitat, 2014). If people cannot safely and conveniently walk to or from a station, they might not use public transport services. Furthermore, the presence of convenience retail stores along the walk-access corridor to a public transport station increases public transport use.

2.3.4 The comprehensive interactions

The implementation of traffic management and urban planning packages plays important role in influencing the modal split and the urban form elements. Although a package of traffic management is designed to influence a certain transport mode, its implementation also impacts the other modes. Besides, traffic management packages might indirectly influence urban form elements. Similarly, the implementation of urban planning packages influences urban form elements directly and the modal split indirectly. There are positive and negative impacts. The changes in modal split influence the urban form elements and vice versa. The comprehensive interactions of transport system and urban form elements are complicated, as shown in Figure 2-11.

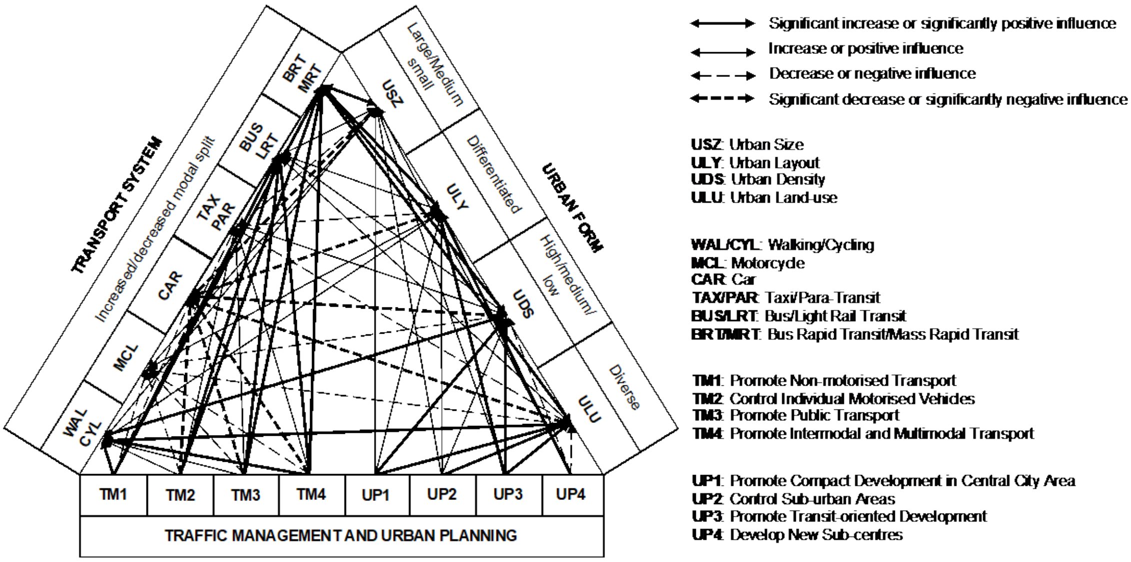


Figure 2-11: Comprehensive interactions of transport system and urban form

Source: Author's representation

In general, cars have strong negative impacts on all aspects of the urban development and the implementation of the measures in the package TM2 – Control Individual Motorised Vehicles - can help to limit the development of individual motorised vehicles, especially cars. By implementing parking management, car ownership and use might be decreased. In Asian developing cities, which are characterised by high density and mixed land-use urban form, cannot afford a significant increase in the number of cars. Motorcycles also have negative influences on the urban form elements, especially urban size and layout. Bus Rapid Transit and Mass Rapid Transit have strong positive impacts on the urban form elements. A simplified graph of significant positive interactions is used to highlight the mechanism of the interactions, as shown in Figure 2-12.

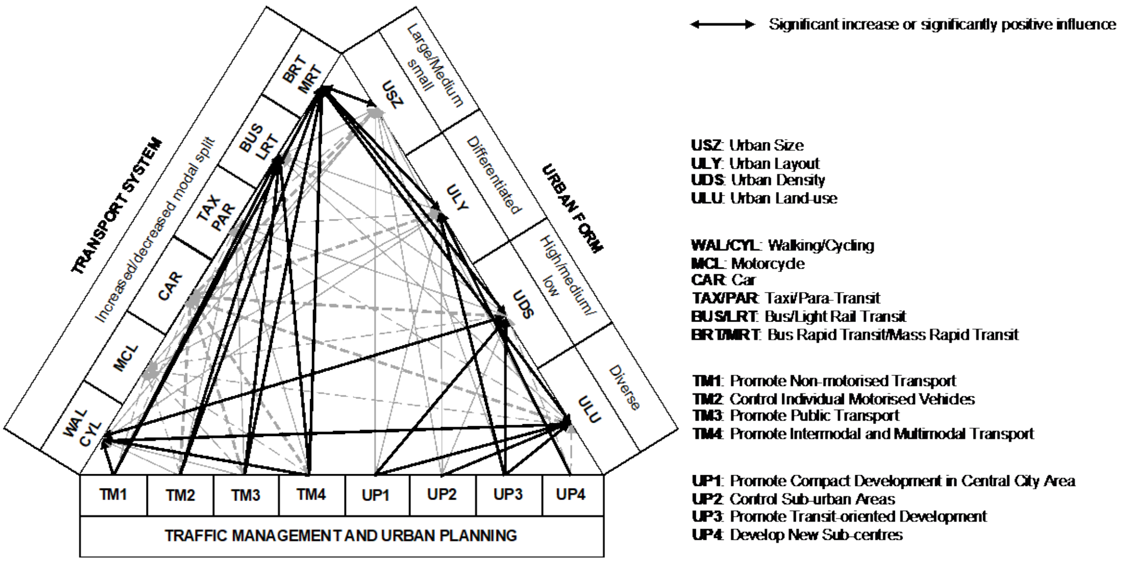


Figure 2-12: Significant increase or significant positive influence

Source: Author's representation

Changes in an urban element can be the results of the implementation of urban planning packages. Besides, changes in modal splits also influence urban form elements. The impacts are combined, which require comprehensive considerations in planning and implementing measures. Considering the significant positive interactions helps to highlight the mechanism of the interactions. For example, the increased use of Bus Rapid Transit and Mass Rapid Transit is the direct result of implementing the TM3 (Promote Public Transport) and TM4 (Promote Intermodal and Multimodal Transport), or the indirect effect of applying the TM1 (Promote Non-motorised Transport) and TM2 (Control Individual Motorised Vehicles). The increasing use of Bus Rapid Transit and Mass Rapid Transit has positive influences on the urban size, which can be supported by the implementation of UP3 (Promoting Transit-oriented Development). The increasing use of Bus Rapid Transit and Mass Rapid Transit positively influences the urban density and land-use, which are supported by the implementation of TM1 (Promote Non-motorised Transport) and TM4 (Promote Intermodal and Multimodal Transport). It can be recognised that the promotion of Bus Rapid Transit and Mass Rapid Transit can significantly influence the urban form. Other measures and packages, with careful consideration of their mutual impacts, can produce the mechanism of the interactions.

2.4 The need for an integrated approach in transport and urban planning

It is undeniable that transport system and urban form elements maintain a close relationship during the development process of cities. The interactions between transport system and urban form elements have a fundamental influence on the overall level of demand for travel, patronage of various travel modes, accessibility, travel distances and costs of travel, as well as the on-going cost of providing essential infrastructure and services (Wadhwa, 2005). Decisions about transport system, the form of urban development and how the land has used all impact on each other. Therefore, it is crucial that decisions about transport system and urban form should be considered together. The interactions of transport system and urban form elements call for an integrated approach to planning, which allows all the interactions to be coordinated. Integrated transport and urban planning – an approach that considers and connects all these considerations – helps to ensure that transport network development and land-use development are coordinated. The purpose of integration must be to achieve a higher performance against the objectives of the strategy than could be achieved by the individual measures on their own (May and Roberts, 1995).

There are several definitions of integrated transport and urban development. For example, (Tornberg, 2011) defined the integrated approach as the extent to which publicly mandated efforts to influence the spatial structures of society, and urban areas are characterised by considerations of the inter-linkages between the perspectives of transport and urban development. According to Kidd (2007), integrated transport and urban development refers to the horizontal "joining up of different public policy domains and their associated factors within a given territorial area". It may also apply to other dimensions, such as the relationship between territorial units, for example, local and national administrative levels, or the organisational relationship between different parts of a strategy-making process. In short, integrated transport and urban development is the development process that considers and coordinates all planning of the transport system and urban form elements to archive sustainable urban development. Integrated planning is an approach that seeks to pull together all the contributing elements to increase the effectiveness of delivered solutions and avoid creating unintended impacts (New Zealand Transport Agency, 2011). In the long term, it will not be possible to solve the transport and urban-related problems of urban areas by one or several measures. The proposal for packages of measures needs to consider how they function as part of a balanced strategy.

2.5 Basic strategies for integrated transport and urban development

Strategies for integrated transport and urban development can be defined as the combination and interaction of policy instruments to achieve higher performance from the overall strategy. Strategies for integration, including bundles of measures, have been developed for dealing with the transport and urban requirements of urban areas in the context of broader strategic land-use, economic and environmental objectives. The coordination of measures brings benefits compared with the piecemeal implementation of individual measures. Most strategies for integrated transport and urban development are developed either in pursuit of synergy, or as a means of overcoming barriers, or both. Therefore, in policy development, it is essential to identify measures, which might achieve synergy (May & Roberts, 1995). The packages of traffic management and urban planning are developed into strategies for integrated transport and urban development in Asian developing countries. There are four transport-related strategies and four urban-related strategies, which are more elaborated in Chapter five. Strategies include:

(1) Promote Non-motorised Transport
(2) Control Individual Motorised Vehicles
(3) Promote Public Transport
(4) Promote Intermodal and Multimodal Transport
(5) Promote Compact Development in Central City Areas
(6) Control Suburban Areas
(7) Promote Transit-oriented Development
(8) Develop New Sub-centres

2.6 Summary

In a city, patterns of urban development are inseparable from the evolution of urban transport. Likewise, urban transport development cannot be considered independently from the urban development (Newman and Kenworthy 1989; UN Habitat 2013). The interactions of transport system and urban form elements in a city are complicated by the fact that changes in any one aspect will also result in changes in the others.

Traffic management packages, which are implemented for effectively managing and controlling traffic, influence modal splits. They might have indirect impacts on the urban form elements. Urban planning packages are designed to influence the urban form elements. They also have indirect impacts on the modal split. The implementation of packages of traffic management and urban planning influence the modal splits and urban form elements. Then, there are interactions of modal splits and urban form elements.

Changes in an urban element can be the results of the implementation of urban planning packages. Besides, changes in modal splits also influence urban form elements. The impacts are combined, which require comprehensive considerations in planning and implementing measures. Considering the significant positive interactions helps to highlight the mechanism of the interactions.

The interactions of transport system and urban form elements call for an integrated approach to planning, which allows all the interactions to be coordinated. Integrated transport and urban planning – an approach that takes into account and connects all these considerations – helps to ensure that transport network development and land-use development are coordinated. The purpose of integration must be to achieve a higher performance against the objectives of the strategy than could be achieved by the individual measures on their own (May and Roberts, 1995). Integrated planning is an approach that seeks to pull together all the contributing elements to increase the effectiveness of delivered solutions and avoid avoids creating unintended impacts (New Zealand Transport Agency, 2011). In the long term, it will not be possible to solve the transport and urban-related problems of urban areas by one or several measures. The proposal for packages of measures needs to consider how they function as part of a balanced strategy. Eight strategies are proposed as basic strategies for achieving integrated transport and urban development in Asian developing countries.

3 Analysis of Problems of Transport and Urban Development in Asian Developing Cities

Chapter 2 provides detail descriptions of the impacts of traffic management and urban planning on transport system and urban form, as well as the interactions of modal splits and urban form elements. In many cities, decisions related to transport and urban development have often been regarded as distinctly separate issues in analysing, planning, designing, operating and managing. The weakly coordinated transport and urban development create negative impacts from one to another (Wadhwa, 2005).

This chapter analyses transport and urban-related problems in Asian developing countries. The problems are rooted for many reasons, which can be grouped into two categories of (1) Insufficient traffic management and (2) Insufficient urban planning. Practical situations and problems in several Asian developing cities, which are reviewed from literature and investigated through the field survey in Ho Chi Minh City, are used for illustration.

3.1 Problems of insufficient traffic management

The problems of insufficient traffic management are results of (1) Lack of promotion for non-motorised transport; (2) Lack of controlling individual motorised vehicles; (3) Lack of promotion for public transport; and (4) Lack of promotion for intermodal and multimodal transport.

3.1.1 Lack of promotion for non-motorised transport

The manifested problems of lacking promoting non-motorised transport are unsafe walking/cycling conditions, occupied sidewalks and inadequate access to public transport system. Consequences are the reduction of the modal share of non-motorised transport and public transport. The problems of lacking promoting non-motorised transport are rooted from (1) Inadequate provision of facilities for pedestrians (2) Lack of pedestrian zones; (3) Lack of bikeway network; and (4) Lack of bicycle-sharing schemes.

In many cities in developing countries, facilities for non-motorised transport are inadequately provided, even in the city centre. In Ho Chi Minh City, only half of the roads in the city have sidewalks, in which, just 27% of sidewalks has the width from more than 3 m (ALMEC, 2015). The quality of non-motorised transport facilities is also reduced due to insufficient maintenance. In Jakarta, one of the major reasons that many people do not use public transport is the poor quality of pedestrian facilities and the danger faced by pedestrians. Zebra crossings are mostly non-functioning due to the behaviour of drivers who ignore the presence of pedestrians (Mochtar & Hino, 2015). The management of sidewalk is insufficient. Street vendors, parked vehicles, telephone booths, improperly trimmed trees, etc., occupy many sidewalks. These obstructions force pedestrians into the street, creates unsafe walking/cycling conditions and decreases the willingness to walk or to cycle. These problems make the level of non-motorised transport use in most Asian developing cities low for such a dense, mixed-use urban environment.

(a) Motorcycle parking in sidewalk in HCMC (b) Electric station in sidewalk in Hanoi

(c) Low quality and occupied sidewalk (d) Coffee business in sidewalk

Figure 3-1: Sidewalk conditions in Ho Chi Minh City and Hanoi, Vietnam

Source: https://vietnammoi.vn/nguoi-di-bo-phai-nhuong-duong-cho-bot-dien-thung-rac-va-shop-thoi-trang-tren-via-he-22240.html

3.1.2 Lack of controlling individual motorised vehicles

The manifested problems of lacking controlling individual motorised vehicles are the increasing congestions, accidents, and pollutions. The problems are rooted from (1) Uncontrolled vehicle registration; (2) Insufficient taxes and duties for individual motorised vehicles; (3) Lack of road pricing for private car; (4) Lack of access control; (5) Lack of traffic calming and speed reduction; (6) Lack of parking pricing; and (7) Lack of parking restriction.

In Ho Chi Minh City, more than 80% of the trips in the city are made by motorcycles, and the reliance on the motorcycle is deeply entrenched. It is usual for people to use motorcycles even for very short trips. Motorcycles are the dominant mode of transport for all distances, from a short trip (less than 5 km) to a long trip (more than 10 km). Motorcycles can satisfy commuters' needs of door-to-door service that current mass transit systems in developing countries cannot offer. Figure 3-2 shows the high share of motorcycles in most trip distances in Ho Chi Minh City. The current over-utilisation of motorcycles for long trips contributes to traffic congestions, decreases the share of buses and threatens the development of new public transport system in the long-term. Besides, higher income and traffic congestion increase car use, which lead to urban sprawl. Consequently, urban size is increased and urban density is decreased, which makes public transport insufficient. These trends will continue in the future of developing countries.

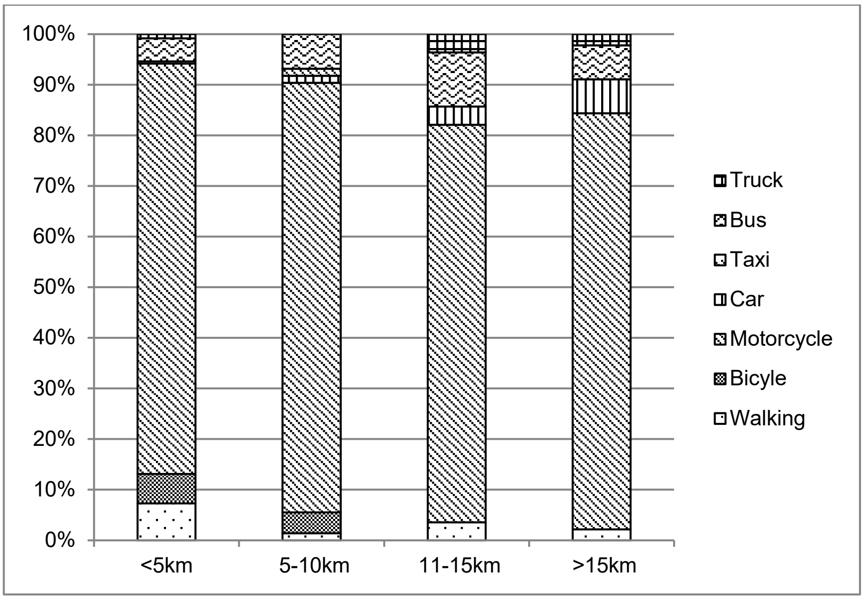


Figure 3-2: Average trip distance and most frequently used mode of household representatives in Ho Chi Minh City

Source: (Nguyen, 2013)

In Asian developing cities, parking is not well managed. Although there are public and low-cost parking places in the central urban areas, parking places are mostly provided by the private sectors at activity centres (schools, shopping malls, hospitals, parks, offices, etc.). In residential apartments, the families living on the ground floor typically offer parking services irregularly. Few apartment blocks provide parking lots on the ground floor. In other forms of residence, motorcycles are frequently parked in the kitchen or living room on the ground floor, especially during night-time (Khuat, 2006). Although the parking fee collected by the private sector is higher than that of the public sector, people prefer to park in private parking places due to their convenient locations. The provision of many unplanned private parking places increases trips by individual motorised vehicles. Besides, enforcement of city governments regarding parking is not strict; vehicles are illegally parked on streets or sidewalks. Improper parking management might result in increased use of car and motorcycle since people can park their vehicles everywhere. On the other hand, parking in the sidewalks forces pedestrians to walk on the road and exposes them to the risk of being hit by speeding vehicles. The number of non-motorised transport users might decrease. Furthermore, on-street parking restricts the flow of traffic and thus makes traffic congestion in Asian developing cities more serious.

The cases of Taipei and Ho Chi Minh City illustrate the situation. In Taipei, there were 342 thousand car parking spaces and 58 thousand motorcycle parking spaces available, which were far fewer in number compared to the population of 667 thousand passenger cars and 960 thousand motorcycles (data in 2000) (Cheng, 2001). Nguyen (2013) conducted a survey on accessibility condition in Ho Chi Minh City. The results showed that parking spaces in the city are very limited. During the daytime, most of the surveyed household representatives responded that they park their vehicles "in-house", which means inside the buildings of their offices (38%). Others park their vehicles in priced public parking places (9%), which are very limited in the city. In the city centre, there are on-street priced parking places, and these are managed and charged by local administrators. Although the on-street parking has negatively impacted the traffic flows, in the case of Ho Chi Minh City, this solution can help improve the problem of lacking parking spaces for vehicles in the city centre. At night, parking demands are mostly "at home" served (88%). Vehicles are parked inside the home front room or on the grounds of the houses. In some cases, vehicles are parked at priced private parking places.

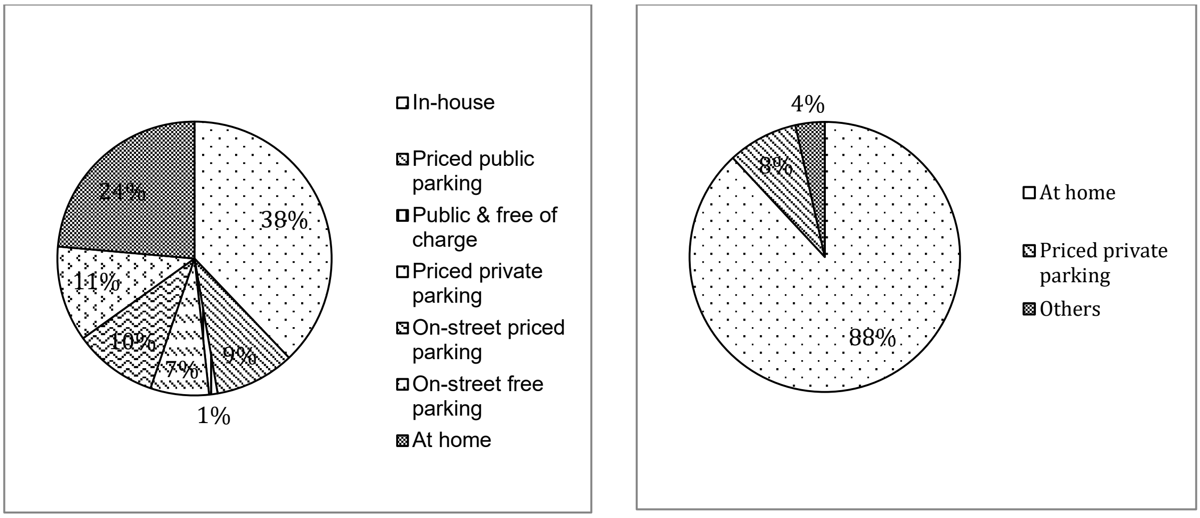
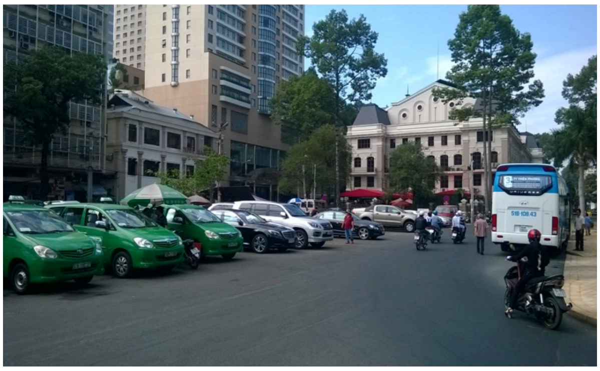


Figure 3-3: Day-time and night-time parking of household representatives

Source: (Nguyen, 2013)

(a) Priced private parking place

(b) Priced public parking place



(c) On-street private parking place

d) On-street public parking place

Figure 3-4: Parking places in Ho Chi Minh City

Source: Authors's representation

3.1.3 Lack of promotion for public transport

The manifested problems of lacking promoting public transport are the limited network and poor public transport services, which lead to the low share of public transport. These problems are rooted from (1) Insufficient public transport service improvement; (2) Lack of priority for public transport; (3) Insufficient public transport feeder services; (4) Insufficient pricing mechanism; and (5) Lack of public transport authorities.

There are public transport system in Asian developing cities, ranging from buses, Bus Rapid Transit, Light Rail Transit to Mass Rapid Transit. Unfortunately, public transport system in these countries have not achieved their expected targets in relieving traffic congestion and shifting individual transport users to public transport, especially to Mass Rapid Transit. The cases of rail systems of Bangkok and Manila illustrate the situation. These deficiencies are the results of lacking priority for public transport, such as traffic signals or separate lanes. Furthermore, incomplete network coverage and non-hierarchical public transport system hinder public transport use. The limited budget for subsidising as well as giving incentives also decrease the attractiveness of public transport. As private transport grows, demand for public transport decreases and results in the decline in service levels of public transport. Transit cannot compete with private transport, which is becoming affordable to greater numbers of people. A comparison of Manila, Jakarta and Surabaya suggests that there is some trade-off between motorcycles and public transport, with public transport having the lowest role in Surabaya where motorcycles are most numerous and a much greater role in Manila where motorcycle numbers are negligible (Barter, 1997). However, in a vicious cycle, public transport suffers further loss of patronage because of high motorcycle use (World Bank, 2002). In Taipei, road congestion seriously affects the effectiveness and speed of bus services. During rush hours, fully loaded buses are congested in traffic with other vehicles. Because trip times are significantly longer and the schedules are unpredictable, the bus system is unable to compete with other modes of transport. Even with low fares, the bus system is experiencing declining patronage due to inconvenient delays. From 1980 to 2000, the buses' share of total daily trips declined from 62% to 21% (Feng, 2001). In Bangkok, the dominant public transport mode is buses, and for most commuters, it is uncomfortable, inconvenient and slow, although cheap (Tagphaisankunn, 2010).

The problems of insufficient public transport management are also rooted in the uncoordinated public transport management. In Ho Chi Minh City, there are many agencies involved in managing public transport system. Moreover, functions of relevant authorities are inadequately assigned and fulfilled (Nikken Sekkei, 2014). Centre for Public Transport Management and Operation (belongs to Department of Transport) manages the bus system while Management Authority of Urban Railway (belongs to Ho Chi Minh City People Committee) manages the Mass Rapid Transit system. Within the Mass Rapid Transit system, there are several investors with different technologies and control systems involved, which make management complicated. Uncoordinated management might lead to the risk of lacking connections of public transport system in Ho Chi Minh City if the issues are not adequately addressed in the management, as well as in planning stages. The coordination at the implementation stage is also a problem in Jakarta. Most bus public transport in Jakarta was operated under traditional management and owned by individuals or co-operatives (Mochtar and Hino, 2015). The role of the government in this system is only to give the licensing to operate based on the determined number of buses on the proposed route by private companies or individuals. The government does not have the authority to control the quality of service of public transport. Sometimes a proposed route has more than 50% overlap with other routes. The bus drivers do not care about the quality of service such as punctuality, convenience and safety.

3.1.4 Lack of promotion for intermodal and multimodal transport

The manifested problems of lacking promoting intermodal and multimodal transport are the poor connectivity among transport system and modes. These problems are rooted from (1) Insufficient intersectional traffic control systems; (2) Lack of Park & Ride systems; (3) priority for public transport; (3) Insufficient Intelligent Transport System.

Public transport system are not well connected, which create difficulties for passengers in transferring among public transport modes and routes. Passengers do not receive sufficient information for the trip, which leads to the decreased use of public transport. Besides, other problems, such as lack of problem integrated ticketing systems, are consequences of the insufficient development of intelligent transport system.

The connectivity between individual motorised vehicles and public transport modes is sufficient due to the lack of multimodal facilities. Passengers of individual motorised transport do not receive enough information for their trips, which make the trip time-consuming and costly.

3.2 Insufficient urban planning

The problems of insufficient urban planning are results of (1) Insufficient compact development in the central city areas; (2) Insufficient control of suburban areas; (3) Lack of Transit-oriented development and (4) Insufficient new sub-centre development.

3.2.1 Insufficient compact development in the central city areas and controlling of suburban areas

The manifested problem of insufficient compact development and insufficient control of suburban areas is urban sprawl, which leads to increasing travel distance, poor accessibility, increasing individual vehicle use and decreased public transport use. The problems are rooted from (1) Insufficient density increase in the central city areas; (2) Insufficient mixed-use development in the central city areas; (3) Lack layout and landscape design in the central city areas; (4) Lack of growth boundaries; and (5) Lack of regulations for parking space.

The central areas of cities are developed compactly. High density and mix land-use are promoted so that destinations can be reached in short travel distances. However, in many cities, land-use patterns are not diverse, and the allocation of destinations is scattered. People must go far for the needs, which increases the number of trips and travel time. In many cities, land areas for non-motorised transport and public transport are inadequately provided. Parking places are also not provided sufficiently enough to facilitate mode shifting from private transport modes to public transport modes. Those facts lead to the over-utilisation of motorised transport modes. Consequently, the central city areas are more and more congested.

In most Asian developing countries, the lack of sufficient land-use planning and control has resulted in unplanned and low-density development into sub-urban areas and decreased density in the central city centres. Urban sprawled development is extending rapidly in all directions from the city centres, creating newly developed residential areas in the suburban areas, without proper provision of technical and social infrastructure (Pucher and Korratyswaroopan, 2004). Individual motorised vehicles, especially motorcycles, are favourable transport mode due to their advantageous accessibility. Due to urban sprawl, there is a growing separation of origins and destinations. Since the length of trips is increased, cars become a favoured transport mode (World Bank, 2002). Urban sprawl hinders public transport supply (Pojani & Stead, 2015). Urban sprawl creates an obstacle to the introduction of fixed-route systems because low-density areas spread outward and ultimately undermine the economies of scale, which suit heavy rail (Dwyer & Williams, 2012). Then, urban form is more favourable for a fast transport mode that would be motorcycles or cars in the case of poor urban transit service (Khuat, 2006). Furthermore, in the middle to long term, mass motorcycle ownership will probably facilitate dispersed business locations and lower density development unrelated to the transit system, thus further plunging transit into a downward spiral and paving the way for an influx of cars (Barter and Kenworthy, 1997).

In the suburban areas, undifferentiated urban layout supports the increased use of the individual motorised vehicle and decreases the effectiveness of public transport. The undifferentiated urban layout results in the creation of "superblocks", a weak ratio of major roads to the areas they serve. The narrow and "zigzag" roads mainly serve these "superblocks". These roads are poorly connected to the main roads (Punpuing & Ross, 2001). These "superblocks" are accessed by motorcycles, which, in turn, influence the urban layout and land-use patterns by maintaining many "motorcycle accessed only blocks". The road network has grown in a vernacular way, with mixed residential and small-business areas served. This uniqueness is a consequence of the lack of consideration on the integration between transport and urban planning. In Jakarta, Surabaya, Hanoi and Ho Chi Minh City, motorcycles can reach many houses located on narrow alleyways (Barter and Kenworthy, 1997). Data from Ho Chi Minh City shows that the proportion of small alley (less than 5-meter width) is 5%; alleys (from 5 to 8-meter width) is 55%, and road (from 8 to less than 15-meter width) is 16%. The proportion of roads, which are suitable for bus operation (more than 15-meter width), is quite low (only 6%). In Hanoi, the situation is worsening; about 50% of the people are living in blocks that are connected by less than 3-meter-wide alleys.

