Parking Management Strategies for Asian Developing Countries

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Abstract

Rapid motorisation with high motorcycle volume is a unique traffic situation in Asian developing countries. The travel behaviour in these countries is dominated by motorcycle-traffic-culture in which the convenience of this transport mode is exploited. With the ability to enter small alleys and to serve door-to-door mobility, motorcycles are excellent in accessibility. They are also relatively small in size, offering manoeuvring flexibility and freedom to park practically nearly anywhere.

At user level, such a motorcycle-dominated culture has resulted in a number of parking issues in Asian developing countries. Transport users are having a unique travel behaviour regarding parking duration, parking searching time and walking distance. The number of private vehicles has been increased while the available space on the roads has remained unchanged, leaving a huge gap between parking supply and demand. Illegal parking occurs frequently in many urban areas, especially central business districts.

At city level, rapid motorisation and its uncertain future growth rate are making the planning for parking a challenge. The parking policy has not only poorly aligned with transport policy but also rarely been a particular focus of policies of urban systems. Furthermore, parking spaces have attracted higher opportunity cost due to increased land price in densely-populated urban areas.

Given the current problematic parking situation in Asian developing countries, parking management is of critical significance and must be addressed. Appropriate parking planning could positively influence destination choice, modal choice, the volume of car traffic, traffic flow quality, and even land-use and urban structure. Proper parking management might significantly contribute to the sustainability of urban transport development.

This study aims to develop parking management strategies for urban areas in Asian developing cities to control motorisation and promote public transport, walking and cycling.

Firstly, the study investigates the parking situation and policies in urban areas of developing countries with a higher focus placed on eight selected Asian cities. Eight principles of parking management are then proposed: 1) Parking policy should align with the overall transport management policy and the urban development policy to ensure the liveability of the cities; 2) Parking policy should be made specific for individual urban zones due to their dissimilar characteristics; 3) Mutual effects of parking policies in neighbouring zones should be considered by implementing an area-wide parking management; 4) Parking demand should be analysed for specific user groups; 5) Qualified demand, which should be satisfied by the parking supply, should be distinguished from the general parking demand; 6) Different parking regulations should be used to prioritise specific user demand groups; 7) The amount of parking supply should be controlled to ensure that not any parts of the supply remain unregulated; and 8) Illegal parking should be avoided by physical measures and strict enforcement of parking regulations.

Secondly, parking planning methodologies are investigated and compared to recommend a method to efficiently analyse parking supply and demand. Data collection in parking studies in Asian developing cities has been a major challenge due to the local rapid motorisation. Two-step planning at macro and micro level is recommended in this study to overcome this

challenge. At macro level, the parking analysis mostly utilises the O-D traffic data within city zones to estimate type and volume of transport mode and required parking spaces. In many Asian cities, data on attraction and modal split of many urban zones are yearly collected. The data can be re-utilised for long period of time. At micro level, the parking analysis helps to verify the planning by analysing parking demand, behaviour and characteristics at typical streets and land use types. The case of Hanoi, focusing on parking supply and demand and parking user's behaviour, is further studied.

Thirdly, potential parking management measures are defined, followed by a thorough discussion on their advantages and disadvantages in the local context. It is argued that a localised parking supply enhancement measure is needed. The concept of para-parking or the legalisation of illegal parking is developed, covering the requirements of different stakeholder groups, detailed parking regulations, strict enforcement of parking, and a parking pricing scheme. Para-parking is positioned as a significant measure which could potentially enhance the sustainable mobility in urban areas of developing cities. It particularly benefits transport planners in the sense that parking resources can be reasonably shared and efficiently utilised and that unplanned land use is controlled. Furthermore, para-parking also helps develop new parking businesses in urban areas while establishing reasonable pricing schemes and effective regulations.

Finally, zone-based parking management strategies are recommended to facilitate the reduction of automobile dependency and promote environment-friendly public transport and non-motorised transport.

In summary, the application of two-step parking planning method, para-parking concept, and zone-based parking management strategies in Asian developing cities would be useful for transport planners and authorities. Those actions facilitate sustainable mobility for all user groups, which has been seen as one of the most important factors for urban development and a vital goal of traffic management.

Kurzfassung

In Entwicklungsländern in Asien herrscht eine einzigartige Verkehrssituation, welche vom schnellen Anstieg des Motorisierungsgrades mit hohem Motorradanteil geprägt ist. Das Reiseverhalten in diesen Ländern ist geprägt von einer Motorrad-Verkehrskultur, in der die Vorzüge dieses Verkehrsmittels ausgeschöpft werden. Mit der Fähigkeit, schmale Gassen zu befahren und Verkehr von Tür zu Tür zu ermöglichen, weisen Motorräder hinsichtlich der Erreichbarkeit ausgezeichnete Eigenschaften auf. Sie sind relativ klein, bieten gute Manövrierbarkeit und die Möglichkeit, nahezu überall zu parken.

Auf Nutzerebene hat eine solche vom Motorrad dominierte Kultur zu einer Reihe von Parkproblemen in asiatischen Entwicklungsländern geführt. Verkehrsteilnehmer weisen ein besonderes Reiseverhalten hinsichtlich Parkdauer, Stellplatzsuchdauer und Länge der Zu- und Abgangswege auf. Die Zahl der Fahrzeuge im Individualverkehr ist gestiegen, während der verfügbare Platz auf den Straßen unverändert geblieben ist, somit besteht eine große Diskrepanz zwischen Parkangebot und -nachfrage. Illegales Parken findet häufig in vielen städtischen Gebieten, insbesondere in zentralen Geschäftsvierteln, statt.

Auf Stadtebene macht die rasche Motorisierung und ihre unbekannte zukünftige Wachstumsrate die Parkraumplanung zu einer Herausforderung. Die Parkpolitik ist nicht bloß schlecht mit der übrigen Verkehrspolitik abgestimmt, sondern war gar selten ein besonderer Schwerpunkt der Stadtpolitik. Außerdem haben Parkplätze aufgrund gestiegener Landpreise in dicht besiedelten Stadtgebieten höhere Opportunitätskosten verursacht.

Angesichts der derzeitigen problematischen Parksituation in den asiatischen Entwicklungsländern ist das Parkmanagement von entscheidender Bedeutung und muss angegangen werden. Eine angemessene Parkplanung könnte die Wahl des Ziels, die Wahl der Verkehrsmittel, das Verkehrsaufkommen, die Verkehrsqualität und sogar die Flächennutzung und die Stadtstruktur positiv beeinflussen. Ein angemessenes Parkmanagement könnte erheblich zur nachhaltigen städtischen Verkehrsentwicklung beitragen.

Diese Studie zielt darauf ab, Parkmanagementstrategien für städtische Gebiete in asiatischen Entwicklungsländern zu entwickeln, um den Motorisierungsgrad zu kontrollieren und den öffentlichen Verkehr, das Zufußgehen und das Radfahren zu fördern.

Im ersten Schritt untersucht die Studie die Parksituation und -politik in städtischen Gebieten von Entwicklungsländern, wobei acht ausgewählte asiatische Städte verstärkt im Fokus stehen. Daraufhin werden acht Prinzipien des Parkmanagements vorgeschlagen: 1) Die Parkpolitik sollte sich an der allgemeinen Verkehrsmanagementpolitik und der Stadtentwicklungspolitik orientieren, um die Lebensqualität der Städte sicherzustellen; 2) Die Parkpolitik sollte für einzelne Stadtgebiete aufgrund ihrer unterschiedlichen Merkmale spezifisch sein; 3) Gegenseitige Auswirkungen der Parkpolitik in benachbarten Gebieten sollten durch die Einführung eines zonenübergreifenden Parkmanagements berücksichtigt werden; 4) Der Parkbedarf sollte für bestimmte Benutzergruppen analysiert werden; 5) Qualifizierter Bedarf, der durch das Parkangebot erfüllt werden sollte, sollte von allgemeinem Parkbedarf unterschieden werden; 6) Es sollten unterschiedliche Parkregeln angewendet werden, um bestimmte Benutzergruppen zu priorisieren; 7) Die Menge an Parkraum sollte kontrolliert werden, um sicherzustellen, dass kein Teil des Parkraumangebots ungeregelt

bleibt; und 8) Illegales Parken sollte durch physische Maßnahmen und strenge Durchsetzung der Parkvorschriften vermieden werden.

Im zweiten Schritt werden Parkplanungsmethodiken untersucht und verglichen, um eine Methode zur effizienten Analyse von Parkangebot und -nachfrage zu empfehlen. Die Datenerhebung im Rahmen von Parkstudien in Städten in asiatischen Entwicklungsländern war aufgrund der lokal schnellen Anstiege der Motorisierungsgrade eine große Herausforderung. Eine zweistufige Planung auf Makro- und Mikroebene wird in dieser Studie empfohlen, um die genannte Herausforderung zu überwinden. Auf der Makroebene nutzt die Parkanalyse überwiegend die Quelle-Ziel-Verkehrsdaten innerhalb der Stadtviertel, um Art und Umfang des Verkehrsaufkommens und der benötigten Parkplätze zu schätzen. In vielen asiatischen Städten werden jährlich Daten über Anziehung und Verkehrsaufteilung vieler städtischer Zonen gesammelt. Die Daten können über einen längeren Zeitraum wiederverwendet werden. Auf Mikroebene hilft die Parkanalyse, die Planung zu überprüfen, indem Parkbedarf, -verhalten und -charakteristika für typische Straßen- und Landnutzungsarten analysiert werden. Der Fall von Hanoi wird vertieft untersucht, hierbei liegt der Fokus auf Parkangebot und -nachfrage, sowie dem Verhalten der Nutzer von Parksystemen.

Im dritten Schritt werden mögliche Parkmanagement-Maßnahmen, gefolgt von einer gründlichen Diskussion ihrer Vor- und Nachteile im lokalen Kontext, definiert. Es wird erörtert, dass eine lokalisierte Maßnahme zur Verbesserung des Parkangebots erforderlich ist. Das Konzept des Para-Parkens, die Legalisierung von illegalen Parkplätzen, wird entwickelt, es umfasst die Bedürfnisse verschiedener Beteiligtengruppen, detaillierte Parkregeln, die strikte Durchsetzung der Parkregeln und ein Parkgebühren-System. Para-Parken ist als bedeutende Maßnahme positioniert, die die nachhaltige Mobilität in städtischen Gebieten von sich entwickelnden Städten potenziell verbessern könnte. Es kommt insbesondere Verkehrsplanern insofern zugute, dass die Parkressourcen sinnvoll verteilt und effizient genutzt werden können, ferner kann ungeplante Landnutzung kontrolliert werden. Para-Parken hilft außerdem, neue wirtschaftliche Aktivitäten bezüglich des Parkens in städtischen Gebieten zu entwickeln und gleichzeitig angemessene Preise und effektive Regelungen zu etablieren.

Abschließend werden zonenbasierte Parkmanagementstrategien empfohlen, um die Verringerung der Abhängigkeit von Personenkraftwagen zu bewirken und umweltfreundliche öffentliche Verkehrsmittel und nichtmotorisierten Verkehr zu fördern.

Zusammenfassend lässt sich sagen, dass die Anwendung der zweistufigen Parkplanungsmethode, das Konzept des Para-Parkens und zonenbasierte Parkmanagementstrategien für Städte in asiatischen Entwicklungsländern für Verkehrsplaner und Behörden von Nutzen wäre. Diese Maßnahmen ermöglichen eine nachhaltige Mobilität für alle Nutzergruppen, was als einer der wichtigsten Faktoren für die Stadtentwicklung und als ein wichtiges Ziel des Verkehrsmanagements angesehen wird.

Glossary

Parking Space	An area to park one vehicle on private grounds or on public grounds.
Parking Lot	An area for parking separated from flowing traffic (public parking place, limited public parking place).
Parking Place	The amount of parking spaces within a given area.
Parking Planning	Covers all planning activities which contribute to the provision of a quantity of parking space seen as useful at the right location and in a suitable operating form.
Parking Management	Action influences parking systems through a bundle of measures to optimise the positive impacts of traffic and transport.
Parking Concept	The planning basis of parking space management. They represent catalogues of measures which are prepared by the municipal authorities and decided by politicians.
Illegal Parking	It is the act of drivers stopping and parking their vehicles in a place restricted by law regulations or in an unauthorized manner. It is against the law virtually.
Illegal Parking Place	The amount of parking spaces used illegally by individuals who offer it to parking users collecting parking fee. The users might not even notice that this is illegal.

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1. Introduction

1.1. Problem statements

Providing sustainable mobility is a vital goal of traffic management. A sustainable mobility for all user groups is one of the most important factors for urban development, especially in cities of Asian developing countries. Among many traffic management measures, parking management is of significant importance. Cautious planning of the parking supply in terms of infrastructure and operation enhances destination choice, modal choice, the volume of car traffic, traffic flow quality, and even land-use and urban structure (FGSV, 2005).

- **Parking challenges in developing cities**

The rapid motorisation with high motorcycle volume is a unique traffic situation in developing countries in Asia. From late 1980s to early 2000s, motorcycle population exponentially grew in Asian countries, for instances, in China by 25% per year, in Vietnam by 15%, in India by 11%, and in Indonesia and Thailand by 9% per year. As a result, Asian cities experienced a rapidly increasing number of motorcycle trips (as % of total motorized trips), remarkably 80-90% in Hanoi and Ho Chi Minh, 60% in Jakarta, and around 30% in Taipei and Bangkok (Morichi & Acharya, 2013). Given that the available space on the roads has remained unchanged, such growth is worsening the parking situation. The construction of public parking spaces has developed slowly and cannot keep up with the demand, which results in a huge gap between parking demand and supply.

Urban zones have specific characteristics regarding population density, traffic demand, and available infrastructure facilities. Parking demand and parking supply are also dissimilar. A typical example for high-density urban areas in developing countries is the Old Quarter Area within the inner ring road of Hanoi (Ring Road I): it only represents 0,3% of the total urban area, but accounts for 13,6% of the total number of trips per day of the entire city (Thanh, 2015). Therefore, a one-fit-all parking management strategy throughout the city seems to be not feasible since it does not conform to traffic situation, parking demand, and parking capacity of each area. Hence the parking facilities are unreasonably shared and an effecient parking demand management is hardly to be achieved.

Transport users in Asian cities have unique parking behaviour relating to walking distance, parking duration, and parking searching time. Since the traffic is dominated by motorcycles (accounting for approximately 85% of the total modal split), travel behaviour is dominated by motorcycle-traffic-culture. Motorcycles provide users with excellent accessibility. They are able to enter small alleys and serve door-to-door mobility. They are also relatively small in size, giving maneuvering flexibility and the freedom to park practically anywhere. Therefore, transport users in many developing countries are much less willing to walk than those in developed countries. They also prefer the lowest parking searching time and are willing to park illegally. On-street parking is dominated by motorcycles. People do not hesitate to park in front of the shops to buy goods in a short time then quickly leave. Illegal parking frequently occurs in central business districts where many small shops are located.

Off-street parking surveys conducted for this study showed that parking duration was different at different land-use types and depended on trip purposes. The longest parking durations were found at office building whereas the shortest were found at shopping malls.

At commercial buildings where both offices and shopping malls are located, all types of short, long and medium intervals were observed.

Illegal motorcycle parking is also the unique parking situation in urban areas of Asian developing countries. Motorcycles are frequently found to be parked at the roadside, across curbs, and on footways and dusty verges (ITDP, 2010). Meanwhile, basement parking lots of many buildings along the street are half empty (P. A. Barter, 2011) because on-street parking is much more convenient (ITDP, 2010). Parking users are charges with high fees for those illegally owned parking spaces. They might not even notice that this is illegal.

Illegal parking occurs partly due to a low investment on transport infrastructure and parking facilities from the central government in developing cities. Overall investment in East Asia and Pacific fell from US$15.9 billion in 2014 to US$13.4 billion in 2015, representing a 16 % decline. Investment in China, Thailand, Indonesia, and Vietnam have declined by more than 50% year over year, contributing to the drop in investment (The World Bank, 2015a). Meanwhile, total investment in infrastructure with private participation in emerging economies in Europe and Central Asia surged by 235% from US$14.5 billion in 2014 to US$48.7 billion in 2015 (The World Bank, 2015b). The question of whether parking should be a part of transport system or a service needs to be urgently addressed.

Asian developing cities are experiencing the lack of ITS (Intelligent Transport System) application in parking information and guidance systems. These smart parking systems typically provide real-time information via changeable message signs (CMSs) to motorists about the number of available parking spaces in parking lots. Illegal parking could be reduced as vehicles were absorbed into the parking lots (Kurogo, Takada, & Akiyama, 1995). Smart parking management systems have been implemented in numerous European and Japanese cities in order to better exploit parking capacity (Shaheen & Kemmerer, 2008). However, the application of these advanced technologies is limited in Asian developing cities (Idris, Leng, Tamil, Noor, & Razak, 2009).

- **Challenges of parking policies**

In Asian developing cities, rapid motorisation and its uncertain future development speed are challenges for parking planning (P. A. Barter, 2012a). In Germany and some other European countries, short-term transport planning is normally made for 5-8 years; and long-term planning is prepared for the next 20-30 years (Köhler, 1995). Traffic growth rate in these countries is about 2-3% (Baron, 1995). However, the 8-9% of motorisation growth rate in Asian developing countries has made transport planning and parking planning uncertain. The demand forecast is hardly made with adequate accuracy level.

Parking has rarely been a particular focus of transport policies or policies of urban systems in general. Parking policies are usually made solely by local governments under regional influences. They can even conflict with other transport policies that attempt to reduce congestion or increase the use of transit or ridesharing (G.Shaw, 1997). In Asian developing cities, they are seldom consistent with urban and transport policies.

Land prices are high in Asian developing cities due to high urban densities. Parking spaces, therefore, have attracted higher opportunity cost (P. A. Barter, 2011). Population density (representing by persons per urbanised hectare) in Mumbai was 97 persons/hectare, Shanghai

134, Manila 106, Jakarta105, Hochiminh 95 and Bangkok 65. The numbers are much different in Western cities, such as Berlin 38 persons/hectare, Paris 36 persons/hectare and Munich 31 persons/hectare (Ken Gwilliam, 2015). It is more expensive to park at denser population areas. As a result, the flat parking fee throughout the city becomes unsuitable.

In many urban areas like Hanoi, Hochiminh, Jakarta, and Manila, minimum parking requirement is regularly used. Parking is mostly free at public on-street parking (ITDP, 2010); off-street parking has a flat parking fee. As such, attracting private investment in off-street parking supply has proven unrealistic. Drivers can park for free on streets because paid parking slots are not sufficient or illegal parking is not enforced (ADB, 2015). ADB has recommended for Beijing that a parking space should be a commodity, not a fundamental right. The government should not be responsible for providing ample parking to residents. Rather, it should be responsible for well-organized traffic and streets (ADB, 2015). The government should also be responsible for making the right policies for off-street parking supply in which real estate developers and private investors play an important role. Finding a parking space is mainly the driver's own responsibility. Space is to be rented from the government (on-street) or building operator (private off-street) at a price that reflects its value and enforces the government's targets for traffic reduction. In many developed cities, parking fee is increased to subsidise bus fare, making it more attractive. The revenue from parking charge surge is used for expanding public transport system (Enoch, 2002; Groote, Ommeren, & Koster, 2016).

In the current situation, once parking management strategies are appropriately implemented in Asian developing countries, parking resources can be reasonably shared and efficiently utilised, illegal parking can be controlled, and the goal of sustainable mobility to some extent can be reached.

1.2. Goal and objectives

This study aims to develop parking management strategies for urban areas in Asian developing cities to control the motorisation as well as to promote the development of public transport, including the development of a new para-parking concept for short-term parking planning. This goal can be divided into the following objectives:

- Understand the unique features of parking situation then develop the principles of parking management;
- Develop a parking planning method to efficiently analyse parking supply and parking demand;
- Investigate potential parking management measures and strategies to adapt for the context of developing countries.

1.3. Scope of the study

Research has been conducted on parking management strategies in Asian developed cities. However, the number of such research in developing cities with their unique traffic features has been limited. Rapid motorisation, automobile dependency, extremely high traffic densities, and frequent occurrence of illegal parking have been identified as major mobility problems. Many measures implemented in developed cities are not feasible in Asian developing cities.

The study mainly focuses on the possible parking management strategies and measures which are directly relevant to local mobility prominence and could practically be applied in Asian developing cities. The general assessment of the traffic situation and parking challenges are limited to eight Asian cities. A wider selection of data is not feasible due to time and budget restrictions. The discussion on a wider application of research findings in other developing countries has been made. The comprehensive analysis, however, is recommended for further research.

1.4. Methodology and structure of the study

The methodological approach and the structure of this study are presented in Figure 1-1:

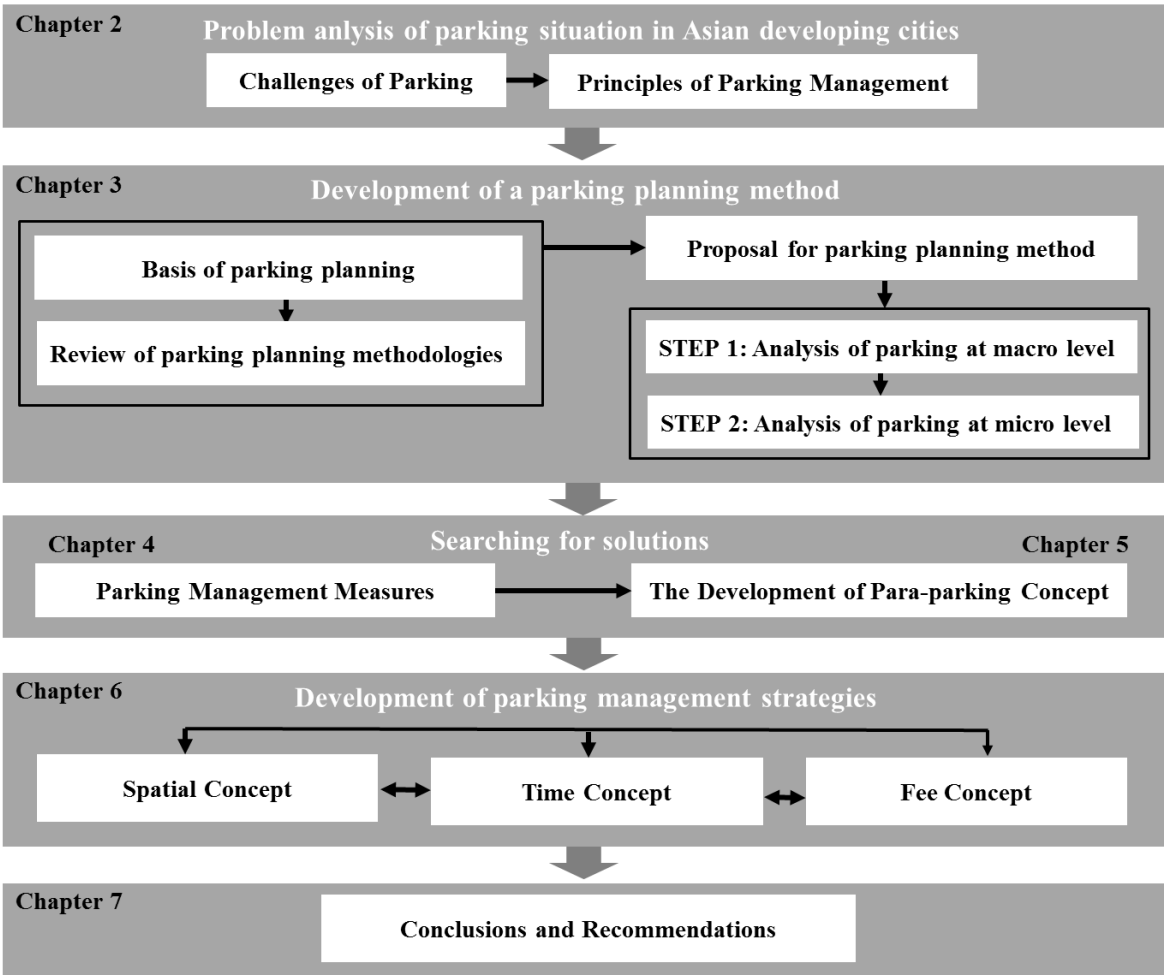

Figure 1-1: Structure of the study

The principles of parking management are presented in **Chapter 2** through analysing parking situation and policies in urban areas of selected Asian developing cities and highlighting the phenomenon of illegal parking.

In **Chapter 3**, different parking planning methodologies are investigated and compared to recommend a method to analyse parking supply and parking demand efficiently for developing cities. The study then goes further on analysing the case of Hanoi, focusing on parking supply and demand, and parking users' behaviour.

In **Chapter 4,** international research on the impacts of parking policies on different parking demand group is investigated and potential parking management measures are defined. The

need for developing a new parking supply enhancement measure through the legalisation of illegal parking is then highlighted.

A more detailed investigation of a parking supply enhancement measure is done in **Chapter 5**. A SWOT analysis is undertaken to look at opportunities, risks, and forms of para-parking. Afterwards, the change process – a linkage between official regulation and reality involving parking authorities, parking operators, and parking users to successfully legalize the illegal parking - is framed. A proposal for para-parking requirements including parking regulations and pricing schemes is given. Finally, a qualitative assessment of the impact of parking supply enhancement measures is introduced.

In **Chapter 6,** parking management strategies based on the parking zoning concept are developed. After conceptual parking management strategies are framed for specific zones, parking measures are selected for particular strategies with the application for Hanoi.

The conclusions and recommendations of the study are provided in **Chapter 7**. The extended application of research outcomes for worldwide developing countries is also emphasised. Finally, the significance and limitations of the study are explained.