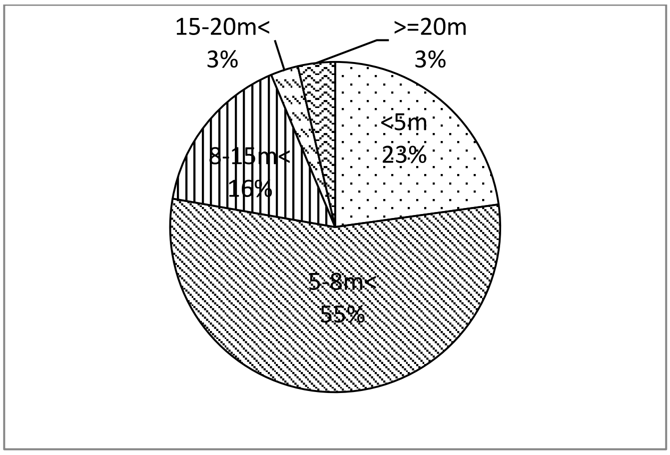


Figure 3-5: Road width in Ho Chi Minh City

Source: JICA (2013)

Figure 3-6: Alleys in Ho Chi Minh City

Source: http://www.tinmoi.vn/Kham-pha-nhung-ngo-hem-Sai-Gon-01232633.html

The development of "motorcycle accessed only blocks" reduces the accessibility to the blocks, especially for emergency services. Also, it decreases accessibility by non-motorised transport and public transport. It encourages the residents to travel by two-wheelers. On the other hand, "motorcycle accessed only blocks" exist as a natural barrier to avoid the growth of car ownership, car use and its adverse impacts (Khuat, 2006).

Cities in Asian developing countries are experiencing sprawl. Ho Chi Minh City is an example. The city is expanded along the Saigon riverbank. During the French occupation (1860-1945), the city was well planned in a grid form with specific areas for administrative, commercial, residential purposes. When the Americans came and replaced the French (1954-1975), there was a massive migration from rural areas to the city, mainly for military purposes. The city received huge investment to build luxury hotels, high-rise buildings, modern factories, etc., and the road network was constructed widely (Nguyen, 2010). After the reunification of the country in 1975, the city started to recover after the war, and economic development was the priority of the city. When "Doi Moi" (an economic reform in Vietnam since 1986) was implemented, noticeable effects on socioeconomic development and the housing industry emerged in response to the housing demand. New housing estates built mostly in the peripheries where vacant green lands were available (Waibel, 2006). The city has sprawled while infrastructure development has not been adequate.

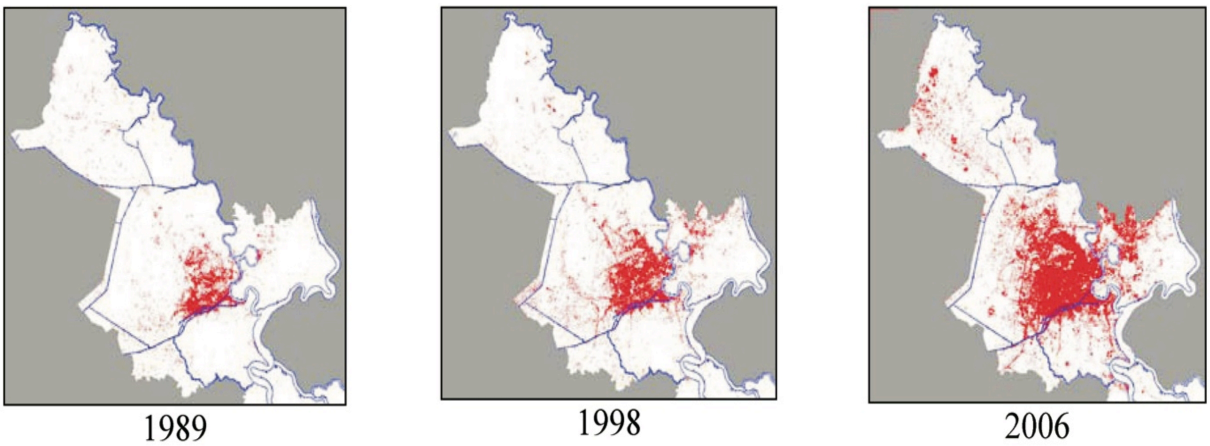


Figure 3-7: Urban sprawl in Ho Chi Minh City

Source: (Nguyen, 2010)

Jakarta experienced a period of rapid growth in suburban areas during the 1990's with the growth of large-scale housing projects for moderate and high-income families (Leaf, 1994). These new towns still heavily depended on the central city. The development of large-scale housing projects intensified the daily interaction between the fringe areas and the central city of Jakarta. This worsened the traffic problems in metropolitan Jakarta (Firman, 1999). The periphery of Jakarta is also made up of specialised zones of commercial and industrial enterprises. In the peripheries of the megacity of Jakarta, agricultural areas and forests were massively converted into industrial estates, large-scale subdivisions and new towns (Firman, 1999; Silver, 2007).

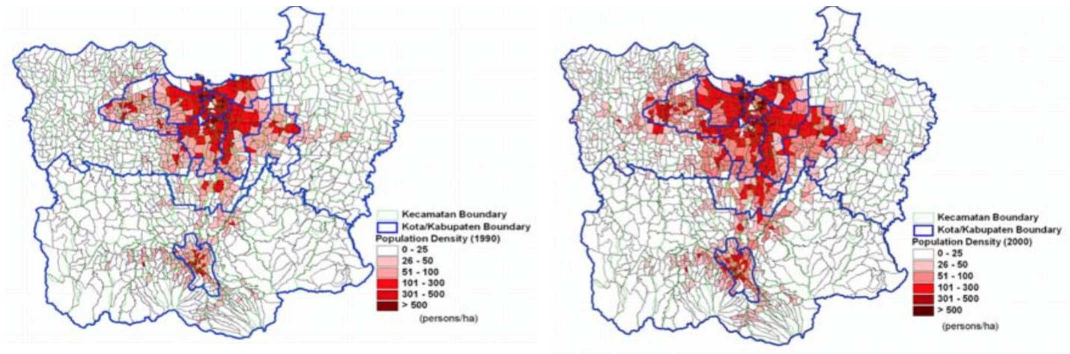


Figure 3-8: Evolution of urban expansion in the Greater Jakarta, 1990 and 2000

Source: (Asri & Hidayat, 2005)

3.2.2 Insufficient Transit-oriented development

The manifested problem of insufficient Transit-oriented development is the low modal share of Mass Rapid Transit systems. The problems are rooted from (1) Insufficient spaces for the mass transit lines and stations; (2) Insufficient mixed-use and high-density development in the neighbourhoods of Mass Rapid Transit stations.

Many metropolitans of developing countries have implemented mass transit systems to relieve traffic congestion in the past decades, such as Bus Rapid Transit in Jakarta, Seoul, and Curitiba as well as rail-based systems, Light Rail Transit/Heavy Rail Transit/Subway in Bangkok, Delhi, and Manila. Most of the mass transits implemented are located along the high-density corridors. Unfortunately, some of the mass transit systems implemented cannot well achieve their expected targets of attracting individual motorised transport users. The obstructions are not only an increase in motorisation and high fare but also poor connectivity with other existing transport modes and access difficulty. The difficulties in accessing mass transits and public transports are caused by inefficient land-use plans, low service coverage, and inadequate feeder systems. In the high-density urban areas of developing countries, land developments have long been settled with ineffective growth control that creates large areas of mixed land use of residences and business activities. This has resulted in a vernacular growth of road network that caused malfunctions of many narrow alleys off the main streets and poor connectivity of roads in such areas. The pessimistic mind-set dissatisfies commuters and leads to low system performance and level of patronage as occurred in two rail systems of Bangkok, and MRT3 of Manila. Even though mass transit systems offer high-speed service, using private car might be faster; car users still have not transferred to ride mass transits (Tagphaisankunn, 2010).

The separation of functions and responsibilities of many agencies involved in transport and urban planning and managing have given rise to problems of incoordination. The problems were mainly associated with the absence of the land-use plan and uncoordinated transport projects and plans. The urban growth control policy and several others land-use and transport measures obviously failed. The result is the establishment of several “fragmented” plans, not a “comprehensive” plan. In Bangkok, the government has adopted the international planning concepts since 1960, but the traffic situations have become more severe. Traffic congestions has unceasingly expanded to the outer areas of Bangkok and passed the controllable limit (Rujopakarn, 2003). Bangkok maintained its primary role. The failure of transport system development in Bangkok can be explained by the mal-coordination of a dozen different government agencies working under several ministries (Pike and Rujopakarn, 1996), and the problem of inconsistency in planning methodology. Rujopakarn (2000) has shown that the Bangkok Land-Use Plan (1999) and policy were not compatible with the 8th Transport Plan prepared 2-3 years earlier by another agency, especially when focusing on the accessibility indices of each planning area. The conflict of the 8th Transport Plan proposals with those of the Bangkok Land-Use Plan demonstrates the situation. Poor coordination amongst government agencies is the main contributor to this. The analysis results from the 8th Transport Plan reflect how the planning authorities in Bangkok function. The urban crisis, especially in relation to transport, is mainly explained by the lack of integration of planning authorities and planning programs.

3.2.3 Insufficient new sub-centres development

The manifested problem of insufficient new sub-centres development is the extremely high density in the central city areas. The problems are rooted from (1) Lack of new urban zones development and (2) Lack of provision of facilities and services in sub-centres.

The imbalanced modal split and high urban density lead to traffic congestion, accident. The high-density population is a big problem for the motorised individual vehicle-oriented transport system. As cities grow and become wealthier, vehicle ownership and use grow rapidly. Asian developing cities have higher levels of private vehicle use per person and per hectare that can be properly accommodated in its dense, tightly woven urban form (Barter, 1997). There is simply not enough space for all transport modes, and the consequence is traffic congestion. Bangkok is facing severe congestion because its population density is very high, and the area for roads is low (Rujopakarn, 1999). Bangkok’s traffic is more congested than that in Hanoi or Ho Chi Minh City, while the population density in Bangkok is lower. In Jakarta, a significant investment in road-based transport system makes the city depend on cars. Public transport infrastructure is inadequate to serve demands. There are lower levels of public transport that would be expected in a city of its dense urban form and limited road availability. This situation has created several problems of traffic congestion, air pollution, road safety and inefficient fuel consumption (Mochtar & Hino, 2015).

Bangkok was a city developed along the riverbanks of the Chao Phraya River. During 1900-1960, urbanisation occurred improperly and was accompanied by relentless road construction, resulting in the ribbon development. In the Land-Use Plan 1999, the city aimed to improve mobility and accessibility with a moratorium on new road construction. Transit zones and centres were developed, the Central Business District expanded and new metropolitan sub-centres created. The city has been transforming into a polycentric urban structure to solve the transport problems and contribute to sustainable development (Rujopakarn, 2003).

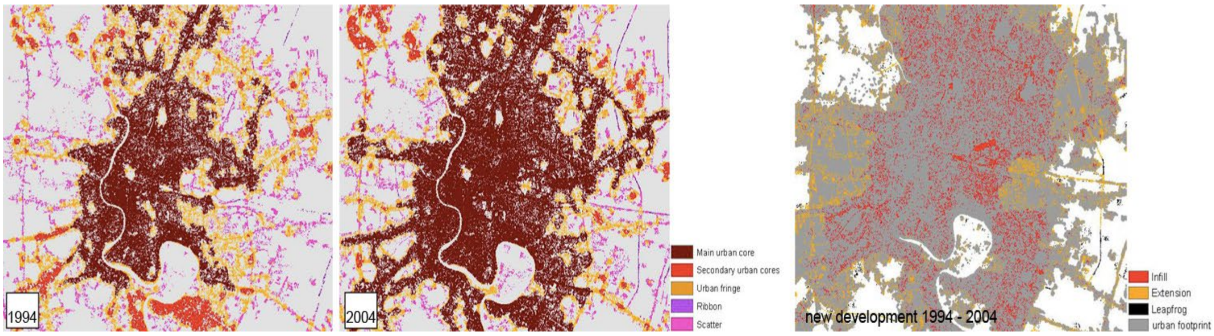


Figure 3-9: Urban expansion in Bangkok, 1994 and 2004

Source: http://urbanalyse.ch/cmswp/wp-content/uploads/2012/09/bkk_urbangrowth_pixelmap.jpg

3.3 Summary

In many cities, decisions related to transport and urban development have often been regarded as distinctly separate issues in analysing, planning, designing, operating and managing. The weakly coordinated transport and urban development create negative impacts from one to another (Wadhwa, 2005). The analysis of problems in Asian Developing cities shows that uncoordinated transport and urban development leads to many problems, due to the complicated interactions of transport system and urban form elements. The transport and urban-related problems are rooted for many reasons, which can be grouped into two categories of (1) Insufficient traffic management and (2) Insufficient urban planning. Practical situations and problems in several Asian developing cities, which are reviewed from literature and explored through the field study of Ho Chi Minh City, are used for illustration.

The problems of insufficient traffic management are the results of (1) Lack of promotion for non-motorised transport; (2) Lack of controlling individual motorised vehicles (3) Lack of promotion for public transport; and (4) Lack of promotion for intermodal and multimodal transport.

The problems of insufficient urban planning are results of (1) Insufficient compact development in the central city areas; (2) Insufficient controlling of suburban areas; (3) Lack of Transit-oriented development and (4) Insufficient new sub-centre development. The lack of properly coordinated transport and urban development created problems, which can be reduced by promoting an integrated approach in transport and urban planning.

4 Framework for Integrated Development in Asian Developing Cities

It is proven in Chapter 2 that there are mutual impacts of transport system and urban form elements and the lack of properly coordinated transport and urban development created problems, as investigated in Chapter 3. It is therefore important to transport and urban planners to develop new approaches to transport and urban planning, emphasising integration to achieve sustainability (Ong et al., 2010). This chapter presents the integrated approach in transport and urban planning, which can be generalised in a framework. Firstly, goals and objectives of sustainable transport and urban development are presented, followed by goals and objectives of integration. The goal system is vital for guiding the formation of strategies for integrated transport and urban development in Asian developing countries. Related methods for assessing measures, which are potential to bundle strategies, are reviewed, as well as assessment criteria.

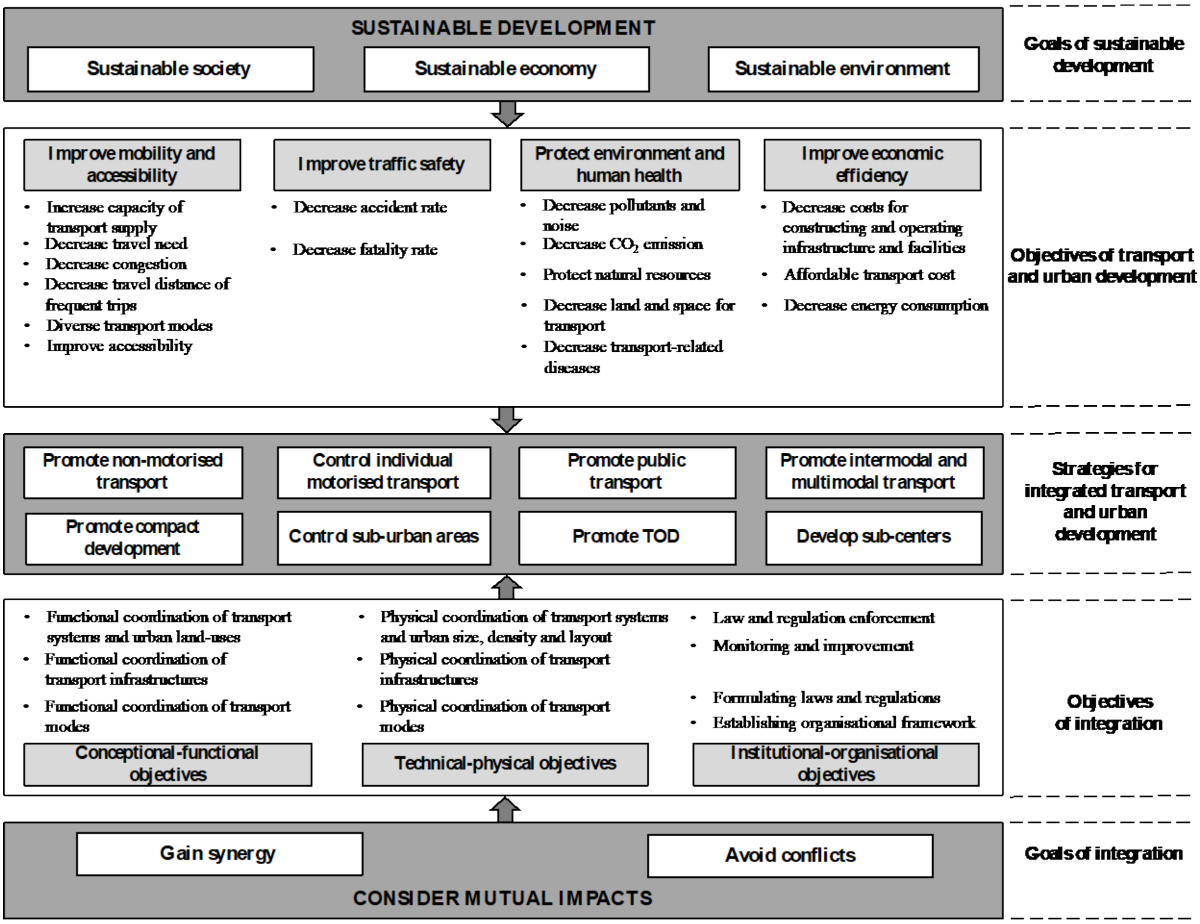


Figure 4-1: Framework for integrated transport and urban development

Source: Author's representation

4.1 Goals and objectives of sustainable transport and urban development

The ultimate goal of transport and urban development is to achieve sustainable development. In the report of the World Commission on Environment and Development (WCED, 1987), the so-called Brundtland Report, sustainable development was initially defined as "development which meets the needs of the present without compromising the ability of future generations to meet their own needs" (Glasby, 1995). This concept is though as "a global agenda for change" (Graaf, Musters and Keurs, 1996). Each country and government, depending on its context and level of development, must devise in detail how sustainable development concept can be implemented. The sustainable development encompasses three major goals of (1) Sustainable society; (2) Sustainable economy; and (3) Sustainable environment. Each goal corresponds to an aspect that has its own distinct driving forces and objectives (Munasinghe, 2004). The social aspect emphasises enriching human relationships, achieving individual and group aspirations, and strengthening values and institutions. The economic aspect is geared toward improving human welfare, primarily through increases in consumption of goods and services. The environmental aspect focuses on protecting the integrity and resilience of ecological systems. Transport interacts critically with the social, economic and environmental aspects of sustainable development. Therefore, the goals of sustainable transport and urban development for Asian developing countries cover both aspects of urban development and transport development. Goals include (1) Improved mobility and accessibility; (2) Improved traffic safety; (3) Protected the environment and human health; (4) Improved economic efficiency (Khuat, 2006). To achieve the goals, objectives are developed, covering both transport planning and urban planning. The goals and objectives are further explained.

4.1.1 Goal 1: Improve mobility and accessibility

Providing mobility and accessibility is the primary function of a transport system. In a society where there are different demand groups varying by age, occupation and income, transport system must ensure the mobility and accessibility of all transport demands by various kinds of transport modes. The improvement of mobility and accessibility implies both transport and urban development aspects. Specific objectives include:

*** Objective 1.1: Increase capacity of transport supply**

The objective focuses on providing quantified and qualified transport infrastructure and facilities. Major transport infrastructure and facilities include roads, parking facilities, transport control facilities, walkways and bicycle lanes, public transport infrastructure. Those infrastructure and facilities need to be sufficient provided and well functioned. The objective also emphasises on maximising the productivity and efficiency of existing urban roads, parking facilities, public transport infrastructure and vehicles through control and operation mechanisms (Khuat, 2006). In economic aspect, a quantified and qualified transport system enables continuous and smooth transport, which are important to individuals and the economy. An adequate and well-connected transport system allows a smooth movement for road users. The supply of road network with good quality improves traffic safety and increases travel speed. However, more road provision might result in the increase of traffic, which create adverse impacts on the environment and traffic safety in the long run. The construction of roads connecting suburban to the city centre leads to urban sprawl, which increases car use. Other impacts are the increasing of emission and noise in suburban areas. In the long term, the overdevelopment of car will lead to car dependence, creating more problems than that of the motorcycle. Those disadvantages need to be considered for mitigation when supplying more transport infrastructure and facilities. This objective is measured by conventional criteria, for instance, road length or road area, or the number of buses or length of the urban rail network.

*** Objective 1.2: Decrease travel need**

Thanks to technological advances, works or businesses can be conducted online, which reduce the need for travelling. Hence, the number of trips is decreased. The increased density and diverse land-use also promote the decrease of travel need since people can combine different purposes within a trip. In social aspects, the decreased travel need reduces time spent for transport. People are released from stress from transport. Traffic conditions are improved by less vehicle operation. Transport-related environmental pollution is also reduced. In economic aspect, transport cost is reduced. This objective is measured by the total number of trip or trip rate.

*** Objective 1.3: Decrease congestion**

The decrease of congestion reflects a balance between transport volume and capacity of transport system. By promoting high capacity public transport modes, the number of individual motorised vehicle ownership and use can be reduced. Hence, traffic congestion is reduced. In social aspect, the decreased congestion improves the reliability of transport services, which is especially important to public transport. A city with less traffic congestion decreases stress in transport. In the environmental aspect, the reduction of congestion means less pollution. Congestion creates the economic loss for individuals and the economy. A congestion-free city attracts more tourists to the city, which develops the city's economy. This objective is measured by the frequency of congestion in a month or average duration of congestion.

*** Objective 1.4: Decrease travel time of frequent trips**

The objectives focus on improving travel speed and promoting high density and mix land-use development. In social aspect, less time consumed for transport increases opportunities for other activities, such as entertainment or business. In economic aspects, decreased travel time improve the efficiency of transport services. The objective is measured by hours or minutes of traveling.

*** Objective 1.5: Decrease travel distance of frequent trips**

This objective is closely related to the objective of decreased travel time. When working places and services can be reached within the neighbourhoods, travel distance is decreased. In social aspect, the decreased of travel distance saves time. In the environmental aspect, the decreased travel distance decrease pollution. In economic aspect, less travel distance reduces the travel cost. The objective is measured by the kilometre of travelling.

*** Objective 1.6: Diverse transport system**

A transport system requires many kinds of transport modes to fulfil travel demand of all user groups. Depending on social-economic conditions and individual preferences, citizens have various options for choosing one or several kinds of transport modes, which meet their travel demand. The more diverse the transport system is, the more possibility it satisfies transport demand of travellers. In a diverse transport system, public transport plays an important role in providing affordable services for most of the user groups. The objective is important to some user groups, for example, the disabled. Therefore, it helps to promote equality in transport. In the environmental aspect, a diverse transport system helps to reduce pollution. In economic aspect, since people have several alternatives, they can consider the most appropriate and affordable transport mode, which meets their travel demand. This objective can be measured by the number of modal choices per trip for different purposes.

*** Objective 1.7: Improve accessibility**

This objective emphasises on improving the ability to reach the desired destinations, such as workplaces, schools, markets, and recreational places, thanks to the provision of transport modes, infrastructure, and facilities. The improvement of accessibility is important to promote equality in transport, and it is critical to the poor, the elderly or the disabilities. The objective can be measured by various criteria such as distance to destinations (measured in kilometre); the availability of transport modes (measured by the number of alternatives); the cost for transport (measured by the amount paid for travelling by a certain transport mode).

4.1.2 Goal 2: Improve traffic safety

Safety is a very important goal in transport. In designing, constructing and operating any transport system, safety is always a priority concern. The increasing of transport volume, mostly by motorised vehicles in cities raises problems of unsafe transport, which requires more efforts to solve.

*** Objective 2.1: Decrease accident rate**

This objective focuses on reducing possibility and occurrence of traffic accidents in all transport forms and modes, especially in developing countries where there are many motorcycles. In social aspect, the reduction of traffic accident decreases physical and mental loss. It creates a safe society. In economic, the decreased accident rate reduces economic loss from accidents. The objective can be measured by the number of accident per one hundred thousand inhabitants or per kilometre of road length.

*** Objective 2.2: Decrease fatality rate**

This objective focuses on increasing survivability of people and reducing the extent of damage to infrastructure, vehicles, facilities and environment in cases of accidents. The objective is measured by the number of death and injury per year, fatality rates.

4.1.3 Goal 3: Protect environment and human health

Transport is one of significant sector causing environmental degradation. Transport sector consumes energy, which is being exploited from natural resources. Then, transport sector releases wastes and emissions to the environment, which are being absorbed by humans and nature. Pollution, noise and pollutants from transport causing adverse impacts on human health. Negative impacts from transport to environment and human health need to be carefully considered when developing the sector.

*** Objective 3.1: Decrease air pollutants and noise**

This objective focuses on reducing air pollution (PM and NO_x) and noise generated from construction, operation, maintenance, and termination of vehicles and infrastructure facilities. In social aspect, the decrease of air pollutants and noise creates a clean environment, which helps to improve the health of the citizens. It also enhances the attractiveness of the city. The reduction of air pollutants and noise also decreases costs for environmental treatment. The objective is measured by the amount of PM and NO_x emitted per year (ton per year), or the level of noise (DbA), at specific measurement points.

*** Objective 3.2: Decrease CO_2 emission**

This objective focuses on reducing CO_2 emission, which is a significant contributor to climate change. The objective is measured by the amount of CO_2 emitted per year (ton per year).

*** Objective 3.3: Protect natural resources**

Transport sector requires energy, which is exploiting the nature. However, natural resources are limited. The exploitation of coal and crude oil for transport-related purposes destroyed the environment. For the long run, consumption of natural resources must be reduced, and alternatives need to be developed for sustainable transport. In social aspect, the protection of natural resources is meaningful for the promotion of an environmentally friendly lifestyle. In economic aspect, the development of alternative sources of energy for transport is costly. The objective is measured by the amount of coal or crude oil use per year for the transport sector.

*** Objective 3.4: Decrease land and space for transport**

This objective focuses on promoting the efficient use of land and spaces for transport purposes. Transport sector requires a lot of land areas and spaces for the construction of infrastructures and facilities. By decreasing land areas and space for transport, there will be opportunities to use the land for other public purposes, such as parks, schools, markets, etc. Saving land and space consumption for transport help to reduce investment for transport and preserve natural land. The objective is measured by the percentage of the land areas for transport in the total land areas of the city (ha of transport land in the entire city's land).

*** Objective 3.5: Decrease transport-related diseases**

Transport sector releases wastes and emissions to the environment, which is harmful to the human health. Transport-related diseases are a burden for the health care system, which is costly for treatment. The objective is measured by the number of the cases or the cost of treatment transport-related diseases.

4.1.4 Goal 4: Improve economic efficiency

Thanks to transport system, businesses are conducted, which created products for the economy. Then, the products are transported to the consumers, and more values are generated. Transport networks connect places to places, which is meaningful for communication and tourism. In areas where having a developed transport system, it is recognised that its economic activities are dynamic and living condition of the citizens is better than areas having inadequate and backward transport system.

*** Objective 4.1: Decrease construction and operation costs**

This objective focuses on reducing costs for constructing and operating transport infrastructure and facilities. With the development of new technologies, transport costs can be reduced. Besides, traffic management measures are implemented for the optimal operation of transport system. A developed and modern transport system can help to reduce transport costs due to the reduction of travel time and fuel consumption. Then, the reduction of total transport cost can help to reduce the price of goods and bring benefits to low-income people. The decrease of construction and operation costs reduces the financial burden on the government budget. The criteria to measure this objective can be total cost per person-kilometre, the total cost per ton-kilometre (of freight transport).

*** Objective 4.2: Affordable transport costs**

This objective focuses on reducing the total travel expenses, making transport affordable to all user groups. With individual users, travel expenses can be reduced by decreasing costs for purchasing, maintaining and operating vehicles or they can choose using public transport. The reduction of transport cost helps to reduce total living expense of households and creates opportunities to improve their quality of life. The criteria to measure this objective can be the percentage of transport expense in the total expenditure of individuals.

*** Objective 4.3: Decreased energy consumption**

This objective focuses on reducing energy consumption in the transport sector by promoting fuel-efficient vehicles and renewable energy. Environmental friendly transport modes, such as non-motorised transport and public transport, are developed. For the society, less energy consumption in transport sector means more options for energy use in other essential sectors. The development of renewable energy, a sustainable source of energy, protects the environment. However, developing renewable energy is costly, which requires huge supports from the government. However, production of renewable energy creates noise, shadow, etc., which might harm the environment. The objective is measured by the amount of fuel consumption for transport sector per year.

4.2 Goals and objectives of integration

The ultimate goal of integrated transport and urban development is to consider mutual impacts of measures. Two sub-goals are (1) to gain synergy and (2) to avoid conflicts (May and Roberts, 1995).

4.2.1 Goal 1: To gain synergy

Policy instruments interact with each other in different ways. The term "synergy" is often used to describe the effects of positive interactions between measures. The gain of synergy involves finding pairs or groups of measures, which reinforce one another in achieving changes in the transport system and urban form elements (May et al., 2006). Gaining synergy between measures is the target of designing strategies for integrated transport and urban development. This goal is specified into three objectives, which cover both transport planning and urban planning, include (1) Conceptional-functional objectives; (2) Technical-physical objectives; and (3) Organisational-institutional objectives (Boltze & Fornauf, 2013).

*** Conceptional - functional objectives**

Conceptional-functional objectives are the starting point in thinking about integration (Boltze & Fornauf, 2013). The conceptional-functional objectives focus on improving the effective connectivity of transport modes and networks. The objectives also enhance the economic efficiency of transport system. Conceptional-functional objectives include (1) Functional coordination of transport modes; (2) Functional coordination of transport infrastructure and (3) Functional coordination of urban land-use and transport system.

- **Functional coordination of transport modes**

Each transport mode has a specific capacity and operational characteristics, which help the mode functions well in particular road conditions and road types. The functional objective in term of passenger facilitates the ability to easily switch from one mode to another. For example, with the organisation of feeder modes and trunk modes, passengers can easily access the public transport system without spending too much time for walking. By functional coordinating transport modes, policymakers can eliminate modal bias; ensure efficient economic operation of all modes in the network.

- **Functional coordination of transport infrastructure**

The objective focuses on enhancing the functional connectivity of different networks so that they can support each other. A well-coordinated road network increases network efficiency and improves traffic safety. For example, within public transport system, the bus network and the rail network are functionally coordinated as feeder network and trunk network so that they can complement one another.

- **Functional coordination of urban land-use and transport system**

The mix of land-use functions, such as recreational, residential, commercial and industrial properties, influences the amount and type of trips to and from a location. In turn, the level of access and convenience provides a transport service has an impact on the demand for land surrounding the transport service. The allocations of mix use functions, especially in the catchment areas of public transport, increase the attractiveness and hence, increase the use of public transport system. The functional coordination between transport system and urban land-use is fundamental to efficient transport and urban development.

*** Technical-physical Objectives**

Physical integration is required to enable functional integration. The goal of physical integration is the non-obstacle connection between transport infrastructures to access different areas. Physical integration objectives include (1) Physical coordination of transport modes; (2) Physical coordination of transport infrastructures; and (3) Physical coordination of urban density, layout and transport system. Physical coordinated transport mode helps to reduce mode conflict and enhance operational performance of modes.

- **Physical coordination of transport modes**

Transport modes are physically coordinated to avoid conflicts in mode operations.

- **Physical coordination of transport infrastructures**

Different infrastructures are physically connected to create a comprehensive network. Physical coordination of transport infrastructures improves operational performances of network as well as traffic safety.

- **Physical coordination of urban size, density, layout and transport system**

The transport network, especially Mass Rapid Transit network, shapes urban form and guides the direction of urban development. Transport network also defines the layout of the urban areas. Transport network links urban centre with sub-centres to ensure socio-economic connectivity. The development of urban sub-centres helps to limit an over-concentration of constructions in the urban centre and, hence, decrease traffic pressure in the city centre, and in the transport network in general.

*** Organisational-institutional Objectives**

The need for integrated development calls for an organisational-institutional coordination that minimises jurisdictional and functional impediments (World Bank, 2002). On the organisational-institutional level, the processes for the development and implementation of strategies are established (Boltze & Fornauf, 2013). Organisational-institutional objectives include (1) Establishing organisational framework; (2) Formulating laws and regulations; (3) Disseminating laws and regulations; (4) Enforcing laws and regulations; and (5) Monitoring and improvement.

- **Establishing organisational framework**

  Organizational-institutional objectives focus on organising a common framework in which, functions and responsibilities of different stakeholders and the coordination mechanism between them are defined. In the absence of such a common framework, cooperation and coordination amongst government agencies, and between sectors, is difficult to achieve (Dwyer & Williams, 2012b). The framework is characterised by considering the inter-linkages between the perspectives of those responsible for transport and urban development (Tornberg, 2011). The establishing of an organisational framework refers to the “joining up” of different public policy domains and their associated actors within a given territorial area. It may also apply to other dimensions, such as the relationship between regional units, or the organisational relationship between different parts of a strategy-making process (Kidd, 2007). The framework promotes the frequent and easy exchange among involved stakeholders. It might range from regular meetings of stakeholders or organising permanent working groups under cooperation agreements to founding superordinated regional authorities (Boltze & Fornauf, 2013). Planning missions might be vested in a single agency or joint-agencies that ensure urban, and transport planning and managing are all coordinated (Dwyer & Williams, 2012).

- **Formulating laws and regulations**

  Since the relationship amongst stakeholders is complicated and inter-dependent, the fundamental requirement for all urban-transport related planning and implementation is laws and regulations. Vuchic (2005) argues that an overall urban transport system cannot be coordinated and upgraded until laws and regulations to coordinate are introduced. Laws and regulations are promulgated to keep all the players on the right track. They clarify the status of transport planning principles and delimitation of tasks, responsibilities of related agencies in planning, service provision, contracting, managing and operating transport system and other related issues, rights to use infrastructure and facilities, such as coordinated timetable, information, ticketing, etc. (Vuchic, 2005).

- **Disseminating laws and regulations**

  Laws and regulations need to be disseminated to the public for the compliance. Depending on the content of laws and regulations that appropriate methods of dissemination are employed. For transport-related laws and regulations, which are generally enforced for the mass, educational or marketing campaigns are effective solutions.

- **Enforcing laws and regulations**

  Laws and regulations are just documents if they are not acknowledged by the stakeholders and not accompanied by the appropriate enforcement. Thus, keeping the commitment and the consistency of government and all stakeholders in implementing the policy and its enforcement afterwards is a requirement (Susilo et al., 2007).

- **Monitoring and improvement**

  Monitoring is conducted continuously for laws and regulations enforcement and improvement. Related organisations are monitored for performance improvement regarding their functions and responsibilities.

4.2.2 Goal 2: To avoid conflicts

The interactions of measures might occur negative impacts. Then, integration is used as an alternative approach to avoid conflicts. Conflicts are obstacles that prevent a given policy instrument being implemented or limit the way in which it can be implemented. The conflicts may lead to certain measures are being overlooked, and the resulting strategies being much less applicable (May et al., 2005). Then, supportive measures are used to overcome or reduce the conflicts. Conflicts are identified, including (1) Cost; (2) Technology; (3) Institution; and (4) Public acceptance.

*** Cost**

Budget restrictions might limit the implementation of a specific measure. Costs also limit the flexibility with which revenues can be allocated to finance the full range of measures. Road building and public transport infrastructures are the two policy areas, which are most commonly subject to financial conflicts constraints (May et al., 2005).

*** Technology**

For infrastructure, engineering design and availability of technology may limit the implementation of policy instruments. Lack of critical skills and expertise in implementing and operating can be a significant barrier to implement the measures.

*** Institution**

These include lack of an organisational or legal framework to implement a measure. The lack of assigning legal responsibilities among agencies limits the ability of the city authority to implement the affected measure. It is usually hard to overcome the institutional barrier in the short term.

*** Public acceptance**

The lack of political or public acceptance might lead to failure of strategies, in planning and implementation stages. In the society, different target groups might be affected by the implementation of a specific measure. Attaining the public acceptance helps to reduce interest conflicts and increase the effectiveness of measures (May et al., 2005).

4.3 Methods and indicators for impact assessment

To achieve goals and objectives of integration, strategies are formed by bundling measures. The assessment of measures is an important step in the overall process of strategy development (Fornauf, 2015). Measure assessment requires appropriate methods and associated assessment criteria. The selection of assessment method depends on the complexity of the situation, which must be assessed.

Methods for measure assessment have been addressed in various publications. According to the review of Fornauf (2015), assessment methods include three groups of non-formalised, semi-formalised and formalised methods. In non-formalised methods, the argumentative method, the argument analysis, the SWOT analysis and the expert consultation, are considered. The semi-formalised methods range from the advantage-disadvantage analysis, the multi-criteria analysis, the compatibility analysis or the elimination method as well as the simple ranking procedure. In the formalised methods, the weighing and ranking procedure, the cost-benefit analysis, the effectiveness-cost analysis and the value-utilisation analysis are considered. There are no clearly defined boundaries between the assessment groups.

The positive and negative impacts are qualified and quantified to assess the effectiveness of a measure. Furthermore, applicability assessment is also conducted to avoid potential conflicts in implementing measures.

Depending on the impact areas of the measure, comprehensive or intensive assessment is conducted (Boltze & Fornauf, 2013). A macroscopic simulation of land-use and transport demands is suitable for large-scale impacts while a microscopic simulation of the traffic flow is suitable for complex situations with multiple interactions. Simple assessment approaches can be used for the assessment of constructing a Park & Ride facility at public transport stations. A comprehensive assessment requires a complete list of criteria, which cover almost influenced areas. Intensive assessment can be done with some key criteria on the major impact areas. Other criteria depend on the key criteria and derived as consequences of the key criteria.

In this study, the multi-criteria assessment is used for assessing measures due to its appropriateness as well as considering budget, time and technological restraints of the author. Multi-criteria assessment allows decision-makers to go beyond single-criterion approaches (Schmale et al., 2015). It can also provide prioritisation of measures, which is vital for the determination of key measures. The multi-criteria assessment is conducted based on the expert consultations for the effectiveness and applicability of measures. Criteria are developed, as summarised in Table 4-1 and Table 4-2.

Table 4-1: Objectives and criteria for assessing effectiveness

No.	Objectives	Criteria		Measurement Units
1	Improve mobility and accessibility (m1)	Increase capacity of transport supply	Road length	km
			Road density	km/km^2
			Number of buses	vehicle
			Length of urban rail network	km
		Decrease travel need	Number of trips generated	trips
			Trip rate	trips/day
		Decrease congestion	Frequency of congestion in a month	cases/month
			Average duration of congestion	minutes
		Decrease travel distance of frequent trips	Travel distance	km
		Diverse transport modes	The number of modal choices/alternatives	
		Improved accessibility	Distance to destinations	km
2	Improve traffic safety (m2)	Decreased accident rate	The number of accidents per one hundred thousand inhabitants	cases/.000 inhabitants
		Decreased fatality rate	The number of death and injury per year	cases/year
			Fatality rates	number of death and injury /case
3	Protect environment and human (m3)	Decreased pollutants and noise	The amount of PM and NO_x emitted per year	ton per year
			The level of noise	DbA
		Decreased CO_2 emission	The amount of CO_2 emitted per year	ton per year
		Protected natural resources	The amount of coal or crude oil use per year for transport sector	ton per year
		Decreased land and space for transport	The percentage of the area for transport in the total area of the city	ha
		Decreased transport-related diseases	Cost for treatment transport-related diseases.	USD
4	Improve economic efficiency (m4)	Decreased costs for constructing and operating infrastructure and facilities	Total cost per person-kilometre Total cost per ton-kilometre	USD/ person-kilometre USD/ton-kilometre
		Affordable transport cost	Percentage of transport expense in total expense of individuals	%
		Decreased energy consumption	The amount of fuel consumption for transport sector per year	ton/year

Source: Author's representation

Table 4-2: Conflicts and criteria for assessing applicability

No.	Conflicts	Criteria	Measurement Units
1	Cost (x1)	Investment cost	USD
		Operation cost	USD
2	Technology (x2)	Technologies and equipment for implementing measures	
3	Institution (x3)	Availability of legal documents for implementing measures	
		Availability and capacity of organizations for implementing measures	
4	Public Acceptance (x4)	Transport users	
		Transport operators	
		Community	

Source: Author's representation

4.4 Summary

The chapter develops the goal systems for sustainable transport and urban development, as well as goal and objectives for integrated transport and urban development. The goal and objectives of integrated transport and urban development are used for the development of strategies. The goal and objectives for integrated transport and urban development are used for the assessment of measures, which might be bundled into strategies. The assessment methods are briefly reviewed and the multi-criteria assessment is selected for the assessment of the measures in the following chapter. Assessment criteria are provided for comprehensive quantitative and qualitative assessment of measures. Then, a qualitative assessment of measures is selected for the development of strategies in the following chapter.

5 Formation of Strategies for Integrated Transport and Urban Development in Asian Developing Cities

To achieve goals and objectives of integrated transport and urban development, strategies are formed. The process of strategy formation includes three steps, as shown in Figure 5-1. Firstly, the pre-selection of measures is conducted, based on the consideration of successfully implemented measures from case studies. Secondly, candidate measures are assessed qualitatively. Finally, strategies are derived by bundling measures.

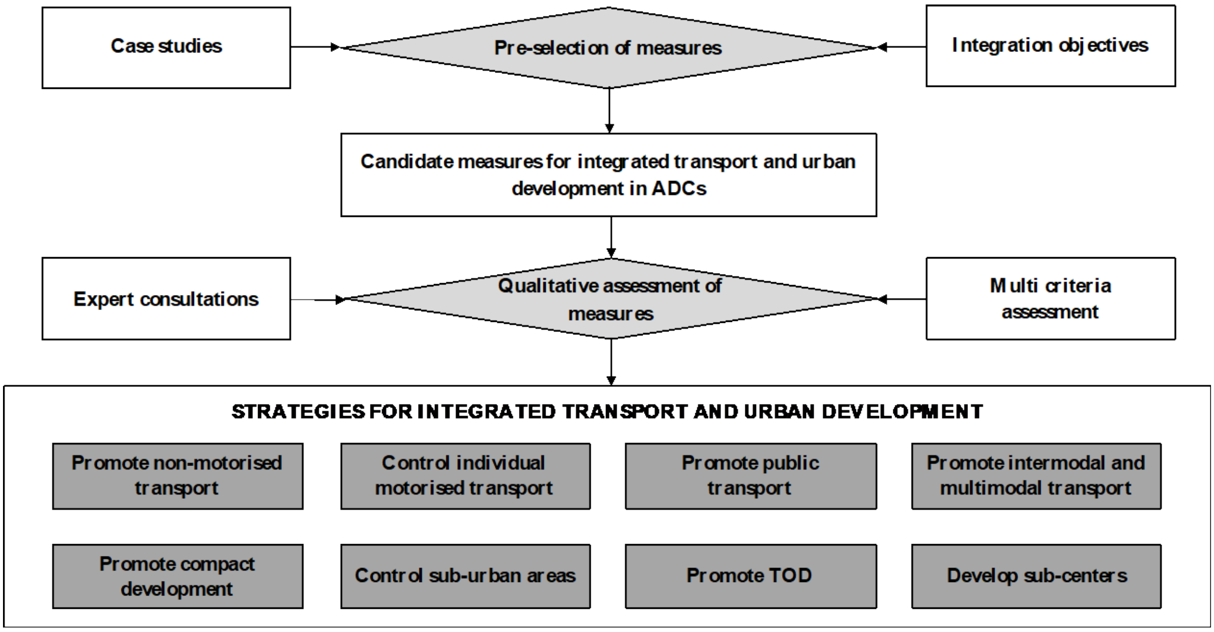


Figure 5-1: Process of strategy formation

Source: Author's representation

5.1 Pre-selection of measures

Every city has its development patterns, which is affected by the city's socio-economic context. The current transport and urban situation of cities are the results of the policy-making and implementation of measures. The review of transport and urban-related measures, which are being implemented in several cities, provides the background for the pre-selection of candidate measures. Many measures in traffic management and urban planning have been implementing in cities in the world. Various degrees of success are achieved in decreasing transport and urban-related problems in those cities. However, not all the implemented measures bring positive impacts. Also, the implementation of a measure is affected by the specific context of the city. Therefore, the analysis of measures can show what is working and what is not, with the reasons behind success or failure. Then, successfully implemented measures, which derived from case studies and fulfil objectives of integrated development, will be considered as candidate measures. It is noticed that the pre-selection of measures based on several case studies, further successfully implemented measures might come. Case studies are presented in Appendix B.

5.1.1 Traffic management-related measures

*** Non-motorised Transport**

- **M1 - Facilities for Pedestrians**

The measure aims to facilitate safe and convenient walking by providing walking paths, zebra crossings, flyovers and the traffic signals. These facilities must be designed and provided appropriately with facilities for individual motorised transport and public transport. The measure is widely implemented in many cities, especially in developed countries. In developing countries, facilities for pedestrians are often neglected in policy-making, which leads to the low share of walking in modal splits.

- **M2 – Pedestrian Zones**

The measure aims to promote walking as well as creating an attracting place in cities. In many cities, such as in Ho Chi Minh City, Hanoi, Bangkok, Taipei, etc., pedestrian zones are organised in the downtown of the city. The zones attract visitors coming for visiting, entertaining and shopping. The organisation of pedestrian zones requires proper allocation of parking places and provision of public transport services.

- **M3 – Bikeway Networks**

The measure aims to improve the quality of cycling by providing facilities for cyclists. In developing countries, cyclists share roads and traffic signals with motorised transport, which are dangerous for them. The lack of sufficient provision of facilities for cycling deters the use of bicycles. Bicycle transport is attractive only when there is a comfortable, direct and safe infrastructure, and the bikes could be stored conveniently and securely at destinations. A connected bikeway network is essential to ensure the provision of a consistent level of service. A bicycle-friendly environment could be created along the road networks to facilitate cyclists and attract more people using bicycles.

Various recent examples of improvements and innovation in promoting cycling in developing countries can be identified. For example, Chinese cities are promoting electric bicycles. The Chinese government has also mandated the reconversion of motorcycle lanes into bicycle lanes. In Taipei, the use of bicycles is gradually gaining momentum again after a long decline. Both the City and County have been adding bikeways in or around parks and recreational facilities (Feng & Sun, 2007). In several Latin American cities, cycle networks have been developed. Bike-friendly design of roads is promoted. Bikeway networks are facilitated by traffic management, which makes cycling safer, easier and more attractive. Traffic management includes traffic signals, motorised vehicle speed limitation, etc.

- **M4 - Bicycle-sharing Schemes**

The measure aims to facilitate cycling. It also provides a convenient and low-cost access mode to public transport. Bicycles can be provided at certain places in central city areas or at public transport stations. Bicycle transport is accessible for people who need a bike only occasionally or for part of their trip. Bicycle-sharing schemes can bring a significant increase in cycling and can facilitate multimodal trips. The implementation of bicycle-sharing schemes requires better cycling facilities and might include the rental systems.

Bicycle-sharing schemes have been successfully applied in some developed and developing cities in the world, such as Rio de Janeiro (Brazil), Daejon (Korea), and Hangzhou (China) (Pojani & Stead 2015).

*** Individual Motorised Vehicles**

Related measures in the case studies aim to reduce the reliance on individual motorised vehicles. These measures have been implementing in many Asian developing countries in responding to the shortage of road infrastructure. The construction of road network, especially highways, has contributed to the increased travel demand by car, faster urbanisation and urban sprawls, which in turn negatively affect mass transit patronage, like in the case of Bangkok. Many cities are implementing measures to control individual motorised vehicles. Measures include (1) Vehicle Registration Control; (2) Taxes and Duties for Individual Motorised Vehicles; (3) Road Pricing for Private Car; (4) Access Control and Traffic Calming; (5) Car Sharing Program; (6) Parking Pricing; and (7) Parking Restriction.

- **M5 - Vehicle Registration Control**

The measure aims to control the number of new car registration annually. The measure is considered politically easier to implement than pricing mechanisms because of the perception that all sections of the population are treated equally (Pojani & Stead, 2015). Several cities have experimented with selective car rationing or banning. In social aspect, the reduction of the number of individual motorised vehicles is important to reduce traffic volume. Consequences are reduced traffic accidents and pollutions. In the long term, since land and serving capacity of transport infrastructure and facilities are limited, the reduction of the number of individual motorised vehicles is required. Transport demands must be met by suitable public modes of transport.

In Singapore, the quota system is implemented to limit the number of new car registration. To buy a new car, people must get the certificate of entitlement and need to pay a lot of money (Han, 2010). Many Chinese cities have started to limit the total number of privately owned vehicles through restrictions on the number of licence plates issued per month. Shanghai has been controlled the growth of private vehicle registrations since 1994 (Wang et al. 2011).

- **M6 – Fees, Taxes and Standards for Individual Motorised Vehicles**

The measure aims to limit the use of individual motorised vehicles through fees, taxes, and standards. The imposing of taxes and fees for individual motorised vehicle ownership and use makes traveling by cars and motorcycles costly. The types of taxes and fees, as well as the collecting methods, differ from country to country. For example, some countries collect environmental fees. In Vietnam, owning a car is expensive due to high imported tax. Car and motorcycle users have to pay annual road maintenance fees. Those fees and taxes discourage the use of individual motorised vehicles. Besides, standards, such as emission levels, noise levels, vehicle weight, fuel consumption, occupancy, etc., are required to operate vehicles.

- **M7 - Road Pricing for Private Car**

Road pricing is implemented in many cities as a useful measure to manage and control car traffic. The measure aims to reduce the number of private cars going to the central urban areas, which is facing more congestion due to the high density and limited road spaces. Pricing mechanisms are considered more effective than regulatory approaches because they offer car users more choices, raise revenues, and can be adjusted according to different conditions (Pojani & Stead, 2015). Money collected from road pricing is used for maintaining road networks and developing public transport system. Road pricing can be conducted on a specific road or in an area, for example, central city areas. In Singapore, the Electronic Road Pricing systems charge cars at every time they go to the downtown areas (Field, 1992). The Electronic Road Pricing work efficiently in keeping the city out of traffic congestion. At the same time, the public transport system in the city are developed to serve huge travel demand. In London, cars entering the central urban areas are charged (Eliasson & Lundberg, 2002). Within one day, car drivers just need to pay once, and they can enter charging areas many times. In Stockholm, the congestion tax is applied to cars going to/out of the central urban areas (Mattsson, 2003). The tax varies according to the time of the day and is collected for each time cars going to the charging areas. The charging systems record the number of time entering the charging areas receipts are sent to the users at the end of the month.

- **M8 - Access Control and Traffic Calming**

Access control can be applied to specific areas, specific groups or transport modes. In some areas of the city, such as in pedestrianised areas, the access of individual motorised vehicles is controlled. To reach the areas, public transport services or parking places are provided. Access control can also be applied in residential areas where the use of individual motorised transport modes is limited to residents only. Non-residents might park their vehicles in the public parking places. In the designated lanes for public transport, the access of individual motorised vehicles is prohibited. Bangkok made efforts to restrict all newly registered cars to use exclusively in non-rush hours. In Guangzhou, only locally registered motorcycles are allowed to circulate. Many other Chinese cities have limited the operation of commercial vehicles in unprecedentedly detailed ways (regarding days, hours, and localities) (Pojani & Stead, 2015).

Traffic calming and speed reduction aim to encourage safer, more responsible driving and potentially reduce traffic flow (Petersen, 2006). The measure is implemented in road sections, mostly in the neighbourhoods. The measure improves safety for motorists, pedestrians and cyclists. Narrowed roads or speed limit measures can be used for facilitating traffic calming and speed reduction.

- **M9 – Car Pooling and Car Sharing**

Carpooling is making arrangements for those who would otherwise be driving solo to share the driving with others, increasing vehicle occupancy. Carpool management includes encouragement for people to carpool and facilitate matches. This may be based on employers, schools, neighbourhoods or destinations (e.g. a group of employers in an employment precinct).

The main function of car sharing is to reduce the need to own a car. Car sharing could help families with the occasional car needs to use a car without the financial burden to own it (Broaddus et al., 2008). Car sharing can be arranged for long-term or short-term use, with the agreement of fees.

- **M10 - Parking Pricing**

The measure aims to limit the use of individual motorised vehicles through parking prices. The measure is applied to both cars and motorcycles. High parking charge is applied to the central urban areas where parking spaces are limited. Parking pricing allows a diverse price structure, which varies by time of the day and duration of parking. This price structure discourages long-time parking. Parking pricing is successfully implemented in many cities as an effective measure to control and limit the use of individual motorised vehicles in the central city areas.

- **M11 - Parking Restriction**

Parking restriction mainly concerns location-restricted, time-restricted, duration-restricted, area-restricted and user group-restricted policies (Truong, 2017). The measure aims to limit long-term parking. In some streets, on-street parking is prohibited entirely. Parking might be restricted at a time or duration of the day. Vehicle parking can also be limited to specific group users, for example, the non-residents. In buildings in the central city area, the maximum parking spaces are regulated to control the total parking spaces in the area. Parking fee might differ by the time of the day. Parking duration is managed so that the parking lot can be used for more vehicles.

*** Public transport**

Related measures aim to promote the use of public transport. By taking public transport modes, people can avoid stress from self-driving. They can use the time for reading, talking or sleeping. It is also safer to go by public transport modes, comparing to self-driving. In economic aspect, using public transport is more efficient in term of road occupancy. A bus requires less space for moving and parking and consumes less fuel than many motorcycles or cars to carry the same number of people. Using bus is more environmentally friendly than using private transport modes in term of emission per person. Public transport users also do not have to expose themselves to the polluted environment. Candidate measures from the case studies include (1) Public Transport Service Improvement; (2) Public Transport Priority Lanes; (3) Public Transport Signal Prioritisation; (4) Public Transport feeder services; (5) Pricing mechanism; and (6) Public Transport Authorities.

- **M12 - Public Transport Service Improvement**

The measure aims to improve the quality of public transport service through high frequency, large vehicles, routes adjustment, optimal timetable, integrated ticket systems etc. Public transport timetables are optimal for being attractive to users who make transfers. The timetable can be attractive if carefully established to ensure coordination between modes. This may also require variations day by day to accommodate different travel patterns. Ticket systems are integrated to facilitate transferring among public transport modes. Electronic ticketing provides a very powerful mechanism to efficiently and effectively operate an integrated fare structure; for example, Hong Kong, Singapore and London all have a smart card system in place, which has underpinned the increase of public transport usage (Gwilliam, 2013). The improvement of quality helps to increase the number of public transport users.

- **M13 - Public Transport Priority Lanes**

The creation of a separate bus lane can be conducted by painting a lane in a different colour from the rest of the road. The separation can also be done with fixed barriers or flexible barriers. In some cases, the separation is time-specific. This is a common low-cost measure for improving the speed, reliability, and safety of bus systems. Taipei has invested in bus systems with exclusive bus lanes and free feeder bus systems to enhance the efficiency and appeal of the overall transit system.

- **M14 – Public Transport Signal Prioritisation**

In many cases, buses share lanes with high-occupancy vehicles, taxis, non-motorised vehicles, and even with vehicles near turning points. New technologies allow public transport by buses, particularly Bus Rapid Transit, to gain priority at intersections. Traffic lights automatically turn green for buses whenever they approach intersections. This priority increases the travel speed of buses.

- **M15 - Public Transport Feeder Services**

Feeder modes are provided for the efficient operation of Bus Rapid Transit and Mass Rapid Transit. Bus Rapid Transit and Mass Rapid Transit should serve as trunk modes on trunk roads. Then, feeder services using Para-transit, buses, van or Light Rail Transit, etc. should be provided to maximise the patronage of the trunk routes of Bus Rapid Transit and Mass Rapid Transit. The facilitation of feeder modes increases accessibility to Bus Rapid Transit and Mass Rapid Transit systems. In some cities, when implementing plans for Bus Rapid Transit and Mass Rapid Transit, public transport improvement initiatives typically propose the transformation of public transport and Para-transit systems from direct services into feeder-trunk-distributor services (Ferro & Behrens 2015). The move from direct services to feeder-trunk-distributor services can have significant implications for travel patterns within the urban areas. In Bangkok, there is a van commuting system, which is very effective in conveying passengers from suburban areas to the urban fringe. Then, passengers can easily transfer to Skytrain systems or Metro systems to reach the city centre. Moreover, a well-integrated Para-transit as a feeder of Bangkok's Bus Rapid Transit project was proposed along with density land use allocation and controlling parallel existing local bus as a set of solutions for improving Bus Rapid Transit performance (Satiennam et al., 2006). It showed that the proposed measures can improve Bus Rapid Transit performance. In Manila, the establishment of Jeepney terminal adjoining MRT3 station was considered a high priority for improvement in people's viewpoint due to the convenient level of access to stations (Okada et al., 2003). Cities such as Hong Kong, Singapore and Kuala Lumpur have been able to redesign bus routes so that they feed into and support the mass rapid transit lines. Similarly, London's underground and buses connect with the above ground heavy rail network to take passengers to their final destinations.

- **M16 - Pricing Mechanism**

Pricing mechanisms for public transport are diverse, which might be given to the service providers or the public transport users. The purpose of pricing mechanisms is to make public transport attractive and affordable to users. Pricing mechanisms for service providers include tax subsidies, preferential loans, etc. so that they can improve the service quality. Pricing mechanisms for users include fare subsidies, discounted tickets, early bird tickets, group tickets, etc. It is especially important to some groups such as students, old people, disabled people, etc., etc. Pricing mechanisms have all been successfully implemented in various developing cities.

- **M17 - Public Transport Authorities**

Public transport authority is established to facilitate the whole activities of public transport system. The public transport authority is responsible for all planning, managing and operating activities of public transport system, enabling smooth and efficient connectivity among them. The public transport authority is also in charge of incident management for public transport. The responsible authority identifies incidents that might impact upon public transport operations and initiates a road management response that gives priority to public transport. This would include the provision and management of train replacement buses when rail services are affected.

*** Intermodal and Multimodal Transport**

An intermodal and multimodal transport system, which comprises diverse modes, is essential to meet multiple objectives of a sustainable transport system, which is economically efficient, environmentally sound, and socially safe and equitable (Acharya et al. 2013).

- **M18 - Intersection Traffic Control Systems**

Traffic control systems can be used to manage the road network and give preferential treatment to different directions of traffic and different special use vehicles (such as public transport). Systems can also optimise traffic flow. Their configuration is generally varied by time of day, whether to a fixed pattern or adaptive to the actual road conditions (World Road Association, 2013).

- **M19 - Intelligent Transport System**

Intelligent transport system have the potential to address urban transport problems in a variety of applications (Pojani & Stead, 2015). In developing countries, common forms of intelligent transport system include traffic signal systems, vehicle tracking systems using GPS, electronic ticketing services, electronic toll collection and fare payment systems, bus management systems, and traveller information systems, etc. Further Intelligent transport system deployment is needed in these settings to improve road safety conditions and mitigate traffic congestion.

Intelligent transport system facilitate road authorities and public transport operators to manage their road networks and transport services. Various data and information regarding traffic conditions, weather conditions, etc., are collected and processed at the traffic control centre. Then, appropriate traffic management measures are applied by the responsible units. It can be dynamic traffic management, based on the real-time monitoring data. The road authorities use the incident management systems to identify, respond and mitigate incidents occurring on the network. Information management systems include a wide range of services, from roadside traveller information to traffic signal control to incident response. Intelligent transport system facilitate transport users; both private and public transport users, through many forms of communication, such as radio, social network, electronic boards, and mobile phone. Providing information helps people prepare effectively for trips. Information provision includes providing guidance and information services to both private transport users (regarding route, address, traffic condition, parking place, weather condition, etc.,) and public transport users (regarding public transport alternatives, routes, fare, etc.,). The signage of timetables and other relevant information at rail and bus stations should be properly designed to convey effective information to travellers. For example, major railway stations in Japan have very clear signs differentiating directions of the high-speed rail network, the intercity trains network and the suburban/local trains network. Besides, there are websites providing detailed information to public transport users relating to the available multi-modal transport options. The information meets specific demands and might influence the choice of transport modes. Adequate provision of public transport information might increase the number of bus users.