2. Specifics of Parking Management for Asian Developing Countries

The purpose of this chapter is to investigate the key challenges of the parking situation and parking policies in developing cities, then propose the principles of parking management. Firstly, urban transport characteristics and parking condition, with a higher focus on eight Asian developing cities (Bangkok, Guangzhou, Hanoi, Hochiminh, Jakarta, Kuala Lumpur, Manila, and Taipei), are examined. Secondly, parking management policies in such cities are reviewed and compared; afterwards, the unique phenomenon is identified. Finally, the principles and the major objectives of parking management for Asian developing cities are suggested.

2.1. Challenges of the parking situation in Asia

To guide transport planners to develop an effective parking management system, the study identifies unique features of parking in developing cities with higher focus placed on eight Asian cities. They do share a range of characteristics as well as representing the characteristics of Asia region. They all have: (a) large and relatively young populations; (b) large cities (including megacities) and/or recent trends in rapid urbanization; (c) rapidly growing economies; and (d) high levels of transport-related externalities such as pollution, accidents, and congestion.

Major demographic factors of seven countries, of which eight cities in seven countries were selected for this study, are presented in Table 2-1 below.

Table 2-1: Demographic factors of selected seven countries

No.	Country	Area (km^2)	Population (2016)	Population Density (inhabitants /km^2)	GDP (nominal), million USD (2016)	GDP (nominal) per capita, USD (2016)	Cities selected for the study
1	Thailand	513,120	68,981,000	135	390,592	$5,662	Bangkok
2	China	9,596,961	1,373,541,278	147	11,383,000	$8,239	Guangzhou
3	Malaysia	329,847	30,751,602	95	302,748	$9,546	Kuala Lumpur
4	Vietnam	331,210	92,637,200	299	200,493	$2,164	Hanoi, Hochiminh
5	Indonesia	1,904,569	258,802,000	144	940,953	$3,636	Jakarta
6	Philippines	342,353	102,904,637	347	311,687	$2,991	Manila
7	Taiwan	36,193	23,519,518	649	588,334	$24,985	Taipei

Source: The World Bank (2016)

It is suggested that no transport approach can address all the issues and that a well-constructed plan can help generate a policy that incorporates all the relevant factors.

2.1.1. Rapid motorisation and automobile dependency

Rapid growth in vehicle ownership and usage has been a big challenge in many Asian developing cities. The changes in population, road density, the density of bus, BRT and rail

during the past two decades (1990-2010) are shown in Table 2-2. Asian cities have been featured with high urban density.

Table 2-2: Changes in key urban transport factors between1990 and 2010

Key factors	Year	Bangkok	Guangzhou	Hanoi	Jakarta	Taipei	Seoul	Tokyo-to
Population density	1990	3,500	..	4,800	14,000	10,000	17,500	5,600
(inhabitants/km^2)	2010	3,800	14,500	8,500	14,400	9,600	17,300	6,200
Road density	1990	2,430	2,610	3,000	9,830	5,330	12,180	10,920
(m/ km^2)	2010	2,600	6,410	3,510	9,650	5,670	13,390	11,560
Road length /population	1990	686.5	592.5	389.3	756.9	545.6	695	1947.1
(M/1.000pop.)	2010	717.6	1143.8	327.6	695	587.8	774.2	1872.1
No.buses /Population	1990	1,477.1	998.9	72.7	..	1,038.0	802.2	..
(Bus/million pop.)	2010	1,193.5	1,313.8	272.8	1,405.3	1,549.8	889.4	..
BRT route length/population	1990	0	0	0	0	4.17	..	..
(Km/million pop.)	2010	2.75	4	0	13.37	5.19	15.74	..
Rail length /population	1990	4.15	2.8	0	..	4.03	27.48	66.02
(Km/million pop.)	2010	7.36	29.87	0	4.93	28.9	47.11	85.36

Source: (Vu, 2012)

- **Road infrastructure**

Road capacity is insufficient in most developing cities due to the slow expansion of road networks. The current road densities in such cities range from 35 m/ha (Hanoi) to 64 m/ha (Guangzhou), much lower than the densities in US cities in 1990 which is 88 m/ha on average. The high population density and the low road density are the central underlying reasons for a low supply of road length over population in every city, including Tokyo. Road length per 1,000 population ranges from more than 300m (Hanoi) to nearly 800m (Seoul). Those figures are much lower than the average levels in European cities (2,400m) and the US cities (6,800m) in the 1990s. Narrow home access roads have made many residential areas only accessible by motorcycles and bicycles. In Hanoi for example, half of the access roads have been alleys narrower than 3m for the past five years. The fairly poor road infrastructures in Asian cities, while challenging private car ownership and use in the long term, seem favourable conditions for the use of motorcycles.

- **Bus services**

Bus has been a key means of public transport in the developing cities. However, the service appears unable to meet the increasing travel demand. Currently, the bus supply level in Hanoi (270 bus/million population) is still far below the standard (1,000 bus/million population) even though the city has expanded the bus network by three times during the past decade. In Jakarta and Bangkok, the supply has even been lower. The operators in the two cities have failed to renew and expand bus fleets due to low fare regulation and declines in bus ridership. In contrast, Guangzhou, Seoul, and Taipei have successfully increased their bus supply to higher-than-standard levels. Bus rapid transit (BRT) has also been introduced. Seoul has the biggest BRT network which provides about 16 km per million population. Jakarta has

developed 10 BRT routes since 2004 and now provides about 13 km per million population. Taipei follows with more than 5km per million population. Bangkok just opened its first BRT route in 2010 and Hanoi is now planning for one.

- **Urban railway services**

In developed countries, extensive urban rail networks had already been established before the motorisation gained momentum. This made it possible to maintain high-quality public transport and dampen the speed of motorisation. In Asia, good experiences could be found in Tokyo and Seoul where their extensive railway networks provide about 86 km and 47 km per million population respectively.

Given the high urban densities, railway services should play an important role in the public transport system. However, in most Asian megacities, urban rail network is yet to be fully developed. The main public transport mode is still the conventional bus which is unable to provide users with the comfort and convenience of private modes (Morichi, 2005). Hanoi and Ho Chi Minh City have no urban railways at the moment. Jakarta upgraded 5 commuter rail lines since the 1980s but failed to introduce new ones for the past two decades. Bangkok introduced two SkyTrain lines in 1999 and one subway in 2004 but made no progress until the opening of the airport-link line in 2010. Urban railway supplies are low in these two cities with about 5 km per million population in Jakarta and more than 7 km per million population in Bangkok. In contrast, Taipei and Guangzhou have drastically expanded subway networks since the mid-1990s and currently provided 102km (9 lines) and 236 km (8 lines) respectively. The supply level in these cities is approximately 29-30 km per million population. Once urban railway systems are enhanced in both quality and quantity, the high travel demand could be met and, at the same time, the management of motorcycles could be supported. In turn, motorisation could be further accelerated since using a car now appears to be a necessity rather than a choice.

- **Rapid motorisation of motorcycles and cars**

The motorisation rate is defined as the number of passenger cars or motorcycles per 1,000 inhabitants. Motorcycle ownership rate in Asia increased rapidly during 1990-2010. For example, it increased from 100 to 700 in Jakarta, 100 to 600 in Hanoi and from 120 to 400 in Bangkok (Vu, 2012). The ownership rates in Hanoi and Jakarta are remarkably high given their low incomes per capita. The rate in Taipei has significantly increased from 240 to over 400 during the period despite its high incomes per capita. In contrast, the ownership rate in Guangzhou increased to more than 150 in 2004 and then has recently declined to 75 thanks to the continuous improvements in public transport services and the banning of motorcycles. In Tokyo and Seoul, the rates have always been lower than 40.

Private passenger car ownership has been increasing in the developing cities. For instance, the ownership rate increased from 110 to 350 in Bangkok, 60 to 240 in Jakarta and from 10 to 140 in Guangzhou. The ownership rate of Bangkok took over that of Tokyo in early 2000s and the ownership of Jakarta recently almost equalled that of Tokyo despite their much lower incomes per capita (Vu, 2012). Car ownership in Taipei has saturated with a level of 220 cars per thousand people. This phenomenon might be explained by the high motorcycle ownership, and the lack of road infrastructure and parking spaces.

- **Modal splits and mode choice behaviour**

The people's mode choice behaviours have been different across the case studies. Motorcycles are chosen for many purposes, including commuting, shopping, private business, delivery services and accessing transit stations. In Hanoi, the share of the motorcycle has remained more than 80% due to the poor bus services (Vu, 2012). In Jakarta, despite the improved bus services, motorcycle share has dramatically increased from 26% to 63% during 2002-2010. In Bangkok, the figure has increased from 18% to 27% during 1990-2010. The share in Taipei has remained at above 30% for decades although its public transport services have been fairly good. In contrast, motorcycle share in Guangzhou has started to decline from 31% (2003) to 7% recently. The rates have always been minor (2-3%) in Tokyo and Seoul thanks to their efficient public transport services (Vu, 2012). People in these two cities tend to use motorcycles for short trips, such as shopping near home, doing delivery services or accessing railway stations and bus stops.

In summary, road infrastructure and public transport services in Asian developing cities, despite recent improvements, have remained inadequate. Car and motorcycle ownership rates have increased rapidly even at the current low incomes per capita. The rates are likely to continue increasing at the higher incomes. Unless actions are taken to boost the infrastructure and public transport system, private vehicles will still be preferred alternatives. Thus, Asian developing cities are strongly recommended to carefully formulate and aggressively implement policy solutions. Parking management must be the critical measure for managing motorisation, reducing automobile dependency, and encouraging public transport development in the long-term.

2.1.2. Regular occurrence of illegal parking

Illegal parking is an issue in many cities in the world. In Asian developing cities, managing on-street and illegal parking has gained little attention. There is limited incentive for drivers to park off-street. Little restriction has been places on long-term on-street parking, leading to high parking occupancies and low turnover rate in streets (ADB, 2015). Illegal parking significantly affects the quality of urban traffic and pedestrian sidewalk. There are two typical forms of illegal parking including illegal parking vehicles and illegal parking spaces.

Illegal parking vehicles are those being parked illegally and parking users pay almost nothing for the parking services. Parking violations may be non-compliance to parking fee payment or parking in a location where parking is not allowed, such as mixed traffic lanes, bike lanes, and sidewalks. Illegal parking spaces are those utilised by third actors for parking business. Owners of parking spaces get parking fees from users although they do not have official permissions and often do not fulfil any standard.

A study on parking problems of Beijing defined illegal parking as a prominent one in cities of China (X. Zhang, 2005). Illegal parking, according to Zhang, occupied the spaces of roads and caused imbalanced demand of garage parking and curbside parking. The prevalence of illegal parking was mainly due to parking supply shortage and the lack of parking information. The improper urban planning also contributed to this problem.

In Makati CBD, on-street parking facilities are widely used for short-term businesses. Sufficient parking slots for vehicles, motorcycles, and food trailers are provided in Makati

CBD. However, on-street parking in Ermita-Malate is not efficiently used. People in Ermita-Malate tend to park anywhere possible. The lack of off-street parking facilities forces drivers to park on-street even when it is prohibited in some areas (Bulactial & Dizon, 2013).

Illegally parked vehicles negatively affect traffic quality. However, illegal parking spaces, if comprehensively investigated, might be recognised as a chance for urban traffic development since they can contribute to overcoming the parking supply shortage.

2.1.3. Unique parking behaviour

Various aspects of parking behaviour (including parking duration, parking searching time, walking distance, and the willingness to pay for the parking fee) have been investigated in many types of research all over the world.

Parking fee significantly influences the selection of parking location and mode choice. A paper of Axhausen & Polak (K. W. Axhausen & Polak, 1991a) presented two studies carried out in the United Kingdom and Germany addressing this issue. Both studies used a stated preference approach in order to collect disaggregate data on travellers' responses to changes in parking attributes and used these data to build simple logit models of parking type choice. The results obtained strongly indicated the need to separately identify the costs associated with different components of the parking activity (e.g., general in-vehicle time, parking search time, egress time) and also pointed to the existence of significant differences in the relative valuation of these components across different journey purposes.

Searching time has been investigated in numerous studies worldwide. In 1997, Teknomo and Hokao introduced a multinomial logit model for the choice between an on-street parking space, off-street parking lot, and an off-street, multi-storey parking facility. The model had its basis in an RP survey among 528 drivers who parked in the centre of Surabaya, Indonesia. According to the model results, the choices made among parking types related to search and queue time, walk time, and parking charge (Teknomo & Hokao, 1997).

Walking distance from parking stall to the destination also affects the selection of parking location. Van der Goot (Van Der Goot, 1982) also presented a multinomial logit model for the choice among 22 parking alternatives that included illegal parking; off-street, multi-story parking; and parking in on-street and off-street lots. The data set had its basis in an RP survey among drivers in the centre of Haarlem, Netherlands. The results confirmed the importance of the walk time from the parking stall to the destination and an inherent preference for off-street parking.

However, the analysis of selected eight Asian cities has revealed that transport users in Asian cities have unique parking behaviour. Accounting for 85% of total modal split, motorcycles are dominant in many Asian cities. With small size, motorcycles can access into small alleys. Therefore, the willingness to walk of transport users in developing cities is much less than those in developed urban areas, within less than 500m equivalent to about 6-8 minutes walking (Truong & Friedrich, 2016). They also prefer the lowest parking searching time and willing to park illegally, particularly for short-duration of 10-15 minutes.

On-street parking is dominated by motorcycles. People do not hesitate to park in front of the shops to buy goods in a short time. Illegal parking occurs regularly in many areas of centre

business districts where many small shops locate along the streets. The lack of police enforcement also contributes to the illegal parking problem.

Based on the off-street parking surveys conducted by the author from June to August 2016, parking duration is dissimilar at different land-use types and depends on trip purposes. At office buildings, the majority of vehicles have very long parking duration (over 8 hours) with 60%; parking duration between 4-8 hours also takes 26%; only 3% vehicles parks less than one hour. On the contrary, the distribution of parking duration is quite similar to that at commercial buildings (utilised for both offices and shopping malls). There is 20% of vehicle parking longer than 8 hours; 14% of vehicles have long parking (between 4h-8h) while 35% of vehicles have medium parking duration (2h-4h). Parking at the shopping mall is dominated by short duration (between 1h-4h) with 76%; only 12% of vehicles have long parking duration (between 4h-8h); and a similar percentage of vehicles park less than one hour.

The willingness to park illegally, particularly on-street and when police enforcement is not seen, is also the unique parking behaviour in urban areas of Asian developing countries. The results of a parking analysis project in Harbin Daoli (China) showed that nearly half of parking occurred informally, usually on walkways and in building setbacks. More than 3,300 cars were found to park on walkways and in setbacks in the Daoli study area during peak times. Adding new off-street parking would have little or no impact on either parking availability or walkway parking. There is ample parking in underground garages already, but drivers continue to park on the walkway, presumably to save money and because it is most convenient (ITDP, 2010).

High parking demand but limited land capacity and low police enforcement are main reasons for illegal parking. Illegal parking could lead to reduced traffic speeds, traffic volume/capacity loss (quality of traffic flow), delays or local congestions, changes in modal choice, loss of revenue from valid parking spaces, a decline in respect for the law compliance and even to accidents (Kevin & Polak, 1992).

The analysis of eight selected Asian studies confirmed unique locals' parking features: strong preference to use motorcycles, willingness to park on-street illegally for short parking duration. It also point to the fact that the parking issues could not be solved by simply adding new parking spaces. The current situation calls for appropriately localised parking management measures.

2.1.4. The parking dissimilarity in different urban zones

Parking characteristics are diverse in different urban zones. The core city centres have unique features of high population density, high traffic demand, mixed and compact land-use, high land price, and excellent provision of public transport service. Therefore, those zones are traffic restricted areas in many Asian cities. Illegal on-street parking is popular. Police enforcements are low. Ermita-Malate and Makati Central Business District (CBD), two centres of business and commerce in the Philippines, are examples. On-street parking is extremely high in Ermita-Malate even it is not allowed. In Makati, on-street parking facilities are widely used for short-term businesses, therefore vehicles are parked disorderly (Bulactial & Dizon, 2013).

Other periphery zones have medium population density, average traffic demand, single use area, medium-to-low land price, and merely provision of public transport service. Therefore, they are categorised from partly restricted to normal traffic area. The parking scarcity is not so popular since public lands are still available.

As a typical example, Beijing is mainly composed of three kinds of areas with different characteristics, namely the old urban area, the built-up area and the new peripheral area. The old urban area within the 2nd Ring Road is only 12% as large as that of the built-up urban area but accounts for 25% of the total travel volume of the entire city (YE et al., 2009).

Land-use characteristics, transport conditions, parking conditions and other influential factors have to be considered in order to zone the city for parking purpose in a differentiated manner, i.e., for differentiated parking zoning. In the current context, a one-fits-all standard is in force for parking supply throughout the cities irrationalising the configuration of parking resources. Differentiated parking policies should be considered.

2.1.5. Low investment on parking facilities from government

Continuous growth of travel demand calls for a huge investment in the transport infrastructure. The financing of transport systems, where parking facilities are part of, has become a problem for many Asian societies. The World Bank reported that there was a low investment on transport infrastructure from the central government in Asian developing cities (The World Bank, 2015a). Overall investment in East Asia and Pacific fell from US$15.9 billion in 2014 to US$13.4 billion in 2015, representing a 16% decline. Investment in China, Thailand, Indonesia, and Vietnam has declined by more than 50% year. At the same time, total investment in infrastructure with private participation in emerging economies in Europe and Central Asia surged by 235% to US$48.7 billion in 2015, a dramatic leap from US$14.5 billion in 2014 (The World Bank, 2015b).

Investment in parking facilities is a heavy burden on many Asian local governments (de Jong et al, 2010; Hwang, Zhao, & Gay, 2013; Puri, 2003; Willoughby, 2013). Parking facilities have been planned for both short-term and long-term vision at many locations in the cities. However, very few parking projects have been implemented. For instance, Hanoi has had a plan for parking space: seven inner-city districts are supposed to have 34 parking spaces, with a total area of 205.838m^2 that can serve 13,588 vehicles. However, the plan has been a complete failure, according to the Report of the sixth session of the Hanoi City People's Council in 2012. All the parking places have become shopping centres, condominiums or office buildings.

Parking projects are hardly to be implemented because of many reasons. One important reason is that the parking fees are regulated to be lower than what the investors expect. Table 2-3 provides insights on the dissimilarly regulated parking charge in Asian countries.

Table 2-3: Use of prices for on-street parking

	How extensive is pricing of on-street parking?	Differences in prices from place to place or time to time?	Highest price found ($/hour)
Jakarta	Extensive in commercial streets	Two zones	0.37 (Rp2,000)
Kuala Lumpur	Extensive in commercial streets	Uniform price within each municipality	0.41 (RM0.80)
Bangkok	Limit to a set of older commercial streets	Uniform price	0.60 (B10)
Hanoi	Extensive	Two zones	0.81 (D5,000)
Guangzhou	Extensive	Zones with different prices	1.05 (CNY4)
Manila	Extensive within Makia but in few other commercial areas if Metro Manila	Different prices around Metro Manila under various cities	1.71 (P40 last hr, P35 first 2hr)
Taipei city	Extensive	Prices higher in high-demand locations. Occupancy influences price revisions	3.45 (NT$60>6hour)
Beijing	Extensive	Two zones with different prices	1.32 (CNY5)
Hong Kong	Many streets, throughout	Uniform legislated price	1.46 (HK$8)
Singapore	Extensive to older commercial streets	Two zones	1.90(S$2)

Source: (P. A. Barter, 2011)

Observed on-street parking prices were very low in Jakarta, Bangkok, and Kuala Lumpur. Conversely, Taipei city stood out with relatively high on-street parking prices. Hong Kong and Singapore have moderate on-street parking prices. However, Hong Kong complements their on-street pricing with time limits. If Beijing proceeds with its announced April 2010 doubling of on-street parking prices at city centre, its rates will be comparable with those of these three rich cities.

Beijing and Guangzhou have concentric zones with different on-street parking prices. Similarly, several cities such as Jakarta, Hanoi and Singapore, had coarse variations with just two prices, a central one and another everywhere else. Similarly, pricing levels and practices in Bangkok, Kuala Lumpur, and Jakarta suggest that demand rationing is not the main objective.

Therefore, the question of whether parking should be a part of transport system or a service has been raised. If parking is assumed to be a part of the transport system, then the local government is responsible for financing it. However, if parking is regarded as a service, it might be financed by private sectors. Only when parking fees follow market-based rules,

parking facilities could be able to attract private investment. In 2010, Hochiminh had a plan to build six underground parking projects under Le Van Tam Park, Tao Dan Park, Trong Dong Stage and Hoa Lu Stadium through public-private-partnership mechanism. However, those projects have not been implemented due to the difficulties in parking fee regulations, land acquisition and renting, and agreement on government subsidies (Report of the sixth session of the Hochiminh People's Council, 2016).

Considering such important issues, it is recommended that parking policies should encourage private entrepreneurs to invest in parking facilitates.

2.1.6. Lack of ITS application in parking information and guidance systems

Modern technologies in telecommunication and informatics - often referred to as ITS (Intelligent Transport Systems) - have recently created new opportunities to improve planning, control, and organisation of parking information system. ITS application has been proved to directly influence parking search time.

The amount of parking search time has been identified as a significant contributor to urban congestion and an important influence in destination choice, particularly for shopping. Studies on parking behaviour found that parking search time could constitute up to 25% of the average total travel time (S. Hess & Polak, 1990). Car drivers valued parking search time at about 1.5 to 2 times of the value of driving time (K. W. Axhausen & Polak, 1991a). Congestion occurs due to a mismatch between parking intentions of the travellers and parking supply. In some cases, this mismatch may simply be due to an overall shortfall of parking supply relative to parking demand and only be effectively dealt with by expanding capacity or limiting demand. However, in many cases, drivers are unaware of prevailing levels of occupancy in key car parks or alternative parking and travel opportunities. In such cases, systems designed to provide travellers with improved information on parking opportunities have the potential to reduce parking congestion by a more efficient use of existing capacity (K. Axhausen, Polak, & Boltze, 1994).

Parking information could potentially contribute to a better utilisation of the existing parking stock and help reduce search traffic by improving drivers' decision making at different stages of the journey. Considering future development needs, ITS application for parking guidance and information in Asian developing cities is significantly required to support the development of innovative, sustainable concepts for integrated traffic and transport systems.

2.2. Challenges of parking policies

Parking will be able to support both accessibility and liveability of cities (COST, 2005b). Parking policies in Asian developing cities have been mostly categorised in "conventional approach" and not included in transport policies. This study, therefore, presents the key aspects of parking policies, then concludes by discussing some of the major challenges Asian policy makers will face in the near future.

2.2.1. No alignment between parking policy and transport policies

In Asian developing cities, parking policy has been a neglected leg of land transport policy platform (P. A. Barter, 2012a). Parking policies mostly influence parking supply. As a result, they are not well aligned with other priorities, including the vehicle quota system, road

pricing, and road building. A typical problem is that regulated parking requirement (the quantities of parking spaces per unit area) is similarly required for every building, even next to metro interchanges, to have "adequate" parking. Consequently, it undermines other transport policies, such as public transport development. In the case of Shenzhen (China), it is found that few urban factors at the district level are involved in the decision making of developers regarding parking provision (J. J. Wang & Liu, 2014).

In most Asian countries, parking policy is a local policy (Marsden, 2006; J. J. Wang & Liu, 2014; R. Wang, 2011; R. Wang & Yuan, 2013a). Each city or town is usually free to set the objectives of the policy and to select the policy instruments to implement it. National governments usually provide guidelines, mostly on parking requirements, but rarely interfere with policy making. Parking has been identified as a local matter and local authorities are believed to deal with it better than any regional or national government.

Parking policy mostly influences parking supply. The number of parking places by type and the location of parking places by type are two key elements of parking supply. Key policy instruments basically consist of parking requirements, parking regulations, marketing, and information and communication.

Parking requirements are the number of parking spaces that must be supplied at a particular location, which is often mandated by zoning codes or development requirements based on publishing standards (Litman, 2006). Parking regulations typically include free parking, time restrictions, user restrictions (e.g. parking only for residents, or disabled, or public transport passengers, etc.) and pricing parking. Car users are persuaded to use specific parking locations through marketing, such as campaigns to use Park and Ride facilities or specific payment methods such as paying by mobile phone. Information and communication are seen in many forms, such as (dynamic) route guidance to (available) parking places, either at the roadside (information) or via the communication system.

Parking requirements and regulations are policy instruments to influence the key elements of parking supply (location and number of parking places). Marketing and communication do have an impact on parking behaviour but do not directly alter parking requirements or regulations.

In many Asian cities, parking is treated as an essential ancillary service that every building will need (P. A. Barter, 2012a). The highest parking requirements are in middle-in-come cities (Kuala Lumpur, Bangkok, Jakarta, and Manila). However, only car users need parking, not public transport users, walking users or cyclists. Parking policy in China is characterised as “high regulation in supply and mispricing”. City governments rely on the “minimum parking requirement” (the conventional approach) to manage parking quantity, which shapes a unique phenomenon called the “developer-led supply pattern” (J. J. Wang & Liu, 2014).

Parking facilities are usually under-priced or even assumed to be free. Under-pricing of goods can result in overconsumption (D. C. Shoup, 1997). Shoup also notes that in most cities, ubiquitous free parking leads to greater use of parking than needed. Although free parking is popular with motorists, it is not an efficient way to use the space devoted to parking lots.

Parking is never really free since the choice is between paying directly or indirectly for parking facilities. Under-pricing tends to increase problems such as traffic congestion, housing inaffordability, sprawl, and pollution. Charging users directly for parking tends to be

more efficient and equitable, and generates revenues that can finance new services or reduce taxes and rents. Some cities such as Amsterdam (Groote et al., 2016) and London (Enoch, 2002) have implemented this policy. However, not much research has captured this trend.

The parking price policy in Asian developing cities is not working properly, with parking prices being negotiated with the parking attendants and discounted from the official price. This also discourages drivers to use vacant spaces in off-street parking. Moreover, the parking revenue is not transparent, with no access to this information by the local government.

The issue does not root from the lack of parking spaces only but from a lack of parking management as well. While on-street parking occupancies are high and illegal parking is popular on streets, sidewalks and setbacks; vast amounts of vacant parking spaces are found in nearby off-street parking facilities. Vacancies in off-street parking facilities can be utilised to host those illegally parked cars. A better designed and enforced on-street parking system, with paid parking on all streets, can facilitate short-term parking and allows for car-free sidewalks and setbacks and bike lanes on most streets.

2.2.2. Confusion about parking as an infrastructure system or a service

Investment in parking facilities is a heavy burden on many Asian local governments (de Jong et al, 2010; Hwang, Zhao, & Gay, 2013; Puri, 2003; Willoughby, 2013). In many Asian cities, parking is considered as a part of the transport system. Therefore, minimum parking requirement is regularly used, fostering automobile dependence. In the case that parking is considered as a service, parking fees are regulated by market-based rules in some cities. Parking facilities are, in this situation, able to attract private sectors to invest in.

- **Minimum parking requirement is regularly used**

Minimum parking requirements, specifying the minimum number of parking spaces that must be built with each development, normally relate to car parking supply standards as they are applied to non-residential real estate developments. All of the Asian developing cities (Table 2-4) have minimum parking requirements (P. A. Barter, 2012a).

Table 2-4: Car parking required with office and retail buildings at Asian developing cities

	CBD office building	Non-central office building	Shopping centre (non-centre)
Beijing	0.5	0.5	0.3
Guangzhou	0.6	0.6	0.6
Taipei	0.7	0.7	0.7
Hanoi	1.0	1.0	1.0
Manila	1.3	1.4	1.0
Jakarta	1.0	1.0	1.7
Bangkok	1.7	1.7	2.6
Kuala Lumpur	1.5	2.6	2.7

Note: The number presents spaces per 100m^2 of gross floor area. Source: (P. A. Barter, 2012a)

This policy, in Western countries, is often associated with fostering automobile dependence. Parking standards in the Asian cities do vary substantially in their style and their levels. It is striking that the richest cities in Barter's study (Tokyo, Singapore, and Hong Kong) have the lowest minimum parking requirements (Table 2-5).

Table 2-5: Car parking required with office and retail buildings at Asian developed cities

	CBD office building	Non-central office building	Shopping centre (non-centre)
Tokyo	0.3	0.3	0.4
Singapore	0.2	0.5	0.5
Hong Kong	0.4	0.6	0.4
Seoul	0.1	1.0	1.0

Note: The number presents spaces per 100m^2 of gross floor area. Source: (P. A. Barter, 2012a)

The highest parking requirements are in middle-in-come cities (Kuala Lumpur, Bangkok, Jakarta, and Manila). These requirements are, however, still below the extremes found in suburban areas of the USA, where it is common for more than 3.0 parking spaces to be required per 100m^2 of floor space (D. C. Shoup, 1997). In Western countries, it is increasingly common for CBDs to have particularly low parking requirements. Among the Asian cities, this is seen only in Singapore and Seoul, although Hong Kong also has the flexibility to allow low levels of parking in its financial district. In major business districts in Seoul, there are also parking maximums (or limits on the parking that can be provided with each building).

Minimum parking standards have been disapproved by liveable street advocates and developers. Cities in the UK and the USA have established maximum parking standards to reduce the use of private cars and the negative environmental impacts associated with them. Moreover, minimum parking requirements have been criticised in the UK and the USA because of their land and transport market imbalance. Those requirements could cause a surplus of parking spaces in most urban areas, which reduces the cost of car parking and thus encourages use of private cars. In addition, critics claim that minimum parking requirements force developers to use a larger area of land, making development projects in expensive areas more costly and less profitable.

Minimum parking requirements are calculated with little consideration of public transport availability, or of the urban design circumstance in which the development project is placed. In some cases, these requirements lead to more off-street parking than appropriate in the local settings, such as in downtowns and neighbourhoods that are oriented towards public transport. Minimum parking requirements result in sprawling urban areas where the costs of driving are transferred to the general public. Parking minimums also tend to ignore transport systems and other means of mobility. Because of a historical prejudice in favour of the car and the search for simplicity, minimum parking requirements assume that all travellers usually arrive at their destinations by car and have free car parking.

The minimum requirements are especially harmful to downtown areas. They reduce urban density and increase the distance between the points of movement, resulting in reduced land values, increased traffic congestion, storm-water runoff pollution, air pollution and increased construction costs. They also impede walking, cycling and the use of public transport. According to many reports, the use of public transport will not rise unless the supply of car parking is reduced. Generous parking availability also leads to a decline in air quality due to the high number of cars on the roads and the low use of public transport.

- **Unreasonable parking pricing and fee**

The primary objective of setting a price on parking, for parking facility owners and operators, is to cover costs and earn a reasonable return on investment. However, this objective must be balanced against others, such as the desire to attract shoppers or employees.

The price of parking may be used to influence travel choice by altering the cost of private vehicle travel. Effective implementation of parking pricing requires careful consideration of the underlying policy objectives.

Parking fees have been suggested as an alternative to roadway pricing. Parking fees can be an effective instrument to influence commute travel. However, for through-travellers and those who can vary the parking time, parking fees may be challenging or leave negative effects on congestion (Glazer & Niskanen, 1992). A concern when manipulating parking fees for policy purposes is the potential to trigger shifts in the locations of trips themselves, leading to economic dislocation.

A study of Barter (2011) provides insights into the extent to which pricing varies from place to place. Parking pricing is seen as an indicator of a demand management tool. The result indicated that on-street parking fees largely varied throughout Asian cities. Beijing, Guangzhou, and Seoul had concentric zones with different on-street parking prices. Similarly, several cities such as Jakarta, Hanoi, and Singapore, had coarse variations with just two price levels, in central and in periphery areas.

Similarly, pricing levels and practices in Bangkok, Kuala Lumpur and Jakarta suggest that demand management is not the main objective. In most of the municipalities of the Kuala Lumpur metropolitan area, monthly payment is an option. The Jakarta government has recently announced plans for annual subscription payment for on-street parking within the whole municipality. One of the parking authorities in Delhi has proposed annual payment for unlimited parking on-street and off-street (CSE India, 2009). These approaches reduce the marginal cost of on-street parking to zero within these large areas. It means that these authorities see pricing simply in terms of revenue.

2.2.3. Uncertainty of parking planning

Rapid motorisation in Asian countries and its uncertain future development are challenges in the process of parking planning.

A study of Flyvbjerg et al. (2005) on traffic forecasting in transport infrastructure projects, covering 210 projects in 14 nations billion, pointed to the problem of estimating the demand. For 9 out of 10 rail projects, passenger forecasts are overestimated; the average overestimation is 106%. For half of all road projects, the difference between actual and forecasted traffic is more than ±20%.

In Asian developing cities, parking planning is even more difficult since most of the parking policies are local ones. Parking planning often includes a selection of parking management policies in order to control the provision of parking supply. Thus, parking requirements and on-street parking policies are implemented inconsistently in different regions. Their impacts on parking demand reduction are also different. Parking is often planned for the whole city or region, but it works effectively in only some parts due to incompatible implementation.

Furthermore, high urban densities increase opportunity cost of parking space, particular in land-price. Knight Frank Asia Pacific is the independent global property consultancy who launches Prime Asia Development Land Index. The Index derives the price of prime residential (apartment or condominium) and commercial (office) development land in 13 major cities across Asia, for the period December 2011 to December 2013. It was shown that in the two years from December 2011, 24 of the 26 markets (9 residential and 9 offices) increased in their indices of prime land prices due to limited supply but strong demand.

Southeast Asian markets see the fastest price growth in prime development land: Bangkok, Jakarta, and Kuala Lumpur being 3 of top 5 cities in terms of price growth. The mature markets of Hong Kong, Singapore and Tokyo saw the lowest price growth. Prime Asia residential and office development land indices increased 50.4% and 38.3% respectively over the last two years.

Table 2-6: Residential development land indices

Residential Development Land Indices			
No.	Market	24-month % change	12-month % change
1	Bangkok	190.70%	24.70%
2	Jakarta	184.00%	58.80%
3	Kuala Lumpur	67.20%	37.30%
4	Beijing	37.00%	25.80%
5	Guangzhou	30.80%	16.00%
6	Shanghai	20.00%	18.40%
7	Tokyo	4.70%	13.20%
8	Hong Kong	0.10%	-5.80%
9	Singapore	-1.40%	1.70%

Table 2-7: Office development land indices

Office Development Land Indices			
No.	Market	24-month % change	12-month % change
1	Jakarta	192.30%	63.00%
2	Kuala Lumpur	64.90%	39.50%
3	Beijing	53.10%	29.10%
4	Bangkok	52.60%	42.30%
5	Guangzhou	28.70%	10.70%
6	Shanghai	19.40%	8.10%
7	Singapore	19.10%	6.50%
8	Hong Kong	8.70%	-5.50%
9	Tokyo	7.00%	10.60%

Source: Prime Asia Development Land Index, Knight Frank Asia Pacific, the independent global property consultancy, 2014.

In the Southeast Asian markets, Bangkok sees the highest growth in the prime residential development land index over the last two years with 190.7%. Jakarta shows the second largest land price increase with 184.0% in the prime residential index and the largest increase in the prime office index with 192.3% over the last two years.

China remains the most active market, with Tier 1 cities seeing significant land price increase over the last two years. Within China, Beijing has emerged as one of the markets with the

strongest price growth with an increase of 37.0% and 53.1% in the prime residential and office development land over the last two years, respectively. Guangzhou followed with 30.8% and 28.7% increase in the prime residential and office indices respectively; whilst Shanghai saw a 20.0% and 19.4% increase respectively.

Land price directly influences the investment on parking facilities. Parking fee, a major source of the revenue for a parking business, is therefore influenced by the cost of land. In the core city centre, where land has the highest price, the parking fee should be different from other zones. Thus parking pricing is important part of parking planning.

2.3. Principles of parking management

The principle means a fundamental truth or proposition that serves as the foundation for a system of belief or behaviour or for a chain of reasoning (Oxford Dictionary). Principles of parking management are investigated and built up as the guidelines for the decisions and actions of transport authorities.

Parking management influences parking systems through a bundle of measures to optimise the positive impacts of traffic and transport (FGSV, 2005). Planning parking supply involves planning the structure, the spatial distribution, the capacity and the operational management of parking facilities.

Based on the in-depth analysis of parking challenges in Asian developing cities, eight principles of parking management are developed as follows.

1. Align the parking policy with the overall transport management policy and the urban development policy;
2. Specify the parking policy for individual urban zones;
3. Consider the mutual effects of parking policy in neighbouring zones;
4. Analyse the parking demand for specific user groups;
5. Distinguish between the qualified demand from the general parking demand;
6. Use different parking regulations to prioritise specific user groups;
7. Control the amount of parking supply to ensure that not any components of the supply remain unregulated;
8. Avoid illegal parking by physical measures and strong enforcement of parking regulations.

2.3.1. Align the parking policy with the overall transport management policy and the urban development policy

Parking policies connect the implementation of land-use and transport policies. They, as a result, should be developed in accordance with the local and regional spatial and transport planning process (G. R. Marsden & May, 2006).

By setting parking policy in tandem with the transport system, solutions can be specifically tailored to local contexts. Accordingly, there are four major recommendations including supporting mobility management, supporting peak management, supporting public transport usages, and reducing land consumption.

- **Supporting mobility management**

Parking policy and parking management play an important role in urban mobility, both in enhancing accessibility and in dealing with urban congestion. In modern "mobility management", parking is the most significant single management tool (COST, 2005a).

Any parking policy eventually aims to shorten parking duration in urban areas. This is to facilitate visitors and business trips and prevent commuters from occupying parking places which are intended for visitors and consumers, especially on street due to the visual impact. A well-organised parking policy has a mitigating effect on urban private-vehicle-mobility. Such a parking policy could support business and economy instead of harming them.

National transport policy is unspecific on parking. The focus is often land-use planning and environmental legislative issues. Parking standards for new developments, based on national legislation or guidance, are mostly local or regional. Being an important aspect in mobility management, parking should be mentioned in the national transport policy. In the field of land use planning, the application of maximum parking standards is recommended. The exact values of these standards must not be fixed in national legislation. Rather, they should be guidelines for different regions to adapt.

- **Supporting peak management**

Special efforts should be made to deal with peak-demand relating to location (in the core city centre or central business districts) and time (in the morning or afternoon rush hours). Parking management measures should be applied accordingly. It might help to shift the parking demand to other locations or times, or even avoid the parking demand if travellers decide to use other transport modes, such as bus, metro or BRT.

- **Supporting public transport usage**

Out of all measures to reduce motor traffic in cities, improvements of public transport and city-wide parking management strategies are key ones (Topp, 1991a). These improvements feature an interactive relationship. With public transport improvements alone, the car cannot be passed over; and a high quality of public transport is a prerequisite for parking restrictions in inner cities.

Increased parking fee could directly influence parking demand. Travellers in that case might be willing to change to public transport to reduce total travel cost. Public transport quality should be improved and public transport alternatives should be enhanced and properly provided to attract users.

Furthermore, parking restriction helps to reduce privatevehicle traffic in urban areas. Usually, this measure is combined with restrictions on traffic flow through capacity restraints at outlying junctions. Parking restrictions are environmentally more favourable because they produce less noise, pollution and driver stress compared with traffic-flow restrictions. Additionally, parking restrictions work selectively. They address different user groups -- residents, employees, customers and visitors and commercial traffic -- in different ways. Easy access for residents and commercial traffic can result from parking restrictions against employees who can easily switch to public transport and park-and-ride.

- **Reducing land consumption**

Parking policy is one of the key links between transport and land-use policy (Marsden, 2006). Parking management can reduce land requirements by changing from minimum to maximum parking requirement in many types of buildings in some specific zones. In the core city centres or in the central business districts where the provision of public transport is good, parking requirements should be set at low rate since travellers easily shift to public transport. It helps to reduce the cost of the buildings since "free" parking spaces have been reduced to a minimum.

Parking management also facilitates to reduce land consumption by shared parking. Shared parking refers to a parking facility that serves multiple users or destinations. This is most successful if destinations have different peak periods, or if they serve patrons so motorists can park at one facility and walk to multiple destinations. Parking facilities can be shared in several ways. Motorists share parking rather than being assigned reserved spaces. For example, 100 employees can usually share 60-80 spaces, since at any time some are on leave, in the field, commute by an alternative mode or work another shift. Hotels, apartments and dormitories can share parking spaces among several units, since the number of vehicles per unit varies over time. Sharing can be optional. For example, motorists could choose between $60 per month for a shared space or $100 for a reserved space. Parking can be shared among multiple destinations. For example, an office building can share parking with a restaurant or theatre. Peak demand for offices occurs during weekdays; while for restaurants and theatres, it is on weekend nights. Sharing can involve mixing land uses on the single site, such as a mall or campus, or by creating a sharing arrangement between sites located suitably close together.

2.3.2. Specify the parking policy for individual urban zones

Parking management strategies should be diversified to accommodate certain requirements of each traffic area. Prioritisation of different parking user groups should be carefully considered, and then the recommendations for the coverage of requirements of each user group are proposed for each zone.

Many cities all over the world have successfully differentiated their measures to control the number of parking spaces by the zone-specific land development, public transport accessibility, and environmental requirements.

American cities define parking supply indexes of local buildings which are suitable to their particular conditions and based on a detailed investigation of parking demand. These indexes are built with reference to the Parking Generation - a periodic publication by the Institute of Transport Engineering (ITE) and the situation in adjacent cities. Therefore, the standard of parking supply is different from one American city to another and even from one region to another in the same city. One example is Portland, which has achieved good results by dividing its central area into 7 parts, and different parking supply indexes are recommended to each of them (Resha & Stein, 1998).

Some other cities of England, Germany, and Australian take into consideration the flexibility and regional differences of parking supply indexes of buildings based on the objectives of urban transport development, as required by the traffic demand management (Alex Anas, Richard Arnott, 1998).

In Singapore, different parking supply indexes are defined for public buildings in different areas. The parking supply standard is distinct from the central area to others. For example, a parking space should be available for every 400 m^2 building area of office at city centre, but for only 200 m^2 in periphery areas (Seik, 1997a).

Some Chinese cities also plan their parking supply standards in a zone-specific manner. Despite the varied directions of zoning research, and varied numbers and areas of zones, these cities commonly define different parking supply indexes in different zones based on the characteristics of parking demand and the directions of parking development policies. This is intended to better address the parking challenge caused by urbanization and motorisation. For example, in Hong Kong, as early as in 1991, different parking supply indexes for regions with different vehicle parking characteristics were defined in its Planning Standards and Guidelines. It is regulated that parking supply should be reduced by 15% at any residential project which has been developed by more than 50% in area and is not more than 500 m^2 away from subways.

2.3.3. Consider the mutual effects of parking policies in neighbouring zones

The mutual effects of parking policies in neighbouring zones could be ensured through area-wide parking management. When parking management is applied in a specific urban zone, the spill-over impacts on parking in neighbouring zones, for instance more search traffic, denser on-street parking etc. are also observed. Those impacts might be avoided by extending the concept of area-wide parking management.

As in the German case, although area-wide parking management has been implemented with the introduction of residential parking permits, only a few cities (Aachen, Heidelberg, Kassel and Saarbriicken) have applied such concepts. Despite frequent discussions about parking policies among planners and politicians, not much has been researched on the effects of such management. In a before-and-after study within the same year in Munich, the effects of residential parking permits on the modal choice of employees were investigated. The share of car solo-drivers dropped from 44 to 32% and the traffic peaks and search traffic during the day were reduced (Topp, 1991b).

Parking management policies pursue several objectives which are interconnected: to meet the parking demands of residents and commercial traffic, to provide some spaces for customers and visitors at market rates, to control urban traffic, to maintain an equilibrium between parking and circulating traffic, and to affect modal choice, especially that of the employees.

Parking management aims at balancing parking demand and supply by parking prices and by rationing the supply (Topp, 1991b). It works with market tools as well as planning and administrative tools. Parking permits for residents, timed parking and parking charges are the most important instruments to control on-street parking. Generally, on-street parking should be charged higher than off-street parking in garages.

2.3.4. Analyse the parking demand for specific user groups

The parking demand of residents, employees, customers and visitors, and delivery and service differs in a number of aspects such as parking time and duration, preference of parking in public streets or in a parking garage, the proximity of destinations, willingness to pay for parking, or readiness to change to other means of transport (Table 2-8). Therefore, it is

necessary to analyse the parking demand of specific user groups to investigate the unavoidable traffic of urban areas.

Table 2-8: Parking user groups should be differentiated regarding their parking demand

Characteristics of Parking Demand \ User Groups		Residents	Employees, trainees, students and pupils	Customer s	Visitors and guests	Service providers	Suppliers
Parking duration	short	○	○	●	◐	◐	●
	long	●	●	○	◐	◐	○
Reliant on public parking spots on street		◐	◐	◐	◐	◐	●
Possible shifting to other transport services		○	●	◐	◐	○	○
Long footwalk reasonable		○	●	◐	◐	○	○
Willingness to pay for parking charge		○	◐	●	●	●	○
Sensitive for parking guidance systems		○	○	◐	●	◐	○

● applicable ◐ partly applicable ○ not applicable

Source: Forschungsgesellschaft für Straßen- und Verkehrswesen (FGSV): Empfehlungen für Anlagen des ruhenden Verkehrs (EAR), Ausgabe 2005, Köln 2005

Parking balances should be separately established for user groups by answering two questions: which parking supply is compatible with urban development and other street uses in each city district; which parking demand results from a staggered priority of the different user groups' demand.

The parking demand of deliveries and services is not included in the parking balances but handled as an indispensible space requirement, as analysed from local observations and interviews. Loading spaces are not disposable for other parking purposes such as bus lanes or cycle lanes. They limit the possible parking supply within the street. In certain cases, loading spaces and bus lanes can be combined in certain times of the day.

2.3.5. Distinguish the qualified demand from the general parking demand

Qualified demand is all traffic which is unavoidable for the urban functions of the inner cities. The qualified demand should be distinguished from the general parking demand. Therefore, parking resources could be appropriately allocated.

Parking scarcity is observed worldwide, however, this problem is even more critical in many Asian developing cities. Public investment on parking is very limited. Private sectors also hesitate to participate in parking business because the parking fee is regulated with a lower level than the cost of parking. Therefore, giving a higher priority for qualified parking should be an important parking of the area-wide parking management policy.

In order to determine the “qualified” demand, the parking space demand will be checked whether it is compatible with transport policy objectives (e.g. promotion of public transport), with specific land-use objectives, and with the environmental objectives (e.g. traffic induced by parking supply).

Parking demand for specific user groups should then be strategically considered. Generally, the aim of an area-wide parking policy is “to cover the qualified requirements” by the complete coverage of requirements for residents and commercial transport (service providers, suppliers), the partially coverage of requirements for shopping trips (customers) and visitor traffic, and only in exceptional cases, the coverage of requirements for commuters (work and school).

2.3.6. Use different parking regulations to prioritise specific user groups

Parking spaces are demanded by residents, employees, customers and visitors, and by delivery and service traffic. The latter groups (customers and visitors, delivery and service traffic) are often categorised as commercial traffic and considered to represent the necessary or unavoidable part of motor traffic in a city. Despite its importance, delivery and service traffic is not usually a direct part of the parking balance due to specific space requirements and diverging performance.

Parking provisions for residents have a high priority, even within streets of existing city districts. Where residential functions are to be encouraged, parking for residents must be obtainable within a reasonable distance and, at the same time, non-residential car traffic should be kept away. Under current conditions, distances of more than 200 to 300 meters are generally not accepted, although distances to bus and tram stops are often longer.

Third in the usual hierarchy of parking demands - following commercial traffic and residents - are those of customers and visitors. This heterogeneous user group includes shopping, business, and private visits. For these mainly short-time parkers, some parking spaces close to the destination should be provided and charged for at the market rate.

Finally, for long-term-parking employees, no on-street parking should be available and off-street parking should only be offered at market-rates. Employees who rely on their cars because of handicaps, business needs or lacking reasonable public transport alternatives, can usually be provided with parking spaces by their firms.

Parking situation observed in many Asian cities are unique. The parking provisions for residents are not appropriately considered. Most of people park their motorcycles in their houses, in the living rooms or even next to the beds. Dedicated parking areas are rarely observed because of space deficit. Resident parking is having very low priority, even within the streets their houses locate.

On the contrary, long-term parking for employees seems to have the highest priority. Motorcycle parking for commuters is guaranteed in many office buildings. Employees are parking for free because their companies paying for that fees. Therefore, commuter group is the less sensitive with the increasing of parking charge, based on author’s parking interview surveys. Encouraging commuters to shift to public transport system could be a big challenge in Asian developing cities.

2.3.7. Control the amount of parking supply

The amount of parking supply should be controlled to ensure that not any components of the supply are unregulated.

Parking supply is mostly divided into public and private parking spaces. On-street parking is totally controlled by the municipality. Therefore, they might be unlimitedly influenced by local authorities.

In many Asian cities, private off-street parking facilities are out of the control of municipal parking policies (P. A. Barter, 2012b). They can only be indirectly affected, for instance, by no parking provision at all for employees in the public realm to induce firms to distribute their private spaces to employees who are car-bound because of handicaps, professional use of the car, and the lack of public transport alternatives. Or they can control the parking supply by regulate parking requirements, especially at the areas easily access to public transport system (for instance, metro station, bus stops, interchange stations…). In the long term, the number of private parking spaces can be controlled by zone-based parking requirements and regulations.

In many Asian cities, the occurrence of illegal parking places is regularly observed. Parking users pay for their parking even with a higher parking fee than that regulated. Many of them do not notice they are parking illegally. As mentioned above, the parking policy should align with the overall transport policy and urban development policy to serve the goal of mobility management. Therefore, all parking facilities should be regulated to ensure that uncontrolled land-use can be reduced and managed.

2.3.8. Reduce illegal parking by physical measures and strong enforcement of parking regulations

Illegal parking is not only the problem of developing countries. Developed countries have also been facing with violated parking vehicles (Topp, 1993). On-street illegal parking has negatively influenced traffic safety and narrowed down the dedicated walkway for pedestrians. The issue should be urgently addressed.

On the one hand, the existing parking capacity should be improved through a bundle of actions, for instance, redesigning existing parking facilities. This is a quick, cost-effective and flexible approach to solve parking problems. It aims to increase the number of spaces in existing parking facilities by utilising currently wasted areas (corners, edges, undeveloped land, etc.) and sizing a portion of spaces for motorcycles and compact cars.

High preference of on-street parking and the willingness to walk for short distance are features of parking users in many Asian developing cities. Such behaviour also leads to illegal parking. Another possibility is to provide more parking facilities around traffic users' destinations and reduced walking distance through the legalisation of illegal parking spaces. It provides more official parking facilities, making parking more convenient to parking users.

On the other hand, parking management measures to steer parking supply and parking demand should be implemented, including regulating on-street parking supply, applying parking prices and charges, limiting parking time with or without parking charges, and prioritising certain user groups, for instance, deliveries and residents.

Furthermore, the success of all parking regulations within the public street depends strongly on their strict enforcement (Topp, 1991b).

Without adequate enforcement and penalties, higher parking prices would entail more illegal parking practices from drivers, business owners, and valet services. Without similar policies

and protective measures for residents, adjacent neighbourhoods may suffer from a resulting spill-over of parking.

As evidenced in many developed and developing cities, even good public transport services are not effective without appropriate parking policies (Aoun, Abou-Zeid, Kaysi, & Myntti, 2013). Urban authorities should consider strengthening law enforcement to discourage illegal parking. Also, the low current parking fine rates could not discourage people from parking illegally. Fines should be increased and enforced so as to motivate legitimate use of parking spaces (Aoun et al., 2013).