- **M20 – Intermodal Connection Centres**

Intermodal connection centres are vital to facilitate connections among transport modes. Public transport modes, individual motorised transport and non-motorised transport modes can be connected at connection centres. Then, people can easily transfer and conduct their trips at an affordable cost and time-saving. At the intermodal connection centres, facilities are provided to support shortest access distances for pedestrians and easy to understand connection information. Besides, adequate capacity for parking, drop off and waiting areas need to be considered for effective organisation of the intermodal connection centres. Major connection centres can include commercial facilities, waiting lounges, and recreational opportunities (World Road Association, 2013).

- **M21 - Park & Ride Systems**

Park & ride systems provide parking at public transport interchange points. They are critical to organise intermodal transport. The Park and Ride facilities are located at transport hubs in the urban fringe. Individual motorised transport users can park their vehicles at the Park & Ride facilities and continue their trips with public transport modes. Park and Ride facilities are the places where public transport modes are connected, such as the feeder and trunk modes. The design of the Park & Ride facilities requires the shortest possible walking distances for pedestrians, good design for moving around the facility, easy to understand connection information and adequate capacity for parking, drop off and waiting areas. Major interchanges can include commercial facilities, waiting lounges, and recreational activities.

5.1.2 Urban planning-related measures

*** Compact development in central city areas**

- **M22 - Density Increase in Central City Areas**

  Compact development requires high density through minimum density standards or height standards. In the central urban areas, the constructions of buildings and house need to meet specific requirements of Floor Area Ratio (FAR) and construction density so that they can contribute to increase the density of the areas and support compact development.

- **M23 - Mixed-use Development in Central City Areas**

  Mixed-use development is promoted in the central urban areas. Various land-use types, especially commercial purposes, services, offices, etc., provide fast and convenient accessibility. The allocation of land for transport purposes in the central urban areas is also important to facilitate mobility and accessibility in the areas. Transport land focus on promoting non-motorised transport and public transport, such as walking paths or public transport stations. Parking places are allocated, designed and managed in a way that reduces the use of individual motorised vehicles.

- **M24 - Layout and Landscape Design in Central City Areas**

  In the central urban areas, the designs of urban layout and landscape have significant influences on travel patterns in the areas. The urban layout, including smaller block sizes, higher building densities and mixed land-use, facilitates connectivity, walkability and social interaction. The design of urban landscape plays an important role in supporting non-motorised transport. The organisation of open spaces creates a positive sense of place, promoting social cohesion, interaction and safety.

- **M25 - Urban Growth Boundaries**

  To support compact development, the clarification of the growth boundary is essential. The compact development is promoted within the boundary, and the suburban areas outside the boundary are controlled.

- **M26 - Maximum Parking Space Regulations**

  Compact development requires management of individual motorised vehicles. Maximum parking space regulations limit parking spaces in buildings in the central urban areas. Depending on the size of the building, the regulation is specified. The regulation can be promulgated under the Construction Law.

*** Control Suburban Areas**

- **M27 - Density Control in Suburban Areas**

  In suburban areas, density remained in medium and low. Density control helps to balance the supply of transport infrastructure and services and the travel demand. The control of density is conducted through construction standards, such as Floor Area Ratio (FAR), Height Standards.

- **M28 - Land-use Control in Suburban Areas**

In the suburban areas, beside density control, land-use functions are also strictly controlled. Residential land-use is mostly promoted. In some cities, sub-urban areas reserve special land of waterfront or green areas, which play an important role in water drainage for the central city area. Therefore, in the suburban areas, land areas are controlled by a careful land-use plan. Land areas for transport focus on developing medium capacity public transport modes, such as buses to serve local travel demand as well as providing feeder services for high capacity public transport modes.

*** Transit-oriented Development**

- **M29 - Sufficient Spaces for Mass Rapid Transit Lines and Stations**

The development of Mass Rapid Transit systems requires sufficient land areas and spaces for the lines, as well as for the corridors. Especially at the stations, land areas are adequately allocated to ensure the station functions regarding passenger boarding and alighting, as well as parking and service provision.

- **M30 - Mixed-use and Compact Development in the Neighbourhoods of Mass Rapid Transit Stations**

A focused plan to encourage compact residential and commercial development along the MRT lines has allowed the city to grow rapidly without a major expansion of the highway network or parking facilities. The creation of well-planned, compact, diverse and interconnected development nodes is vital for creating efficient public transport system. High densities are incorporated appropriately in neighbourhoods of the proposed Mass Rapid Transit stations. To achieve the maximum benefit, new residential density should be focused on areas with the greatest access to transit service and coordinated with new transit investments. Together, these plans promote efficient development by establishing housing and employment targets for carefully selected centres and corridors throughout the metropolitan area and region. In effect, the region and city are planned with the objective of creating compact, mixed-use, well-defined growth nodes.

Taipei, Jakarta and Bangkok have been planning for high density and mixed land-use development around railway stations. The residential or commercial area designed to maximise access to public transport, and mixed-use/compact neighbourhoods tend to use transit at all times of the day. Diverse land-use development is critical to attracting people using public transport services since they can combine their major trip for other purposes, such as shopping. Hence, the diverse land-use helps to reduce the need for travel. High-density development is critical to ensure the effectiveness of public transport services, especially mass transit. It also promotes non-motorised transport since service can be reached within a short travel distance. Hence, the increasing density can help to reduce traffic pollution.

*** Develop Sub-centres**

The development of sub-centres helps to decrease the over-concentration in the existing central city centre. Therefore, traffic volume in the existing central city centres and traffic density in major roads to the centres are decreased. Sub-centres development is transforming the urban form of Asian developing cities, for example, Ho Chi Minh City, Hanoi and

Bangkok, from monocentric form to polycentric form. Mass Rapid Transit systems are the trunk network to connect the existing central city areas and the sub-centres. To develop sub-centres, measures include (1) New Urban Zones Development; (2) Provision of sub-regional facilities and services; and (3) Public transport hub connecting the sub-centres to central city areas.

- **M31 – New Urban Zones Development**

  The development of new urban zones contributes to the creation of sub-centres. These new urban zones usually connect to major primary roads. Most of the zones include the mixed use of office buildings, retail, commercial centres, and residential areas. The new urban zones are often adjacent to traditional residential neighbourhoods that will then benefit from the proximity of primary roads, commerce and new employment areas (Bertaud, 2011). The commercial activities from the new urban zones can spread to the adjacent neighbourhoods. As a result, the residential densities of the conventional neighbourhoods are likely to increase further. The development of the primary road network and the Mass Transit systems structure cities into polycentric form (Ferro & Behrens, 2015).

- **M32 - Provision of Facilities and Services in Sub-centres**

  In the sub-centres, the provision of facilities and services for health, education, justice, administration and employment activities are vital to meet the needs of the communities. In some cities, some major hospitals and universities are reallocated to the sub-centres to reduce the pressure for health care and education systems, as well as reducing traffic concentration in the central city areas.

5.1.3 Superordinate measures

Integrated transport and urban development require the establishment of superordinate authorities which have enough capacity to coordinate different institutions to plan and implement measures. The coordination framework, which identifies responsibility and working process, needs to be clearly defined. Measures include (1) Integrated Transport Authority and (2) Regional Traffic Management Authorities.

- **M33 - Integrated Transport Authority**

  Integrated Transport Authority is in charge of managing and operating all transport system within a city, including the road-based transport, rail-based transport, waterway transport, etc., to ensure the good functionalities and connectivity of different systems. In Vietnam, the Department of Transport of provinces or cities is responsible for coordinating all activities of all transport system.

- **M34 - Transport and Urban Authority**

  Planning, which includes both transport and urban development on a regional scale, requires the establishment of a transport and urban authority. This authority is responsible for master plans, which cover a wide range of areas and sectors. For example, to promote Transit-oriented development, a Transport and Urban Authority is formed. The Authority includes transport planners and urban planners. A working framework, which clarifies the cooperative procedures among stakeholders, need to be established.

5.1.4 Interdisciplinary measures

The interdisciplinary measures involve the coordination of several sectors to facilitate the implementation of other measures. Measures in the groups include (1) Marketing Campaigns and Educational Campaigns; (2) Enforcing regulations; and (3) Monitoring and improvement.

- **M35 – Marketing Campaigns and Educational Campaigns**

  Marketing campaigns and educational campaigns are conducted to promote the use of non-motorised transport and public transport modes and decrease the use of individual motorised vehicles. These campaigns aim to disseminate related policies and regulations, as well as provide necessary information to facilitate mode choice. The dissemination of policies and regulations facilitates the process of enforcement. For example, in Ho Chi Minh City, to get the agreement of the citizens regarding parking restriction, campaigns of disseminating regulations are conducting. Then, strong enforcement is followed effectively.

- **M36 – Enforcing Regulations**

  Regulations, which are promulgated for traffic management and urban planning, require strong enforcement to ensure full compliance. For example, enforcement of parking restriction reduces illegal on-street parking, which improves traffic flow. In Ho Chi Minh and Hanoi, strong enforcement of parking restriction results in good conditions of sidewalks. Public transport is accessed better, and the city's landscape is improved. Traffic calming and speed reduction are not effective without the traffic law enforcement to ensure that limits are followed.

- **M37 - Monitoring and Improvement**

  To improve the effectiveness of measures, monitoring is continuously conducted. Deficiencies, which might occur due to the implementation of the measures, are considered for improvement. Monitoring can be conducted by responsible agencies, local communities or affected people.

5.2 Qualitative assessment of measures

The candidate measures, which can potentially form strategies for integrated transport and urban development, are qualitatively assessed. The purpose of the assessment is confirming the candidate measures as well as getting the priority of measures. This is the multi-criteria assessment, done by expert consultation.

*** The expert consultation**

The expert consultation is conducted online, using a questionnaire (See Appendix C). The consultation consists of experts who have experiences in urban planning and management, transport engineering, planning and management.

The questionnaire was designed in three parts. In Part 1, the experts were asked for their personal information, including their professions and years of professions. In Part 2, the experts gave weighting on objectives of two categories - effectiveness and applicability. In Part 3, the experts give a score for each objective and conflict.

*** Calculation of effectiveness score of measure**

In the effectiveness assessment, firstly, an expert weights four objectives of effectiveness, including: (m1) Improve mobility and accessibility; (m2) Improve traffic safety; (m3) Protect environment and human health; and (m4) Improve economic efficiency (see page 66). The total weight of four objectives is 100%. Secondly, the expert gives point "0" or "1" or "2" or "3", depend on the effectiveness of the measure. The point "0" means the measure is not effective; "1" means the measure has low effectiveness; "2" means the measure has medium effectiveness; "3" means the measure has high effectiveness.

The effectiveness score of measure i, scoring by expert n (ES_i^n) is calculated by multiplying the weighting of objective m (WC_m) with the effectiveness point of measure i on that objective (EP_m^i), as shown in the formula 5-1:

$$ES_i^n = \sum_{m=1}^{4} WC_m * EP_m^i \qquad \text{(Formula 5-1)}$$

Where:

n	: The number of the expert (n = 1 to 4)
i	: The number of the measure (i = 1 to 37)
m	: The number of the objective (m = 1 to 4)
ES_i^n	: Effectiveness score of measure i, scoring by expert n
WC_m	: Weighting of objective m
EP_m^i	: Effectiveness points of measure i on objective m

Finally, the average effectiveness score of measure i, scoring by all expert (ES_i) is calculated, as shown in the formula 5-2.

$$ES_i = \frac{\sum_{n=1}^{4} ES_i^n}{N} \qquad \text{(Formula 5-2)}$$

Where:

ES_i	: Average effectiveness score of measure i
$ES_i \geq 2.5$	: Measure i has high effectiveness level (H)
$1{,}5 \leq ES_i < 2.5$	: Measure i has medium effectiveness level (M)
$ES_i < 1.5$	: Measure i has low effectiveness level (L)
ES_i^n	: Effectiveness score of measure i, scoring by expert n
N	: Total number of experts

*** Calculation of applicability score of measure**

In the applicability assessment, firstly, the expert weights four conflicts, including: (x1) Cost; (x2) Technology; (x3) Institution; and (x4) Public acceptance (see page 67). The total weighting of four conflicts is 100%. Secondly, the expert gives point "0" or "1" or "2" or "3" for the applicability of measures. The point "0" means the measure is not applicable; "1" means the measure has low applicability; "2" means the measure has medium applicability; "3" means the measure has high applicability. Measures which have low applicability will have high conflicts in implementing.

The applicability score of measure i, scoring by expert n (AS_i^n) is calculated by multiplying the weighting of conflict x (WC_x) with the applicability point of measure i on that conflict (AP_x^i), as shown in formula 5-3:

$$AS_i^n = \sum_{x=1}^{4} WC_x * AP_x^i \quad \text{(Formula 5-3)}$$

Where:

n	: The number of the expert (n = 1 to 4)
i	: The number of the measure (i = 1 to 37)
x	: The number of the conflict (x = 1 to 4)
AS_i^n	: Applicability score of measure i, scoring by expert n
WC_x	: Weighting of conflict x
AP_x^i	: Applicability points of measure i on conflict x

Finally, the average applicability score of measure i, scoring by all expert (AS_i) is calculated by the formula 5-4.

$$AS_i = \frac{\sum_{n=1}^{4} AS_i^n}{N} \quad \text{(Formula 5-4)}$$

Where:

AS_i	: Average applicability score of measure i
$AS_i \geq 2.5$	: Measure i has high applicability level (H)
$1.5 \leq AS_i < 2.5$	: Measure i has medium applicability level (M)
$AS_i < 1.5$	: Measure i has low applicability level (L)
N	: Total number of experts

*** Terms of measure selection**

The priority level of measures i is based on the effectiveness level of measures i (ELi) and applicability level (ALi), following the rules:

- The group of priority level 1 consists measures that have high (H) level of effectiveness and high (H) level of applicability; Measures that have high (H) level of effectiveness and medium (M) level of applicability and; Measures that have medium (M) level of effectiveness and high (H) level of applicability;
- The group of priority level 2 consists measures that have a high (H) level of effectiveness and low (L) level of applicability; Measures that have low (L) level of effectiveness and high (H) level of applicability and; Measures that have medium (M) level of effectiveness and medium (M) level of applicability;
- The group of priority level 3 consists of measures that have a low (L) level of effectiveness and medium (M) level of applicability; Measures that have medium (M) level of effectiveness and low (L) level of applicability and; Measures that have a low (L) level of effectiveness and low (L) level of applicability.

*** Assessment results**

Table 5-1: Results of the Assessment

No.	Measures	Effectiveness Score (ES)	Effectiveness Level (EL)	Applicability Score (AS)	Applicability Level (AL)	Priority level
1	Facilities for Pedestrians	2.54	H	1.56	M	1
2	Pedestrian Zones	1.63	M	1.85	M	2
3	Bikeway Networks	1.44	L	1.59	M	3
4	Bicycle-sharing Schemes	2.03	M	2.16	M	2
5	Vehicle Registration Control	1.20	L	1.06	L	3
6	Fees, Taxes and Standards for Individual Motorised Vehicles	1.29	L	1.14	L	3
7	Road Pricing for Private Car	1.10	L	1.11	L	3
8	Access Control and Traffic Calming	1.33	L	1.24	L	3
9	Car Pooling and Car Sharing	2.01	M	2.29	M	2
10	Parking Pricing	1.66	M	1.45	L	3
11	Parking Restriction	1.69	M	1.59	M	2
12	Public Transport Service Improvement	2.48	M	1.35	L	3
13	Public Transport Priority Lanes	1.55	M	1.24	L	3
14	Public Transport Signal Prioritisation	1.98	M	2.01	M	2
15	Public Transport Feeder Services	2.65(*)	H	1.89	M	1
16	Pricing Mechanism	1.61	M	1.55	M	2
17	Public Transport Authorities	2.50	H	2.55(***)	H	1
18	Intersection Traffic Control Systems	1.83	M	1.85	M	2
19	Intelligent Transport System	2.23	M	2.15	M	2
20	Intermodal Connection Centres	2.40	M	2.53	H	1
21	Park & Ride Systems	2.45	M	1.43	L	3
22	Density Increase in Central City	2.15	M	1.94	M	2

No.	Measures	Effectiveness Score (ES)	Effectiveness Level (EL)	Applicability Score (AS)	Applicability Level (AL)	Priority level
	Areas					
23	Mixed-use Development in Central City Areas	2.19	M	1.50	M	2
24	Layout and Landscape Design in Central City Areas	2.43	M	1.85	M	2
25	Urban Growth Boundaries	1.78	M	1.83	M	2
26	Maximum Parking Space Regulations	1.43	L	1.14	L	3
27	Density Control in Suburban Areas	2.06	M	2.24	M	2
28	Land-use Control in Suburban Areas	2.25	M	1.95	M	2
29	Sufficient Spaces for Mass Rapid Transit Lines and Stations	1.75	M	1.75	M	2
30	Mixed-use and Compact Development in the Neighbourhoods of Mass Rapid Transit Stations	2.51	H	2.00	M	1
31	New Urban Zones Development	1.41	L	1.75	M	3
32	Provision of Facilities and Services in Sub-centres	0.91(**)	L	1.00	L	3
33	Integrated Transport Authority	2.25	M	1.86	M	2
34	Transport and Urban Authority	2.03	M	2.00	M	2
35	Marketing Campaigns and Educational Campaigns	2.23	M	1.16	L	3
36	Enforcing Regulations	1.58	M	1.01(****)	L	3
37	Monitoring and Improvement	2.09	M	2.00	M	2

Source: Author's representation

Note: (*) Highest effectiveness score

(**) Lowest effectiveness score

(***) Highest applicability score

(****) Lowest applicability score

The results from the expert consultation regarding effectiveness and applicability highlight the priority of measures, which are useful for the consideration of implementing measures in practice. There are five measures in the group of priority level 1. Priority level 2 has eighteen measures and priority level 3 has fourteen measures.

In the group of priority level 1, measures include (1) Facilities for Pedestrians; (2) Public Transport Feeder Services; (3) Public Transport Authorities; (4) Intermodal Connection Centres; and (5) Mixed-use and Compact Development in the Neighbourhoods of Mass Rapid Transit Stations.

The group of priority level 2 includes measures (1) Pedestrian Zones; (2) Bicycle-sharing Schemes; (3) Car Pooling and Car Sharing; (4) Parking Restriction; (5) Public Transport Signal Prioritisation; (6) Pricing Mechanism; (7) Intersection Traffic Control Systems; (8) Intelligent Transport System; (9) Density Increase in Central City Areas; (10) Mixed-use Development in Central City Areas; (11) Layout and Landscape Design in Central City Areas; (12) Urban Growth Boundaries; (13) Density Control in Suburban Areas; (14) Land-use Control in Suburban Areas; (15) Sufficient Spaces for Mass Rapid Transit Lines and Stations;

(16) Integrated Transport Authority; (17) Transport and Urban Authority; and (18) Monitoring and Improvement.

In the group of priority level 3, measures include: (1) Bikeway Networks; (2) Vehicle Registration Control; (3) Fees, Taxes and Standards for Individual Motorised Vehicles; (4) Road Pricing for Private Car; (5) Access Control and Traffic Calming; (6) Parking Pricing; (7) Public Transport Service Improvement; (8) Public Transport Priority Lanes; (9) Park & Ride Systems; (10) Maximum Parking Space Regulations; (11) New Urban Zones Development; (12) Provision of Facilities and Services in Sub-centres; (13) Marketing Campaigns and Educational Campaigns; and (14) Enforcing Regulations.

5.3 Resulting strategies

Based on the developed measures, eight strategies are formed. Each strategy includes key measures and supportive measures. These strategies are proposed for Asian developing countries, which have some similar transport and urban development patterns. The implementation of strategies in a specific city needs to consider the local context.

*** STRATEGY 1: PROMOTE NON-MOTORISED TRANSPORT**

The strategy aims to improve walking and cycling conditions, enhancing the comfort and safety of pedestrians and cyclists. The strategy contributes to objectives of improving traffic safety, protected environment and human health and improving economic efficiency.

Key measures

M1 - Facilities for Pedestrians

M2 - Pedestrian Zones

M3 - Bikeway Networks

M4 - Bicycle-sharing Schemes

Supportive measures

M8 - Access Control and Traffic Calming

M11 - Parking Restriction

M12 - Public Transport Service Improvement

M15 - Public Transport Feeder Services

M18 - Intersection Traffic Control Systems

M20 - Intermodal Connection Centres

M22 - Density Increase in Central City Areas

M23 - Mixed-use Development in Central City Areas

M24 - Layout and Landscape Design in Central City Areas

M30 - Mixed-use and Compact Development in the Neighbourhoods of Mass Rapid Transit Stations

M33 - Integrated Transport Authority

M34 - Transport and Urban Authority

M35 - Marketing Campaigns and Educational Campaigns

M36 - Enforcing Regulations

M37 - Monitoring and Improvement

*** STRATEGY 2: CONTROL INDIVIDUAL MOTORISED VEHICLES**

The strategy aims to control the ownership and use of individual motorised vehicles, in particular, cars and motorcycles. The strategy contributes to objectives of improving traffic safety, protected environment and human health, improving economic efficiency.

Key measures

M5 - Vehicle Registration Control

M6 - Fees, Taxes and Standards for Individual Motorised Vehicles

M7 - Road Pricing for Private Car

M8 - Access Control and Traffic Calming

M9 - Car Pooling and Car Sharing

M10 - Parking Pricing

M11 - Parking Restriction

Supportive measures

M18 - Intersection Traffic Control Systems

M19 - Intelligent Transport System

M20 – Intermodal Connection Centres

M21 - Park and Ride Systems

M26 - Maximum Parking Space Regulations

M27 - Density Control in Suburban Areas

M28 - Land-use control in Suburban Areas

M33 - Integrated Transport Authority

M34 - Transport and Urban Authority

M35 - Marketing Campaigns and Educational Campaigns

M36 - Enforcing Regulations

M37 - Monitoring and Improvement

*** STRATEGY 3: PROMOTE PUBLIC TRANSPORT**

This strategy aims to facilitate the operation of public transport modes. The strategy contributes to objectives of improving traffic safety, protected environment and human health, improving economic efficiency.

Key measures

M12 - Public Transport Service Improvement

M13 - Public Transport Priority Lanes

M14 - Public Transport Signal Prioritisation

M15 - Public Transport Feeder Services

M16 - Pricing Mechanism

M17 - Public Transport Authorities

Supportive measures

M1 - Facilities for Pedestrians

M2 - Pedestrian Zones

M4 - Bicycle-sharing Schemes

M5 - Vehicle Registration Control

M6 - Fees, Taxes and Standards for Individual Motorised Vehicles

M7 - Road Pricing for Private Car

M8 - Access Control and Traffic Calming

M9 - Car Pooling and Car Sharing

M10 - Parking Pricing

M11 - Parking Restriction

M18 - Intersectional Traffic Control Systems

M19 - Intelligent Transport System

M20 – Intermodal Connection Centres

M21 - Park & Ride Systems

M22 - Density Increase in Central City Areas

M23 - Mixed-use Development in Central City Areas

M29 - Sufficient Spaces for Mass Rapid Transit Lines and Stations

M30 - Mixed-use and Compact Development in the Neighbourhoods of Mass Rapid Transit Stations

M31 - New Urban Zones Development

M33 - Integrated Transport Authority

M34 - Transport and Urban Authority

M35 - Marketing Campaigns and Educational Campaigns

M36 - Enforcing Regulations

M37 - Monitoring and Improvement

*** STRATEGY 4: PROMOTE INTERMODAL AND MULTIMODAL TRANSPORT**

The strategy facilitates the connectivity among transport modes and transport system.

Key measures

M18 - Intersectional Traffic Control Systems

M19 - Intelligent Transport System

M20 – Intermodal Connection Centres

M21 - Park & Ride Systems

Supportive measures

M1 - Facilities for Pedestrians

M2 - Pedestrian Zones

M4 - Bicycle-sharing Schemes

M10 - Parking pricing

M11- Parking Restriction

M12 - Public Transport Service Improvement

M15 - Public transport feeder services

M33 - Integrated Transport Authority

M34 - Transport and Urban Authority

M35 - Marketing Campaigns and Educational Campaigns

M36 - Enforcing Regulations

M37 - Monitoring and Improvement

*** STRATEGY 5: PROMOTE COMPACT DEVELOPMENT IN THE CENTRAL CITY AREAS**

The creation of compact central urban areas is a critical element of efforts to arrest urban sprawl and to protect the climate (Ong et al., 2010). The strategy contributes to objectives of improving traffic safety, protected environment and human health, improving economic efficiency.

Key measures

M22 - Density Increase in Central City Areas

M23 - Mixed-use Development in Central City Areas

M24 - Layout and Landscape Design in Central City Areas

M25 - Urban Growth Boundaries

M26 - Maximum Parking Space Regulations

Supportive measures

M1 - Facilities for Pedestrians

M2 - Pedestrian Zones

M3 - Bikeway Networks

M4 - Bicycle-sharing Schemes

M5 - Vehicle registration control

M6 - Fees, Taxes and Standards for Individual Motorised Vehicles

M7 - Road Pricing for Private Car

M8 - Access Control and Traffic Calming

M9 - Car Pooling and Car Sharing

M10 - Parking Pricing

M11 - Parking Restriction

M20 - Intermodal Connection Centres

M34 - Transport and Urban Authority

M35 - Marketing Campaigns and Educational Campaigns

M36 - Enforcing Regulations

M37 - Monitoring and Improvement

*** STRATEGY 6: CONTROL SUBURBAN AREAS**

Suburban areas are controlled to avoid urban sprawl.

Key measures

M27 - Density Control in Suburban Areas

M28 - Land-use Control in Suburban Areas

Supportive measures

M5 - Vehicle Registration Control

M6 - Fees, Taxes and Standards for Individual Motorised Vehicles

M7 - Road Pricing for Private Car

M12 - Public Transport Service Improvement

M15 - Public Transport Feeder Services

M20 - Intermodal Connection Centres

M34 - Transport and Urban Authority

M35 - Marketing Campaigns and Educational Campaigns

M36 - Enforcing Regulations

M37 - Monitoring and Improvement

*** STRATEGY 7: PROMOTE TRANSIT-ORIENTED DEVELOPMENT**

Transit-oriented development is defined as "a compact, mixed-use community within a walkable catchment of a transit place, blending housing, shopping, employment and public uses in a pedestrian-friendly environment that makes it convenient and practical for residents and employees to travel by public transport" (Ashton-Graham et al., 2005). Transit-oriented Development is characterised by places offering both land-use and transport variety and choice. The residential or commercial areas are designed to maximise access to public transport. The mixed-use and compact neighbourhoods enhance the use of transit systems.

Key measures

M29 - Sufficient Spaces for Mass Rapid Transit Lines and Stations

M30 - Mixed-use and Compact Development in the Neighbourhoods of Mass Rapid Transit Stations

Supportive measures

M1 - Facilities for Pedestrians

M3 - Bikeway Networks

M4 - Bicycle-sharing Schemes

M12 - Public Transport Service Improvement

M13 - Public Transport Priority Lanes

M14 - Public Transport Signal Prioritisation

M15 - Public Transport Feeder Services

M16 - Pricing Mechanism

M17 - Public Transport Authorities

M20 - Intermodal Connection Centres

M21 - Park & Ride Systems

M34 - Transport and Urban Authority

M35 - Marketing Campaigns and Educational Campaigns

M36 - Enforcing Regulations

M37 - Monitoring and Improvement

*** STRATEGY 8: DEVELOP NEW SUB-CENTRES**

The strategy helps to reduce overcrowding in existing central city areas. Therefore, traffic volume in main roads leading to the existing central city areas is also decreased. Sub-centres are connected to the existing central city areas by public transport system, in which, Mass Transit Rapid plays a critical role. Development of activities in sub-centres due to the provision of facilities and services help to reduce average trip distances and mitigate traffic increases. Such development is essential to maintain a compact urban form (Petersen, 2006).

Key measures

M31 - New Urban Zones Development

M32 - Provision of Facilities and Services in Sub-centres

Supportive measures

M12 - Public Transport Service Improvement

M15 - Public Transport Feeder Services

M19 – Intermodal Connection Centres

M20 - Park & Ride Systems

M34 - Transport and Urban Authority

M35 - Marketing Campaigns and Educational Campaigns

M36 - Enforcing Regulations

M37 - Monitoring and Improvement

Table 5-2: Strategies for integrated transport and urban development

No.	Measures	Strategies							
		S1	S2	S3	S4	S5	S6	S7	S8
M1	Facilities for Pedestrians	●		○	○	○		○	
M2	Pedestrian Zones	●		○	○	○			
M3	Bikeway Networks	●				○		○	
M4	Bicycle-sharing Schemes	●		○	○	○		○	
M5	Vehicle Registration Control		●	○		○	○		
M6	Fees, Taxes and Standards for Individual Motorised Vehicles		●	○		○	○		
M7	Road Pricing for Private Car		●	○		○	○		
M8	Access Control and Traffic Calming	○	●	○		○			
M9	Car Pooling and Car Sharing		●	○		○			
M10	Parking Pricing		●	○	○	○			
M11	Parking Restriction	○	●	○	○	○			
M12	Public Transport Service Improvement	○		●	○		○	○	○
M13	Public Transport Priority Lanes			●				○	
M14	Public Transport Signal Prioritisation			●				○	
M15	Public Transport Feeder Services	○		●	○		○	○	○
M16	Pricing Mechanism			●				○	
M17	Public Transport Authorities			●					
M18	Intersection Traffic Control Systems	○	○	○	●				
M19	Intelligent Transport System		○	○	●				
M20	Intermodal Connection Centres	○	○	○	●	○	○	○	○
M21	Park & Ride Systems		○	○	●			○	○
M22	Density Increase in Central City Areas	○		○		●			
M23	Mixed-use Development in Central City Areas	○		○		●			
M24	Layout and Landscape Design in Central City Areas	○				●			

No.	Measures	Strategies							
		S1	S2	S3	S4	S5	S6	S7	S8
M25	Urban Growth Boundaries					●			
M26	Maximum Parking Space Regulations		○			●			
M27	Density Control in Suburban Areas		○				●		
M28	Land-use Control in Suburban Areas		○				●		
M29	Sufficient Spaces for Mass Rapid Transit Lines and Stations			○				●	
M30	Mixed-use and Compact Development in the Neighbourhoods of Mass Rapid Transit Stations	○		○				●	
M31	New Urban Zones Development			○	○				●
M32	Provision of Facilities and Services in Sub-centres				○				●
M33	Integrated Transport Authority	○	○	○	○				
M34	Transport and Urban Authority	○	○	○	○	○	○	○	○
M35	Marketing Campaigns and Educational Campaigns	○	○	○	○	○	○	○	○
M36	Enforcing Regulations	○	○	○	○	○	○	○	○
M37	Monitoring and Improvement	○	○	○	○	○	○	○	○

Source: Author's representation

Note: ● Key measure

○ Supportive measure

5.4 Summary

The chapter develops strategies for integrated transport and urban development in Asian development cities. The process of strategy formation based on a model, which ensure that the resulted strategies are agreed with the goals and objectives of integrated development. The model comprises three steps, including (1) Pre-selection of measures; (2) Qualitative assessment of measures; and (3) Bundle of measures.

Measures, which are being implemented in cities to cope with transport and urban issues, are collected. Successfully implemented measures, which are proven through the case studies, are pre-selected as candidate measures. The candidate measures, which potentially contribute to form strategies for integrated transport and urban development, are assessed to clarify their effectiveness and applicability. The multi-criteria assessment is conducted by expert consultation with the purposes of confirming as well as getting the priorities of measures.

Finally, the strategies for integrated transport and urban development in Asian developing cities are formed by bundling measures.

6 Proposal for Application in Ho Chi Minh City

In this chapter, there is a proposal for applying the developed strategies in the specific case of Ho Chi Minh City. Firstly, the background of the city is introduced. Secondly, the need for integrated transport and urban development in Ho Chi Minh City is presented. Then, there are illustrations of strategy implementation in practice. The potential impacts, which might occur due to the implementation of strategies, are estimated. Furthermore, the dependence of the strategies on the specific context of Ho Chi Minh City is analysed.

6.1 Background

Ho Chi Minh City is in the southern part of the Socialist Republic of Vietnam. The total area of the city is 2,095 km^2 (equivalent to 0.6% of the area of the whole country). The city was initially developed as a River Port city for the entire southern region of the country. With the advantages of the location and weather conditions, Ho Chi Minh City has been achieving higher economic growth rate than those of other provinces of Vietnam. The city is a pleasant living place for Vietnamese and foreigners due to the provision of infrastructure and services, as well as economic development.

*** Population**

Ho Chi Minh City is the most crowded city in Vietnam. Currently, the city has the population of 7.4 million inhabitants, which is equivalent to 8.5% of the national population (Ho Chi Minh City Statistic Office, 2011). The average population density is 3,532 inhabitants per km^2. The population is concentrated mainly in the central districts with the density of 11,265 inhabitants per km^2. The suburban districts have the population density of 678 inhabitants per km^2. The population of the city has been increasing rapidly during the last 20 years. Table 6-1 shows population increase, differentiated by area and by gender.

Table 6-1: Population increase in Ho Chi Minh City during the past 20 years

Year		1989		1999		2009	
Total Population (inhabitants)		3,988,124	100%	5,037,155	100%	7,123,340	100%
By Area	Urban	2,946,426	73.88	4,204,662	83.47	5,929,479	83.24
	Rural	1,041,698	26.12	832,493	16.53	1,193,861	16.76
By gender	Male	1,890,343	47.40	2,424,415	48.13	3,425,925	48.09
	Female	2,097,781	52.60	2,612,740	51.87	3,697,415	51.91

Source: General Statistics office of Vietnam (1989, 1999, 2009)

The population growth has been the results of natural increase and immigration. During the period 1979-1989, the population natural growth rate was 1.61% per year and dropped to 1.52% per year from 1989 to 1999. Then, the population natural growth rate reduced to 1.27% per year from 1999 to 2009. The reason for the decline in the population natural growth rate is attributed to the “Family Planning Program” of Ho Chi Minh City from 1999 to 2009. However, the immigration rate during the period remained high with an average rate of 2.3%

per year. Therefore, the total average population growth in the past ten years (1999-2009) was 3.53% per year.

There were also population changes in specific areas of the city during the period 1999-2004. Table 6-2 indicates that the population growth rate of the central city areas (including 13 urban inner districts) slowly decreased from 1.4% per year during the period 1999-2004 to 0.85% per year during the period 2004-2009. Because of urban expansion, six newly developed districts have been established, including Thu Duc District, Binh Tan District, District 2, 7 and 9. The emergence of many industrial parks led to the attraction of labours. Thus, the immigration to Ho Chi Minh City reached 1.8 million people during the period 1999-2004. Inadequate controls and management of land-use according to Plans resulted in spontaneous development without sufficient infrastructure provisions. In suburban areas, the population also increased rapidly although the growth rate was less than that in the newly developed areas. The population growth rate was 1.36% per year during the period 1999-2004 and reached to 5.5% per year from 2004 to 2009. It is forecasted that population growth rate in suburban areas will continue to increase significantly.

Table 6-2: Population increase by area from 1999 to 2009

Year	**1999**		**2004**		**2009**		**Growth rate (% per year)**	
							1999-2004	**2004-2009**
Total Population (inhabitants)	5,037,155	100%	6,117,251	100%	7,123,340	100%	3.96	3.09
Central city areas (13 Districts)	3,384,106	67.2	3,627,426	59.3	3,781,886	53.1	1.40	0.84
Newly developed areas (6 districts)	740,181	14.7	1,512,986	24.7	2,060,101	28.9	15.37	6.37
Suburban areas (5 districts)	912,868	18.1	976,839	16.0	1,281,353	18.0	1.36	5.58

Source: General Statistics office of Vietnam (1989, 1999, 2009)

The population pyramid of Ho Chi Minh City is considered as a "Golden Population Structure", due to the high share of the young population (from 20 to 29 years old) (Ho Chi Minh City Population and Housing Census, 2009). The proportion of the population in working-age accounted for 71.3% of the total population. The population provides abundant labours to the city (General Statistics Office of Vietnam, 2009).

*** Economic development**

Ho Chi Minh City functions as a growth engine of the Vietnamese economy. The city is the core of the Southern Economic Focal Zone, which leads to the economic development of the region. Since 1986, the Vietnamese Government initiated a series of economic and political reforms. The national economy shifted from a centrally planned to a market-based economy. Consequently, the economics of Ho Chi Minh City has been developed drastically, integrating into the world economy. In 2010, the city contributed 21.1% to the national Gross Domestic Product (GDP). Industrial sector and service sector are primary economic drivers of the city (CAI-Asia Centre and HIDS, 2011).

Table 6-3: Ho Chi Minh City economic growth by sectors

Periods	Total GDP growth rate per year (%)	Contribution to the national GDP (%)		
		Agricultural Sector	Industry Sector	Service sector
1991 - 1995	12.62	3.78	16.21	11.16
1996 - 2000	10.11	1.09	13.18	8.34
2001 - 2005	10.99	4.97	12.37	10.03
2006 - 2010	11.18	4.83	10.12	12.29
1996 - 2010	10.76	3.62	11.88	10.21

Source: CAI-Asia Centre and HIDS (2011)

6.2 The need for integrated transport and urban development in Ho Chi Minh City

Ho Chi Minh City is facing many problems in transport and urban development, which call for an integrated approach to transport and urban planning. The practical problems are analysed concerning insufficient traffic management and insufficient urban planning.

6.2.1 Insufficient traffic management

In Ho Chi Minh City, there are several agencies involved in transport planning and traffic management. Department of Transport is responsible for transport planning and traffic management. The duty of maintaining transport infrastructures and facilities is mostly decentralised to district authorities. Regarding public transport system, the Centre for Public Transport Management and Operation (which is under the administrative management of Department of Transport) manages bus systems. The Management Authority of Urban Railway, which is under the administrative management of Ho Chi Minh City People Committee, manages the Mass Rapid Transit system. Within the Mass Rapid Transit system, there are several investors with different technologies and control systems involved. There is a considerable risk of insufficiently integrated planning and managing which might lead to the risk of lacking rail-based hinterland connections of Ho Chi Minh City if the issues are not adequately addressed.

*** Road network**

Ho Chi Minh City is an important transport hub, connecting local provinces in the South to other parts of the country, and to the world. During the period 2000-2010, there was a huge investment in transport infrastructure and the systems were developed rapidly, especially road network.

In Ho Chi Minh City, road infrastructure is insufficient regarding quantity and quality, especially in newly developed areas and suburban areas. The average growth rate of road length is about 6.7% per year, and road area is about 5.4% per year (during period 2001-2010) (Nguyen, 2013). Roads with a width of more than 12 metres (which are suitable for bus operation) are limited. It is necessary for Ho Chi Minh City to construct a hierarchical road network with systems of ring roads, trunk roads, feeder roads, etc.

Table 6-4: Development of transport sector through years

No.	Indicators	Unit	Year		
			2000	2005	2010
1	Proportion of transport land/non-agricultural land	(%)	8,08	12,91	12,62
2	Transport land area per inhabitant	m^2/inhabitant	11,38	17,19	15,48
3	Total road length	km	1.915	3.038	3.688
4	Average road density in total natural land	km/km^2	0,91	1,45	1,75
5	Average road density in total population	km/1,000 inhabitant	0,36	0,48	0,5

Source: HCMC DONRE and HCMC DOT (2010)

*** Transport vehicles**

In Ho Chi Minh City, during the period 2001 - 2010, the average growth rate of motorcycles was 11.21 % per year, from 1,569,355 in 2001 to 4,541,371 in 2010. The average growth rate of private cars was 13.26 % per year, from 131,182 in 2001 to 455,845 in 2010. The number of registered vehicles in Ho Chi Minh City is about 6.3 million vehicles (2013). Besides, there are approximately 1 million motorcycles and 60,000 cars, which are registered outside Ho Chi Minh City, operating in Ho Chi Minh City.

Table 6-5: The number of cars and motorcycles

Unit: vehicle

Year	New Registrations			Existing Registrations		
	Car	Motorcycle	Total	Car	Motorcycle	Total
2002				66,000	2,040,000	2,106,000
2003	21,782	141,369	163,151	221,665	2,305,415	2,527,080
2004	35,214	211,045	246,259	252,861	2,428,989	2,681,850
2005	33,178	218,935	252,113	275,160	2,619,525	2,894,685
2006	31,985	343,142	375,127	296,143	2,917,502	3,213,645
2007	27,995	378,021	406,016	326,679	3,338,913	3,665,592

Year	New Registrations			Existing Registrations		
	Car	Motorcycle	Total	Car	Motorcycle	Total
2008	39,387	320,560	359,947	370,785	3,685,648	4,056,433
2009	14,075	155,710	169,785	408,688	4,071,567	4,480,255
2010	32,051	381,366	413,417	442,526	4,445,013	4,887,539
2011	30,399	396,181	426,580	494,614	5,029,342	5,523,956
2012	20,002	496,634	516,636	523,606	5,465,356	5,988,962
2013			556,715	487,638	5,899,199	6,386,837

Source: Ho Chi Minh City Traffic Safety Committee (2013)

*** Public transport**

Currently, the public transport system in Ho Chi Minh City includes buses and taxis, which meet about 8% of total travel demand. Although the bus network covers almost the whole city, bus transport is quite poor with about 1,300 buses and 120 bus lines. The bus system serves only 6% of total travel demand. The system is planned for improvement and expansion. To increase the capacity of public transport, Ho Chi Minh City has been planning for eight Mass Rapid Transit lines and three Bus Rapid Transit lines. The first Mass Rapid Transit line is under construction, and other Mass Rapid Transit lines are in the planning process.

6.2.2 Insufficient urban planning

In Ho Chi Minh City, the speed of urbanisation in recent decades has been so fast that the administrative needs have not been able to keep up. The authorities responsible for city planning do not have sufficient information and capacities to project the coming changes for Ho Chi Minh City and prepare Plans to manage and develop the city. Moreover, functions of relevant authorities are inadequately assigned and fulfilled (Nikken Sekkei, 2014). In general, institutional problems are caused by (1) Inconsistent planning and (2) Complicated procedures and lack of coordination between related authorities.

*** Inconsistent planning**

At the city level, there are three master plans, including (1) The Socio-economic Development Master Plan; (2) The General Construction Plan; and (3) The Land-use Master Plan. The Socio-economic Development Master Plan, which is formulated by Ho Chi Minh City Institute for Development Studies, gives context to the General Construction Plan and Land-use Master Plan. The General Construction Plan, which is formulated by Construction and Planning Institute, and Land-use Master Plan, which is formulated by Department of Natural Resource and Environment, guides construction and land-use development of the city. These three plans differ in the legal origin and the competent authorities. Although they should have common targets in urban development, differences are sometimes found among these plans. For example, the land-use classification in the urban construction plan does not match with that in the land-use plan. This may lead to confusion of land-use, especially when land is allocated for a specific purpose. Furthermore, land-use cannot be appropriately controlled as planned. Therefore, effort should be made to bring harmony to Plans.

Regarding planning at the district level, the District Master Plan is prepared by the Urban Planning Institute in cooperation with district departments, approved by the City People's Committee. However, this formulation process sometimes brings problems due to the inconsistency between the city and district authorities. This is because the district authorities tend to estimate a larger volume of industrial, housing and infrastructure development projects in their boundaries without proper consideration for the total balance within the city.

According to the Construction Master Plan, Ho Chi Minh City is divided into three areas, including central city areas, newly developed areas and suburban areas. Central city areas (Area 1) include 13 urban districts - 1, 3, 4, 5, 6, 8, 10, 11, Go Vap, Tan Binh, Tan Phu, Binh Thanh, and Phu Nhuan. There are many high-rise buildings, shopping malls, schools and hospitals concentrated in central city areas. Newly developed areas (Area 2) include six newly developed districts - 2, 7, 9, 12, Binh Tan, and Thu Duc. Those districts were mostly established from rural districts in 1997. The urbanisation rate in those districts is quite high, compared to the others. Located in favourable places nearby the city centre, these districts have been receiving huge investments in recent years to develop new residential areas. Besides, investments in infrastructure are also provided to support urban development. Suburban areas (Area 3) include five rural districts - Hoc Mon, Nha Be, Can Gio, Cu Chi and Binh Chanh. They are remote districts with low population densities. Infrastructure systems in these areas are still poor due to limited investment.

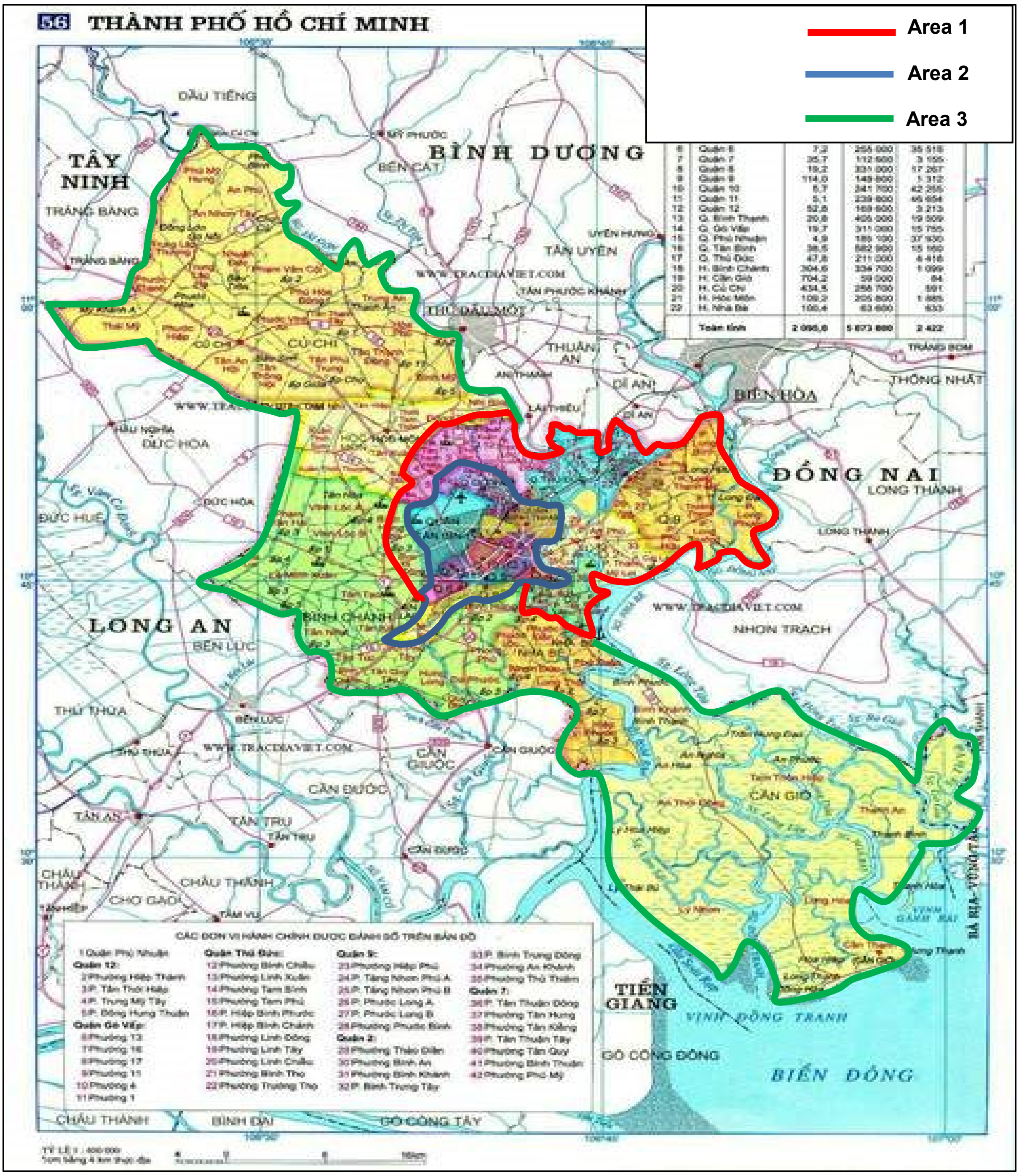


Figure 6-1: Ho Chi Minh City Distributed by Area

Source: Decision 2631/QĐ-TTg (2013)

Rapid urbanisation has been changing land-use patterns of Ho Chi Minh City significantly. Agricultural land is converting to construction land, and the rural areas are transitioning to urban areas. Construction land of the whole city has been increased from 49,909 ha in 2005 to 57,104 ha in 2010. In the central city areas, construction land increased by 116.57 ha (mostly in Go Vap District). In the newly developed area, construction land increased by 2,910.8 ha (mainly in Thu Duc District, District 2, District 9 and Binh Tan District). In suburban areas, construction land increased by 4,167.63 ha (mostly in Binh Chanh District).

Table 6-6: Construction land by areas

No.	Area	Unit	2005	2010	Increased areas
1	Central city areas	ha	12,520	12,636.57	116.57
2	Newly developed areas	ha	17,417	20,327.80	2,910.80
3	Suburban areas	ha	19,972	24,139.63	4,167.63
Total		**ha**	**49,909**	**57,104**	**7,195**

Source: HCMC DONRE (2010)

*** Complicated procedures and lack of coordination between related authorities**

The procedure to get approval for projects in Ho Chi Minh City is complicated, time-consuming, and costly. The elaborate and awkward procedure can lead to illegal constructions, especially in newly developed areas. Despite the improvement in procedures and decentralisation, the process is still ineffective.

The Ho Chi Minh City People Committee approves most of the construction projects. The process of project approval requires the appraisal of many relevant authorities such as Department of Planning and Investment, Department of Construction, Department of Transport, Department of Architect and Planning, Department of Natural Resource and Environment. Projects are approved following objectives and indicators, which have been set in several Plans. The involvement of many authorities in the process can result in a scattering of responsibilities. Furthermore, it is hard for the People Committee to give the final decision if there are conflicts among appraisals.

6.3 The case study – Metro Line 1

Ho Chi Minh City has planned a network of Metro with eight lines. The total length of the network is 172 kilometres (Decision 2631/QĐ-TTg, 2013). Metro Line 1 is the first under construction line in Ho Chi Minh City. The total length of the lines is 19.7 kilometres, including 2.6 kilometres underground and 17.1 kilometres elevated, and 14 stations. The project was started in 2012. It is expected that by the end of 2020, the first section of the line will be operated. Japanese government funds the project. The total cost of the project is nearly US$ 2.5 billion (HCMC MAUR, 2007). The project plays a vital role in improving traffic and urban condition of the city, as well as promotes economic development.

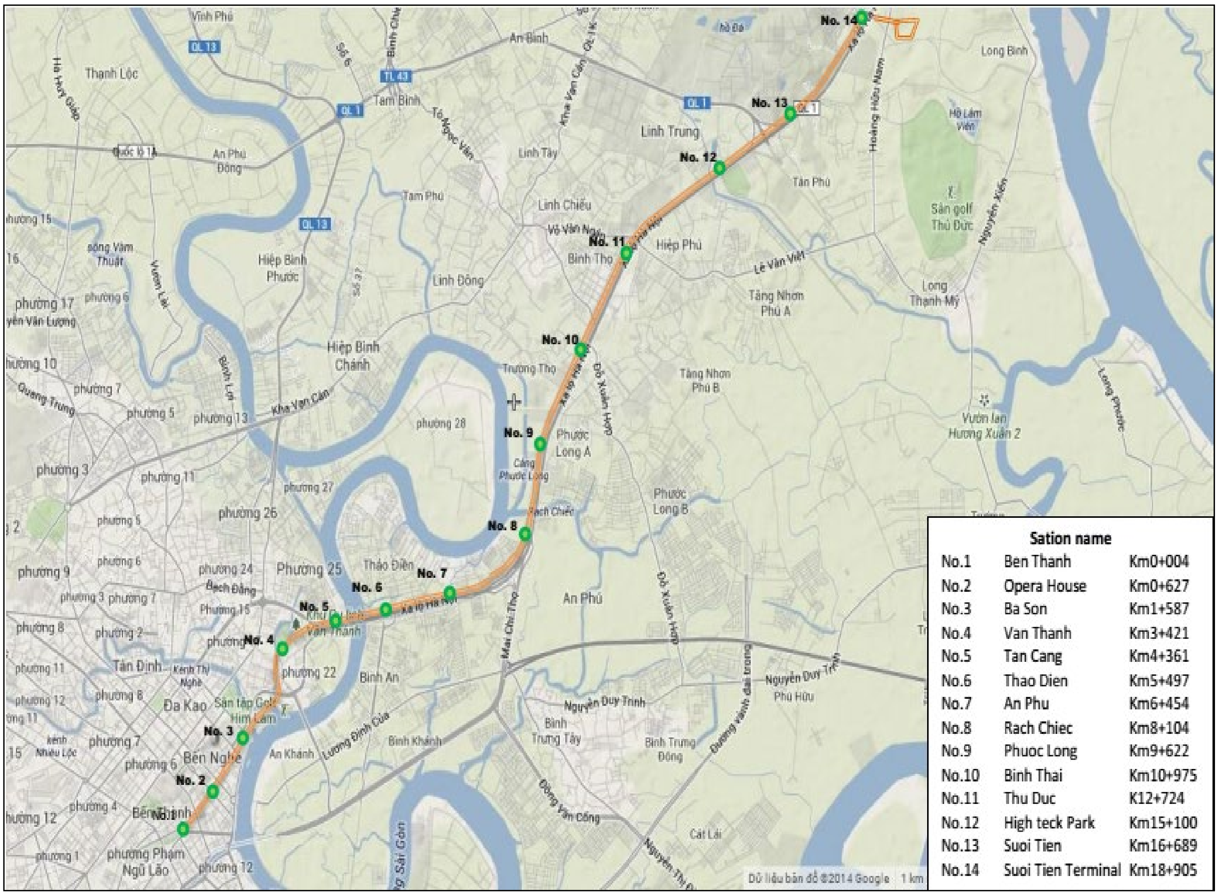


Figure 6-2: Ho Chi Minh City Metro Line 1

Source: HCMC MAUR (2007)

6.4 Application of developed strategies in the Metro Line 1 project

The concept of integrated transport and urban development is proposed to the Metro Line 1 project. The development of the project is important to the areas along the corridor in particular, and to the whole city in general. Some strategies can be implemented, with the consideration of practical context and relevant planning of the city. In each strategy, appropriate measures are implemented, and key measures are presented. The dependence of the measures on the local conditions is highlighted. Potential changes in transport and urban conditions of the surrounding areas are estimated. The impact estimation is mostly based on the results of the study "Special Assistance for the Project Implementation for Ho Chi Minh City Metro Urban Railway Project (Ben Thanh – Suoi Tien Section (Line 1))" - SAPI study (JICA, 2013), conducted in 2013.

*** STRATEGY 1: PROMOTE NON-MOTORISED TRANSPORT**

In order to achieve widespread use of Metro systems, passengers should have convenient and safe access to stations by walking and cycling. Designation of roads and a road network with pedestrian and bicycle lanes into land use and transport plans to ensure the accessibility to the station from surrounding areas and promote the utilisation of public transport. The key measure is providing facilities, including crossing tunnels, flyovers and traffic signals. This is especially important in the catchment areas of the Metro line. Since the Metro Line 1 has an elevated section, the ticket gates and the pedestrian bridges crossing the Hanoi Highway are located on the second floor. Therefore, establishing the pedestrian networks at such a level, which connect between the stations and their surrounding urban areas, will be important.

*** STRATEGY 2: CONTROL INDIVIDUAL MOTORISED VEHICLES**

In order ensure the attractiveness and efficiency of Metro Line 1; it is necessary to control the use of individual motorised vehicles. Key measures include (1) Road pricing and (2) Parking pricing.

Road pricing is proposed for car use in Hanoi Highway, which is parallel to Metro Line 1. Besides, motorcycle use is considered for road pricing. High parking charge would be applied in the city centre. To do so, parking areas need to be well organised and equipped in locations that facilitate transferring from individual motorised vehicles to non-motorised transport and public transport. Parking fees could be reasonably calculated based on parking location and parking time and duration. The payment collection systems for parking fees also need to be established to ensure the convenience and accurate payment. High parking charge helps to decrease parking demand in the city centre area and hence, reduces traffic by individual motorised vehicles. Parking fee collected in the area can be used for the improvement of non-motorised transport infrastructure and facilities in the central city areas and the catchment areas of Metro lines.

*** STRATEGY 3: PROMOTE PUBLIC TRANSPORT**

The strategy includes measures of (1) Public Transport Feeder Services and (2) Public Transport Authorities.

- **Public Transport Feeder Services**

  Metro system is the backbone of urban transit. To expand the catchment area of Metro lines and improve service quality, it is vital to provide feeder services. The feeder services might include bicycles, motorcycles, motorcycle taxis, taxis and buses. The road network along the corridor must be structured hierarchically to accommodate the planned feeder services. The bus network needs to be re-planned and adjusted to the feeder function, to the benefit of both the trunk system and the feeder system. As the development of the Metro system will take place over many years, the adjustment of the bus network must be carried out in parallel. The feeder bus should be organised with stations located at intervals of 300 to 500 metres, covering the whole residential area. Besides, other transport modes such as taxis and motorcycle taxis can also serve as feeder modes for Metro line.

  To understand the preferred access mode choices to the station, which are helpful for organising feeder services, a Stated Preference survey was conducted under SAPI study. The access mode choice is illustrated in Figure 6-3.

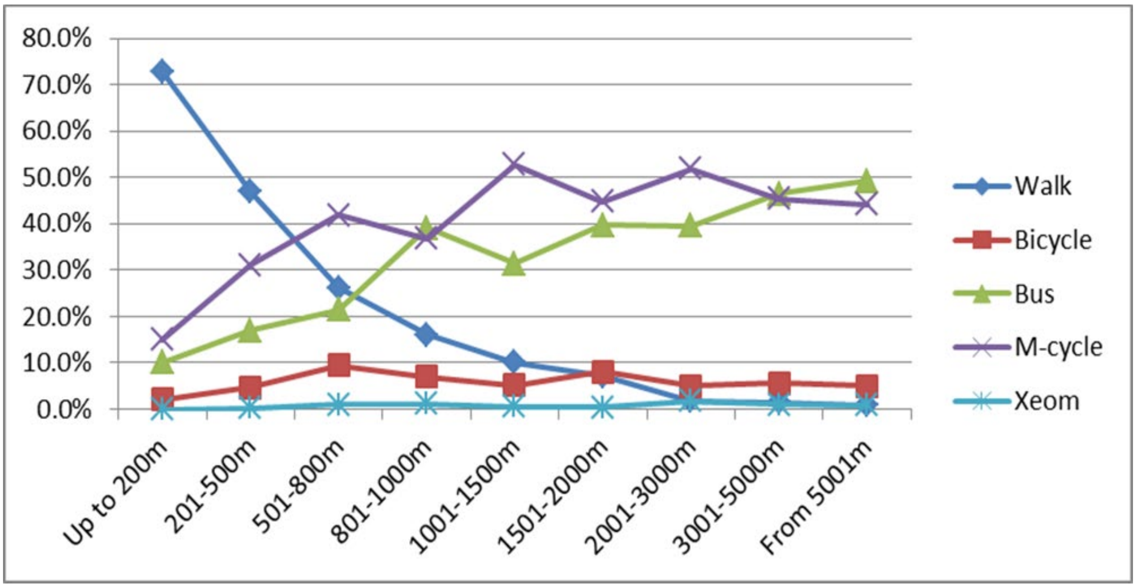


Figure 6-3: Stated access mode choice to Metro stations (N=3,691)

Source: JICA (2013)

People who are living or working along the corridor may choose different access modes depending on the access distance. Walking is mostly chosen within a range of 800 metres or shorter. The use of bicycles is limited due to safety reasons. Motorcycles and buses would be preferred modes for a distance beyond 800 metres. Because bus and motorcycle seem to be competitive, it is important to carefully consider the local road network conditions to coordinate the supplies of these two services. Feeder bus service must be prioritised in areas where local roads are in good conditions for bus operation. Motorcycles can be used as an effective feeder mode in areas where the roads are still poor.