2.4. Summary

Rapid motorisation and high level of automobile dependency are unique features in Asian developing countries. Parking situations are dissimilar in different urban zones regarding population density, traffic demand, land-use and land price, and the provision of public transport service. On-street parking is popular, and people prefer short walking distance from parking facilities to final destination. Additionally, the high level of motorcycle usage with short-time trips and short-duration parking results in the high level of illegal parking.

Those challenges mostly result from the current poor alignment between parking policies and urban transport policies. Transport authorities in many Asian developing cities are confused whether parking should be a part of infrastructure system or purely a service. Therefore, parking management measures are inconsistent with transport management measures.

Enhancing public transport and implementing an area-wide parking management are significant (Topp, 1991a). Eight principles of parking management have been developed: 1) Align the parking policy with the overall transport management policy and the urban development policy; 2) Specify the parking policy for individual urban zones; 3) Consider the mutual effects of parking policies in neighbouring zones; 4) Analyse the parking demand for specific user groups; 5) Distinguish between the qualified demand from the general parking demand; 6) Use different parking regulations to prioritise specific user groups; 7) Control the amount of parking supply to ensure that not any parts of the supply remains unregulated; and 8) Avoid illegal parking by physical measures and strong enforcement of parking regulations. These principles are applicable in any context, not only in motorcycle dependent cities or developing countries.

As urbanisation and motorisation are speeding up, liveability in Asian developing cities can be seriously threatened. Parking resources should therefore be reasonably shared and efficiently utilised by appropriate parking management strategies.

3. Parking Planning Method

Parking planning is a significant part of transport planning. However, data collection in studies on parking has been a major challenge in many Asian developing cities. With fast changes in traffic development, the traffic forecast tends to be quickly out-of-date (Paul Barter, 2000). The purpose of this chapter is to propose a proper parking planning method to serve the specific requirements of parking in Asian developing cities. This method is then applied in the case of Hanoi.

3.1. Basis of parking planning

Parking planning is the significant organ of urban transport planning. Therefore, it should be compatible with the overall transport planning methods, should be a part of the urban traffic development plans and specific to each demand groups. It should also depend on the size of town as well as the types of area.

- **Parking planning as part of transport planning**

The provision of parking supply impacts the choice of destination and means of transport, the quality of the traffic flow, and even the individual use of surface areas. The distinction between general parking demand and “qualified demand” needs to be made clear. Qualified demand is all traffic which is indispensable for the urban functions of the inner cities. The parking space competes with areas for buildings, areas for undeveloped space, green areas and with the design quality in the public area. By observing the interactions between parking space supply and demand, parking spaces could be designed to fit local conditions.

- **Different prioritisation of parking supply to different user groups**

A balance of interests should be created between various demand groups: residents; employees, apprentices, students and pupils; customers; visitors and guests; service providers, and suppliers. Residents look for parking spaces in the direct vicinity of their apartment. Employees, apprentices, students and pupils need parking spaces for the working or studying time. Customers require parking spaces during business hours, whereby parking duration can vary considerably. Visitors and guests have highly varied demands for parking spaces depending on their purposes (e. g. private visitors, event visitors, visitors of leisure facilities or guests). Service providers require parking spaces in the direct vicinity of the destination. Suppliers require parking areas in the direct vicinity of the destination for delivering and loading goods for a short period of time. The generation of parking space requirements through use and demand groups is presented in Table 3-1.

- **Composition of parking supply**

The total parking volume of a city district consists of different types of parking spaces related to ownership, operation and usability (Figure 3-1). The most important distinction is "public or private". Most public parking spaces are on-street, preferably for residents or the handicapped. These spaces are totally controlled by the municipality. Therefore, they are usually the starting point of parking concepts.

The municipal influence on parking garages - even the public ones- is limited because of legal issues such as the share of permanently let spaces or parking tariffs.

Private spaces can only be controlled by municipal parking management policies through parking requirement standards. They can only be indirectly affected. For example, firms could be encouraged to distribute their private parking spaces to employees who are car-bound because of handicaps, professional use of the car, or hard to access public transport alternatives.

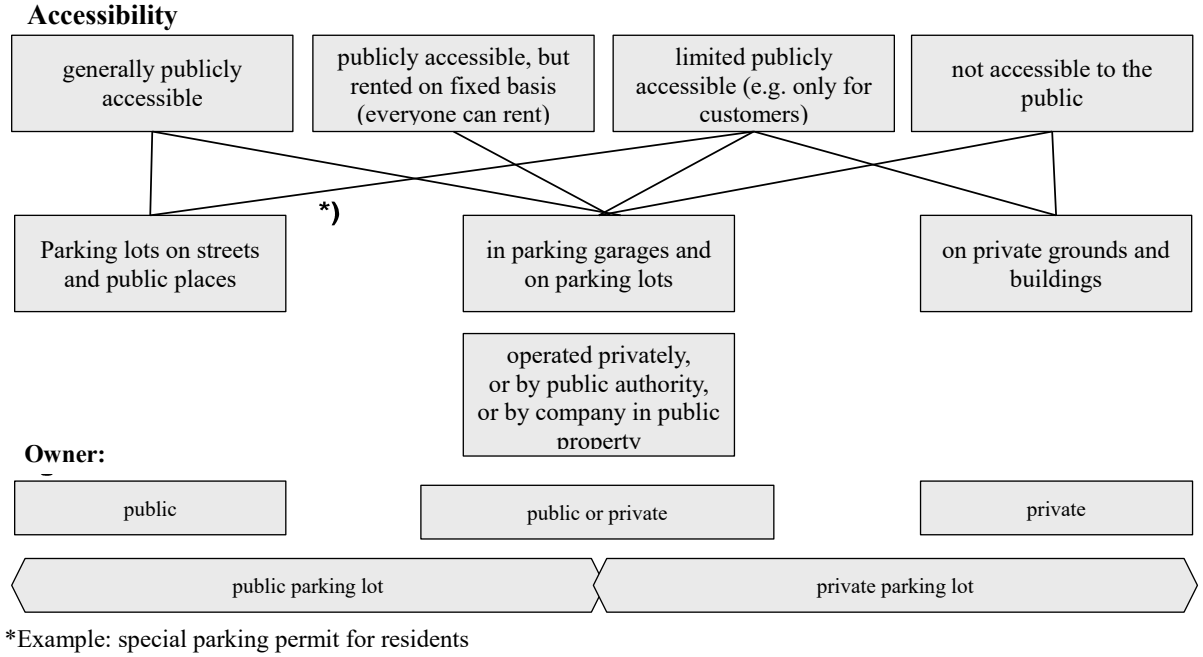

Figure 3-1: Public and private parking space
Source: Parking policies in large cities in Germany (Topp, 1991)

- **Size of town**

Large cities or high-level centres often have a good offer of public transport. City centres and commercial areas near the city centres feature a large variety of use with a broad range of goods and services. Long distances on foot appear reasonable between the parking spaces and the destinations. The significance of the parking spaces depends on the quality of local public transport. In medium-sized towns, one can assume a low offer of public transport. The provision of parking space is co-determined by the competition to other centres. In small towns or low-level centres, the parking spaces are expected to be in the direct vicinity of the destinations.

- **Types of area**

The distinction according to types of the area takes into account various expectations of the demand groups, various aims of parking planning and various parking space offers. Specific information is included in Table 3-1.

Table 3-1: Generation of parking space requirements through use and demand groups

Type of area		Demand groups / Typical use	Inhabitants	Employees, apprentice	Students, pupils	Customers	Visitors	Guests	Service providers	Suppliers
City centre areas		Apartments	x				x		x	
		Offices		x		x			x	
		Shopping centres		x		x			x	x
		Facilities for common needs		x	x		x		x	
		Hotels and restaurants		x				x	x	x
		Cultural facilities		x			x		x	x
		Leisure facilities		x			x		x	x
Old building areas		Apartments	x				x		x	
		Offices		x		x			x	
		Industrial estates		x		x			x	x
		Shopping centres		x		x			x	x
		Facilities for common needs		x			x		x	
		Hotels and restaurants		x				x	x	x
		Cultural facilities		x			x		x	x
		Leisure facilities		x			x		x	x
Residential areas	pure	Apartments	x				x			
		Shopping centres		x		x			x	x
		Facilities for common needs		x	x		x		x	
		Leisure facilities		x			x		x	x
	general	Apartments	x				x			
		Offices		x		x			x	
		Industrial estates		x		x			x	x
		Shopping centres		x		x			x	x
		Facilities for common needs		x	x		x		x	
		Leisure facilities		x			x		x	x
Commercial and industrial estates		Offices		x		x			x	
		Business enterprises		x		x			x	x
		Shopping centres		x		x			x	x
		Apartments	x				x			
		Business enterprises		x		x			x	x
Village areas		Shopping centres		x		x			x	x
		Facilities for common needs		x	x		x		x	
		Restaurants		x				x	x	x
		Leisure facilities		x			x		x	x
Recreation areas		Shopping centres		x		x			x	x
		Cultural facilities		x			x		x	x
		Leisure facilities		x			x		x	x

Note: x means use generally generates parking space requirement through demand group (EAR, 2005)

3.2. Parking planning process

The German guideline "Empfehlungen für Anlagen des ruhenden Verkehrs" includes recommendations for stationary traffic installations edited by the Research Society for Roads and Traffic - Forschungsgesellschaft für Straßen-und Verkehrswesen (FGSV). The guideline overviews the actual tools of parking planning and parking space management which could be applied not only in Germany but also worldwide. It specifically addresses the objectives, effects, fields and forms of application as well as the implementation of parking policies. The guidelines helps forming the systematic description of principle approaches and structures of parking space policies in respective cities. Parking planning process is illustrated in Figure 3-2.

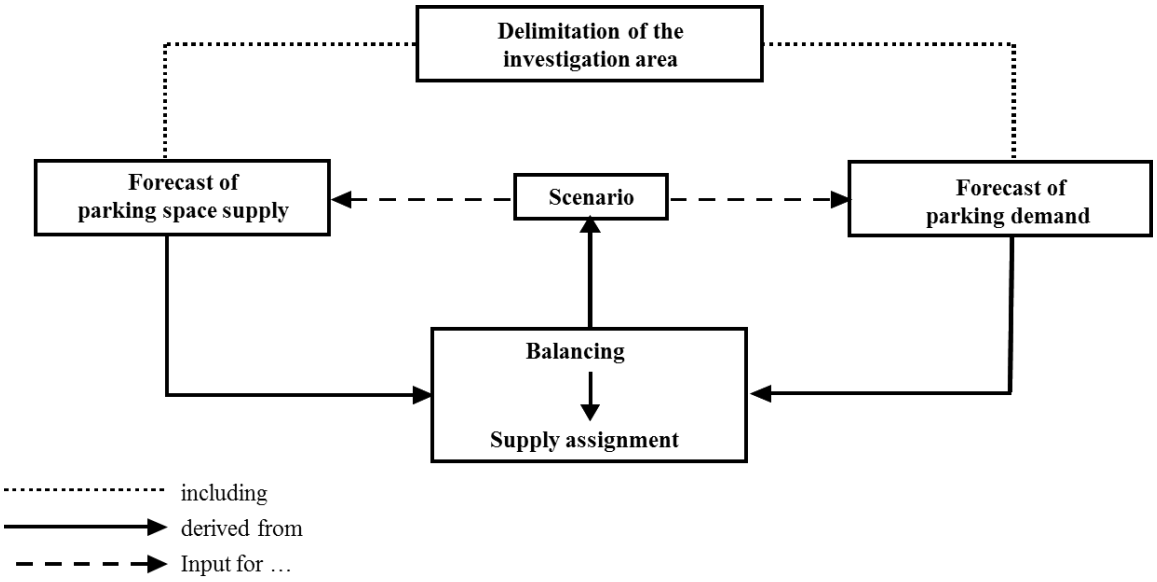

Figure 3-2: Parking planning process

Source: Forschungsgesellschaft für Straßen- und Verkehrswesen (FGSV): Empfehlungen für Anlagen des ruhenden Verkehrs (EAR), Ausgabe 2005. Köln 2005

- **Delimitation of the investigation area**

In principle, the investigated area should be as small as possible. The available statistical data required (inhabitants, employees, sales areas) should be assigned to the area. Futhermore, a displacement into neighbouring areas must be considered.

In the investigated area, the parking lot is to be collected and the parking space needs to be projected. The offer and requirements must be checked; an appropriate allocation of the offer must be made. It is necessary to check whether the offer is in line with the target. Possibly, current and further scenarios are to be defined; supply and demand are to be redefined and reassessed or reassigned, etc.

- **Analysis of the current parking situation**

The analysis focuses on the distribution of parking duration and parking space occupancy, temporal distribution of inflow and outflow, share of parking regulation violators, user groups (derived from parking time and parking duration), and walking distance between parking lot and destination.

License plates, time and location are first compared. The parking time and occupancy of the parking lots, the time distribution of inflow and outflow as well as the incorrect parking areas are then determined.

Over the parking duration, it is possible to make conclusions about the demand groups. Then a possible replacement or new location of parking facilities can be determined, basing on 1) the distance between the parking area and the destination and 2) the demand groups determined at the parking level.

- **Forecast of parking demand distinction between types of area**

Apart from the user groups, spatial aspects considerably influence parking demand (whereby user groups and spatial function are mutually interrelated).

Different urban areas feature different parking situations. For example, in urban core areas, the number of parking spaces are very limited and be utilised throughout the day; while in business and industrial areas, there seldom occur the parking of residents, students and guests.

- **Forecast of parking demand - integrated method according to EAR (2005)**

Parking demand is forecasted to answer the following questions: where and which type of parking space is required, whether public spaces can be regained for other purposes, where future parking facilities should be established, which parking space capacity is required in case of certain changes in land use, and which quality of the road network will result from the predicted traffic flows.

It is important to distinguish types of area, including city centre area, old building area close to city centre, residential area, commercial and industrial area, rural area, and recreation area.

The basic steps to forecast parking demand include the analysis of current structural data, the determination of future changes in land use and car ownership rate. The future structural data could then be determined and the general parking demand could be calculated, basing on the restrictions to specific user demand groups.

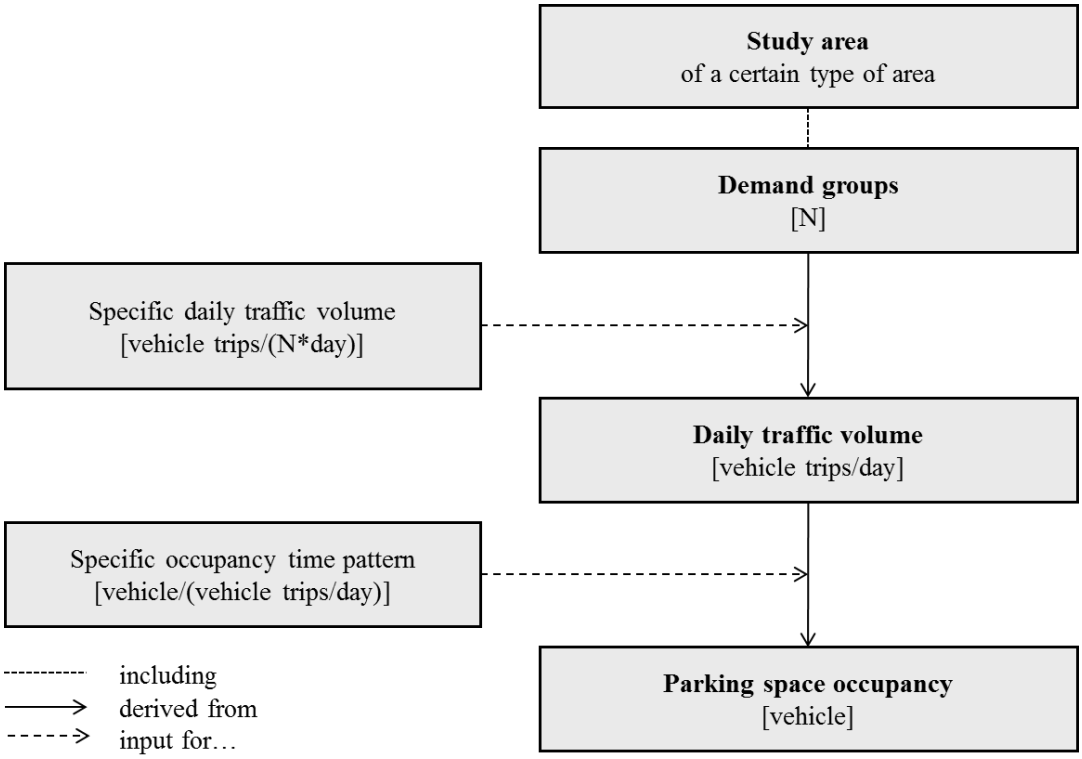

Figure 3-3: Integrated method to forecast parking demand

Source: Forschungsgesellschaft für Straßen- und Verkehrswesen (FGSV): Empfehlungen für Anlagen des ruhenden Verkehrs (EAR), Ausgabe 2005. Köln 2005

The demand groups include residents, employees and customers in certain sales areas. Then the specific daily traffic volume could be simplified to target or source traffic volume. It is to be calculated on the basis of the transport options and occupancy rate, and if applicable, on the basis of the future parking space buyers. An example of specific daily traffic volume based on EAR (2005) is showned in Table 3-2.

Table 3-2: Specific daily traffic volume by user demand groups and type of areas

Type of area	**Demand groups**	**Specific daily traffic volume**
Urban core area in regional cities with less than 400.000 inhabitants	Residents Employees Customers	0,53 trips/(inhabitants*d) 0,59 trips/(employees*d) 0,16 trips/(m² sales area*d)
City centres in medium-sized cities	Residents Employees Customers	0,52 trips/(inhabitants*d) 0,70 trips/(employees*d) 0,21 trips/(m² sales area*d)
Old building area close to city centres	Residents Employees Customers	0,49 trips/(inhabitants*d) 0,64 trips/(employees*d) 0,19 trips/(m² sales area*d)

Source: Forschungsgesellschaft für Straßen- und Verkehrswesen (FGSV): Empfehlungen für Anlagen des ruhenden Verkehrs (EAR), Ausgabe 2005. Köln 2005

- **Balancing parking supply and demand**

After the integrated parking planning process, a supply and demand analysis must be considered. The analysis features the following steps: comparing parking supply and demand, considering each user group and parking time differently, and determining parking shortage and surpluse for each area.

In order to determine the future parking space supply, it is important to consider the urban development objectives in the transport concept, with possible modification. It is also necessary to identify the parking capacity required in the future (according to the qualified demand), then make suggestions for possible replacements or new locations of parking facilities. Finally, the recommendations for parking management should be made (e.g. short-term parking zone and so on).

3.3. Methods to forecast parking demand

Methods to estimate parking demand have long been investigated. The most commonly used methods are discussed in Table 3-3.

Table 3-3: Methods of parking demand forecast

Methods	Inputs	Processes	Outputs
O-D based model	▪ O-D survey data; ▪ Area and site-specific surveys; ▪ Parking capacities;	▪ Forecast traffic demand; ▪ Calculate future volume of trip;	▪ Parking demand volume; ▪ Indicators on parking spaces;
Generation rate model	▪ Statistics on the average peak parking demand, categorised by land use type; ▪ Set of empirical data of actual parking demand observations;	▪ Predict parking demand through the generation rate	▪ The number of trips generated and attracted by developments; ▪ The required number of parking spaces for facilities.
Regression model	▪ Statistic data; ▪ SP survey; ▪ Impact indicators; ▪ Influence indicators;	▪ Statistical analysis, to measure parking demand changes under the influence of walking distance, parking price, parking availability, land use mixture, and multimodal mixture.	▪ Parking demand changes under the impact of tested indicators;
Economic model	▪ Selection of economic function; ▪ Statistic data;	▪ Analyse the parking volume; ▪ Determine the quantity and pricing of parking by concentrating factors;	▪ The economical role of cruising for parking, spatial competition, minimum and maximum parking requirements, parking pricing and road pricing in the traffic regulation policy;

EAR Guideline Based on "Empfehlungen für Anlagen des ruhenden Verkehrs" (Recommendations for stationary traffic installations)	▪ Parking space structural analysis; ▪ Size of area; ▪ Types of area; ▪ Types of land-use; ▪ The interest of different demand groups; ▪ Mobility behaviour (survey on car drivers, passers-by, retailers and business people, residents);	▪ Generation of parking space requirements through use (type of area and type of land-use) and demand groups; ▪ Analysis of parking demand; ▪ Analysis of parking supply;	Parking planning concept: ▪ Spatial concept; ▪ Time concept; ▪ Fee concept;

Source: Author's representation

- **Origin-destination (O-D) based model**

The O-D based model, or four-step model (trip generation, trip distribution, route choice, and mode choice), has been the dominant modelling approach of traffic demand modelling (Mcnally, 2007). The O-D based model is the primary tool to forecast future traffic demand and performance of a transport system, typically at a regional or sub-regional scale (smaller scales often apply simplified models) (Mcnally, 2007). The model system is developed for evaluating large-scale infrastructure projects. It is not for more subtle and complex policies which manage and control existing infrastructure or directly influence travel behaviour. Application of travel forecasting models is a continuous process. The period required for data collection, model estimation, and subsequent forecasting exercises may take years. Activities, transport systems and policies change during the time. New data collection efforts and a new modelling effort are then required.

There has been argued that four step model is popularly applied since it is the only approach available given current institutional requirements and financial limitations (Mcnally, 2007). The traffic demand is forecasted throughout the whole city or most of the urban zones. In almost every city, the data on attraction and model split of every zone are collected yearly. Therefore, the data can be re-utilised for a long period of time, hence it is not much expensive. The collection process does not require much effort at one time.

For the application, the O-D based model can be applied at the initial stage of parking planning process to forecast the city-wide parking demand. Based on origin-destination traffic, parking demand to enter or exit each urban zone is also forecasted. Then the parking spaces for a certain zone are analysed based on the data of vehicle occupancy and parking turnover rate of each land-use type.

The O-D based model is advantageous in parking planning processes that employs current data of traffic demand at city-wide level, for instance, a National Travel Survey of each country. The process, therefore, can be time-saving and not expensive to be implemented. This method is recommended for Asian developing cities. However, given that parking demand is analysed based on traffic demand at a city-wide level, the verification of results is required. In this study, the verification process is proposed and the application of this method will be detailed in Section 3.3.

- **Generation rate model**

The generation rate model is primarily based on parking generation rate. It is similar to the concept of trip generation. A trip is defined as a one-way person movement by one or more modes of travel and having an origin and a destination. Trip generation refers to the production and attraction of trips by origins and destinations, respectively. Parking is a derivative of trip generation. The term "parking generation" refers to the parking spaces required as a result of trip attraction.

Parking generation summarizes parking demand observation data made by land use type. Parking generation provides statistics on the average peak parking demand, when the peak demand occurs, range, and coefficient of variation and standard deviation data.

Parking generation is usually documented and published at city-level in many countries. In Germany, the Car Parking Demand Indices are regulated by the Research Society for Roads and Transport (FGSV, 2005) for more than thirty land-use types. In the United State, Parking Generation is a document published by the Institute of Transportation Engineers (ITE), regulating the parking generation rate for more than hundreds of land-use types (Institute of Transportation Engineers, 2010). This document is updated every five to ten years, incorporating recent observations that have been submitted to ITE. In the United Kingdom, the parking requirements have been regulated as the parking standards for more than twenty land-use types, which cover the parking for different vehicles including cars, motorcycles, bicycles, and light vans (The Planning Service UK, 1999). In Singapore, the Code of Practice outlines the requirements of the Parking Places Rules for the provision of parking places and spaces. It also cites examples of good practices in the industry. Diagrams, sketches, and photographs are used to illustrate some of the parking requirements and practices (Land and Transport Authority, 2011).

The parking generation rate model is conventionally used in forecasting vehicle parking demand. However, all parking requirements in such countries are regulated as minimum parking provision standards for various land-use types. Therefore, they do not consider either the price motorists pay for parking or the cost of providing the required parking spaces (D. C. Shoup, 1997). By reducing the market price of parking, minimum parking requirements provide subsidies that inflate parking demand. Based on the conclusion of Shoup (1997), eliminating minimum parking requirements would reduce the cost of urban development, improve urban design, reduce automobile dependency, and restrain urban sprawl.

Additionally, the parking generation method has been developed mostly in car-dominated cities thus the generation rates of each land-use type are mostly defined for the cars. In Asian developing cities, where motorcycles account for 80-85% of modal splits, parking generation rates are not really practical. Therefore, it is necessary to select another proper method.

- **Regression model**

The aim of regression method is to test the changes of parking demand according to indicators like walking time, parking charge, parking location availability, and land use mixture. The input data of this method consist of statistic data, stated preference analysis, and impact indicators. Based on the statistical analysis, changes in parking demand are measured. Many scenarios might be tested, such as the ability of parking users to relocate to other available parking areas or relocate their final destinations, or the possibility of parking users to switch

to public transport, to accept higher parking prices, or to retime their current activities to limit the length of parking time (Arnott & Rowse, 1999; K. W. Axhausen & Polak, 1991b; Hensher & King, 2001).

As a form of data collection for regression model, stated preference (SP) method is widely used in travel behaviour research and practice to identify behavioural responses to choice situations. It presents a choice setting in exactly the same way that an individual sees the trip alternatives but enriches the context by combining observed levels of attributes. Through this enrichment strategy, we can identify how individuals evaluate. Hence trade-off levels of attributes such as parking prices and hours of operation at various locations are defined. The provision of greater variation in prices and hours of operation that we observe in real markets is critical to understanding the preferences of a sample of individuals.

It is recognised that the manner a parking space is provided could influence the choice of destination and means of transport or the quality of the traffic flow. For that reason, stated preference analysis is a strong method to investigate the "qualified parking demand" after general parking demand is calculated by O-D based model. Qualified parking demand should be understood as less sensitive under the impact of parking charge, walking time, the availability of parking facilities and the provision of public transport. In this study, stated preference analysis is selected. It plays an important part in the parking planning process proposed for Asian developing cities, as detailed in the next section.