Results from the Stated Preference survey shows that despite the introduction of Metro and feeder bus services, a large percentage of the commuters may still prefer to use motorcycles for daily commuting. Two scenarios were tested under the survey. In the first scenario, it was assumed that the respondents walk to the destination. Having compared travel time and travel costs of the various modes as given in seven alternatives, each respondent chose his/her preferred alternative. Figure 6-4 shows that 50.3% of the respondents might consider shifting to the Metro while 49.7% might still use their current mode (10.5% keep going by bus and 39.2% still using motorcycle/car). In the second scenario, it is assumed that the respondents use the planned feeder bus to go to the destination. As shown in Figure 6-5, there would be still 41.9% of the respondents choosing “Motorcycle/car”, followed by “Motorcycle-Metro-Feeder bus” (19.6%) and “Feeder Bus-Metro-Feeder Bus” (18.7%). The share of “Conventional Bus” is 10.4%. “Xe om-Metro-Feeder Bus” was the least popular option selected (0.4%).

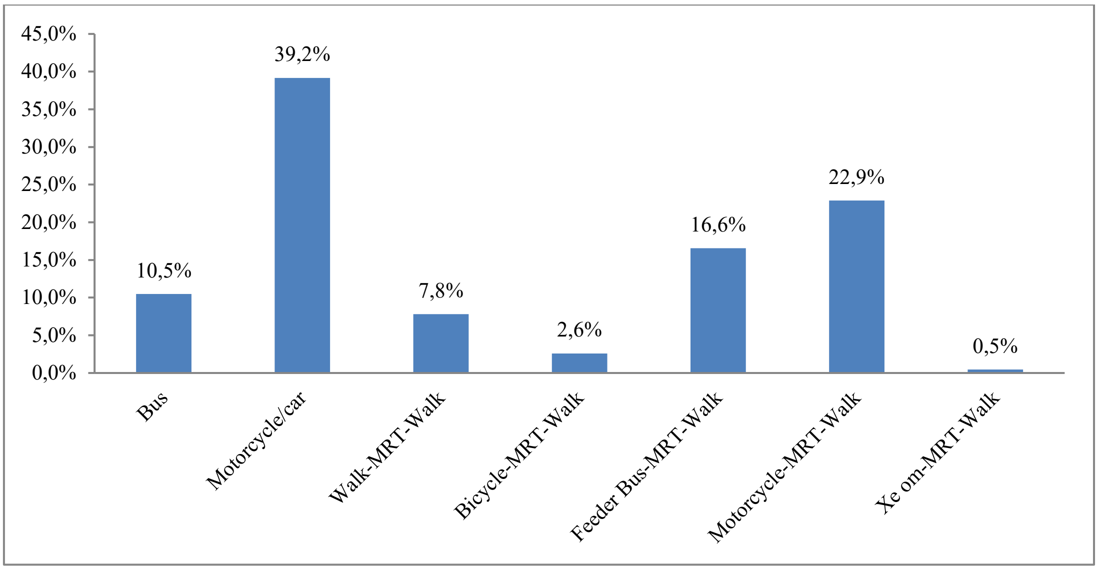


Figure 6-4: Stated preferences of combined mode choice assuming that the respondents walk to the final destination (N=3,691)

Source: JICA (2013)

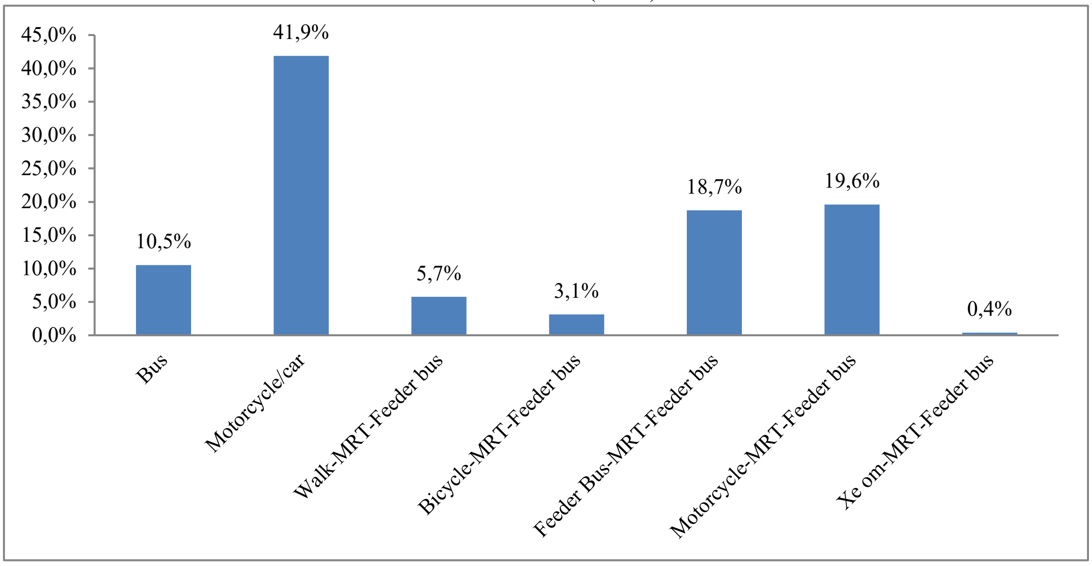


Figure 6-5: Stated preferences of combined mode choice assuming that the respondents take feeder bus to the final destination (N=3,691)

Source: JICA (2013)

The feeder services will bring greater accessibility to the Metro stations. The Stated Preference survey shows that the development of seamless transfer facilities and good connections with bus services at the railway stations is likely to increase the ridership by nearly 20% and fare revenue by more than 5 % in 2020 (JICA, 2013).

- **Public Transport Authorities**

The establishment of the Public Transport Authority is essential for ensuring the harmonious coordination of the whole public transport system. Foreign experiences show that it is necessary to have a Public Transport Authority to manage and operate a large-scale system with various transport modes. The authority needs to be powerful and capable to implement approved plans and issue regulations for the management and operation of the system. The Public Transport Authority is responsible for balancing the revenues and subsidies to ensure the efficient operation of the systems, as well as facilitating users. Revenues come from ticket selling and from other commercial activities (such as parking services, commercial activities at the station areas, providing information systems, ticketing systems, etc.).

*** STRATEGY 4: PROMOTE INTERMODAL AND MULTIMODAL TRANSPORT**

The strategy includes measures of (1) Park & Ride development and (2) Promoting Intelligent Transport System.

- **Park & Ride Systems**

The construction of Park & Ride facilities at the gateway position to the inner city helps to promote multimodal transport. Therefore, it supports the use of public transport and decreases traffic congestion in the city centre.

- **Intelligent Transport System**

The development of Intelligent Transport System facilitates information provision for the whole transport system. Advanced applications of the Intelligent Transport System would collect and analyse live data. Then, information, including schedule, ticket prices, traffic situations, road condition, parking guidance, mode alternatives etc., is provided to both public and private transport users. Benefits of the Intelligent Transport System applications can vary significantly. Applications that improve private transport provide benefits such as safety and reduced traffic congestion. Those that encourage transit or ridesharing can provide benefits associated with the mode shift to public transport. By integrating information, both public and private transport users can quickly and easily access information and select the most suitable transport mode among the alternatives, which will facilitate time-saving and costs associated with transfers.

In Ho Chi Minh City, there is a plan to build an Intelligent Transport System for the city. A Traffic Control Centre is establishing to facilitate traffic management. The operation of Metro lines is connected with Traffic Control Centre through the facilitation of detectors, controllers, traffic signals, CCTV, transmission system, variable message signs, etc.).

*** STRATEGY 5: PROMOTE TRANSIT-ORIENTED DEVELOPMENT**

The Ho Chi Minh City Metro Line 1 is being constructed along National Highway No. 1, in which many urban development projects are either on-going or being planned. If these urban development projects are implemented in an integrated manner with the public transit system, the synergy of development can be enhanced. Creating a functional and pleasant living in the areas adjacent the stations, which takes into consideration the suburban development typology of Ho Chi Minh City, is important. Since the potential development of areas surrounding the stations will be enhanced, medium- or high-density urban development projects may be viable. Planning criteria include medium or high-density (high floor area ratio, building coverage ratio and height restriction) and with mixed land-use to utilise the impact of station development.

The planned station area development would play as a catalyst and provide opportunities for integration with urban activities surrounding the stations, thus contributing to the realisation of the Transit-oriented development concept. The result from the Transit-oriented development is less frequent and shorter travel distances. The beneficiaries are the people who spend less time in traffic, the economy that reduces time losses and cost, and the environment that is less burdened by greenhouse gas emissions. Specific benefits would be:

- Promotion of the mode shift towards public transport through optimum accessibility to transit systems within walking distance;

- Reduction of travel distances and the need for motorised trips through concentration of bundling activities in the Transit-oriented development notes.

Transit-oriented development concept along Metro Line 1 corridor is illustrated in Figure 6-6.

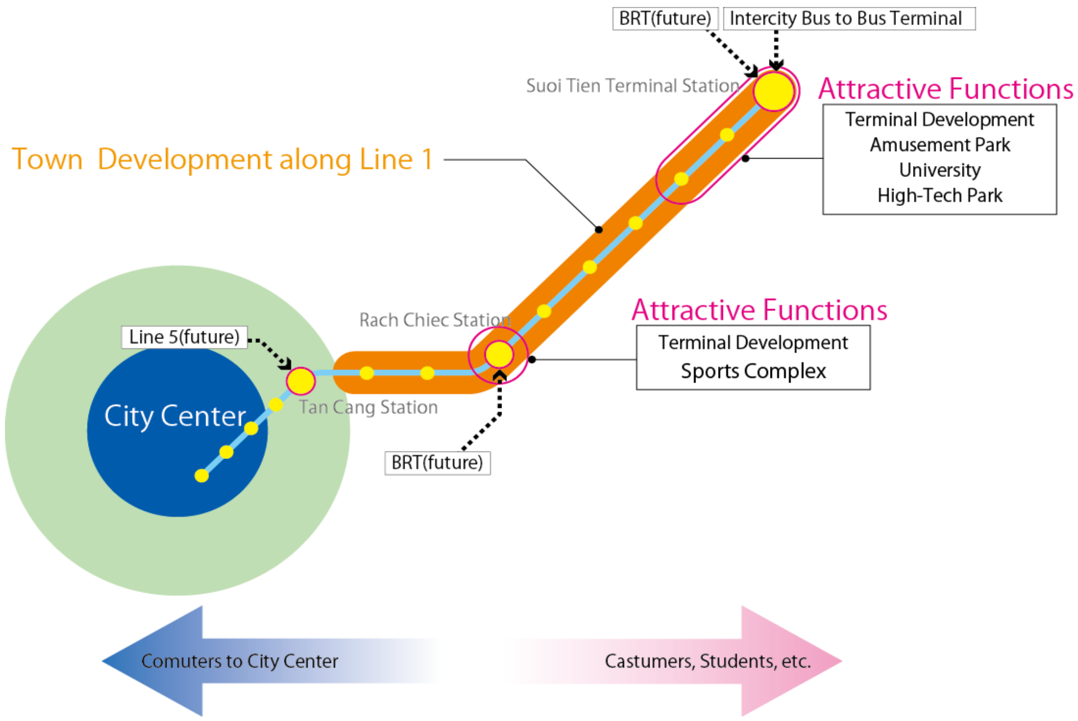


Figure 6-6: Transit-oriented development concept for Ho Chi Minh City Metro Line 1

Source: JICA (2013)

The corridor of the Ho Chi Minh City Metro Line 1 covers various urban land-uses from the Central Business District to suburban areas and thus is expected to bring many opportunities for urban development along the corridor. Different land-uses at station areas require an adequate development approach to fit the appropriate socioeconomic activities and for peoples' mobility, while the line is expected to encourage the development and formation of the corridor in an integrated manner. The formation of urban transport nodes in conjunction with station area development is illustrated in Figure 6-7.

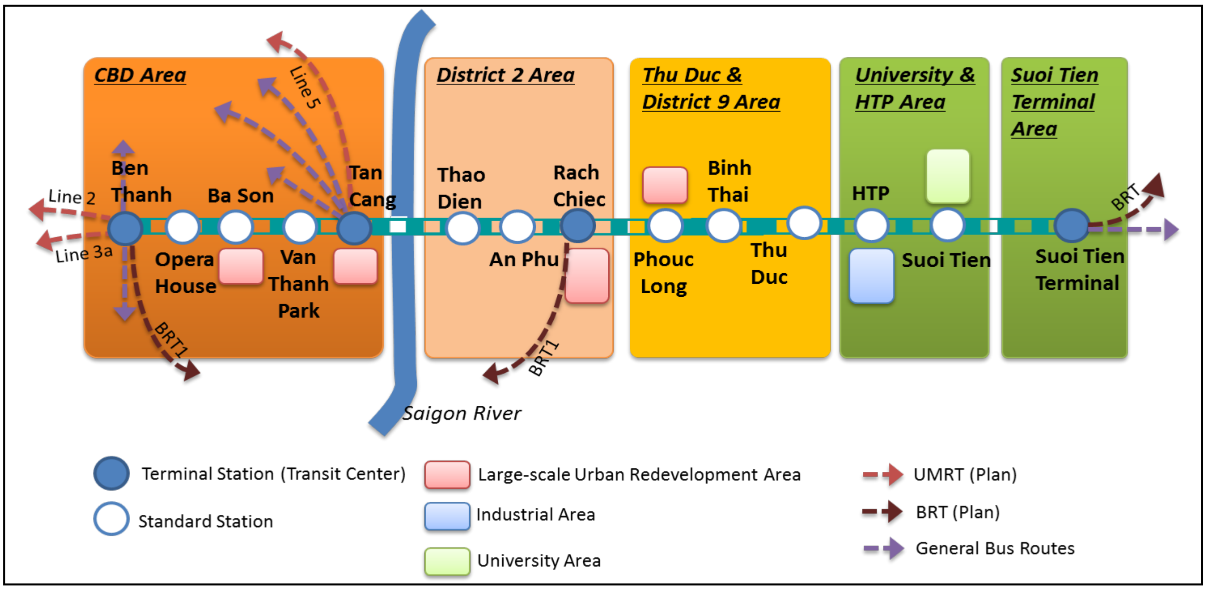


Figure 6-7: Land-use developments along Metro Line 1 corridor

Source: JICA (2013)

The concept considers transport and urban development aspects of specific areas along the corridors simultaneously to ensure the integration, as shown in Table 6-7.

Table 6-7: Transport and urban development of the Metro Line 1 corridor

Area	Urban Development Aspect	Urban Transport Aspect
Central Business Districts	Promote station area development such as the Ba Son shipyard or Tan Cang port area	Provide adequate feeder bus services by the rerouting of existing bus routes Promote seamless transfers at Tan Cang station to buses
District 2	Promote the Sports City Development	Provide adequate feeder bus services Rerouting of existing bus routes on the overlapping section with the Metro Line 1 Develop station plazas Provide parking facilities Promote the seamless transfer at Rach Chiec Station to Bus Rapid Transit Line 1 Promote the seamless transfer at Suoi Tien Terminal Station to Bus Rapid Transit and buses
Thu Duc District and District 9	Promote station area development following the concept of Transit-oriented development Provide organised urban lands ahead of urbanisation to prevent sprawl	
University and High-Tech Park	Promote the master plan of national university and High-Tech Park	
Suoi Tien Terminal	Promote and lead station area development by using the concept of Transit-oriented development	

Source: JICA (2013)

6.5 Summary

The chapter analyses the transport and urban background of Ho Chi Minh City. Then the need for integrated transport and urban development is highlighted. The Metro Line 1 project is considered for the application of the concept of integrated transport and urban development. This is an important project, which influences the social-economic development of the city.

The project also improves traffic situation and contributes to urban development. Some strategies could be implemented, with the consideration of mutual impacts. In each strategy, appropriate measures are implemented, and key measures are presented. There are illustrations of strategy implementation in practice. The potential impacts, which might occur due to the implementation of strategies, are estimated. Furthermore, the dependence of the strategies on the specific context of Ho Chi Minh City is analysed. Potential impacts, which might occur in the future due to the implementation of the measures, are estimated.

7 Conclusions and Recommendations

The following chapter summarises the contents and the most important results, as well as highlighting the significance and limitations of the study. The recommendations for further studies are also presented.

7.1 Summary of the research results

The study has accomplished the research goal and the objectives, as described in section 1.2. The results are summarised below.

*** Interactions of transport system and urban form were identified**

In a city, patterns of urban development are inseparable from the evolution of urban transport. Likewise, urban transport development cannot be considered independently from the urban development (Newman and Kenworthy 1989; UN Habitat 2013). The interactions of transport system and urban form elements in a city are complicated by the fact that changes in any one aspect will also result in changes in the others.

In general, the interactions of transport system and urban form elements include (1) The impacts of traffic management on modal splits; (2) The impacts of urban planning on urban form elements; and (3) The interactions of modal splits and urban form elements. Although a package of traffic management is designed to influence a certain transport mode, its implementation also impacts on other modes. Furthermore, traffic management packages might indirectly influence urban form elements. Similarly, the implementation of urban planning packages influences urban form elements directly, and the modal split indirectly. Then, changes in modal splits influence the urban form elements and vice versa.

There are four packages of traffic management, including (1) Promote Non-motorised Transport (TM1); (2) Control Individual Motorised Vehicles (TM2); (3) Promote Public Transport (TM3); and (4) Promote Intermodal and Multimodal Transport (TM4).

Urban planning packages include (1) Promote Compact Development in the Central City Areas (UP1); (2) Control Sub-urban Areas (UP2); (3) Promote Transit-oriented Development (UP3); and (4) Develop New Sub-centres (UP4).

A change in an urban form element can be the result of the implementation of urban planning packages, or it can be influenced by changes in modal split. The impacts are combined, which requires comprehensive considerations in planning and implementing measures. Considering the significant positive interactions helps to highlight the mechanism of the interactions.

For example, the increased use of Bus Rapid Transit/Mass Rapid Transit is the direct result of implementing the TM3 (Promote Public Transport) and TM4 (Promote Intermodal and Multimodal Transport), or the indirect result of implementing the TM1 (Promote Non-motorised Transport) and TM2 (Control Individual Motorised Vehicles). The increasing use of Bus Rapid Transit/Mass Rapid Transit has positive influences on the urban size, which can be supported by the implementation of the UP3 (Promote Transit-oriented Development). The increasing use of Bus Rapid Transit/Mass Rapid Transit positively influences on the urban density and land-use, which also supported by the implementation of TM1 (Promote Non-motorised Transport) and TM4 (Promote Intermodal and Multimodal Transport). It can be recognised that promoting Bus Rapid Transit/Mass Rapid Transit is a powerful measure to influence the urban form. Also, other measures and packages, with careful consideration of their mutual impacts, can show the mechanism of the interactions.

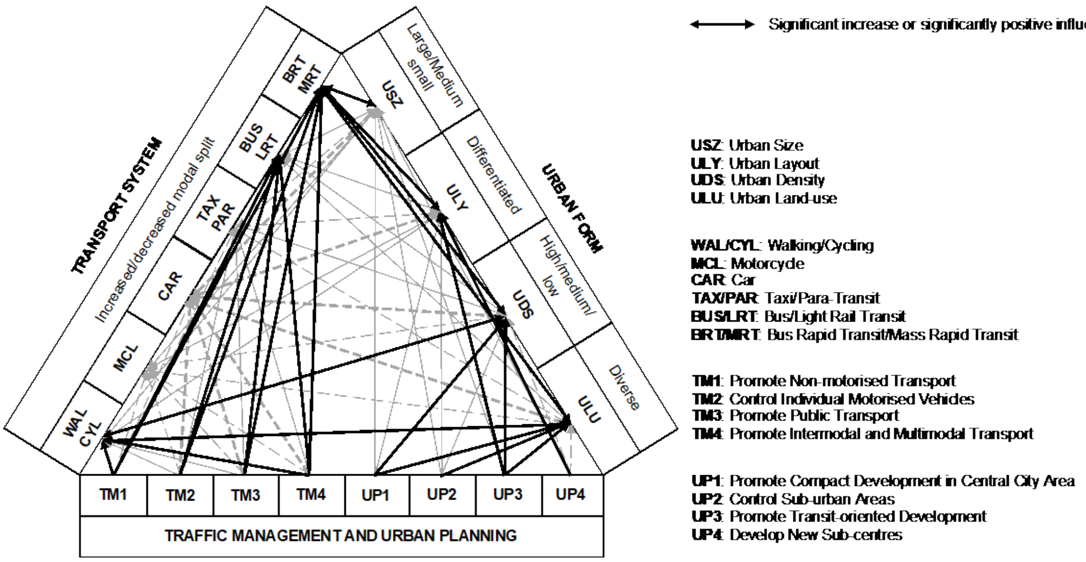


Figure 7-1: Significant increase or significant positive influence

Source: Author's representation

The interactions of transport system and urban form elements call for an integrated approach to planning, which allows all the interactions to be coordinated.

The interactions of transport system and urban form elements have a fundamental influence on the overall level of travel demand, patronage of various travel modes, accessibility, travel distances and costs of travel, as well as the on-going cost of providing essential infrastructure and services (Wadhwa, 2005). Therefore, it is crucial that decisions about transport system and urban form are considered together. In the long term, it will not be possible to solve the transport- and urban-related problems by one or several measures. The proposal for packages of measures needs to consider how they function as part of a balanced strategy. The recent transport and urban planning in many cities in the world have developed the concept of integrated transport and urban as a planning solution for improving the quality of life and livability in the cities.

Integrated planning is an approach that seeks to pull together all the contributing elements to increase the effectiveness of delivered solutions. Integration allows individual activities to be coordinated to achieve the best solutions in meeting the needs of people and communities. Decisions about transport system, the form of urban development and how the land has used all impact each other. Integrated transport and urban planning - an approach that takes into account and connects all these considerations - helps to ensure that transport network development and land-use development are coordinated. In short, integrated transport and urban development is the development process that takes into account and coordinates all planning of the transport system and urban form elements to archive sustainable urban development.

The analysis of the interactions of transport system and urban form elements provides ideas of basic strategies for integrated transport and urban development, which are further developed for Asian developing cities.

Strategies for integrated transport and urban development can be defined as the combination and interaction of measures to achieve higher performance from the overall strategy (May et al., 2006). Strategies include bundles of measures, which have been developed for dealing with the transport and urban requirements of urban areas in the context of broader social, economic and environmental objectives. The mutual impacts of measures bring benefits compared with the piecemeal implementation of individual measures.

Most strategies for integrated transport and urban development are developed either in pursuit of synergy, or as a means of overcoming barriers, or both. Therefore, in policy development, it is essential to identify measures which might achieve synergy (May & Roberts, 1995). The strategies include:

(S1) Promote Non-motorised Transport;

(S2) Control Individual Motorised Vehicles;

(S3) Promote Public Transport;

(S4) Promote Intermodal and Multimodal Transport;

(S5) Promote Compact Development in the Central City Areas;

(S6) Control Suburban Areas;

(S7) Promote Transit-oriented Development; and

(S8) Develope Sub-centres.

*** Problems of transport and urban development in Asian developing cities were identified**

In many cities, decisions related to transport and urban development have often been regarded as distinctly separate issues in analysing, planning, designing, operating and managing. The weakly coordinated transport and urban development creates negative impacts from one to another (Wadhwa, 2005).

Every city has its development patterns, which are being affected by the city's socioeconomic characteristics and urbanisation processes. The transport and urban-related problems are rooted for many reasons, which can be grouped into two categories of (1) Insufficient traffic management and (2) Insufficient urban planning. Practical situations and problems in several Asian developing cities, which are reviewed from literature and explored through the field study in Ho Chi Minh City, are used for illustration.

The problems of insufficient traffic management are the results of (1) Lack of promotion for non-motorised transport; (2) Lack of controlling individual motorised vehicles (3) Lack of promotion for public transport; and (4) Lack of promotion for intermodal and multimodal transport.

The problems of insufficient urban planning are the results of (1) Insufficient compact development in the central city areas; (2) Insufficient control of suburban areas; (3) Lack of Transit-oriented development and (4) Insufficient new sub-centre development.

The lack of properly coordinated transport and urban development created problems, which can be reduced by promoting an integrated approach in transport and urban planning.

*** Framework for integrated transport and urban development in Asian developing cities were established**

The ultimate goal of transport and urban development is to achieve sustainable development. The sustainable development encompasses three major goals of (1) Sustainable society; (2) Sustainable economy; and (3) Sustainable environment. Each goal corresponds to an aspect that has its own distinct driving forces and objectives (Munasinghe, 2004). Transport interacts critically with the social, economic and environmental aspects of sustainable development. Therefore, the goals of sustainable transport and urban development for Asian Developing Countries cover both aspects of urban development and transport development. Goals include (1) Improve mobility and accessibility, (2) Improve traffic safety, (3) Protected environment and human health, (4) Improve economic efficiency (Speer and Partner, 1993 in Khuat, 2006). Objectives are specified for both transport planning and urban planning. Descriptions of goals and objectives are provided.

Integration approach increases the effectiveness of delivered solutions, ensures higher performances against the objectives of the strategy than could be achieved by the individual measures on their own (May and Roberts, 1995). Integration also promotes the most efficient use of resources and avoids creating unintended impacts (New Zealand Transport Agency, 2011). The ultimate goal of integrated transport and urban development is to consider the mutual effects of measures. Two sub-goals are (1) to gain synergy and (2) to avoid conflicts (May and Roberts, 1995).

The gain of synergy involves finding pairs or groups of measures, which reinforce one another in achieving changes in the transport system and urban form elements (May et al., 2006). Gaining synergy between measures is the target of designing strategies for integrated transport and urban development. This goal is specified into three objectives, which cover both transport planning and urban planning, including (1) Conceptional-functional objectives; (2) Technical-physical objectives; and (3) Institutional-organisational objectives (Boltze & Fornauf, 2013).

The interactions of measures might occur negative impacts. Then, integration is used as an alternative approach to avoid conflicts. Conflicts are obstacles that prevent a given policy instrument being implemented or limit the way in which it can be implemented. The conflicts may lead to certain measures are being overlooked, and the resulting strategies being much less effective (May et al., 2005). Then, supportive measures are used to overcome or reduce the conflicts. Conflicts are identified, including (1) Financial conflicts; (2) Technical conflicts; (3) Institutional conflicts; and (4) Public acceptance.

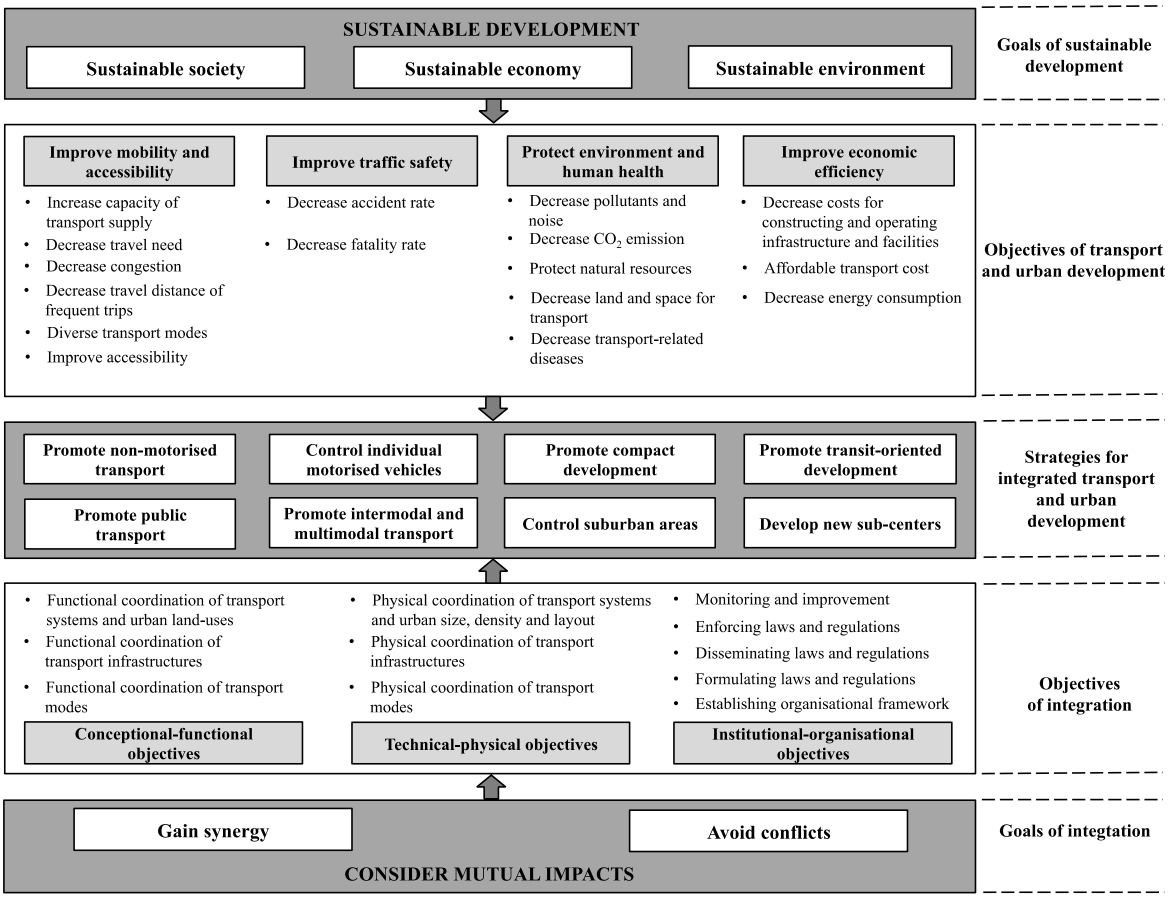


Figure 7-2: Framework for integrated transport and urban development

Source: Author's representation

The process of strategy formation is based on a model, which ensure that the resulted strategies are agreed with the goals and objectives of integrated development. The model comprises three steps, including (1) Pre-selection of measures; (2) Qualitative assessment of measures; and (3) Bundle of measures.

Measures which are being implemented in cities to cope with transport and urban issues are collected. Successfully implemented measures, which are proven through the case studies, are pre-selected as candidate measures. The candidate measures, which potentially contribute to form strategies for integrated transport and urban development, are assessed to clarify their effectiveness and applicability. This is the multi-criteria assessment, done by expert consultation with the purposes of confirming as well as getting the priorities of measures. Finally, the strategies for integrated transport and urban development in Asian developing cities are formed by bundling measures. The dependency of the strategies on the local context is also indicated.

*** Specific resulting strategies for an integrated transport and urban development in Asian developing cities formed**

Traffic management and urban planning consist of groups of measures, which are coordinated by strategies. The strategies for integrated transport and urban development need to meet the objectives of gaining the synergy and avoid conflicts. Eight strategies have been identified in the course of this study.

Table 7-1: Strategies for integrated transport and urban development

No.	Measures	Strategies							
		S1	S2	S3	S4	S5	S6	S7	S8
M1	Facilities for Pedestrians	●		○	○	○		○	
M2	Pedestrian Zones	●		○	○	○			
M3	Bikeway Networks	●				○		○	
M4	Bicycle-sharing Schemes	●		○	○	○		○	
M5	Vehicle Registration Control		●	○		○	○		
M6	Fees, Taxes and Standards for Individual Motorised Vehicles		●	○		○	○		
M7	Road Pricing for Private Car		●	○		○	○		
M8	Access Control and Traffic Calming	○	●	○		○			
M9	Car Pooling and Car Sharing		●	○		○			
M10	Parking Pricing		●	○	○	○			
M11	Parking Restriction	○	●	○	○	○			
M12	Public Transport Service Improvement	○		●	○		○	○	○
M13	Public Transport Priority Lanes			●				○	
M14	Public Transport Signal Prioritisation			●				○	
M15	Public Transport Feeder Services	○		●	○		○	○	○
M16	Pricing Mechanism			●				○	
M17	Public Transport Authorities			●					
M18	Intersection Traffic Control Systems	○	○	○	●				
M19	Intelligent Transport System		○	○	●				
M20	Intermodal Connection Centres	○	○	○	●	○	○	○	○
M21	Park & Ride Systems		○	○	●			○	○
M22	Density Increase in Central City Areas	○		○		●			
M23	Mixed-use Development in Central City Areas	○		○		●			
M24	Layout and Landscape Design in Central City Areas	○				●			

No.	Measures	Strategies							
		S1	S2	S3	S4	S5	S6	S7	S8
M25	Urban Growth Boundaries					●			
M26	Maximum Parking Space Regulations		○			●			
M27	Density Control in Suburban Areas		○				●		
M28	Land-use Control in Suburban Areas		○				●		
M29	Sufficient Spaces for Mass Rapid Transit Lines and Stations			○				●	
M30	Mixed-use and Compact Development in the Neighbourhoods of Mass Rapid Transit Stations	○		○				●	
M31	New Urban Zones Development			○	○				●
M32	Provision of Facilities and Services in Sub-centres				○				●
M33	Integrated Transport Authority	○	○	○	○				
M34	Transport and Urban Authority	○	○	○	○	○	○	○	○
M35	Marketing Campaigns and Educational Campaigns	○	○	○	○	○	○	○	○
M36	Enforcing Regulations	○	○	○	○	○	○	○	○
M37	Monitoring and Improvement	○	○	○	○	○	○	○	○

Source: Author’s representation

Note: ● Key measure

○ Supportive measure

*** The developed strategies were applied in Ho Chi Minh City**

The developed strategies are proposed for Ho Chi Minh City. Based on the analysis of the transport and urban background of the city, the need for integrated transport and urban development in Ho Chi Minh City is highlighted. There are illustrations of strategy implementation in practice. The potential impacts, which might occur due to the implementation of strategies, are estimated. Furthermore, the dependence of the strategies on the specific context of Ho Chi Minh City implementation of strategies is analysed. This is an important project, which influences the social-economic development of the city. The project also plays a significant role in improving traffic situation of the city and contributes to urban development.

The concept of integrated transport and urban development is proposed to the Metro Line 1 project. The development of the project is important to the areas along the corridor in particular, and to the whole city in general. Some strategies can be implemented, with the consideration of practical context and relevant planning of the city. In each strategy, appropriate measures are implemented, and key measures are presented. The dependence of the measures on the local conditions is highlighted. Potential changes in transport and urban conditions of the surrounding areas are estimated. The impact estimation is mostly based on the results of the study "Special Assistance for the Project Implementation for Ho Chi Minh City Metro Urban Railway Project (Ben Thanh – Suoi Tien Section (Line 1))" - SAPI study (JICA, 2013), conducted in 2013.

*** Recommendations for Ho Chi Minh City**

It is proposed that Ho Chi Minh City applies the developed strategies to achieve integrated transport and urban development. The strategy should take into account the following recommendations:

- The proposed strategies should consider timescale for the implementation;
- The impact estimation is currently project-based, comprehensive and combined impacts can be considered in accordance with the impact areas of the measures;
- The application could be expanded for larger scale, for the corridors of other Metro lines and if possible, a proposal for application of the developed strategies in the city scale;
- The establishment of the Integrated Transport Authority and the Transport and Urban Authority is emphasised for the integrated planning and implementing strategies;
- Public consultation should be conducted regarding the proposed strategies and measures.

7.2 Significance and limitations of the study

*** Significance of the study**

The interactions of transport system and urban form elements have been comprehensively analysed. Based on the understanding of the interactions, problems of lacking coordinated transport and urban developments are investigated in typically selected cities in Asian developing cities. The mechanism of the interactions is highlighted, which are the basis for the development of integration approach.

The study has also built a system of goals and objectives, which guide the integrated development. At the same time, **indicators for assessing measures are provided**. The **development of the strategies**, which has gone through a careful process of measure selection and assessment, ensures the resulting strategies meet the developed goal and objectives of integration.

Through the case study of Ho Chi Minh City Metro Line 1, the developed strategies are illustrated with the estimation of impacts. These are examples of how the proposed strategies can be implemented in practice and what could be the potential impacts. The integration approach in transport and urban planning, as well as the proposed strategies, can be applied to other cities and the potential impacts can be compared with Ho Chi Minh City.

The results of this study would be useful for transport planners and authorities to formulate effective strategies for integrated transport and urban development in developing countries.

*** Limitations of the results**

The study has examined problems of lacking coordinated transport and urban development in some Asian developing cities. Data and information are collected from the literature as well as the field survey in Ho Chi Minh City. The results are limited due to the data. Some findings might be subjective and are limited in the sense that they reflect individual viewpoint and opinions.

The review of implemented measures based on some transport and urban related-studies, which might result in an incomplete list of measures. Furthermore, the pre-selection of measures based on the argument of a number of successful case studies. More measures, after being carefully reviewed and assessed, might be taken into account in the future.

The study has developed strategies for integrated transport and urban development in Asian developing cities. The qualitative assessment has been applied to the selection of measures that lack quantitative evidence. Moreover, the assessment indicators are mostly transport related. There are a few urban-related indicators, which reflect the impacts of transport development on the urban side. Further studies are needed to confirm the results of impact assessment by quantitative evidence. Urban-related indicators need to be added for a comprehensive assessment of the integration.

The application for Ho Chi Minh City is limited to Metro Line 1 project. Impact estimation was provided, but not much due to the limited data from available studies. Similar applications, which applies developed measures appropriately, can be conducted in other projects.

7.3 Recommendations

The interactions of transport system and urban form are complicated, which require a comprehensive approach to analysing and assessing. The assessment of measures must base on sets of indicators, which cover both transport and urban aspects. It is essential to have

- Traffic impact studies for urban development measures/projects, and
- Urban development impact studies for transport-related measures/projects.

In order to develop strategies for integrated transport and urban development, measures should be further reviewed, selected and assessed. The review of implemented measures should be expanded for more measures. The pre-selection of measures should consider more cases for selecting the candidate measures. Then, the assessment step, using expert consultation to confirm and prioritise measures, should employ more experts for more convincing results.

For the implementation of strategies, it is recommended that a formal process is established. The process includes specific steps, which can be applied by stakeholders. The process also clarifies responsibilities of relevant organisations and the coordination procedures among organisations.

Public participation in transport and urban planning should be considered to avoid ambitious planning goals and to reduce interest conflicts when implementing the measures.

7.4 Suggestions for further research

To promote integrated transport and urban development in Asian developing cities, the following studies are suggested:

- Quantification of the transport-urban interactions;
- Comprehensive assessment of the mutual impacts of transport development and urban development;
- The process to implement strategies for integrated transport and urban development, including the coordination framework of related organisations.

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List of Abbreviations

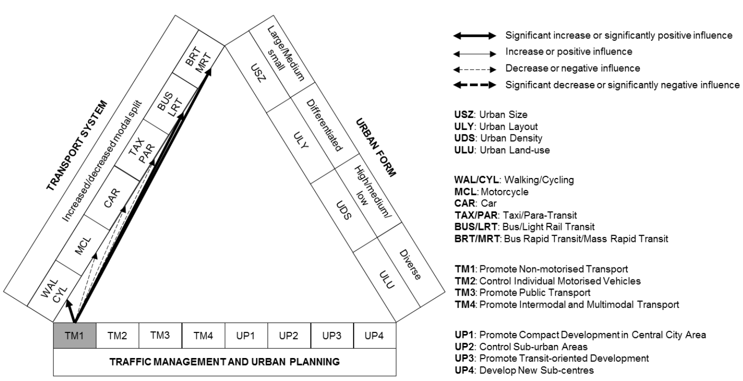
ADCs	Asian Developing Cities
BRT	Bus Rapid Transit
CBD	Central Business District
FAR	Area Ratio Floor Area Ratio
FGSV	Forschungsgesellschaft für Straßen- und Verkehrswesen
ITS	Intelligent Transport System
LRT	Light Rail Transit
MRT	Mass Rapid Transit
TOD	Transit-oriented Development
TM	Traffic Management
UP	Urban Planning

Appendix A - Interactions of transport system and urban form elements

Impacts of package TM1 (Promote Non-motorised Transport) on modal splits

Measures: (1) Facilities for Pedestrians; (2) Pedestrian Zones; (3) Bikeway Networks; and (4) Bicycle-sharing Schemes

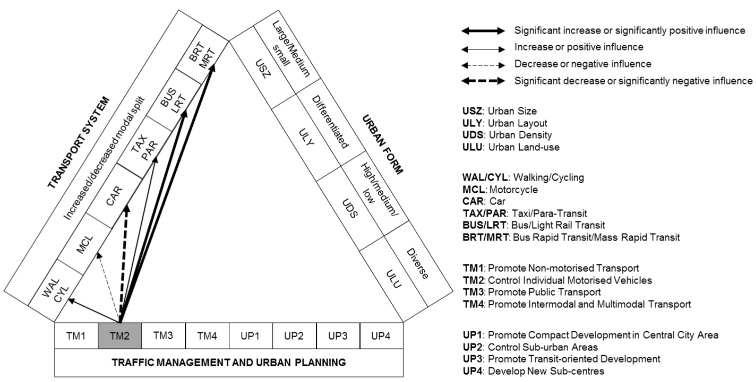
TM1 →WAL/CYL	+ +
TM1 → MCL	-
TM1 → CAR	-
TM1 → TAX/PAR	-
TM1→ BUS/LRT/	+ +
TM1→BRT/MRT	+ +



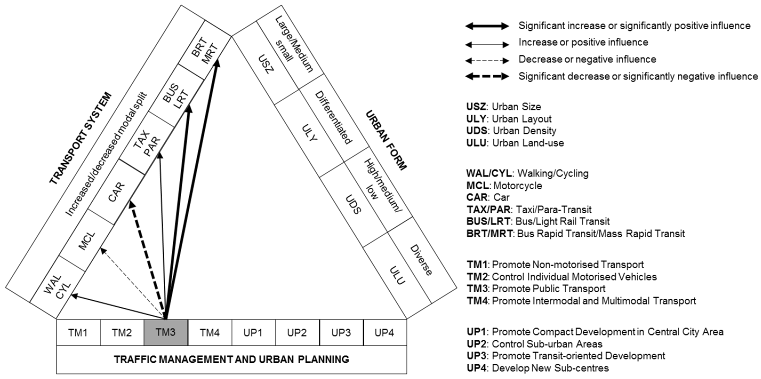
Impacts of Package TM2 (Control Individual Motorised Vehicles) on modal splits

Measures: (1) Vehicle Registration Control; (2) Fees, Taxes and Standards for Individual Motorised Vehicles; (3) Road Pricing for Private Car; (4) Access Control and Traffic Calming; (5) Car Polling and Car Sharing; (6) Parking Pricing; and (7) Parking Restriction.

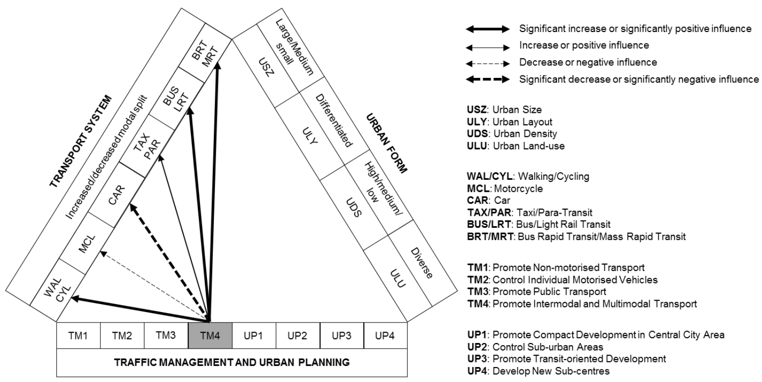
TM2→WAL/CYL	+
TM2 → MCL	-
TM2 → CAR	- -
TM2 → TAX/PAR	+
TM2→ BUS/LRT/	+ +
TM2→ BRT/MRT	+ +



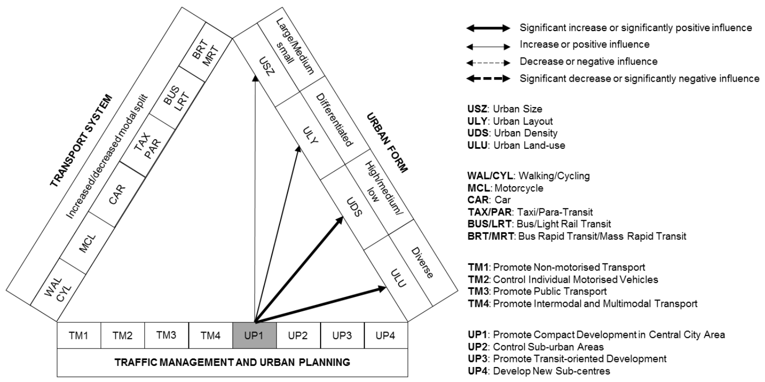
Impacts of Package TM3 (Promote Public Transport) on modal splits Measures: (1) Public Transport Service Improvement; (2) Public Transport Priority Lanes; (3) Public Transport Signal Prioritisation; (4) Public Transport Feeder Services; (5) Pricing Mechanism; and (6) Public Transport Authorities.	
TM3 → WAL/CYL	+
TM3 → MCL	-
TM3 → CAR	- -
TM3 → TAX/PAR	+
TM3 → BUS/LRT/	+ +
TM3 → BRT/MRT	+ +



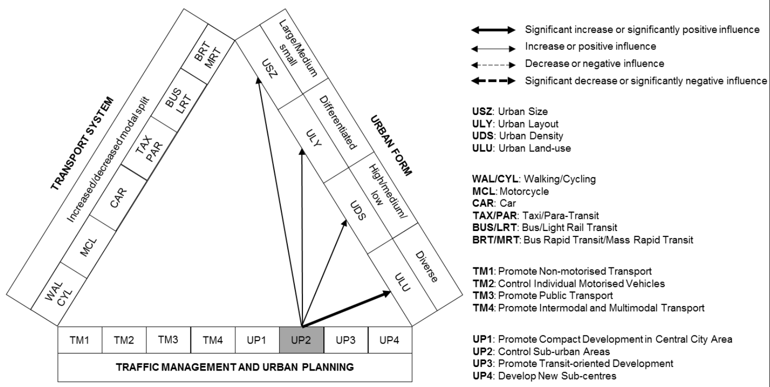
Impacts of Package TM4 (Promote Intermodal and Multimodal Transport) on modal splits Measures: (1) Intersection Traffic Control Systems; (2) Intelligent Transport System; (3) Intermodal Connections Centre; and (4) Park & Ride Systems.	
TM4 →WAL/CYL	+ +
TM4 → MCL	-
TM4 → CAR	- -
TM4 → TAX/PAR	+
TM4 → BUS/LRT/	+ +
TM4 → BRT/MRT	+ +



Impacts of Package UP1 (Promote Compact Development in Central City Area) on urban form elements Measures: (1) Density Increase in Central City Areas; (2) Mixed-use Development in Central City Areas; (3) Layout and Landscape Design in Central City Areas; (4) Urban Growth Boundaries; and (5) Maximum Parking Space Regulations		
Impacts		**Description**
UP1 →USZ	+	
UP1 → ULY	+	
UP1 → UDS	++	
UP1 → ULU	++	

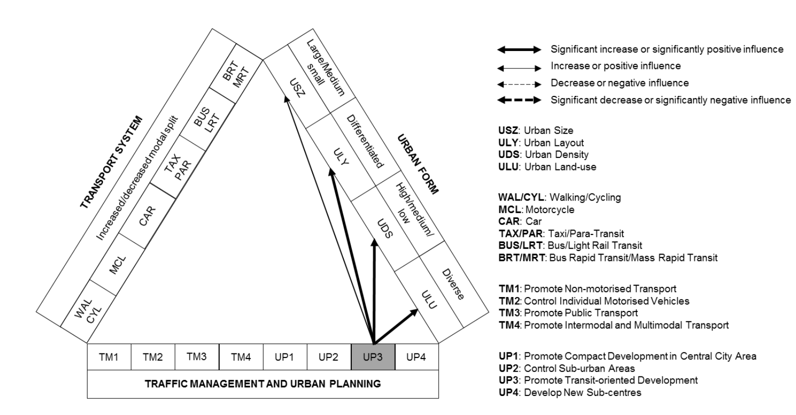


Impacts of Package UP2 (Control Sub-urban Areas) on urban form elements Measures: (1) Density Control in Suburban Areas and (2) Land-use Control in Suburban Areas.		
UP2 → USZ	+	
UP1 → ULY	+	
UP1 → UDS	+	
UP1 → ULU	++	



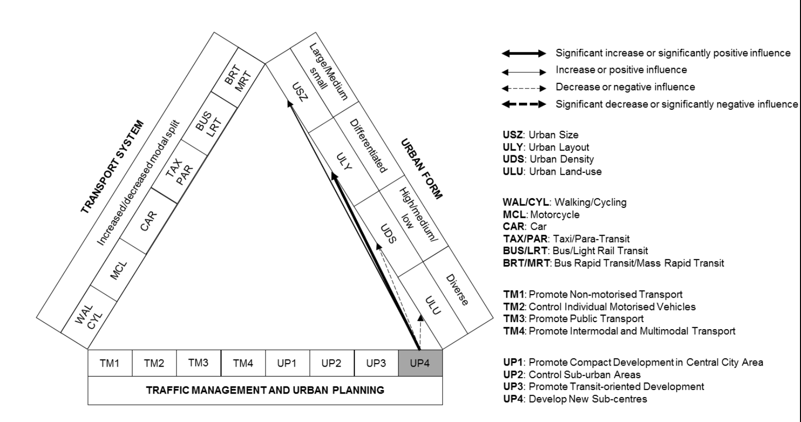
Impacts of Package UP3 (Promote Transit-oriented Development) on urban form elements

Measures (1) Sufficient Spaces for Mass Rapid Transit Lines and Stations and (2) Mixed-use and Compact Development in the Neighbourhoods of MRT Stations.

UP1 → USZ	+	
UP1 → ULY	+ +	
UP1 → UDS	+ +	
UP1 → ULU	+ +	

Impacts of Package UP4 (Develop New sub-centres) on urban form elements

Measures: (1) New Urban Zones Development and (2) Provision of Facilities and Services in Sub-centres

UP1 →USZ	+	
UP1 → ULY	+ +	
UP1 → UDS	-	
UP1 → ULU	-	

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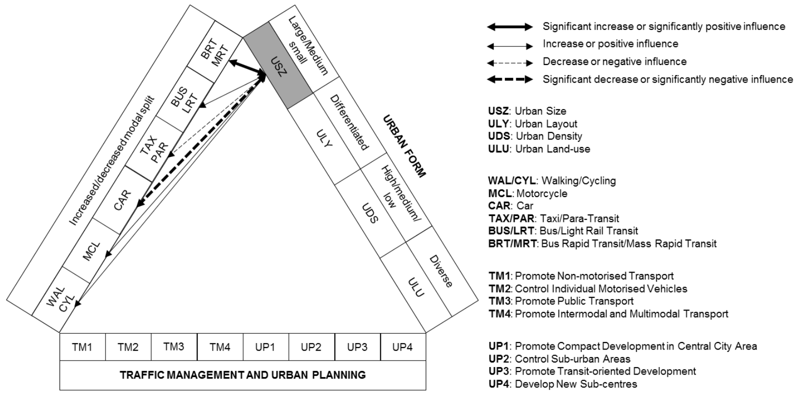
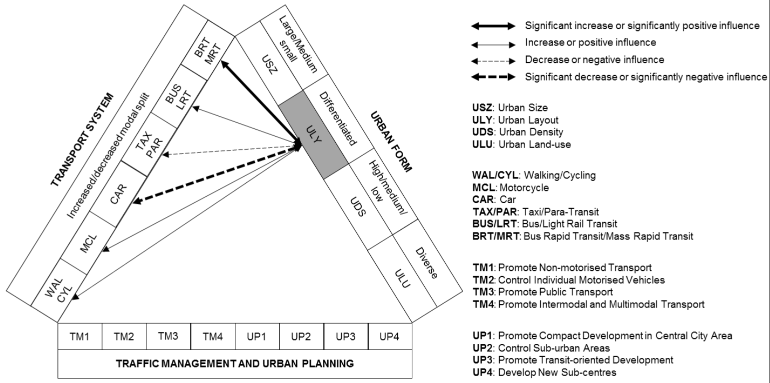
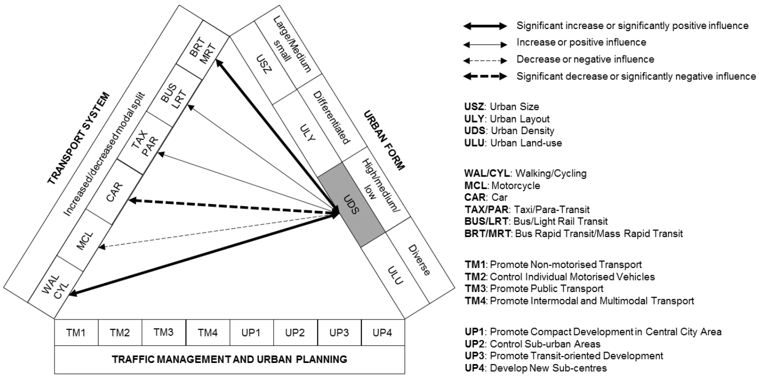
<tr><td>WAL/CYL ←→ USZ</td><td>+</td><td rowspan="6">
</td></tr>
<tr><td>MCL ←→ USZ</td><td>-</td></tr>
<tr><td>CAR ←→ USZ</td><td>- -</td></tr>
<tr><td>TAX/PAR ←→ USZ</td><td>-</td></tr>
<tr><td>BUS/LRT ←→ USZ</td><td>+</td></tr>
<tr><td>BRT/MRT ←→ USZ</td><td>+ +</td></tr>
</table>

<table>
<tr><th colspan="3">Interactions of modal splits and urban layout (ULY)</th></tr>
<tr><td>WAL/CYL←→ ULY</td><td>+</td><td rowspan="6">
</td></tr>
<tr><td>MCL←→ ULY</td><td>-</td></tr>
<tr><td>CAR←→ ULY</td><td>- -</td></tr>
<tr><td>TAX/PAR←→ ULY</td><td>-</td></tr>
<tr><td>BUS/LRT←→ ULY</td><td>+</td></tr>
<tr><td>BRT/MRT←→ ULY</td><td>+ +</td></tr>
</table>

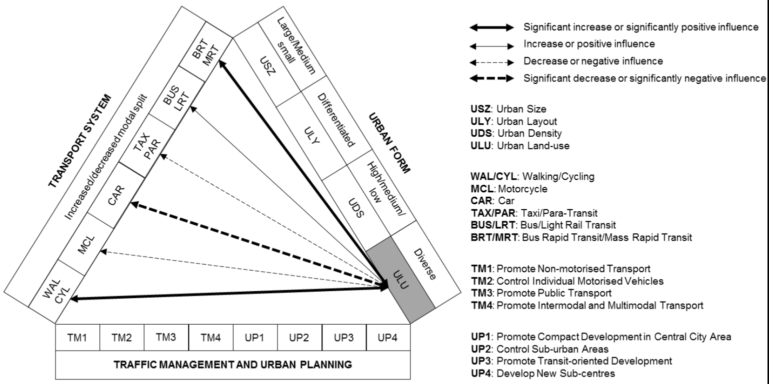
Interactions of modal splits and urban density (UDS)

WAL/CYL←→ UDS	+ +
MCL←→ UDS	+
CAR←→ UDS	- -
TAX/PAR←→ UDS	+
BUS/LRT←→ UDS	+
BRT/MRT←→ UDS	+ +



Interactions of modal splits and urban land-use (ULU)

WAL/CYL←→ ULU	+ +
MCL←→ ULU	+
CAR←→ ULU	- -
TAX/PAR←→ ULU	-
BUS/LRT←→ ULU	+
BRT/MRT←→ ULU	+ +



Appendix B - Case studies

Case study 1 – Taipei

*** Background**

Taipei, the political and commercial centre of Taiwan, has an area of 272.8 km^2, in which nearly 4.5 million people live or travel every day. Motorcycles are used intensively as a daily transport mode in Taiwan. The common use of motorcycles results in transport and urban-related problems. Also, it reduces the effectiveness of investment in public transportation (Chang & Wu, 2008). Facing urban transport problems and the changing environment, Taipei has begun to consider the long-term future based on the concept of a sustainable urban transportation system (Feng, 2001). The major objectives are to improve public transportation and to reduce congestion. The other objectives include improving the environment, reducing the need for highway construction, and improving urban structure. Urban transport connectivity and reliability are improved in Taipei through the implementation of transport and urban network integration strategies.

*** Implemented strategies and results**

(1) Promote non-motorised transport

- **Provision facilities for pedestrians**

  Pedestrians in Taipei have the option of using the sidewalk systems or the arcade systems at the ground level of buildings along many primary or secondary roads. However, sidewalks are narrow or even non-existent in many neighbourhood areas. In recent years, walkways and arcades have been progressively renovated, and barriers in them such as parked motorcycles have been gradually removed. Pedestrian countdown traffic signals at intersections have been widely installed to inform pedestrians of the time remaining to cross the roads. Pedestrian-only traffic signal phasing has been applied at major junctions where having a high volume of pedestrians (Cheng & Sun, 2007).

- **Bikeway system**

  The use of bicycles in Taipei is gradually gaining momentum again after a long decline. Both the city and county have been adding bikeways in or around parks and recreational facilities. A 250-km recreational bikeway system has been completed in the metropolitan area plus a 10-km bike lane system in the new city centre district. Bicycle parking spaces at Rapid Transit stations have been constructed, and bicycles are allowed on Rapid Transit trains under specific provisions (Cheng & Sun, 2007). The proposal of cycling route generates the slow network in urban mobility (Huang, Paris, & Hague, 2009).

(2) Promote public transport

- **A hierarchical public transport network**

  The city's public transportation networks, which include six metro lines and a vast bus network, play an essential role in connecting the city centre and the peripheral areas of Taipei City. The Taipei Mass Rapid Transit network is planned as a combination of radial, circumferential and grid configurations (Cheng, 2001). The layout fits into the planned spatial structure of Taipei Metropolitan Area; a multi-nucleated conurbation served by six corridors. The length of Taipei's Mass Rapid Transit network has expanded from 10.5 km in 1996 to 74.4 km and six lines in 2007. Besides Mass Rapid Transit, Taipei offers a high-density public transportation service; include commuter rail, buses, and taxis. Express bus and exclusive bus lanes are provided where there is no Mass Rapid Transit service. The total ridership of public transport, including bus and Mass Rapid Transit, has grown significantly by around 70% from 1.75 million in 1996 to 2.96 million in 2007. Public transport currently accounts for around 43% of the total urban transport market in Taipei, and this has contributed to the city's higher average travel speed, lower travel time and lower road accident rate (Chang & Yeh, 2007).

- **Feeder service for Mass Rapid Transit**

  To increase the use of the Mass Rapid Transit system, the city government implemented a policy that adjusted the bus routes to better complement the Mass Rapid Transit system. Bus routes are reorganised following Mass Rapid Transit routes. Buses perform as a feeder system where bus routes are parallel with a Mass Rapid Transit route. The grid-type bus network became an essential means for passengers to connect more conveniently to the metro system. Metro stations started to act as public transport hubs and were used as terminals for bus routes. As a result, the planning of the bus routes became oriented toward the shorter distances between metro stations instead of toward longer distance routes.