- **Economic models**

Some economic models aim to understand the economic role of such influences as cruising for parking, spatial competition, minimum and maximum parking requirements, parking pricing, and road pricing in the traffic regulation policy. Through the selection of economic models and statistical data, parking volume is analysed and the pricing of parking is determined. Then, various distortions in the parking market are taken into account to determine optimal parking quantity and price.

One of the most frequently studied topics is the phenomenon of cruising for parking. Cruising for parking is an inefficient transport activity. Cars slow down traffic while they are cruising for parking leading to traffic congestion, increased fuel consumption, air pollution due to carbon emissions, and increased probability of traffic accidents.

Researchers have constructed a series of parking models to analyse the economic effects of cruising for parking. Search time is an increasingly important indicator (Glazer & Niskanen, 1992; Inci & Lindsey, 2015). It explains why drivers are willing to pay more than required. Arnott and Inci (2006) developed the first "bathtub model" of downtown parking, via which they analysed the effects of cruising on traffic and provided parking pricing recommendations. Calthrop and Proost (2006) concentrated on the optimal regulation of curb-side parking spaces when off-street garage parking was also available as a perfect substitute. The theory on cruising for parking largely assumes under-priced curb-side parking. As discussed before, cruising for parking will exist as long as there is a difference between the full prices of curb-side and garage parking. The optimal policy in those cases is to increase the curb-side parking fee until cruising for parking is eliminated.

Spatial competition in the parking location is also an important issue of the economics of parking since walking time strongly influences visitors' choice (Van Der Goot, 1982). Arnott

(2006) was probably the most comprehensive. It analysed downtown parking policies by modelling spatial competition between parking garages. The paper first underlined that horizontal economy of scale in garage parking stems from the fact that the central ramp in a parking garage entails a fixed cost. Due to these horizontal economies of scale, parking garages are discretely spaced. A driver, mindful of his walking time, is willing to pay a premium to park in a closer parking garage.

Anderson and de Palma (2004) presented another spatial model of parking with search. In their model, a central business district (CBD) was the most desirable parking location. Parking was provided on side streets perpendicular to the main streets. It became more difficult to find a parking vacancy if there were more parking users. The most desirable parking spaces closer to the CBD are overused, while the spaces further away from the CBD are underused.

The discussion of the parking price fluctuation should also cover the trade-off between parking duration and parking fees. Glazer and Niskanen (1992) highlighted this trade-off clearly. A higher parking fee induced drivers to park for shorter durations, which increased parking turnover. Thus, traffic congestions are likely to increase when parking fees increase because more people will be using parking spaces.

A large part of the literature evaluates minimum and maximum parking requirements which determine how many parking spaces should be supplied by each land use. There is empirical evidence that minimum parking requirements affect parking supply on a parcel. Cutter and Franco (2012), in their research in Los Angeles, analysed whether minimum parking requirements were binding for suburban land uses by using data for commercial, industrial, and retail property sales.

Although parking minimums are set to ensure that “enough” parking spaces are provided by property developers, the word “enough” turns out to be tricky. As Shoup (1999) pointed out, the zoning and building codes determined parking capacity for each land use so as to satisfy peak demand for free parking. When parking is free, everyone, not just the drivers, bears the costs of providing parking spaces, because those costs are embedded pretty much in the prices of everything else in the city, especially in the property prices and rents.

In a study of six neighbourhoods in San Francisco, McDonnell et.al. (2011) found that the prices of single family houses and condominiums were more than 10% higher when they included off-street parking than when they did not. Manville (2013) proved that parking requirements strongly affect housing, vehicle, and population densities. It was found that a 10% increase in residential minimum parking requirements in New York would increase vehicles per square mile by 5%, vehicles per person by 4%, and decrease housing and population density by 6%.

Most of the recent work on urban planning has recommended eliminating parking requirements completely and replacing them with a more market-based approach in which costs and benefits become the main determinants of parking supply. Wilson (1992) provided prescriptions on how to reform parking requirements. Shoup (1999, 2005) provided convincing arguments on why minimum parking requirements could also excessively increase car ownership and usage.

Guo and Ren (2012) analysed the 2004 parking reform in London: minimum parking requirements are replaced with maximum parking requirements. They analysed garage parking in new housing properties in 22 boroughs from 2004 to 2010. They found that the parking supply in residential developments decreased by 40% after the parking reform. The removal of the minimums explained 97.8% of the change while imposing maximums explained only 2.2%. Without maximum parking requirements, more parking is supplied in the unregulated parking market in high-density areas with abundant public transport. An unregulated market ignores the high social cost of driving. Thus, maximum parking requirements appear to be an important policy tool when curb-side parking is controlled.

The economics models are capable of determining the quantity and pricing of parking by analysing such factors as cruising for parking, spatial competition, minimum and maximum parking requirements. Additionally, many other issues might also be covered by those economic models, for instance, parking pricing and road pricing in the bottleneck model, temporal-spatial pricing, and forms of parking.

- **Integrated method according to EAR Guideline**

The method starts with the space structural analysis. The analysis aims to describe the mobility potentials and needs of the individual demand groups and as far as possible award these empirical features. Then, the area is described on a small scale according to various criteria. Both secondary sources and field surveys are used for this purpose, for instance the size of area, types of area, mobility characteristics (place of origin, purpose of parking, destination, distance of the parking place to the destination, parking duration, time spent looking for a parking space), the interest of different demand groups, or mobility behaviour (surveys on car drivers, passers-by, retailers and business people, residents).

Through the analysis of parking supply and demand, the parking space balance is calculated. A parking balance realistic for the implementation of the parking space concept is prepared based on the current parking space situation and surface area developments relevant for planning. Changes could then be made to the parking space supply and demand and to the general development trends in the overall town context.

Finally, the parking space concept is prepared. Parking possibility largely depends on the types of area: its location, use mixture and use intensity, building form and roadside environments. In particular, the inner cities, the residential and mixed areas near the centre are problematic. The parking space concept is prepared three-dimensional and covers the spatial concept, time concept, and fee concept.

In summary, this method provides with a comprehensive analysis of parking supply and demand in a certain location of urban areas, proposes parking space balance forecast and parking management strategies for the urban area of European cities. Its application in Asian developing cities is possible because of the similarity in parking composition, especially for the micro level of parking planning. However, the areas are described on a small scale according to various criteria. Both secondary sources and field surveys are used for the investigation process so more efforts should be made at a time.

This method is difficult to be applied at the level of city parking planning since data collection process is costly. The surveys are conducted in large and complex urban areas with hundreds of roads, thousands of building with tens of land-use types.

Therefore, the proposed application of EAR guideline limits to micro levels for verification process of a comprehensive parking planning method. The in-depth proposal will be extensively discussed in the following part.

3.4. A proposal of a parking planning process for Asian developing cities

Data collection in studies on parking is a major challenge. The diversity of parking types and the multiple variations of their vocations contribute to this difficulty (Diallo, Morency, & Saunier, 2012). The proposal of a parking planning method will form the basis for analyses of parking planning requirements in Asian developing cities. The general parking planning process (Figure 3-4) covers three major steps including the estimation of parking demand and supply, macro data collection, and micro data checked.

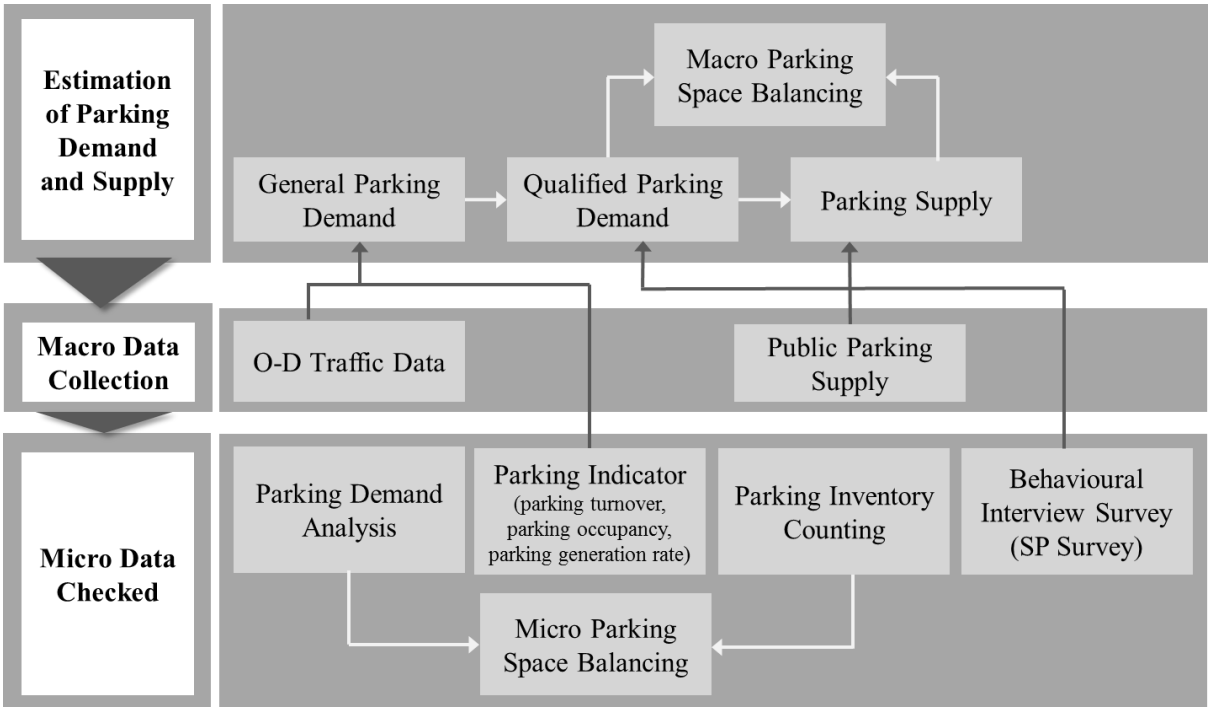

Figure 3-4: General parking planning process

Source: Author's representation

- **Estimation of parking demand and supply**

This process covers model structure and techniques for analysing parking requirements, including general parking demand, qualified demand, parking supply, and the process of parking space balancing. The model is designed as shown in Figure 3-5.

Firstly, general parking demand is analysed at the macro level through O-D based model. The method to evaluate the use of parking spaces from O-D survey data was first developed by Tong et al. (2004) and Morency et al. (2006) for the Montreal area. Car trips observed in the travel survey were sequentially processed in order to follow the movement of cars in time and space. This enabled the analysis of the use of parking spaces during a typical day.

O-D traffic data is collected and distributed into zones. Then, the mode share coefficient and occupancy rate are used to estimate the volume of each mode in each zone. Afterwards, the share of trip purpose is used to calculate the volume of mode into each land-use type, and parking turnover rate is applied to estimate parking spaces required in each zone.

Secondly, the stated preference analysis (data to be collected at micro level) is used to analyse the "qualified demand" which is all unavoidable traffic for the urban functions of the inner cities. In this study, the stated preference analysis aims to investigate the impact of parking charge and bus accessibility on travel mode choice as well as the selection of parking location; then measure the sensitivity of each demand group. Residents and customers are supposed to be the least sensitive demand group whereas employees, apprentices, students, and pupils are assumed to be the most sensitive demand group to parking charge and public transport availability.

Thirdly, the public parking supply is collected at the macro level, and the planning of parking supply is reviewed. In this step, the parking supply is hard to be divided into private or public, on-street or off-street.

Finally, macro parking space balancing is processed with the focus on two major scenarios. The conventional scenario mostly covers the supply-oriented policies, where parking spaces are supplied as required and almost no parking management is applied. On the contrary, market-based scenario covers demand-focused policies, where parking supply is designed to serve the "qualified demand" and parking management measures are applied in combination with the enhancement of public transport service.

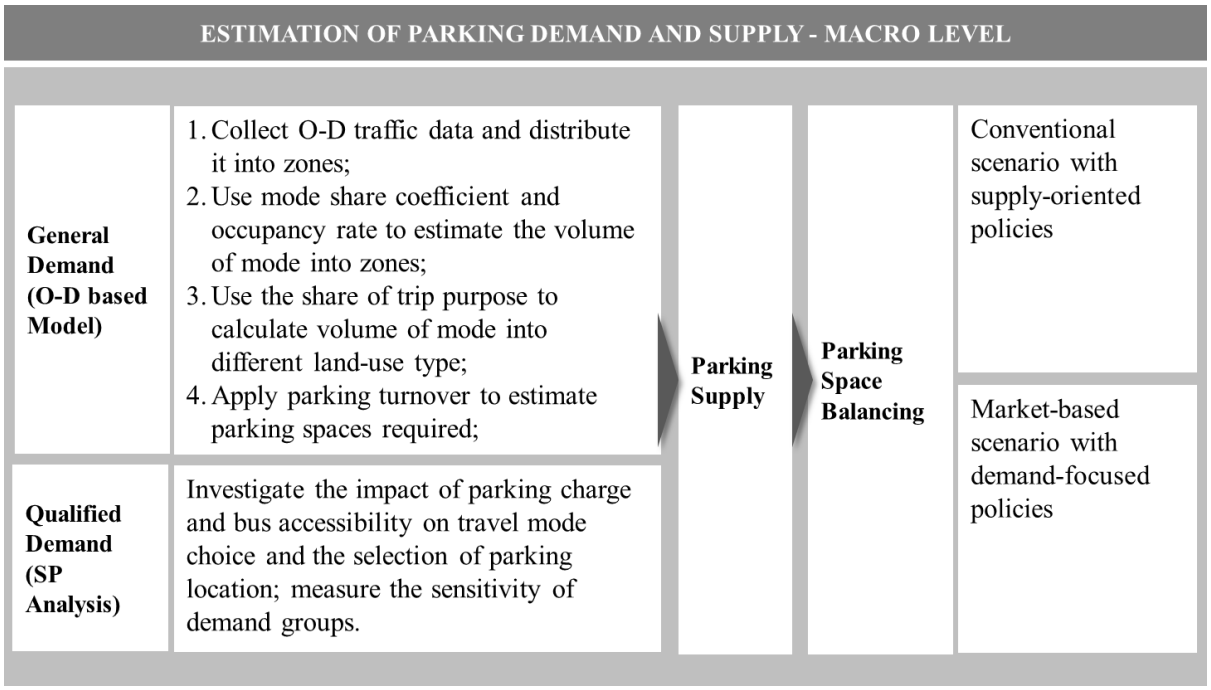

Figure 3-5: Forecast of parking demand and parking supply at macro level

Source: Author's representation

- **Macro data collection**

This process deals with types of data, collection approaches and techniques. Three different types of data need to be collected, including O-D traffic data, observation and traffic counting survey, and behavioural interview survey.

O-D traffic data are collected through the database of the city as secondary data, and used for the analysis of general parking demand at the macro level. Observation and traffic counting survey is directly collected on site at each land-use type at each urban zone. This data set is

conducted at the micro level and utilised for model validation. Behavioural interviews are conducted through a stated preference survey with a selected set of interviewees. The number of interviewed people is determined by statistic requirement.

- **Micro data checked**

The estimation of parking demand and supply is checked by comparing parking supply and demand to observe data in different land-use types in different urban zones (Figure 3-6). The initial analysis is conducted for parking demand pattern, which covers on-street and off-street parking demand and illegal parking. The next step is to analyse parking demand indicators, including parking duration, parking turnover rate, parking occupancy, and parking generation rate. Finally, the analysis of parking inventory is implemented to investigate on-street and off-street parking facilities, multi-storey and underground facilities as well as private parking facilities. Micro data checked process helps to understand how parking balancing analysed by model is compatible with the observed balancing.

MICRO DATA CHECKED			
	Analysis of parking demand		**Analysis of parking inventory**
EAR Method	**Parking demand pattern** On-street parking demand; Off-street parking demand; Illegal parking;	**Parking demand indicators** Parking duration; Parking turnover rate; Parking occupancy; Parking generation rate;	**Analysis of parking inventory** On-street and off-street parking facilities; Multi-storey facilities and underground facilities; Private parking facilities;
Micro data checked by conducting observation and counting survey in three streets in three zones.			

Figure 3-6: Data checked at micro level

Source: Author's representation

3.5. Application for the case of Hanoi

3.5.1. Parking regulations in Vietnam

Parking has been regulated by the central government in Vietnam. It has also been controlled by local regulations and standards that conform to or adapt from national policies. This part of paper starts with the overall regulatory framework at the central and local government levels. It then elaborates on the two most important aspects of parking regulation – supply and price.

- **Quantity regulations**

Similar to the practice in many other countries (Kodransky & Hermann, 2011), Vietnamese cities regulate the quantity of off-street parking spaces (Table 3-4) through minimum parking requirements. The 1988 "Regulations on the design standard of office buildings" was the first national regulation on the minimum size of parking lots for certain buildings and public structures. The regulation, then, was supplemented with a specific standard for condominium through "Construction Building Code TCXDVN 323:2004". The 2010 "Circular No. 02/2010/TT-BXD, promulgation of national technical standards for urban infrastructure" included the first comprehensive national standard on minimum parking space requirements of different vehicle type.

Table 3-4: Minimum requirement for parking space in buildings

Type of area	Parking space (% of construction space)	Parking requirement (m2/person)
Parking restriction area	2.0 – 2.5	1.5 – 2.5
Expanding areas	2.5 – 3.0	2.5 – 3.0
New construction area	3.0 – 3.5	(*) 4.0 – 5.0
High-rise apartment	(**) 4.0 – 5.0	(**) 4.0 – 5.0

Source: Decision No.165/2003/QĐ-UB of HN People's Committee
Note: (*) Use the high number for Parking restriction area and Expanding areas
(**) For the apartments over 15 floors, use high number 5% or 5m2/person

- **Price regulations**

Vietnamese cities control parking prices extensively. Cities commonly set parking fees, even in residential areas. The day and night residential parking price standards remained constant in Hanoi during 2002–2011 (40,000VND/120minute/car and 3,000VND/turn/motorcycle) (Decision No. 47/2011/QD-UBND about charging for bicycle, motorcycle, car in the area of Hanoi, 2011) and in Hochiminh during 2004–2012 (20,000VND/turn/car in daytime and 40,000/turn/car in night time; 3,000VND/turn/motorcycle in day time and 5,000VND/turn/motorcycle in night time) (Decision No. 32/2012/QD-UBND about charging for bicycle, motorcycle, car in the area of Hochiminh, 2012). Compared to the fairly flexible residential price standards, parking prices in non-residential areas remain tightly controlled by the government. The curb and off-street parking fees in non-residential areas increased in both Hanoi and Hochiminh from 2000 to 2010, with significant increases in curb parking fees recently as a response to market demand.

According to Article 83, section 6, of the Law on Road Traffic (Vietnam Ministry of Justice, 2008) fees for car parking have to be stipulated by the local People's Committee. Hanoi People's Committee regulates parking fees for both on-street and off-street parking. The city promulgated Decision No. 47/2011/QD-UBND to guide parking charges for bicycles, motorcycles, and cars. Both privately and government-operated parking lots have to comply with the regulations. Motorists are charged per turn, not per hour. However, there is a monthly collected parking fare. During night time, the parking fee is higher. Cars are charged more than motorcycles. Parking fees for cars vary according to their capacity and the parking duration. The maximum length of car parking time per turn is 120 minutes. In fact, parking charges and parking duration fluctuate across the areas. Normally, actual fees are higher than regulated ones at both authorized and unauthorized parking spaces.

3.5.2. Analysis of parking demand at macro level

- **An introduction of Hanoi**

Hanoi is the capital of Vietnam and the country's second largest city by population with 7.7 million people, area of 3,345 km² and the population density of 2,279 person/km² (General Statistics Office of Vietnam, 2016). Hanoi after being expanded in 2008 includes 12 districts, one town and 17 suburban districts (peri-urban area). The peri-urban areas are characterised with a high percentage of free land and low density of population and vehicles. Therefore, parking here currently is not a big problem. Therefore, the study only focuses on the urban area with twelve districts as shown in Figure 3-7.

Figure 3-7: The map of research area in Hanoi

Based on the development of economics and housing and population density, twelve districts in urban area of Hanoi are divided into three major zones, including the core city centre (district of Hoan Kiem), the developed area (district of Dong Da, Ba Dinh, and Hai Ba Trung) and the newly developed area (district of Cau Giay, Tay Ho, Long Bien, Hoang Mai, Thanh Xuan, Bac Tu Liem, Nam Tu Liem, and Ha Dong).

- **Step 1: O-D traffic data**

O-D traffic data is collected from Hanoi Department of Transport and presented in Table 3-5.

Table 3-5: O-D traffic data in twelve districts in Hanoi

No.	Districts	Daily Trip Attraction (2015)	Area (km^2)	Trip Density (number of trip/km^2)
1	Ba Dinh	1,027,260	9.25	111,055
2	Hoan Kiem	1,303,230	5.29	246,357
3	Tay Ho	362,922	24.01	15,115
4	Long Bien	387,047	59.93	6,458
5	Cau Giay	531,044	12.03	44,143
6	Dong Da	1,634,743	9.96	164,131
7	Hai Ba Trung	1,498,900	10.09	148,553
8	Hoang Mai	1,407,222	40.32	34,901
9	Thanh Xuan	1,426,201	9.08	157,071
10	Bac Tu Liem	368,853	43.35	8,509
11	Nam Tu Liem	265,737	32.27	8,235
12	Ha Dong	740,790	48.34	15,325

The mapping of trip density in 12 districts in Hanoi is illustrated in Figure 3-8.

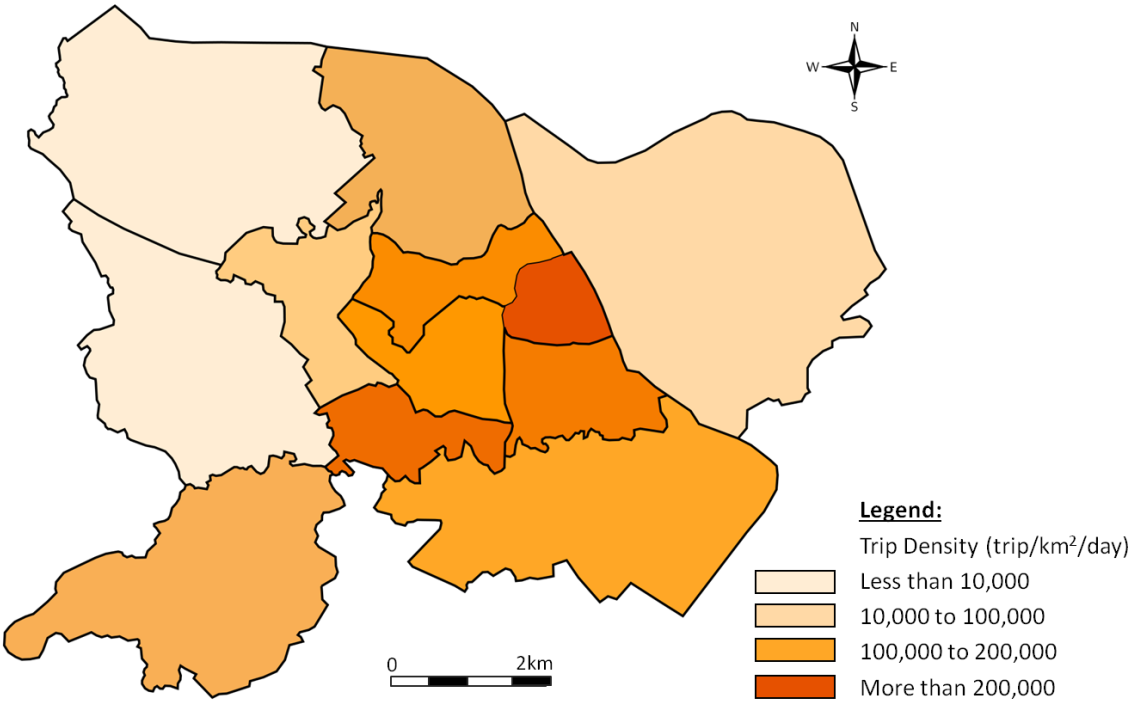

Figure 3-8: Trip density - spatial distribution in 12 districts in Hanoi
Source: Author‘s representation

- **Step 2: Trips distributed into districts by mode**

Based on model split data, the volume of trip is distributed into districts and divided by mode is calculated. Modal split of the trip is collected from Hanoi Department of Transport in Table 3-6.

Table 3-6: Modal split rate

Mode	Modal Split Rate
Bicycle	5%
Motorcycle	78%
Car	10%
Bus	5%
Urban Rail	0%
Truck	2%

Then, the volume of trip by private vehicles (bicycles, motorcycles and cars) by mode and distributed into districts is calculated in Table 3-7.

Table 3-7: The volume of trip by mode

No.	Districts	Bicycle	Motorcycle	Car
1	Ba Dinh	51,363	801,263	102,726
2	Hoan Kiem	65,161	1,016,519	130,323
3	Tay Ho	18,146	283,079	36,292
4	Long Bien	19,352	301,896	38,705
5	Cau Giay	26,552	414,214	53,104
6	Dong Da	81,737	1,275,100	163,474
7	Hai Ba Trung	74,945	1,169,142	149,890
8	Hoang Mai	70,361	1,097,633	140,722
9	Thanh Xuan	71,310	1,112,437	142,620
10	Bac Tu Liem	18,443	287,705	36,885
11	Nam Tu Liem	13,287	207,275	26,574
12	Ha Dong	37,039	577,816	74,079
Total		547,697	8,544,080	1,095,395
		10,187,172		

- **Step 3: Vehicles distributed into districts**

Based on the vehicle occupancy rate, the number of vehicles distributed into districts is calculated. The vehicle occupancy rate is collected from Hanoi Department of Transport as presented in Table 3-8.

Table 3-8: Occupancy rate

Vehicle	Occupancy Rate (person/vehicle)
Car	1.65
Motorcycle	1.3
Bicycle	1.0

The number of vehicles distributed into districts is calculated as in Table 3-9:

Table 3-9: Number of vehicles distributed by mode and districts

No.	Districts	Bicycle	Motorcycle	Car	Total
1	Ba Dinh	51,363	616,356	62,258	729,977
2	Hoan Kiem	65,161	781,938	78,984	926,083
3	Tay Ho	18,146	217,753	21,995	257,895
4	Long Bien	19,352	232,228	23,457	275,038
5	Cau Giay	26,552	318,626	32,184	377,363
6	Dong Da	81,737	980,846	99,075	1,161,658
7	Hai Ba Trung	74,945	899,340	90,842	1,065,127
8	Hoang Mai	70,361	844,333	85,286	999,981
9	Thanh Xuan	71,310	855,721	86,436	1,013,467
10	Bac Tu Liem	18,443	221,312	22,355	262,109
11	Nam Tu Liem	13,287	159,442	16,105	188,834
12	Ha Dong	37,039	444,474	44,896	526,410
Total		**547,697**	**6,572,369**	**663,876**	**7,783,942**

- **Step 4: Vehicles distributed by trip purpose**

Based on the trip purpose rate, the number of vehicles distributed by trip purpose is calculated. The trip purpose rate is collected from Hanoi Department of Transport as illustrated Table 3-10. The number of vehicles distributed by trip purpose is calculated in Table 3-11.

Table 3-10: Trip purpose

Trip purpose	Percentage of Total Trip
Work	52%
Education	23%
Other (Shopping/Entertainment/Fitness)	25%
Total	100%

Table 3-11: The number of vehicle distributed by trip purpose

No.	Districts	Trip Purpose	Bicycle	Motorcycle	Car	Total
1	Ba Dinh	Work	8,561	345,737	37,355	729,977
		Education	23,462	126,356	2,767	
		Other	19,340	144,264	22,136	
2	Hoan Kiem	Work	10,860	438,617	47,390	926,083
		Education	29,765	160,300	3,510	
		Other	24,536	183,020	28,083	
3	Tay Ho	Work	3,024	122,146	13,197	257,895
		Education	8,289	44,640	978	
		Other	6,833	50,967	7,821	
4	Long Bien	Work	3,225	130,265	14,074	275,038
		Education	8,840	47,608	1,043	
		Other	7,287	54,355	8,340	
5	Cau Giay	Work	4,425	178,729	19,311	377,363
		Education	12,129	65,320	1,430	
		Other	9,998	74,578	11,443	
6	Dong Da	Work	13,623	550,192	59,445	1,161,658
		Education	37,337	201,077	4,403	
		Other	30,778	229,577	35,227	
7	Hai Ba Trung	Work	12,491	504,472	54,505	1,065,127
		Education	34,234	184,368	4,037	
		Other	28,220	210,499	32,300	
8	Hoang Mai	Work	11,727	473,617	51,172	999,981
		Education	32,140	173,092	3,790	
		Other	26,494	197,624	30,324	
9	Thanh Xuan	Work	11,885	480,005	51,862	1,013,467
		Education	32,574	175,426	3,842	
		Other	26,851	200,290	30,733	
10	Bac Tu Liem	Work	3,074	124,142	13,413	262,109
		Education	8,424	45,370	994	
		Other	6,944	51,800	7,948	
11	Nam Tu Liem	Work	2,214	89,437	9,663	188,834
		Education	6,069	32,686	716	
		Other	5,003	37,319	5,726	

12	Ha Dong	Work	6,173	249,321	26,938	526,410
		Education	16,919	91,119	1,995	
		Other	13,947	104,033	15,963	

- **Step 5: Parking spaces and parking area required for each district**

Based on parking turnover rate, the parking spaces required for each district are calculated. The parking turnover rate is calculated in Table 3-12 based on the parking surveys conducted at different land-use types (see section 3.4.3 for details).

Table 3-12: Parking turnover rate

Trip Purpose	Parking Turnover Rate (vehicle/parking space)
Work	1.1
Education	1.8
Other (Shopping/Entertainment/Fitness)	5.1

Based on the parking space requirement for each mode (Table 3-13), the parking area required for each district is calculated. The parking space requirement for each mode is regulated in Circular No. 02/2010/TT-BXD, Promulgation of national technical standards for urban infrastructure as followed:

Table 3-13: Requirements of parking area for each mode

No.	Vehicles	Minimum space (m^2/vehicle)
1	Bus	40
2	Truck	30
3	Car	25
4	Side-car	8
5	Motorcycle	3
6	Bicycle	0,9

The parking spaces and parking area required for each district are calculated as in Table 3-14.

Table 3-14: Parking spaces and parking area required for each district

No.	Districts	Number of Parking Spaces (space)			Parking Area (m^2)			Total (ha)
		Bicycle	MC	Car	Bicycle	MC	Car	
1	Ba Dinh	24,647	413,071	39,880	22,182	1,239,212	996,992	225.84
2	Hoan Kiem	31,268	524,040	50,593	28,141	1,572,121	1,264,830	286.51
3	Tay Ho	8,707	145,934	14,089	7,837	437,803	352,229	79.79
4	Long Bien	9,286	155,635	15,026	8,358	466,905	375,642	85.09
5	Cau Giay	12,741	213,537	20,616	11,467	640,612	515,396	116.75
6	Dong Da	39,222	657,345	63,463	35,299	1,972,035	1,586,575	359.39
7	Hai Ba Trung	35,962	602,721	58,189	32,366	1,808,163	1,454,734	329.53
8	Hoang Mai	33,763	565,857	54,630	30,387	1,697,570	1,365,758	309.37
9	Thanh Xuan	34,218	573,488	55,367	30,796	1,720,465	1,384,178	313.54
10	Bac Tu Liem	8,850	148,319	14,319	7,965	444,957	357,985	81.09
11	Nam Tu Liem	6,376	106,855	10,316	5,738	320,566	257,907	58.42
12	Ha Dong	17,773	297,878	28,758	15,996	893,635	718,962	162.86
Total		262,813	4,404,681	425,248	236,532	13,214,043	10,631,188	2,408.18
		5,092,741			24,081,762			

The mapping of parking demand distribution in 12 districts in Hanoi is shown in Figure 3-9.

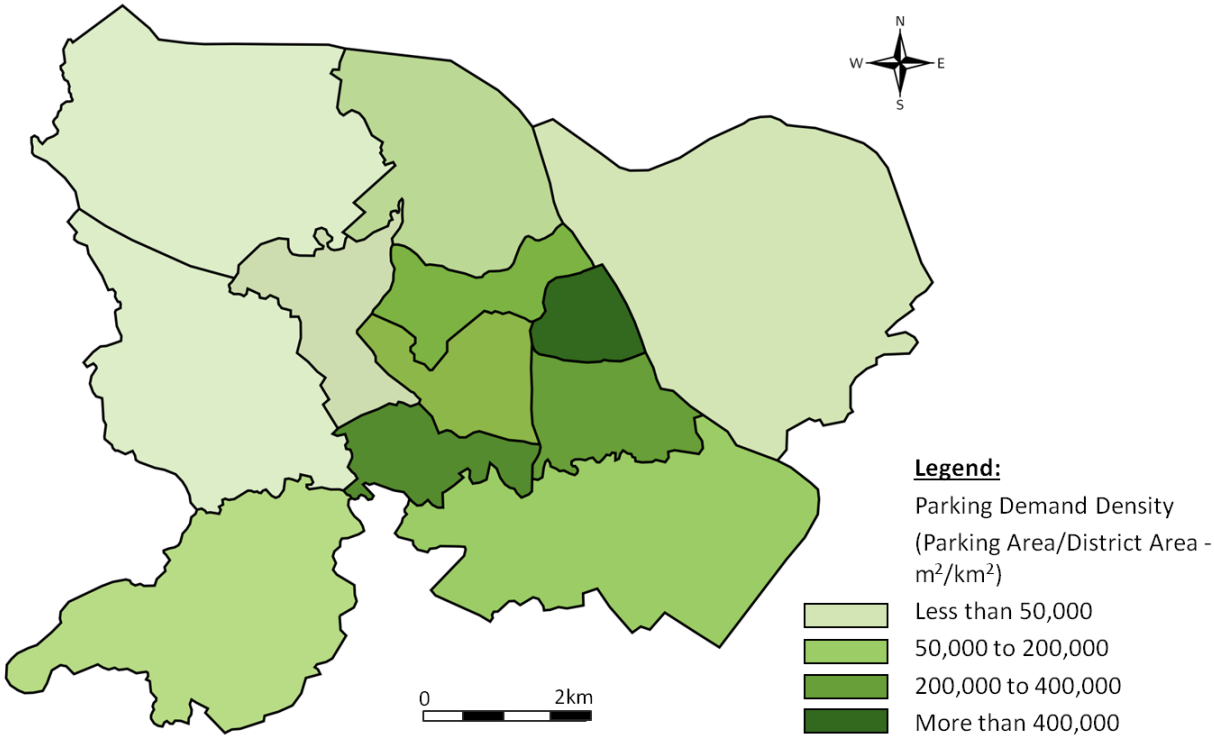

Figure 3-9: Parking demand density - spatial distribution in 12 districts in Hanoi
Source: Author‘s representation

Based on the analysis at the macro level, Hanoi urban area requires nearly 4.9 million parking spaces (for bicycles, motorcycles, and cars) equivalent to the parking area of 1,876ha. The parking area required for Hanoi urban region was planned at 1,706ha, based on Decision No. 519/QD-TTg of the Prime Minister “To approve the planning of Hanoi transport system up to 2030, with a vision to 2050”.

3.5.3. Provision of parking supply

In the early stages of the motorisation process, many Vietnamese cities seemed sympathetic to motorists looking for parking and tried to accommodate the demand for parking by (a) providing more parking facilities financed by the private sectors and (b) laxly enforcing existing regulations in light of a perceived “inadequate” level of parking. Nonetheless, while smaller cities may still witness the rapid expansion of parking places, parking supply has already decreased in large cities like Hanoi. The majority of new parking places have been located outside of the city core and off-street parking has been developed much than on-street. Although many vehicle owners still park free of charge, the number of public parking places has grown faster than that of free parking spaces.

As of 2015, in Hanoi urban area, there was a total area of 377,069 m^2 public parking, only serving 2% of total demand as calculated above. 33.4% were on-street parking and 66.6% were off-street parking. The remaing 98% of parking demand was served unofficially in school yards (for surrounding resident areas), temporily in the contruction sites when the projects have not started yet, or under the spans of city viaducts. Table 3-15 shows the numbers of parking places and area of parking in 12 districts in Hanoi in 2005 and 2015. By 2015, the number of parking places grew 407% (more than 4 times), while area of parking

grew by 146%. The area of parking grew by 161% in Hoan Kiem (core city centre), 127% in Dong Da (developed area), and 140% in Cau Giay (newly developed area).

Table 3-15: Parking supply in Hanoi (2015)

No.	District	Area of Parking 2015 (m^2)	Number of Parking Places (2015)	Area of Parking 2005 (m^2)	Number of Parking Places (2005)
1	Hoan Kiem	34,025	182	21,190	63
2	Hai Ba Trung	61,574	125	15,038	27
3	Ba Dinh	49,646	73	39,848	26
4	Dong Da	10,673	34	8,416	11
5	Tay Ho	188	9	320	2
6	Cau Giay	57,455	53	41,148	11
7	Thanh Xuan	28,552	47	-	-
8	Hoang Mai	26,844	19	26,717	2
9	Long Bien	658	5	12,993	1
10	Ha Dong	1,536	6	-	-
11	Nam Tu Liem	100,586	32	93,000	2
12	Bac Tu Liem	5,332	5		
	Total	377,069	590	258,670	145

Source: Department of Transport, Hanoi (2016)

The mapping of parking supply distribution in 12 districts in Hanoi is presented in Figure 3-10. It has revealed in Dong Da and Cau Giay, parking supply cannot meet the demand, as shown in the mapping of density spatial distribution (Figure 3-9). Parking demand in Dong Da is the second highest in 12 districts, however, the parking supply is the fifth lowest. Similarly, parking demand in Cau Giay District is the seventh lowest but the parking supply is the fourth highest.

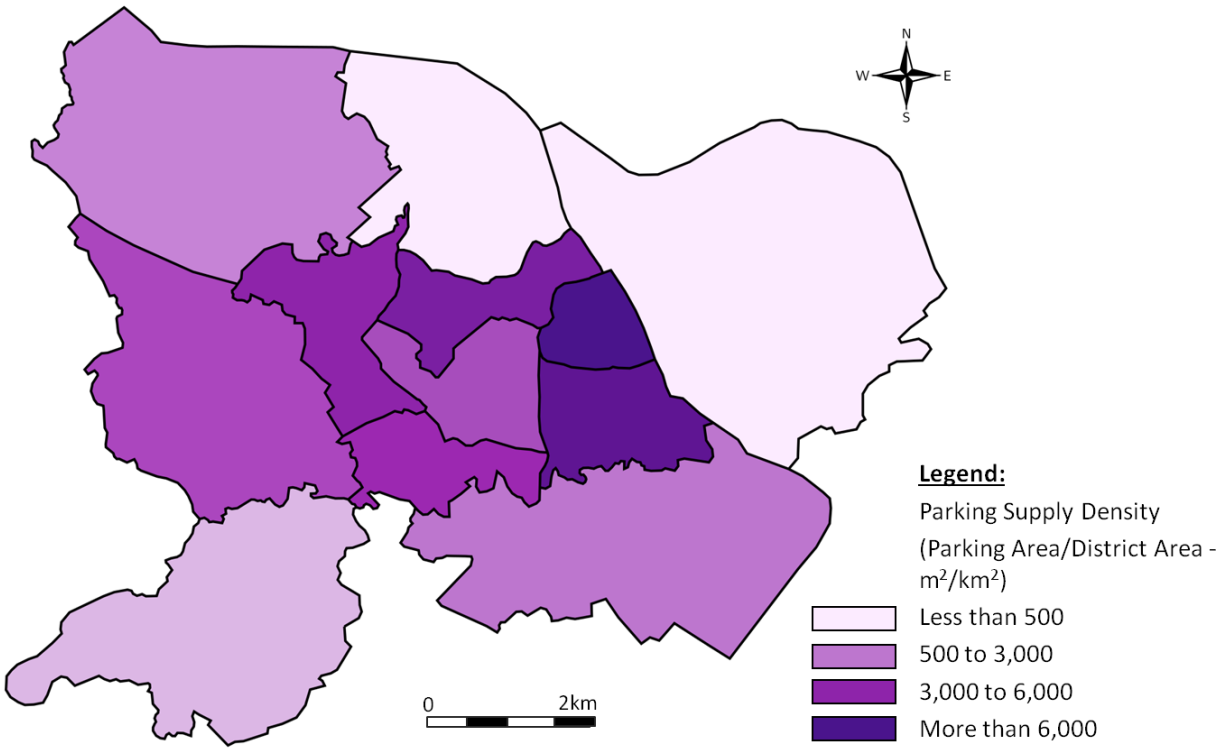

Figure 3-10: Parking supply density - spatial distribution in 12 districts in Hanoi
Source: Department of Transport, Hanoi (2016)

However, as one of forerunners of motorisation, Hanoi has witnessed a decrease in parking supply recently. Number of public parking places and parking spaces increased by 228% and 388%, respectively, from 2005 to 2015. However, the average annual compound growth rate of public parking spaces was 10% during 2010–2015, significantly lower than the annual growth of 14.5% during 2005–2010 (Hanoi Department of Transport, 2005–2015). On the contrary, smaller cities such as Hue have kept a relatively high growth rate in parking supply – on-street parking spaces gradually increased from 8367 in 2007 to 9367 in 2008 and 11,249 in 2009, yet further jumped to 17,345 in 2010 (Hue Department of Transport, 2010).

The most remarkable increase in parking supply has been witnessed in Hanoi's traditional urban core. During the period of 2005–2015, as shown in Figure 3-11, the four central city districts inside the inner Hanoi city (including Hoan Kiem, Hai Ba Trung, Ba Dinh, and Dong Da Districts) constructed more than 40% (155,918 out of 377,069) of new public area of parking and 70% (414 out of 590) of new parking places. As a result, the share of total area of parking in the inner city, compared with the whole central city of Hanoi, increased from 33% to 41%, suggesting the diminishing potential for new parking places in Hanoi's densely developed inner area (Hanoi Department of Transport, 2005–2015).

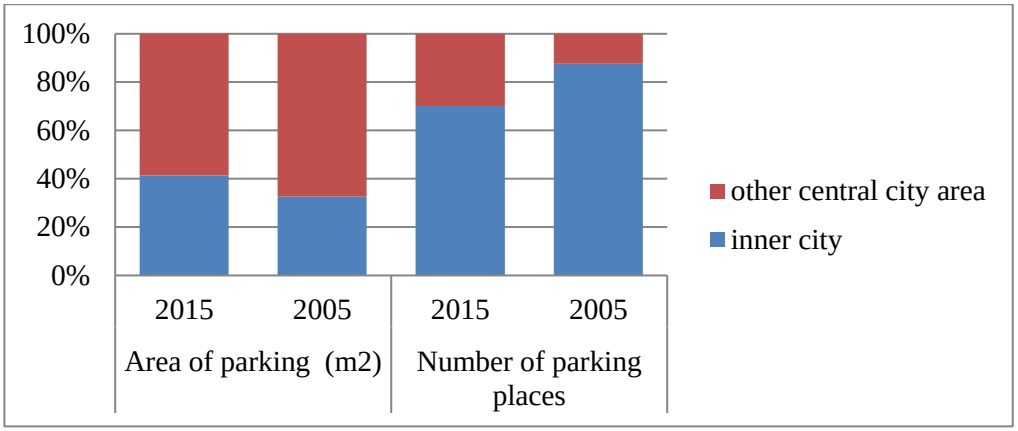

Figure 3-11: Parking area and number of parking places of Hanoi, 2005–2015
Source: Hanoi Department of Transport, 2016

Within the public parking supply in Hanoi's central city, off-street parking facilities developed faster than on-street parking. From 2005 to 2015, on-street parking area in Hanoi increased by only 15%, while off-street parking lots went up by 46%, from 185,467 m^2 to 269,906 m^2. As shown in Figure 3-12, after increasing by more than 45% since 2005, off-street parking area has accounted for over 72% of the total parking area in Hanoi (Hanoi Department of Transport, 2005–2015).

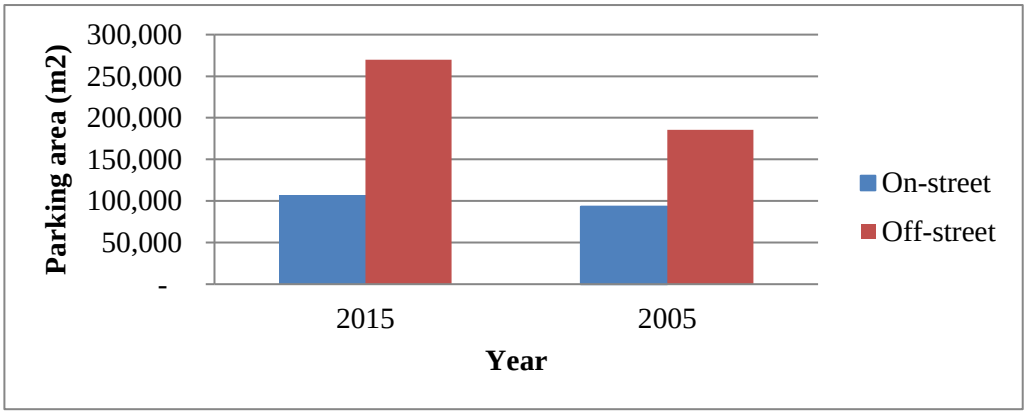

Figure 3-12: Public parking area in Hanoi, 2005–2015
Source: Hanoi Department of Transport, 2016

3.5.4. The widening supply-demand gap

Available data show that the gap between supply and demand in parking in Hanoi has been enlarged. The city government has little experience and is institutionally unprepared for the proper planning, regulation, and management of parking.

According to the Hanoi Department of Transport, the area of parking in Hanoi increased by 4.07% annually from 2005 to 2015. The number of motorcycles during 2005-2015 however, increased from 1.5 million to 5.03 million during this period, showing an average annual growth of 23%. The number of cars increased even more dramatically, more than sextuple, from 51,173 in 2005 to 334,273 in 2015, showing an average annual growth of 55%. As shown in Figure 3-13, in Hanoi, the total number of private cars and motorcycles remained significantly higher than the number of public parking spaces and the supply-demand gap continued to grow between 2005 and 2015 (Hanoi Department of Transport, 2005– 2015).

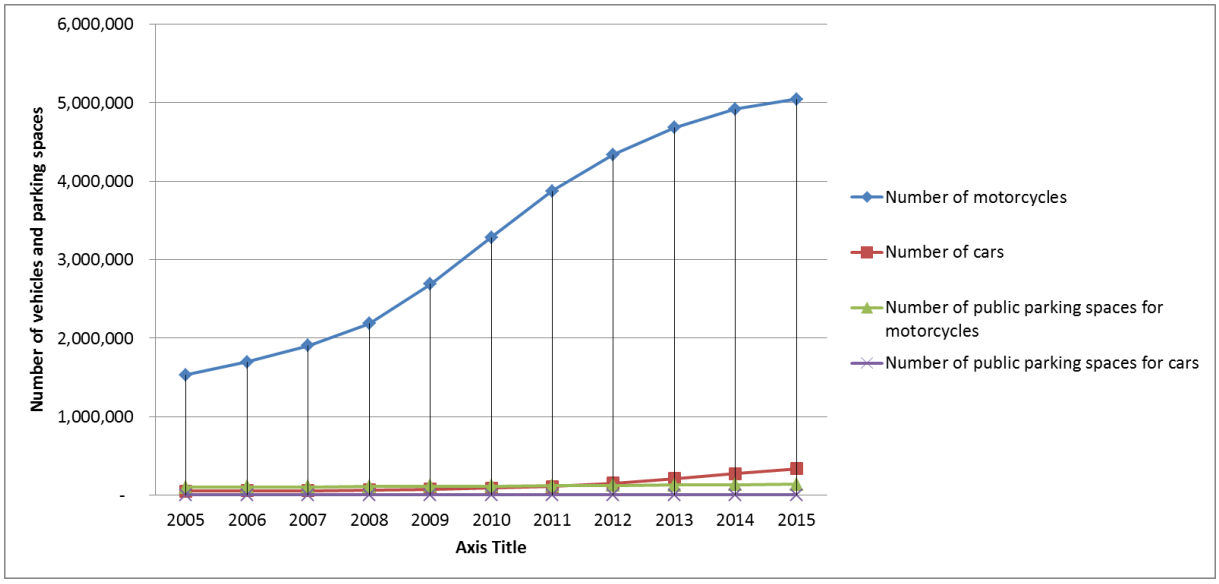

Figure 3-13: Numbers of private vehicles, public parking spaces in Hanoi, 2005-2015
Source: Department of Transport, Hanoi (2016)

By the end of 2015, there were approximately 850,000 residential parking spaces in Hanoi, compared to an estimated demand of more than two million parking spaces for overnight parking. This gap was largely filled by unauthorised parking spaces, such as utilising undesignated street and sidewalk space for parking, as one could easily encounter in Hanoi today. Occupying traffic lanes for parking became unavoidable. It is common to find that people park their cars on dead-end streets or even in bicycle lanes on main roads overnight.

In summary, the study has calculated the parking demand and parking supply at macro level. The supply-demand gap has been identified based on the O-D method. In order to verify this data, the analysis of parking at micro level is conducted in the next section.

3.5.5. Analysis of parking at a micro level

- **Data collection**

For this study, four types of surveys have been conducted, including parking demand survey and parking user interview survey.

The on-street parking survey was conducted in July and August 2014. Thirty street sections were selected to represent major road network and distributed equally in three districts including Hoan Kiem (core city centre), Dong Da (developed area), Cau Giay (newly developed area). The on-street parking survey is in Appendix A.

A survey on illegal parking behaviour was conducted in November 2014. A total of 360 people were interviewed to investigate their parking characteristics and their perception of illegal parking. The illegal parking behaviour survey is in Appendix B. Most of the results of this survey are presented in Chapter 5.

The off-street parking survey was conducted in June and July 2016, covering different land use types (office buildings, shopping malls, residences…) in the same three districts as illustrated in Figure 3-14. The off-street parking survey is detailed in Appendix C.

Additionally, a survey on travel behaviour was conducted in June 2016. A total of 311 people were randomly selected at the buildings of different land use types. They were directly

interviewed to analyse parking behaviour changes under the impacts of parking fees, covering five different office buildings with different type of parking users (bicycle, motorcycle, and car). The travel behaviour survey is in Appendix D.

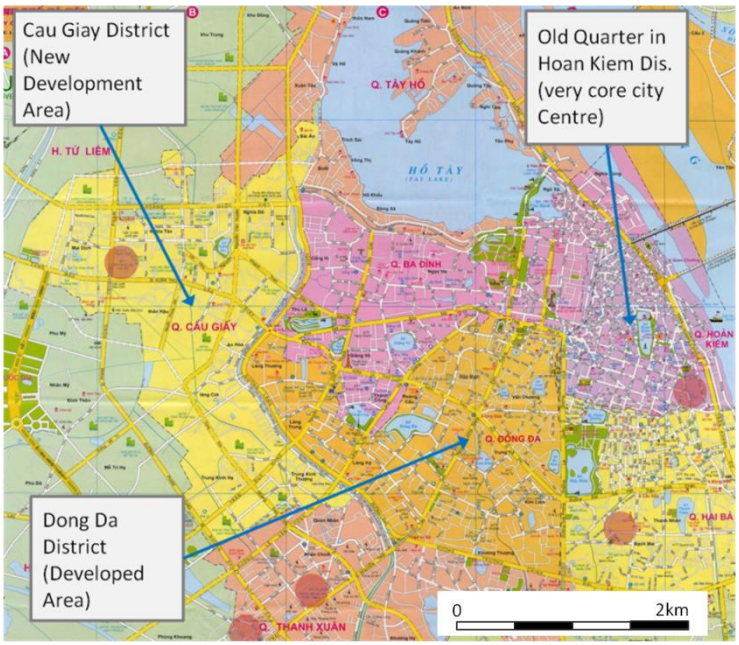

Figure 3-14: Distribution of parking locations

To determine on-street parking demand, parking counting surveys were conducted in two weeks. The first week was from 15th July, 2014 and the second week was from 25th August, 2014. Time of survey was split into two shifts, from 5:00 AM to 23:00 PM.