- **Exclusive bus lanes**

  Because of the higher carrying capacity of buses and increased impediments to smooth traffic flows on existing arterials, bus priority lanes have been implemented to increase bus patronage and to reduce the conflicts between buses and auto vehicles. Eight arterials have exclusive lanes for buses, which results in a chessboard bus network. The total length is 47 km with 114 bus stops near intersections for the safety of patrons. Taipei Department of Transport reported after evaluating the exclusive bus lanes that bus travel speed has increased by 35%, and ridership has increased by 3.85%. According to polls in 1996, more than 70% of Taipei citizens support bus priority lanes.

- **Public transport subsidy**

  To attract more passengers from private transport to public transport, since 1996 the Taipei City Government has implemented a discount scheme for riders transferring from Mass Rapid Transit and then buses, either a feeder bus or a regular bus. In the beginning, the discount was 25% of bus fares, but it provided free transfer from 2000 onwards. This discount scheme has successfully increased the number of Mass Rapid Transit-Bus passengers from 3,000 to 120,000 every day. Taipei City Government provides the subsidy at the beginning, and the subsidisation is given by Taipei Rapid Transit Corporation later.

- **Integrated ticketing systems**

  Taipei City Government has been implementing the contactless smart card since 2002 to provide passengers with a more convenient way to use public transport. The aim is to integrate ticket systems among Mass Rapid Transit, buses, intercity buses and public parking together. The smart card has the characteristics of contactless within 10 cm, large storage memory, better security, and quick data processing. To offer greater convenience to the smart card users, they can go to specialised arrangement shops, Mass Rapid Transit stations or automatic value-added machines to add further value to the card via cash, credit card or cash card. Furthermore, Taipei City Government introduced Building-Operating-Transfer (BOT) to set up the smart card to reduce government expenditure and to make the establishment more efficient. The Government invited public bidding from the private sector to set up the system and to operate the business. Finally, the whole system and business transferred to the government after a certain concession period.

- **Taipei's Department of Transport**

  The Department is responsible for the development of plans to meet urban transport needs of both passengers and goods. The department has one planning office and five divisions dealing with comprehensive planning, traffic engineering, public transport, traffic safety, tourism, and Mass Rapid Transit supervision. Other divisions of the Department of Transport are the Motor Vehicles Inspection Administration, the City Bus Administration, the Parking Management Administration, and the Traffic Engineering Administration. The Department also deals with special problems such as the education and training of drivers, arbitration of vehicle accidents, and traffic adjudication. It is guided and supervised by the Ministry of Transport and Communications, which, on occasions funds special programs.

(3) Transit-friendly intermodal systems

Integration of a sidewalk system and a Mass Rapid Transit system is also an important issue for creating a transit-friendly environment for passengers. A questionnaire conducted by Department of Transport, Taipei City, showed that 50% of passengers walk to and from Mass Rapid Transit stations approximately and half of the passengers transfer to Mass Rapid Transit stations via other modes. The Taipei City Government has planned sidewalk systems that emphasise on an idea of "walkers have the priority; vehicles are next" within 500 m area of a Mass Rapid Transit station. It requires them a minimum width of a sidewalk to be 2.5 m. It also ensures the continuity and without obstruction for the sidewalk systems between these facilities and Mass Rapid Transit stations. In the meantime, Park & Ride facilities for Mass Rapid Transit-Bus passenger are provided at suitable locations.

(4) Land-use planning and control

City zoning regulations have been the major means of guiding land-use patterns and have resulted in a high level of mixed-use developments in Taipei City (Lin & Shin, 2008). These zoning regulations include land-use types and land-use zones. Both commercial and residential zones allow for retail use. For instance, residential zone permits the following land-use types: single-family houses, community recreational facilities, community communication facilities, agriculture, and retail use. The typical land-use pattern in Taipei is mixed use with residential and various commercial uses co-existing in the same building or adjoining sites. In recent years, a major high-tech business corridor is taking shape in Taipei City, causing a significant shift in employment and population toward the eastern districts (Feng & Sun, 2007). Overall, the land use in Taipei City tends to be moderate to heavily mixed-use (Lin & Shin, 2008).

(5) Transit-oriented development

To increase the Mass Rapid Transit ridership, Taipei City Government has updated the zoning ordinance in the Mass Rapid Transit station areas to allow more mix land-uses and to reinforce high-density development. Other tools such as joint development, station area renew plan, circulation plan, and site plan ordinance are applied for supporting Mass Rapid Transit development (Lin & Shin, 2008).

The urban form and transport network planning measure adopted by Taipei's Government has a close relationship with retail patterns. Several studies have verified that zoning regulations have significant effects on urban development, especially on land-use patterns, whereas improvements in transport affect land-use in term of the accessibility of locations (Lin, Feng, and Hu, 2006; Zhu & Liu, 2004). Improvement in transport networks is regarded as a powerful measure for restructuring spatial activities (Tsou and Cheng, 2013).

(6) Develop new sub-centres

The urban form of Taipei is evolving into a tri-centre metropolitan, with an old commercial and administration centre in the western part of the City, a new sub-centre in the eastern part of the City, and another new sub-centre in the County. New sub-centres are connected to the existing centre through the network of Metro and Expressway.

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Case study 2 – Bangkok

*** Background**

Bangkok is a mega city comprising 50 districts with the total area of 1568.74 km^2. The registered population of the city is 10.162 million (BMA, 2009). The rapid growths of population, urbanisation and motorisation have witnessed since 1960. Following the western development pattern, Bangkok had emphasised plans that accelerate economic growth and road infrastructure development without much consideration of land-use. This gradually converted Bangkok into an automobile dependent city and made the city spread outwards (Rujopakarn, 2003). Thus, these have generated many travel demands and excessive longer trips to the city areas of Bangkok because they are the centres of many activities (Vichiensan, 2007).

*** Implemented strategies and results**

(1) Promoting public transport

*** Public transport network**

In Bangkok, two rail transit systems, operated mainly in the central areas of the city, are widely known as Skytrain System (BTS) and Mass Rapid Transit System (MRT) in 1999 and 2004, respectively. BTS is elevated rail system that comprises two main lines with the total of 23.5 km and operated by The Bangkok Transit System Company (BTSC) under the concession from Bangkok Metropolitan Administration (BMA). MRT is the subway line with 20 kilometre-service lengths, operated by Bangkok Metro Public Company Limited (BMPC) under the authorisation of the Mass Rapid Transit Authority of Thailand (MRTA). Beside transit systems, there are bus systems with more than 400 bus routes. Furthermore, some sub-urban people are commuting to the central Bangkok by using sub-urban railway; a service provided by State Railway of Thailand (Vichiensan, 2007). However, the public transport network is inadequate to improve traffic condition in Bangkok.

*** Feeder services for MRT**

Feeder services for Bangkok Mass Rapid Transit systems were proposed to enhance public transport performance (Satiennam et al., 2006). Feeder services include Para-transit (motorcycle-taxi, Songtaew, Silor-lek, Tuk-tuk, and taxi), private vehicles (car and motorcycle), public buses, and vans (Chalermpong and Wibowo, 2007). Since BTS system was established, 13 routes of free shuttle bus service were provided by BTSC and they could handle approximately 20,000 passengers/day. Unfortunately, the free shuttle bus services were reduced to 6 routes in 2001. Finally, there was only one route in September 2004 under the operation of a private company because of financial problem.

(2) Intermodal and Multimodal Transport

In Bangkok, Park & Ride (P&R) and Kiss & Ride (K&R) handled around one-fifth of access trips. Within a 2-kilometre radius from stations, the three most popular access modes to BTS and MRT stations are walking (around 40%), motorcycle-taxi (approximately 30%), and bus (approximately 15%), respectively. The share of walking sharply declined beyond the distance of 400 metres (from 70% to 40%), and less than 20% of travellers walked from the distance longer than 800 metres. Studies on access mode to the stations found that motorcycle-taxi becomes the dominated access mode in the distance beyond 900 metres. The share of motorcycle-taxi rose eminently from 30% to 60% at the access distance beyond 900 metres. Moreover, other motorised modes such as Songtaew (a converted pick-up truck), Silor-lek (a small four-wheel vehicle), bus, etc. also become preferable than walking beyond the distance of 1 kilometre.

(3) New sub-centres development

The new Bangkok International Airport, named Suvarnabhumi Airport, is located 20 kilometres east of Bangkok. The airport full service started in September 2006. There are presently five highway routes to access the airport. There is one railway, connecting the airport to the central city areas. The systems of highway and railway improve accessibility to the regions. So far, land speculation can be observed in the airport vicinity. Previously there were only a few industrial factories and warehouses, but presently a lot of real estates firms are present and developing the high-class residential village, industrial estates, office buildings, etc. The government proposed to develop the airport area for industrial, commercial, and residential uses, covering 521.8 km^2. These areas cover Bangkok Metropolitan Administration and its surrounding cities. Two districts of Bangkok Metropolitan Administration are Ladkrabang and Prawet. Total population in the new city is expected to be 462,100 inhabitants.

(4) Transport administration/organization reform

Thailand has just made a huge transport administration/organisation reform. The actual government has recently merged the scattered transport related agencies into a quasi-single unit under the Ministry of Transport and Communications. However, several agencies remain under the Ministry of Interior. This administration reform is an essential change in the Thai history and certainly, have a significant effect on society. This reform is expected to assist improved coordination of planning issues.

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Case study 3 – Jakarta

*** Background**

Jakarta Metropolitan Area (JMA), the capital of the Republic of Indonesia, is the largest metropolis in Southeast Asia. Today, as a mega-city, Jakarta's nucleus area has spatially and economically expanded beyond its original fringes and has been integrated with four other proximate cities, namely Tangerang (in the west), Bekasi (in the east), Bogor, and Depok (in the south). The metropolitan area has been called "Jabodetabek" since 1999 (Parikesit, 2007). The JMA encompasses a total land area of 6,580 km^2 and a population of

21 million inhabitants. The fast-growing economy and tourism make JMA an attractive destination. Traffic congestion is a chronic problem faced in the Jabodetabek region, and the situation is expected to worsen. At present, the economic loss caused by traffic congestion in the region could be as much as $ 68 million per year due to traffic congestion – and this estimate excludes the impacts of traffic congestion and pollution on human health (Dikun, 2003).

*** Implemented measures and results**

The Transportation Master Plan of JMA focus on two strategies includes (1) Public transport development and (2) Traffic restraint zone.

(1) Public Transport Development

Jakarta Mass Rapid Transit network of rail-based according to plans will be established in approximately 100 km. The Mass Rapid Transit project is a national project organised by the Provincial Government of Jakarta. The Mass Rapid Transit systems are expected to overcome congestion in Jakarta.

The Jakarta Light Rail Transit is a light rail transit system that currently is constructed to connect Jakarta city centre with suburban in Greater Jakarta. A groundbreaking ceremony was held on September 9, 2015, with the first phase of the construction. This phase will be 42.1 km long, which include 18 stations, and expected to be opened to the public by 2018.

Based on the planning of Macro Transportation Patterns in Jakarta, one of the strategies is optimising the mass public transport buses, using Bus Rapid Transit, named TransJakarta. Bus Rapid Transit already established since 2004, development of corridor 1 to 7 had been planned and be constructed in 2004 to 2007. The construction of the corridor 8 to 15 has planned for 2007 to 2010. The busway of the Bus Rapid Transit currently has eight corridors in operation with a total length of 123.35 km. TransJakarta's Bus Rapid Transit was designed to provide the citizens of Jakarta fast public transport system to help reduce rush hour traffic (Sebhatu, Enquist, & Johnson, 2010). This policy was successfully implemented due to an exceptional strong-will of the head of Jakarta's city government. Although it has only been operating since 2004, it is already considered a success in the JMA and a good example for other cities in Indonesia as well as in other developing countries.

The Jakarta city government provided all the initial construction costs for the infrastructure and the buses (Susilo, 2007). In the first year of operation (2004), 15.9 million passengers travelled by this system (approximately 44,000 passengers per day or 3,600 persons/hour/two directions). The average bus way load factor during the week is 91% and during the weekend is 75%, with the highest load factor during the evening peak on weekdays, up to 143% (BP Trans Jakarta Bus Way, 2005).

(2) Traffic Restraint Zone

To reduce traffic jams, some major roads in Jakarta have a "three in one" rule system during rush hours. The policy first introduced in 1992, prohibiting vehicles carrying less than three passengers on certain roads. In 2005, this rule covered the areas of Sudirman and Gatot Subroto. The implementation of this rule has provided new income for some people, who are paid to join a vehicle and boost its number of passengers to the obligatory three. However, the implementation of three-in-one has not been as effective as expected (Mochtar & Hino, 2015).

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Case study 4 - Singapore

*** Background**

Singapore demonstrates a solution for managing motorisation and fostering sustainable urban transport under the pressure of economic development and resource constraints. Singapore has 707.1 km^2 land area, with little natural resources (Singapore Department of Statistics, 2008). The country has been successful in tackling severe traffic congestion due to its comprehensive and highly coordinated land transport policy, which combines integrated land-use and transport planning, and demand management measures (Sim, Malone-Lee, & Chin, 2001).

*** Implemented strategies and results**

(1) Integrated land use and transport planning

The government placed a high priority on solving traffic congestion problems through integrating urban development with a high-quality Mass Rapid Transit system (Newman & Kenworthy, 1996). At the same time, it introduced effective demand management measures to reduce reliance on car usage.

High-density housing and a complementary mix of commercial activities are integrated with an efficient transport system. However, the extensive inter-regional travel will only be reduced when the other regional centres are fully developed, and the availability of jobs and worker mobility complement each other. Government simultaneously introduced severe restrictions on car ownership and use, while dramatically improving public transport (Newman and Kenworthy, 1996).

In 1971, the first concept plan was formulated. This plan guided the integration of transport and land use development. Main features of the Concept Plan 1971 include the organisation of land-use into high-density groups, which are connected through their centres by a planned transport network. A network ring around the central catchment reservoir, accompanied by east-west train lines, was envisaged to link land-use for industrial development and residential new towns (Han, 2005). This ring concept plus the east-west line were later implemented as the first Mass Rapid Transit lines linking the city centre to Woodlands and further to Jurong East in the west, and from Boon Lay to Tampines. Design of other elements in the public transport network and the road system were also integrated with land use through careful coordination in physical planning.

Many researchers claim that this effort at integration has laid the foundation for sustainability in Singapore's transport system. There is macro level coordination between Mass Rapid Transit lines and new towns, and micro level integration around MRT stations (Cervero, 1998 and Newman and Kenworthy, 1999). Richmond (2008, p. 368) provides an example of land use and transport integration at station level by discussion the Sengkang town centre station. Similarly, the physical networks of public transit are integrated using a hub-and-spoke structure (LTA, 2008a). The hubs or town centres are linked by the MRT, while LRT and buses connect the housing estates to the MRT stations. However, it may be that in the efforts to manage the rate of motorisation that adds most to meeting sustainability objectives.

Since the first Master Plan in 1958, there were several other Plans introduced (the Concept Plan 1972 and revised Concept Plan 1991). The land-use and transport relationship were comprehensively addressed through these Plans (URA, 1991). A series of new regional centres was proposed to achieve more employment decentralisation, and thus attain a better home - work relationship. The four regional centres proposed were Tampines in the East, Seletar in the North-East, Woodlands in the North and Jurong-East in the West. These centres were planned as "mini-downtowns" to provide a range of commercial, retail, hotel, entertainment and other facilities within walking distance of the MRT station and the bus interchange. This is a good example of the successful integration of land-use and transport planning. The development of regional centres to become alternative centres of employment to the CBD lead to the reduction of work-travel in terms of the distances travelled and the number of trips generated to the CBD and across the island (Olszewski & Skeates, 1971).

(2) Promoting public transport

*** A hierarchical public transport system**

The Singapore way of promoting public transit is to make public transport a “choice mode” (LTA, 2008a). This means that effort to maintain and extend a convenient and comfortable public transport system takes place alongside policy to control car ownership and usage. The objective is to make the quality, frequency and diversity of the public transit system and its services a viable alternative to the car for a wide array of the population.

Singapore aims to establish and maintain a “world class” transport system, including a high-quality public transport network that occupies a small amount of land but carries a major portion of trips (LTA, 1996). The main components of Singapore’s public transport infrastructure include the Mass Rapid Transit (MRT) as the backbone of the system, the Light Rapid Transit (LRT), buses as feeder services to the MRT, and taxis as high-end services. Singapore’s MRT covers 109 km with 66 stations. The LRT network has 29 km with 33 stations. The MRT and LRT networks form Singapore’s Rapid Transit System (RST). By 2020, LTA plans to double the RST network from 138 km today to 278 km by adding new lines and extensions (LTA, 2008a, p. 6). The average bus fleet operated in 2007 was 3255, and the number of bus routes in operation was 325 (LTA, 2008b). This represents a 36% increase from the number of bus services in 1996 (i.e., 239 services) (LTA, 2008a p. 16). In 2007, there were 24,446 taxis in operation, a 45% increase from the taxi numbers in 1996 (LTA, 2008a).

*** Feeder service for MRT**

The LRT system is smaller in scale and area coverage. Its function is to increase the catchments area of MRT by providing a feeder service. The 8 km Bukit Panjang Light Rapid Transit (BPLRT) system is the first light rapid system in Singapore. BPLRT links residential estates (Bukit Panjang New Town and Teck Whye Estate) and a shopping complex (Ten Mile Junction) to the MRT station at Choa Chu Kang. It has 14 stations. Most of the apartment blocks at Bukit Panjang and Choa Chu Kang are within 400 m from these stations. The Sengkang LRT system (with its East Loop and the West loop) and Punggol LRT system connect to the North-East MRT Line.

*** Increasing the coverage area of MRT and LRT**

One policy is to increase the coverage area by MRT and LRT. The four new lines and extensions planned by the LTA will increase the density of RTS from 31 km per million population to 51 km per million population in 2020 – a density that is ‘comparable to that in cities like New York and London, and surpassing that in Hong Kong and Tokyo’ (LTA, 2008a, p. 34). In 2007 there was 120 km of bus lanes and 7.6 km full-day bus lanes in Singapore (LTA, 2008a). In mid-2008, this was to be extended to 150 and 23 km respectively.

*** Improving public transport services**

A comfortable ride is also emphasised by increasing frequencies of train services, within the limit of operator’s return on investment, so that trains will be less crowded. The current maximum passenger loading is 3.7 pax/sqm, less than the 4.0 pax/sqm in

Hong Kong and the 5.0 pax/sqm in London (LTA, 2008a, p. 36). Even so, the LTA plans to work with the RTS operators to have more frequent services, so that passengers will have a more comfortable ride. These extensions will be integrated with land use outcomes as the MRT links all the new town centres while the new LRT lines will increase the catchment area of MRT stations.

The quality of bus service is emphasised by a management approach that includes service standard and efficiency along with low cost of travel. The Public Transport Council (PTC) set a standard to guide the two main bus operators: the SBS Transit Ltd and Trans-Island Bus Services Ltd (TIBS). Since 1994 the bus companies have been audited every year to check on their performance concerning these standards.

*** Priority traffic signal for public transport**

The LTA has also looked at traffic management to improve bus services. A number of rules and mechanisms have been introduced. These include a priority to buses at more traffic light junctions by fitting more traffic lights with a special bus "B" signal, installing intelligent traffic lights to detect approaching buses so the lights turn green automatically, and introducing more bus lanes (LTA, 1996). The 'B' signal comes on before the green light for other vehicles, which gives buses a head start and allows bus drivers to filter across lanes.

*** Timetable coordination**

The LTA recognises the need to improve scheduling problems associated with transfers. At present, the two bus companies make their schedules with little coordination. This may represent a problem as some routes have poorer frequencies than others. It has been proposed that the LTA take over the role of central bus network planner in 2009, to improve the match between the frequencies of buses and trains so that the waiting time for a transfer will not be more than 10 minutes (LTA, 2008a, pp. 28–31).

*** Low fare**

In terms of travel cost, bus fares are low in Singapore and have had small increases. For example, the increase of bus fare was hardly felt compared to the increase in wages in the period 1986–1996: the bus fare increased 1.5% while real wages increased 7–9% in the period (LTA 1996). A fare rebate was built in the EZ-link card when a transfer is involved. The LTA has planned to introduce a distance-based through-fare structure to enable further savings on public transport fares (LTA, 2008a, p. 31).

(3) Individual motorised transport

*** Control motorisation**

An additional feature in Singapore's policy was the addition of a policy to control motorisation. These faced a complex set of issue. Policies on car ownership, known to researchers as demand management tools, are likely to be unpopular with the public and are probably unfair "in the sense that all motorists must pay them regardless of how much their particular usage patterns contribute to congestion or other impacts" (Barter, 2005, p. 527). Besides, the Singapore Government recognised that there is a space limit that acts as a further constraint for the growth of vehicle population (LTA, 1996). Thus, controls over car ownership were justified not only to achieve efficiency in moving people and goods but also to protect the scarce land. The outcome of the controls on motorisation is perhaps unexpected: the Singaporean government has facilitated a steady increase in the vehicle to population ratio. From 1980 to 1996, the ratio increased from 1:15 to 1:10. In other words, car ownership increased from 67 cars per thousand people to 100 cars per thousand people. This trend is expected to continue so that in 2010 the ratio will be 1:7 or 143 cars per thousand people. Because of this policy, the car population increased 45% in the period 1986–1996. From 1996 to 2006, the car population increased from 3,41,052 to 4,21,904, or by about 24% (LTA, 2007). Hence, this part of the transport policy was not one of simple restriction, but rather of one of managed growth. The approach is outlined in more detail in the following section.

Research has suggested that innovative management policies are needed if a car-dependent transport system is to move some way towards a sustainable transport system (Greene and Wegener, 1997 and Black, 2000). The policy innovations in Singapore are fundamental to the evolution of all parts of its transport network, and thus the Singapore model. The policy has evolved from initial approaches that included high import taxes, registration fees and road taxes, which were not seen as adequate as the road fleet continued to grow (Chin and Smith, 1997) to a sophisticated mix of a vehicle quota system, and road pricing.

*** Demand management**

Regarding demand management, various measures were undertaken to deal with the increased amount of work-travel (distances and number of trips) and reliance on the private car. Another set of measures was aimed at effective travel demand management by controlling vehicle ownership and usage and improving traffic management, such as the Area Licensing Scheme and the Park-and-Ride Scheme (introduced in the 1970s). Results from these measures included the reduction of the number of cars entering the CBD during peak periods. In the 1990s these measures were modified, the Vehicle Quota System, the Electronic Road Pricing and the Car-Sharing Co-operative were introduced which effectively reduced the number of private vehicle ownership and usage.

*** Vehicle quota system (VQS)**

Under the VQS scheme, state planning and market mechanisms work together to allocate vehicles to users and so manage the vehicle population. The government plans for a rate of growth of the vehicle population according to the prevailing traffic condition and road capacity. This rate is translated to the number of new vehicles to be added to each of the vehicle categories (such as cars with engine capacity of less than 1.6 cc; cars with engine capacity of 1.6 cc and greater, taxis, motorcycles etc), taking into consideration the existing vehicle population and the number of vehicles to be deregistered at the end of the preceding year (Koh and Lee, 1994). This determines the supply of the quota. On the demand side, all purchasers of new vehicles are required to bid for a license known as Certificate of Entitlement (COE). A public tender is held twice a month by the Registry of Vehicles (ROV).8 The willingness to pay determines the price of a COE. One COE lasts for ten years. For early deregistration, a COE rebate will be awarded. This rebate is calculated according to the COE premium that the owner paid, prorated by the number of months remaining of the ten years (Phang et al., 1996). From 1 September 2008, car owners are allowed to encash the Preferential Additional Registration Fee (PARF) and Certificate of Entitlement (COE) rebates. This option was not available before as car owners could only use the rebates to off-set their new car purchase. This change was to encourage car owners to shift to public transport users (LTA, 2008c). As such the motorisation policy can be seen as part of a comprehensive approach to transport that includes public transit, which will be discussed in more detail below.

The VQS is effective in controlling the vehicle population in Singapore. In the 1990s, the VQS had successfully reduced the annual growth rate of vehicles to three percent. This was a significantly slower rate of growth compared with an average of 6.8% in the three years under the old policy before 1990 (Sharp, 2005). From 2009, the vehicle population growth rate will be further reduced to an annual 1.5%. This is planned for at least three years before it is reviewed, as the road expansion program slows down from the current 1% per annum to about 0.5% per annum over the next 15 years (LTA, 2008a, p. 9).

*** Road Pricing**

Singapore's road pricing began in 1975 when the Area Licensing Scheme (ALS) was introduced. ALS involved the creation of a permit to solve the congestion problem in the Central Area. It applied to a restricted area which was about 725 ha. This includes Singapore's CBD and its commercial and retail corridor along the 'famed Orchard Road' (Foo, 1997). This is an area with high concentration of jobs, services, and tourists. In 1990, there were about 3,15,000 jobs in the catering, shopping and tourism sectors located within the restricted zone. This high concentration of activities and jobs generates huge travel demand and traffic congestion. The user pay element of the permit charge was expected to reduce this traffic demand by charging all vehicles except ambulances, fire engines, police vehicles and public buses for entering the zone. In operation, all vehicles had to purchase and display a special permit to enter the zone.

Electronic road pricing (ERP) was introduced to replace the permit system in 1998. The main advantage of ERP is convenience and flexibility. This system uses a sophisticated combination of radio-frequency, optical-detection, imaging and smart-card technologies to implement its charges. An in-vehicle unit which can be detected by a road sensor is installed on all vehicles. This unit can process a cash card so that charges are automatically deducted each time the vehicle passes a sensor. The latter is installed on gantries which are visible as entry or exit points of a charging area/road.

The ERP technology is advanced enough to handle multiple vehicles travelling at high speeds (i.e., 120 km per hour or faster).

Statistics show that the ERP is effective in controlling the traffic volumes. In the first month of its operation, the average daily traffic flow during weekdays in the central area fell in volume by more than 20% (Foo, 2000). Traffic speed increased by 10 km per hour from 30 to 35 km per hour under the old ALS to 40–45 km per hour under the new ERP system. On weekends the traffic volumes fell by almost 20%. Experiments with higher ERP charges in selected areas had a further effect on traffic. For example, higher ERP charges, from 3.00 to 5.30 pm on weekdays for Orchard Road, led to 44% fewer motorists. This is a result of route/modal shift and rescheduling of the trips. The ability to vary the charges at different times and on different routes shows another advantage of using ERP as compared to manual road pricing schemes such as ALS (Foo, 2000).

The ERP experience shows that motor vehicle users respond to road pricing in selecting the routes and time to travel. To the Singapore Government, this means that higher growth in car population could now be allowed (Sharp, 2005), as there is confidence that the traffic levels can be managed by the manipulation of ERP costs. In the latest Master Plan of transport in Singapore, LTA "will continue to lower vehicle ownership costs and reply more on usage charges" (LTA, 2008a, p. 57), thus to allow growth in car ownership but to control car use.

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Appendix C – Questionnaire of the Expert Survey

SURVEY ON TRANSPORT - URBAN DEVELOPMENT

The survey is a part of the dissertation of doctoral candidate Nguyen Thi Cam Van, TU Darmstadt, Germany. Study tittle "Strategies for Integrated Transport and Urban Development in Asian Developing Cities"

The survey aims to collect expert's assessment on the effectiveness and applicability of measures.

Information collected from the survey is confidential and only be used for this study.

PART 1

Name: ____

Working place: ______________________________________

Professions: ____

Years of professions: __________________________________

PART 2

Weighting for Effectiveness Assessment (total weighting of 4 objectives is 100%)

Objective 1 "Improve mobility and accessibility"____

Objective 2 "Improve traffic safety"____

Objective 3 "Protect environment and human health"____

Objective 4 "Improve economic efficiency"____

Weighting for Applicability Assessment (total weighting of 4 conflicts is 100%)

Conflict 1 "Cost"____

Conflict 2 "Technology"____

Conflict 3 "Institution"____

Conflict 4 "Public acceptance"____

PART 3

To assess the effectiveness of a measure, please give a point "0" or "1" or "2" or "3"

"0" means the measure is not effective; "1" means the measure has low effectiveness; "2" means the measure has medium effectiveness; "3" means the measure has high effectiveness.

To assess the applicability of a measure, please give a point "0" or "1" or "2" or "3"

"0" means the measure is not applicable; "1" means the measure has low applicability; "2" means the measure has medium applicability; "3" means the measure has high applicability.

No.	Measures	Effectiveness				Applicability			
		Improve mobility and accessibility	Improve traffic safety	Protect environment and human health	Improve economic efficiency	Cost	Technology	Institution	Public Acceptance
1	Facilities for Pedestrians								
2	Pedestrian Zones								
3	Bikeway Networks								
4	Bicycle-sharing Schemes								
5	Vehicle Registration Control								
6	Fees, Taxes and Standards for Individual Motorised Vehicles								
7	Road Pricing for Private Car								
8	Access Control and Traffic Calming								
9	Car Pooling and Car Sharing								
10	Parking Pricing								
11	Parking Restriction								
12	Public Transport Service Improvement								
13	Public Transport Priority Lanes								
14	Public Transport Signal Prioritisation								
15	Public Transport Feeder Services								
16	Pricing Mechanism								
17	Public Transport Authorities								
18	Intersection Traffic Control Systems								
19	Intelligent Transport System								
20	Intermodal Connection Centres								
21	Park & Ride Systems								
22	Density Increase in Central City Areas								
23	Mixed-use Development in Central City Areas								
24	Layout and Landscape Design in Central City Areas								
25	Urban Growth Boundaries								
26	Maximum Parking Space Regulations								

No.	Measures	Effectiveness				Applicability			
		Improve mobility and accessibility	Improve traffic safety	Protect environment and human health	Improve economic efficiency	Cost	Technology	Institution	Public Acceptance
27	Density Control in Suburban Areas								
28	Land-use Control in Suburban Areas								
29	Sufficient Spaces for Mass Rapid Transit Lines and Stations								
30	Mixed-use and Compact Development in the Neighbourhoods of Mass Rapid Transit Stations								
31	New Urban Zones Development								
32	Provision of Facilities and Services in Sub-centres								
33	Integrated Transport Authority								
34	Transport and Urban Authority								
35	Marketing Campaigns and Educational Campaigns								
36	Enforcing Regulations								
37	Monitoring and Improvement								