In order to determine parking turnover rate and parking occupancy in buildings, total parking demand was measured by in-out survey. At first, the occupancy count was taken at the beginning; then the number of vehicles entering the parking lot for each 5 minutes was counted. The number of vehicles that leave the parking lot was taken. The final occupancy in the parking lot was also taken.

Parking duration was measured by vehicle license plate survey at three different land-use types, including a shopping mall, commercial buildings, and office buildings. Five parking stalls (total 100 parking spaces) were monitored at a continuous interval of 15 minutes and every license plate number was noted down. The survey was conducted from 5:00 AM to 24:00 PM on a Wednesday and a Sunday. The results of parking demand are presented in the following part.

- **On-street parking utilisation**

On-street parking utilisation varied in three surveyed areas. In Old Quarter Area, the streets with over 100% parking utilisation (including illegally parked vehicles) accounted for 70%. In those streets, on-street parking is banned in the roadsides and sidewalks but vehicles still parking illegally. The mapping of parking utilisation is illustrated in Figure 3-15.

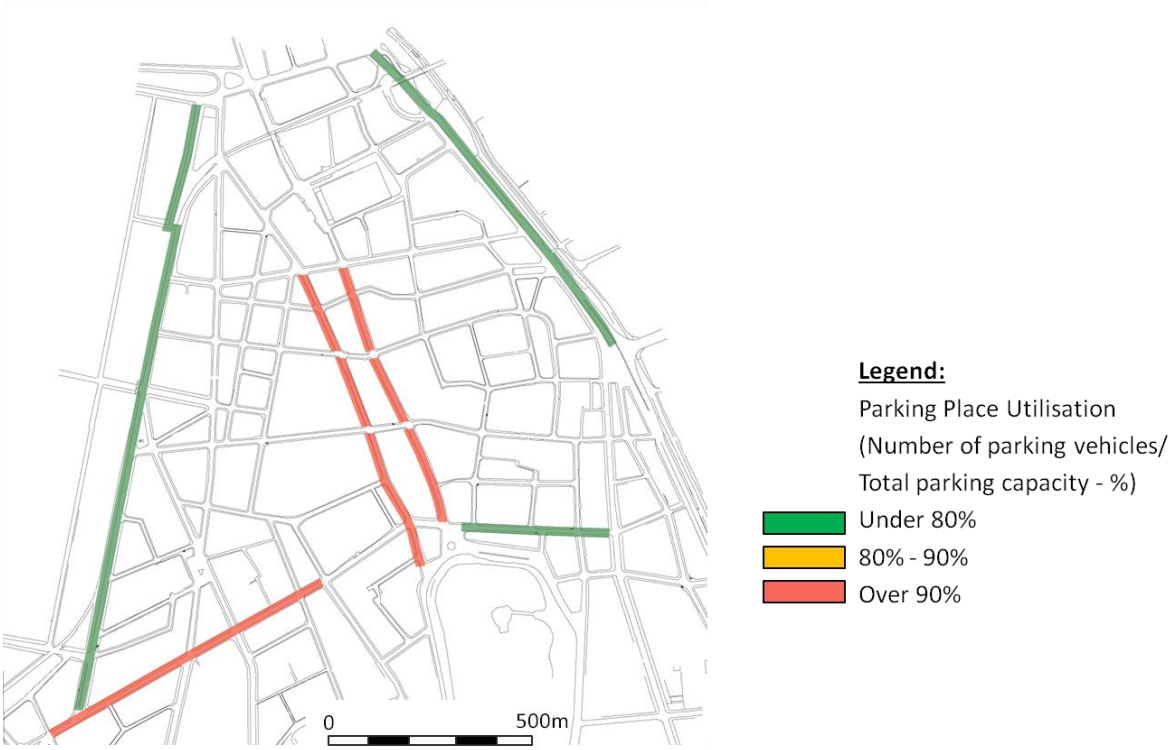

Figure 3-15: Mapping of on-street parking utilisation in Old Quarter Area – Car
Source: Author‘s representation

In Developed Area, the utilisation of motorcycle parking was higher than that of car parking. The streets with over 100% utilisation of motorcycle parking accounted for 40%, whereas it was about 20% for car. The mapping of parking utilisation is shown in Figure 3-16.

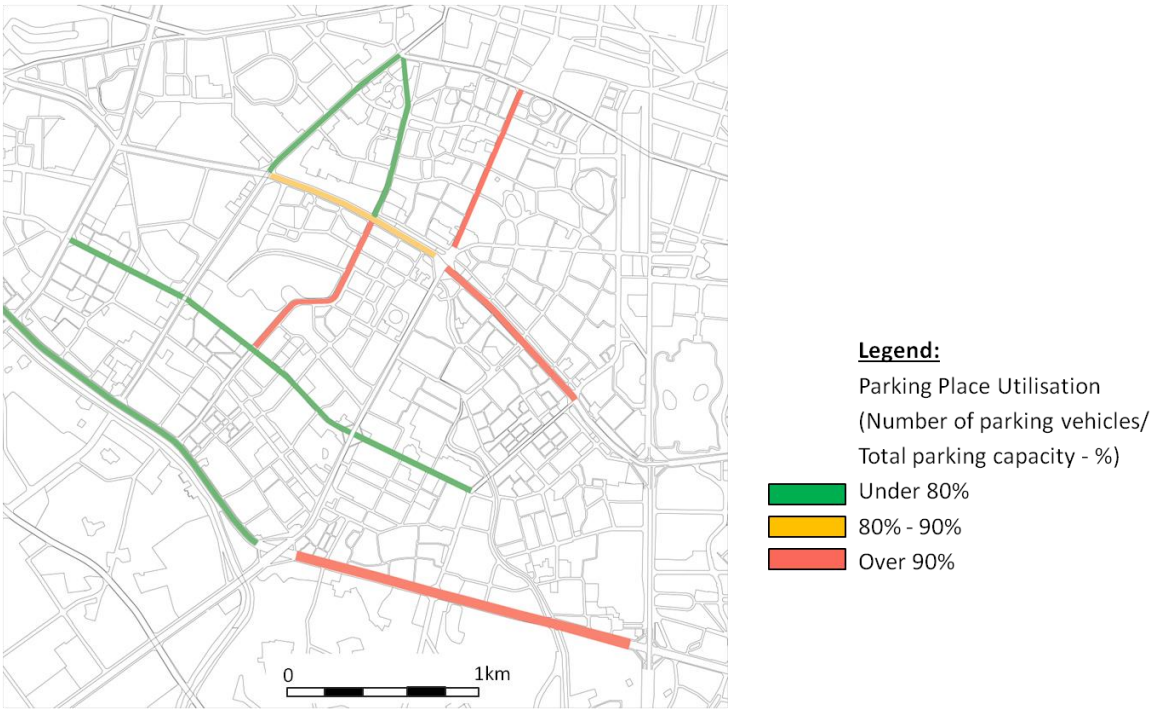

Figure 3-16: Mapping of on-street parking utilisation in Developed Area - Motorcycle
Source: Author‘s representation

In New Development Area, parking utilisation for car and motorcycle with over 100% were similar (accounted for about 30%). In those streets, on-street parking is not banned but the number of parked vehicles exceeded the parking capacity. The mapping of on-street parking utilisation is shown in Figure 3-17.

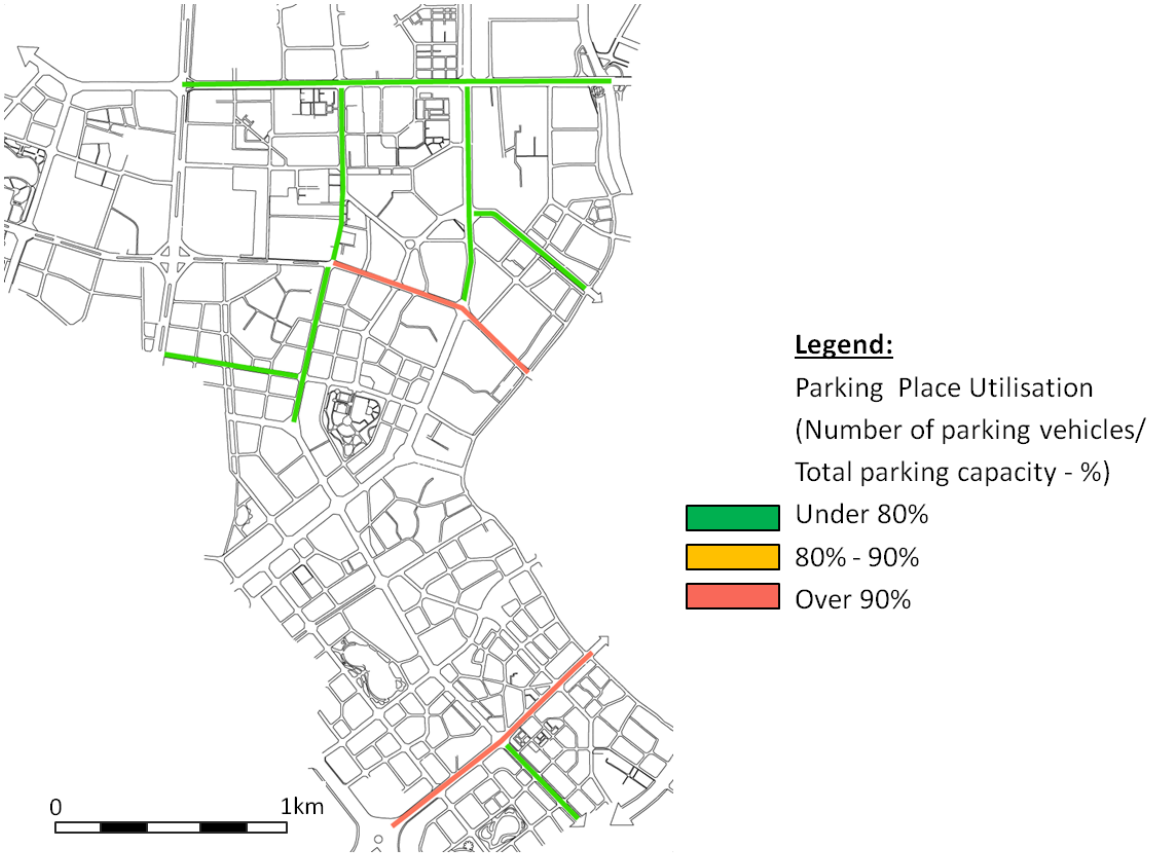

Figure 3-17: Mapping of parking utilisation in New Development Area - Car
Source: Author‘s representation

- **Parking demand pattern**

The demand pattern of on-street car and motorcycle parking in three survey areas (Old Quarter Area, Developed Area and New Developed Area) are shown in Figure 3-18 and Figure 3-19.

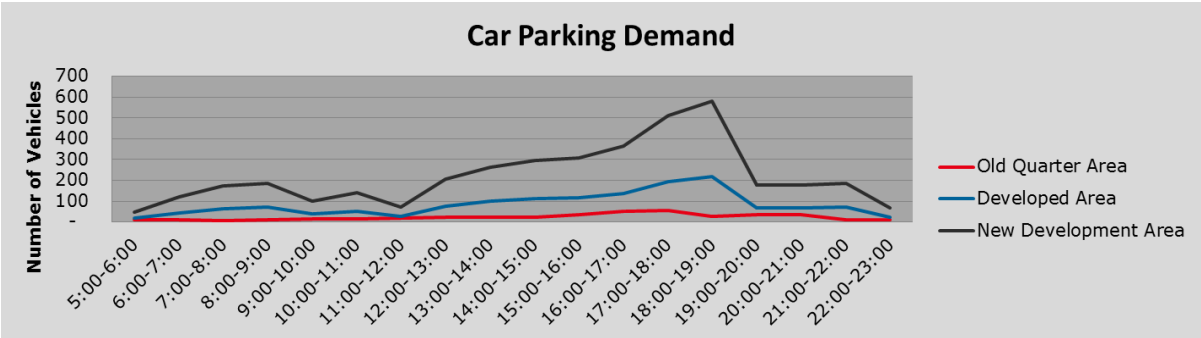

Figure 3-18: The demand pattern of on-street car parking in three survey areas

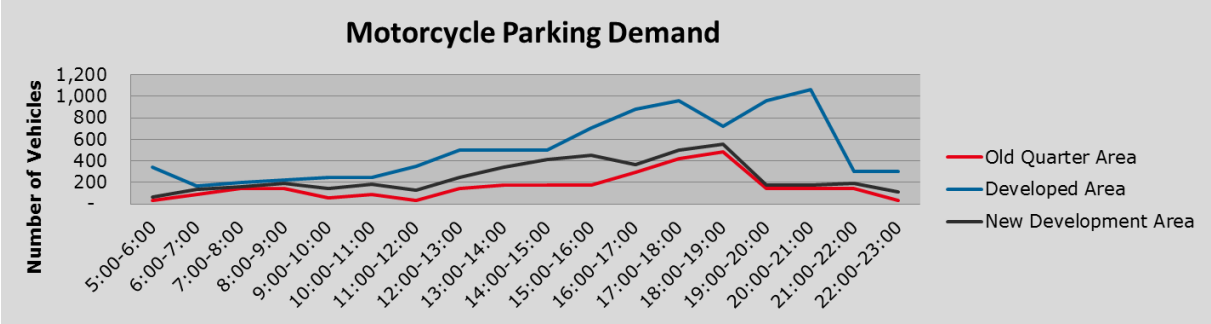

Figure 3-19: The demand pattern of on-street motorcycle parking in three survey areas

Off-street parking was investigated at commercial buildings, shopping malls, commercial condominiums and low-income condominiums in three survey areas. The examples of parking demand pattern are illustrated in Figure 3-20 and Figure 3-21.

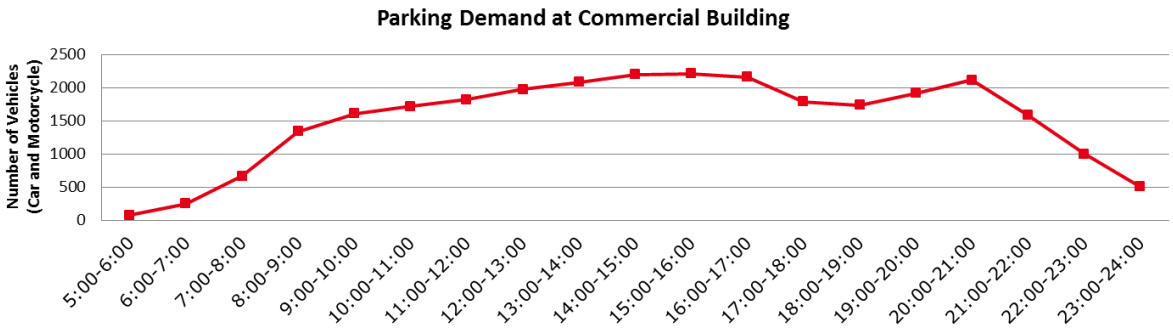

Figure 3-20: Parking demand at commercial building in Duy Tan Street

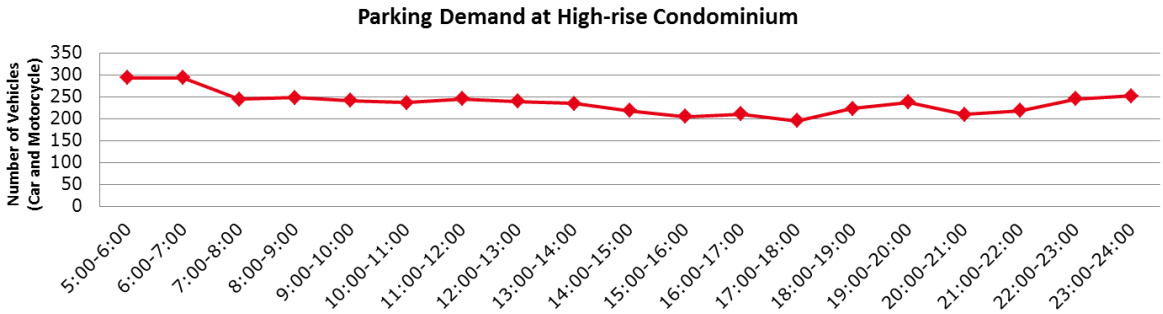

Figure 3-21: Parking demand at high-rise condominium in Duy Tan Street

- **Demand pattern of illegal parking**

Illegal parking was regular at all survey areas, especially on-street parking in the core city centre. There was more motorcycle illegally parked in the core city centre than in other areas (Figure 3-22). Meanwhile, there was more illegal car parking in new development area (Figure 3-23). The demand patterns of illegally parked vehicles are shown in Figure 3-24 and Figure 3-25.

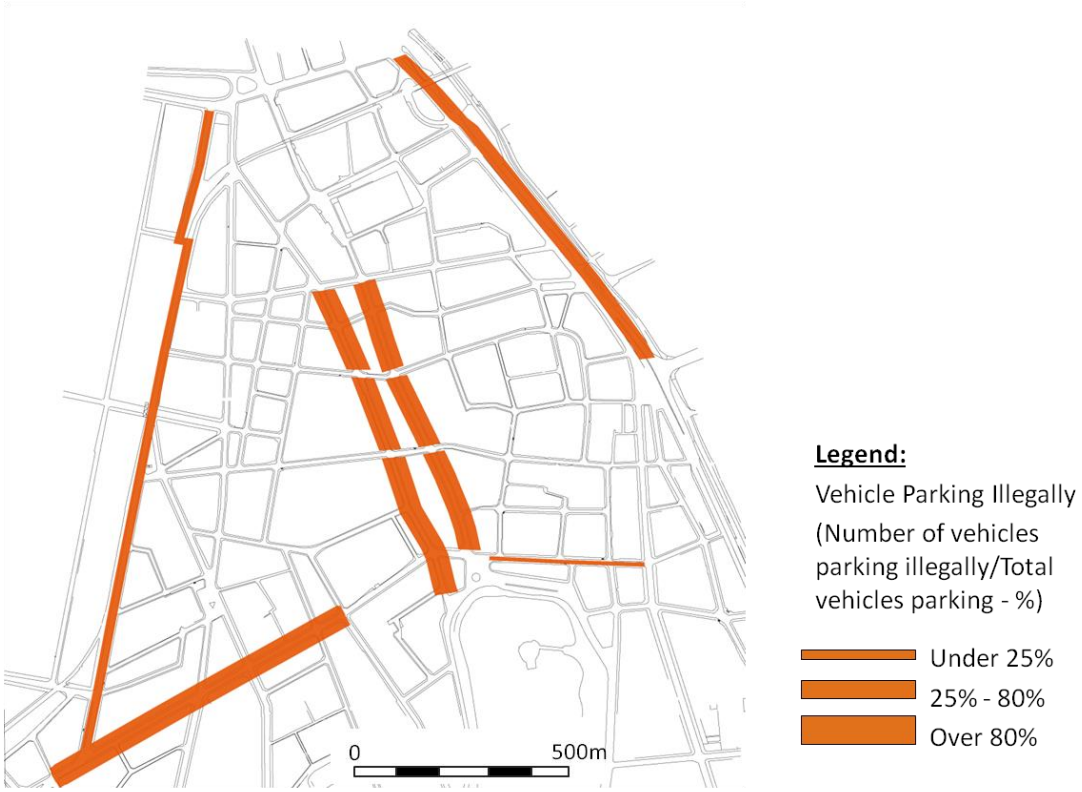

Figure 3-22: Mapping of motorcycle illegal parking in Old Quarter Area

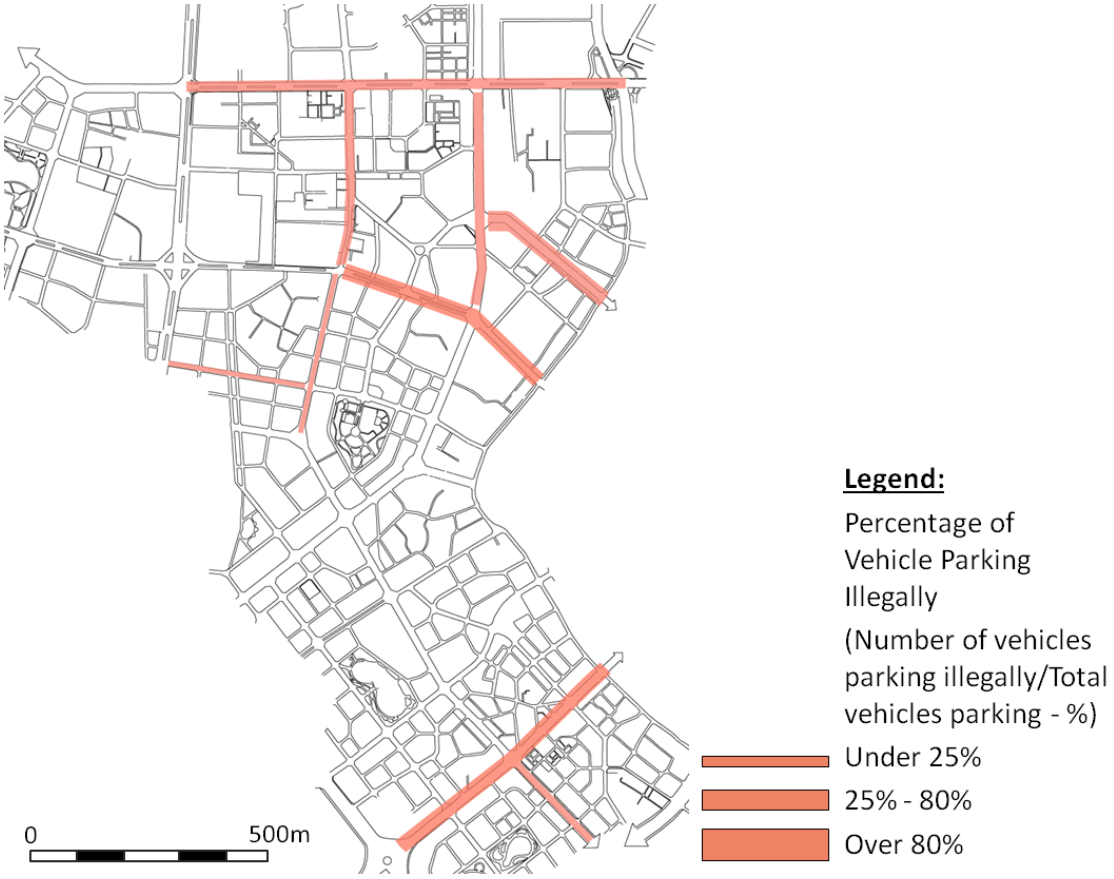

Figure 3-23: Mapping of car illegal parking in New Development Area

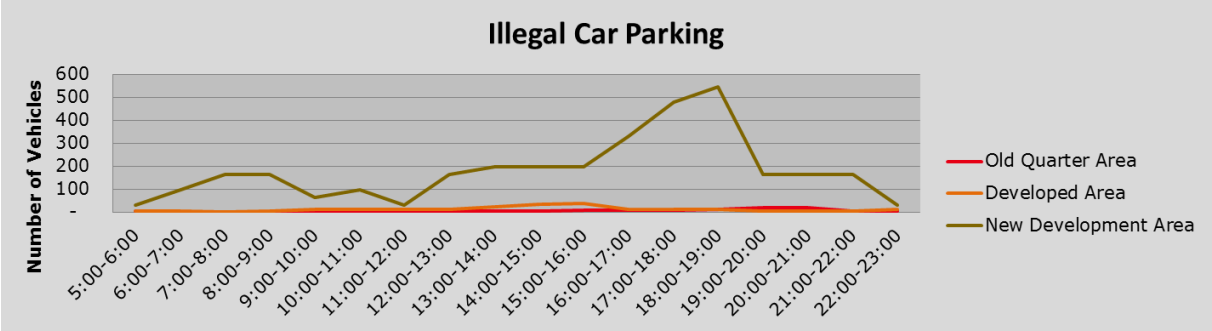

Figure 3-24: Car illegal parking in three survey areas

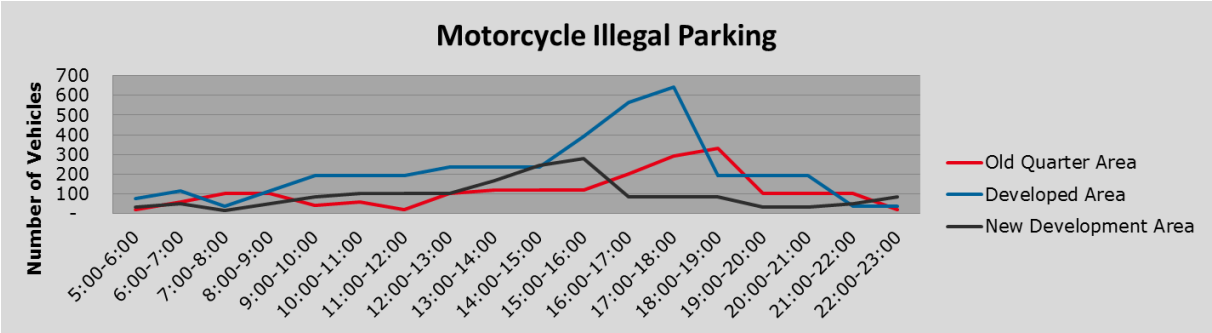

Figure 3-25: Motorcycle illegal parking in three survey areas

- **Parking inventory**

The parking inventory surveys were conducted in three streets in three zones, including Hang Ngang Street (Old Quarter Area), Chua Boc (Developed Area), and Duy Tan Street (New Development Area). The type of parking supply is illustrated in Table 3-16.

Table 3-16: Categories of parking facilities

No.	Categories of Parking Facilities
1	**Non-managed on-street and off-street parking facilities**
2	**Managed on-street and off-street parking facilities**
2.1	with user group dedication
2.2	with limitation of parking duration free of charge
2.3	with limitation of parking duration for a fee
2.4	without limitation of parking duration for a fee
3	**Parking in underground facilities**
3.1	accessible to the public
3.2	not accessible to the public
4	**Private parking facilities (home)**
4.1	accessible to the public
4.2	not accessible to the public

The parking inventory in Duy Tan Street is shown as an example of the survey (Table 3-17).

Table 3-17: Example of parking inventory in Duy Tan Street (New Development Area)

No.	Categories	Total Number of Parking Spaces		
		Car	MC	Bicycle
1	**Non-managed on-street and off-street parking facilities**	**220**	**1,650**	**330**
2	**Managed on-street and off-street parking facilities**	**80**	**120**	**-**
2.1	with user group dedication	x	x	x
2.2	with limitation of parking duration free of charge	x	x	x
2.3	with limitation of parking duration for a fee	x	x	x
2.4	without limitation of parking duration for a fee	80	120	-
3	**Parking in underground facilities**	**1,740**	**30,400**	**1,090**
3.1	accessible to the public	x	x	x
3.2	not accessible to the public	1,740	30,400	1,090
4	**Private parking facilities (home)**	**110**	**220**	**110**
4.1	accessible to the public	x	x	x
4.2	not accessible to the public	110	220	110
	TOTAL	2,150	32,390	1,530

Source: Author's data survey

- **Parking duration**

Parking duration at different parking areas are given in Figure 3-26. Parking duration was dissimilar at different land-use types and the results also complied with trip purposes. At the office buildings, the majority of vehicles had long parking duration (over 8 hours) with 60%. Parking duration between 4-8 hours took 26%. Only 3% of vehicles parked less than one hour. Results gained at commercial buildings (utilised for both offices and shopping malls) were quite different: 20% of vehicle parked longer than 8 hours; 14% of vehicles had long parking (between 4h-8h); 35% of vehicles had medium parking duration (2h-4h). Parking at the shopping mall was dominated by short duration (between 1h-4h) with 76%; 12% of vehicles had long parking duration (between 4h-8h); and a similar number of vehicles parked less than one hour.

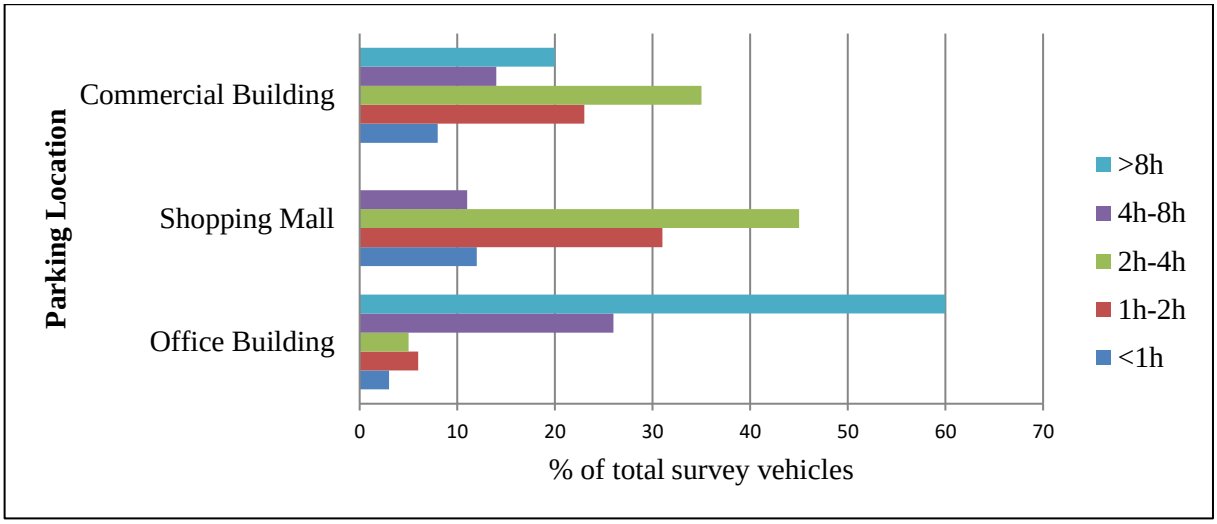

Figure 3-26: Parking duration of the surveyed vehicles at different land-use

- **Parking turnover rate and parking occupancy**

The average turnover rate is the rate of usage of a parking facility and is determined by dividing a total number of vehicles parked in a parking facility into the number of available parking spaces of this facility in a certain period of time. To determine parking turnover rate, the following formula is used:

$$\mu_i = \frac{A_i}{D_i}$$

Where:
μ_i: average turnover rate
A_i: total number of parking vehicles;
D_i: total number of parking spaces

Parking space occupancy refers to the utilization rate of the parking facility and is determined by dividing total parking time of vehicles into total operating of the parking facility. The following formula is used to determine parking occupancy:

$$\gamma_i = \frac{\sum t_{ij}}{D_i T} \quad (j = 1, 2, \cdots D)$$

Where:
γ_i: parking space occupancy
t_{ij}: parking time in each parking space;
T: working time of parking facility.

The index of parking turnover rate and parking occupancy are shown in Table 3-18. Shopping malls had highest parking turnover rate of 5.7 (on average, 5.7 vehicles can park at one parking space during 24 hours) and also high parking occupancy of 81%. Meanwhile, commercial buildings had lower turnover rate (4.4) but very high parking occupancy (98%). High parking turnover rate of shopping malls is reasonable since parking duration of the shopping trip is short (during 1h-4h). Very high parking occupancy at commercial building pointed to the effective utilisation of parking facilities. Such buildings are used for both offices and shops, hence parking facilities are used for officers during day-time and shoppers during evening time on weekdays. During weekends, the parking facilities are used for people coming for shopping, entertainments, and recreations. Office buildings had the lowest parking

turnover rate (1.1) and parking occupancy (41%) since the parking facilities were mostly used during daytime on weekdays and they were almost empty at weekends. This data reveals that shared parking might be a good parking management measure for office buildings. Parking facilities should be utilised for not only officers but for other parking users such as customers of café, restaurants or fitness centres.

Table 3-18: Parking turnover and parking occupancy of different land-use types

Parking Type	Parking Turnover Rate	Parking Occupancy
Shopping mall	5.7	81%
Commercial building (office and shop)	4.4	98%
Office building	1.1	41%
High-rise condominium	1.3	51%

- **Parking generation rate**

The parking generation rate is the parking demand quantity generated from land use in per unit area, on the basis of land use types. This index is used to calculate the total parking spaces required for a certain land-use such as residence buildings, offices, restaurants, shopping malls… To determine the parking generation rate, the following formula is used:

$$a_i = \frac{y}{R_i \times \mu_i}$$

Where:
a_i: refers to parking generation rate, which are the quantities of parking demand per unit area;
y: refers to parking demand in a certain area; unit is parking vehicle;
R_i: refers to the individual area m^2
μ_i: average turnover rates

In order to calculate the parking generation rate, physical information of survey buildings was collected, such as: total floor, number of basement floor (for parking), number of floor for office renting (or residence), construction area for a floor (m^2), used area for a floor(m^2), total construction area (m^2), total area for office (or live) (m^2), parking area (m^2), maximum of parking vehicle for bicycle, motorcycle and car; number of apartment in a floor and in the whole apartment. Then, the parking generation rates are calculated as such index: parking space per $100m^2$ construction area, parking space per $100m^2$ used areas and parking space per apartment.

The parking generation rate of different land-use is illustrated in Table 3-19. Office buildings, characterised by low parking turnover and very low parking occupancy, had the highest parking generation rate: each $100m^2$ used area (the real areas utilised for office renting) required 7.79 parking spaces. On the contrary, shopping malls had lowest parking generation rate since the parking facilities were effectively used in such kind of buildings. The low-income condominium (characterised by small apartments, high density) had higher parking generation rate (2.83 parking spaces per $100m^2$ used areas) than commercial condominium (1.62 parking spaces per $100m^2$ used areas).

Table 3-19: Parking generation rate of different land-use types
(Number of parking spaces/unit area)

	Commcercial Building	Shopping Mall	Office Building	High-rise Condo	Low Income Condo
Car, Motorcycle, and Electric Bike					
Parking space/100m^2 construction area	2.81	1.49	5.63	1.18	2.14
Parking space/100m^2 used area	3.44	1.82	7.79	1.62	2.83
Parking space/1 apartment				2.15	2.78
Car Only					
Parking space/100m^2 construction area	0.44	0.20	0.36	0.31	0.28
Parking space/100m^2 used area	0.54	0.25	0.50	0.42	0.37
Parking space/1 apartment				0.56	0.37
Motorcycle and Electric Bike					
Parking space/100m^2 construction area	2.37	1.29	5.26	0.88	1.85
Parking space/100m^2 used area	2.89	1.57	7.29	1.20	2.46
Parking space/1 apartment				1.60	2.41

3.5.6. Influences on travel alternative

There are many factors influencing travel alternatives including mode choice, parking location selection, and destination choice. The impact aspects relate to socio-economic characteristics of travellers, including gender (White, 1977), occupation (Brown, 1986; DeSalvo & Huq, 2005), income (Brown, 1986; Sasaki, 1990), trip cost (DeSalvo & Huq, 2005; M. Zhang, 2004), travel distance (Böcker, Prillwitz, & Dijst, 2012), travel mode and departure time (Zou et al., 2016), the quality of walkway (Park, 2008), and car ownership rate (Ding, Wang, Liu, Zhang, & Yang, 2017; He & Thøgersen, 2017).

The influences might come from the spatial configuration of land use (Anas & Moses, 1979; Li, Shao, Yang, Hoz, & Monzón, 2009; Limtanakool, Dijst, & Schwanen, 2006; Wan, Chen, & Zheng, 2009; M. Zhang, 2004), urban structure (Sasaki, 1990), and transport structures (Anas & Moses, 1979).

Other influences relate to public transport service, for instance, the accessibility to the bus station (walking distance and the quality of the walkway) (Park, 2008), provision of transit system (Zahabi, Miranda-Moreno, Patterson, & Barla, 2012), bus fare (Torres-montoya, 2014), and the quality of bus service (Chee & Fernandez, 2013)

Many impact factors directly relate to parking characteristics, for instance, walking time and walking distance from parking location to the destination (Park, 2008), provision of free parking (D. B. Hess, 2010), parking requirements (Rowe, Bae, & Shen, 2012), strategies for parking (Zahabi et al., 2012), parking pricing (Torres-montoya, 2014), and parking fee scheme (Chang, Chung, Sheu, Zhuang, & Chen, 2014).

Among those influences, parking pricing has been used as an effective instrument for traffic management (Glazer and Niskanen, 1992; Kelly and Clinch, 2009; Caicedo, 2012). Economists are among the first to suggest that parking is not independent of the rest of the transport system and that optimal parking policy often depends on how road usage is priced. Glazer and Niskanen (1992) questioned the intuitive idea that congestion would be reduced by increasing the price of parking. If road usage is sub-optimally priced, then a lump-sum parking fee can increase welfare, but a parking fee per unit time does not. This is because, under a marginal parking cost scheme, an increase in parking fee encourages each person to park for a shorter period of time. It allows more people to use parking spaces each day, and subsequently increases traffic. For this reason, consumers may not prefer free parking.

Verhoef et al. (1995) suggested the possibility of using differentiated parking fees to regulate traffic in the absence of road pricing. By simulating alternative policy scenarios in an urban transport market, Calthrop et al. (2000) further suggested that the second-best pricing of all parking spaces produced higher welfare than the use of a single-ring cordon scheme.

Through evaluating alternative parking policies, economists generally believe that parking fees prove superior to restrictions on parking space supply (Verhoef et al., 1995). A prominent planning scholar against free parking, Donald Shoup, emphasized several aspects of distortions in parking cost. Using case studies of eight firms that complied with California's employer parking cash-out requirement (employees were offered money instead of free parking), Shoup (1997) showed that by eliminating employees' free parking, the benefits to commuters, employers, taxpayers, and the environment exceeded the program costs by at least three times.

Addressing the popular minimum parking requirements, Shoup (1999) and Shoup & H.Pickrel (1978) argued that a forced supply of parking spaces reduced the price of parking, but the cost translated into the price of goods and services. By modeling the curb parking behavior, Shoup (2006) suggested that below-optimal curb parking prices entailed inefficient cruise searching for cheap curb parking, leading to traffic congestion, air pollution, and additional energy and safety costs. Shoup's work has convinced countless practitioners that efficiency can be restored by pricing on-street parking and abandoning required off-street parking.

Theoretical advances and empirical evidence on parking policies have resulted in significantly improved understanding of the importance of efficient parking in transport and the regional economy (Marsden, 2006). Changes and innovations in parking have been implemented. Several reports of conventional and best practices in parking policy and management in recent years are now available in North America (Litman, 2006; Weinberger et al., 2012; FHWA, 2012; Nelson & Schrieber, 2012), Europe (Kodransky & Hermann, G., 2011), and Asia (P. A. Barter, 2011; P Barter, 1999; Paul Barter, 2011).

Appropriate parking pricing scheme, on the one hand, can manage traffic demand; on the other hand, it can attract the private sector to invest in parking facilities. However, little information on parking pricing policies and practices in Asian developing cities has been collected and analysed.

3.5.7. Impacts of parking fees on mode choice and destination choice

- **Characteristics of the samples**

As mentioned in section 3.4.5, the fourth survey was conducted to investigate travel behaviour and the impacts of parking fees on mode choice and destination choice. There were totally 311 people interviewed, including 24 car users, 242 motorcycle users, 27 bicycle users and 18 users of others mode. Their socioeconomic characteristics are presented in Figure 3-27. The survey revealed that among 311 interviewees, the majority of the car users used their vehicles for working purposes with 75% and for shopping purpose with 21%. Meanwhile, 65% of the motorcyclists used their vehicle for work and 29% used it for shopping trips. As for bicycle users, 70% used their vehicle for shopping, 15% for going to school and 11% for going to work.

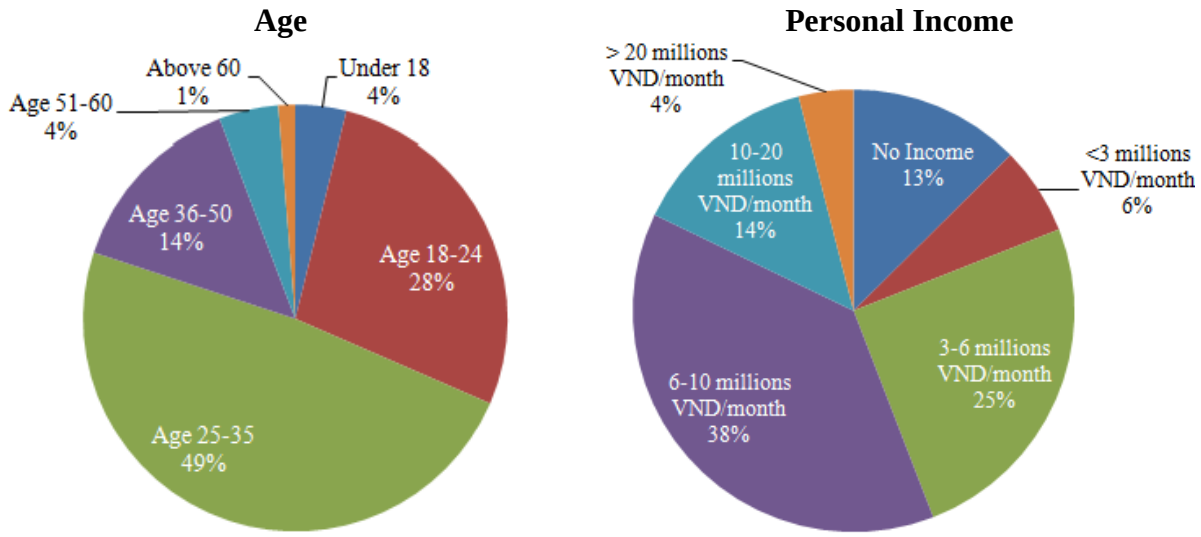

Figure 3-27: Socioeconomic characteristics of the samples (N=311)
(Exchange rate in 2017: 1 USD = 22,680 VND)

- **Stated mode choice**

Parking policy measures can affect many different dimensions of travel behaviour; for example, travellers' choice of parking type and location (K. W. Axhausen & Polak, 1991a). This dimension of travel choice has, to date, received little attention, yet is of vital importance if we are to properly understand and predict the effects of parking policy measures.

Parking cost is an important part of the trip cost, hence it might have a significant influence on the sensitivity of travel demand. In order to test the influence of parking charges on travel mode choice, two scenarios were set up.

In the first scenario, commuter mode choice was tested under the impact of increased parking fee. Parking fee was set at three levels: (1) pay at the current rate (100%), two times higher (200%), and three times higher (300%). Many commuters did not need to pay for their parking since their companies already did. The same case could be seen with the shoppers: many of them did not pay the parking fee since this charge was included in their receipt.

The respondents were given five options in each impact level: (1) still use current mode, (2) change to use bus, (3) change to walk, (4) change to use a taxi, and (5) change to other destination. Only three participants, who currently used cars, reported that they might use a

taxi for their working trips. These observations are excluded from further analysis. Finally, only 308 respondents were selected for the analysis with four options: (1) still use current mode, (2) change to use bus, (3) change to walk, and (4) change to other location.

In the second scenario, commuter mode choice was tested under the impact of two indicators, including increased parking fee increasing and improved bus accessibility. Parking fee was also set at three levels: pay at the current rate (100%), two times higher (200%), and three times higher (300%). Bus accessibility was measured by the walking time to the bus station, set at three levels: 5 minutes walking, 10 minutes walking and 15 minutes walking.

A multinomial logit model was employed to estimate the influence of parking fee on the decision to choose a certain travel alternative of commuters. This study defines three dependent variables: P1 (the probability that a respondent chooses to drive his/her current transport mode), P2 (the probability that a respondent chooses to shift to the bus), P3 (the probability that a respondent chooses to walk), and P4 (the probability that a respondent chooses to change to other destination).

By definition, the three probabilities sum to unity:

$$P1 + P2 + P3 + P4 = 1$$

The fitted regression model for the first scenario is given by three equations:

$$\log\left(\frac{P2}{P1}\right) = \alpha_a + \beta_a x \qquad \text{(Equation A)}$$

$$\log\left(\frac{P3}{P1}\right) = \alpha_b + \beta_b x \qquad \text{(Equation B)}$$

$$\log\left(\frac{P4}{P1}\right) = \alpha_c + \beta_c x \qquad \text{(Equation C)}$$

The fitted regression model for the second scenario is given by three equations:

$$\log\left(\frac{P2}{P1}\right) = \alpha_a + \beta_{a1}x_1 + \beta_{a2}x_2 \qquad \text{(Equation D)}$$

$$\log\left(\frac{P3}{P1}\right) = \alpha_b + \beta_{b1}x_1 + \beta_{b2}x_2 \qquad \text{(Equation E)}$$

$$\log\left(\frac{P4}{P1}\right) = \alpha_c + \beta_{c1}x_1 + \beta_{c2}x_2 \qquad \text{(Equation F)}$$

In these equations, x and x1 and x2 denote the attributes of alternative (i) that are relevant to the choice being considered; αa and αb and αc are the intercepts, and ßa and ßb and ßc are the coefficients of equations a and b and c that are determined using SPSS software. The dependent variables were mode choice and destination selection.

The model was estimated for two demand groups. In the first case, parking charge impact was tested with three groups and at three cases of parking fee: (1) A pool of all parking users (308 respondents * 3 cases per respondent); (2) Commuters only (182 * 3); and (3) shoppers only (103 * 3). In the second case, parking charge impact was tested with other three groups: (1) Car users (24 respondents * 3 cases per respondent); (2) Motorcycle users (242 * 3); and (3) Bicycle users (27 * 3).

- **Scenario 1: Possible impact of parking fee**

Case 1: Comparison among all parking users, commuters, and shoppers

Table 3-20 gives the results of the multinomial logit regression for travel alternative (use current mode, change to a bus, change to walk, and change the destination) on the factor of

travel parking fee. Generally, the results show that parking fee has a significant influence on travel alternative in three models.

Model 1 uses the parking cost to examine the travel alternative of all parking users. The parking fee increase produces the expected positive coefficient (0.011 for equation a, 0.012 for equation b, and 0.015 for equation c), all with a high level of significance. It means that when parking fee increases, parking users are more likely to shift to the bus, change to walk or change their destination comparing with keeping using their current transport mode. The coefficients of parking fee variable in Model 2 (commuters only) are also significant, that 0.011 for equation a, and 0.02 for equation b. For commuter demand group, there was no option of change destination. The coefficients of parking fee variable in Model 3 (shoppers only) are also significant, that 0.013 for equation a, 0.011 for equation b, and 0.018 for equation c.

The coefficients for three equations in three models indicate that higher parking fee increases the chance that parking users (both commuter and shopper demand groups) choose to use the bus, change to walk or change their destination.

Table 3-20: Estimated multinomial logit models of stated mode choice

Independent Variable		**Model 1: Pool of all parking users (N=924)**			**Model 2: Commuters Only (N=546)**			**Model 3: Shoppers Only (N=309)**		
		Estimated Coefficient	Std. Error	Sig.	Estimated Coefficient	Std. Error	Sig.	Estimated Coefficient	Std. Error	Sig.
Equation A (Shift to bus)	Intercept	-3.875	0.316	0.000	-4.217	0.454	0.000	-3.732	0.510	0.000
	Parking fee	0.011	0.001	0.000	0.011	0.002	0.000	0.013	0.002	0.000
Equation B (Shift to walk)	Intercept	-6.182	0.906	0.000	-9.240	2.790	0.001	-5.108	1.055	0.000
	Parking fee	0.012	0.004	0.001	0.020	0.010	0.048	0.011	0.004	0.012
Equation C (Change destination)	Intercept	-5.868	0.597	0.000				-5.126	0.652	0.000
	Parking fee	0.015	0.002	0.000				0.018	0.003	0.000
Pseudo R-Square		Cox and Snell: 0.147 Nagelkerke: 0.186 McFadden: 0.101			Cox and Snell: 0.099 Nagelkerke: 0.159 McFadden: 0.107			Cox and Snell: 0.255 Nagelkerke: 0.291 McFadden: 0.140		

Note: Significant at the 0.05 level. The reference category is: Keep using current transport mode.

- **Probability predictions**

Three models are used to make probability predictions for the mode choice of parking users. This is done by solving the multinomial logit equation for probability using a range of values for one particular variable using the estimated coefficients and intercept (see Table 3-21).

The analysis shows that parking users are sensitive to the increase in parking fees. The shoppers are more sensitive than the commuters: they are not only willing to change their current mode but also willing to change their destination.

When people have to pay 100% parking fee, 4% of commuters and 8% of shoppers are willing to shift to the bus, 2% of shoppers are willing to walk, and another 3% of them change their destination.

When the parking fee doubles, people are more willing to change the current mode: 13% of commuters and 20% of shoppers are willing to shift to the bus and, interestingly, 15% of shoppers are willing to change their destination.

Table 3-21: Effects of parking cost on mode choice probability

Parking fee level	Pool of all users				Commuters Only			Shoppers Only			
	Use current mode	Shift to bus	Shift to walk	Change destination	Use current mode	Shift to bus	Shift to walk	Use current mode	Shift to bus	Shift to walk	Change destination
20%	97%	3%	0%	0%	98%	2%	0%	95%	3%	1%	1%
50%	96%	3%	0%	1%	97%	3%	0%	93%	4%	1%	1%
100%	92%	6%	1%	1%	96%	4%	0%	87%	8%	2%	3%
150%	87%	10%	1%	2%	92%	8%	0%	77%	13%	3%	7%
200%	78%	15%	2%	5%	87%	13%	0%	62%	20%	4%	15%
250%	66%	23%	3%	9%	79%	20%	1%	44%	26%	4%	26%
300%	51%	31%	4%	14%	67%	30%	2%	26%	30%	5%	39%

Case 2: Comparison among car users, motorcycle users, and bicycle users

Table 3-22 shows the results of the multinomial logit regression for travel alternative under the impact of parking fee. Generally, the results show that parking fee has a significant influence on travel alternative in three models. In Model 1, the significant is higher than 0.05, then the model is not significant for the conclusion. Model 2 uses the parking cost to examine the travel alternative of motorcycle users. The higer parking fees produce the expected positive coefficient (0.015 for equation a, 0.013 for equation b, and 0.015 for equation c), all with a high level of significance. It means that when parking fees increase, motorcyclists are more likely to shift to the bus, change to walk or change the destination. The coefficients of parking fee variable in Model 3 (bicycle users only) are also significant, that 0.018 for equation a, 0.176 for equation b, and 0.02 for equation c. The coefficients for two equations in two models (model 2 and model 3) indicate that higher parking fees increase the chance that motorcyclists and bicyclists choose to use the bus, change to walk or change their destination.

Table 3-22: Estimated multinomial logit models of stated mode choice

Independent Variable		**Model 1: Car users (N=72)**			**Model 2: Motorcycle Users (N=726)**			**Model 3: Bicycle Users (N=81)**		
		Estimated Coefficient	Std. Error	Sig.	Estimated Coefficient	Std. Error	Sig.	Estimated Coefficient	Std. Error	Sig.
Equation A (Shift to bus)	Intercept	-7.280	2.843	0.010	-5.214	0.487	0.000	-5.067	1.198	0.000
	Parking fee	0.020	0.010	0.052	0.015	0.002	0.000	0.018	0.005	0.000
Equation B (Shift to walk)	Intercept				-6.665	1.120	0.000	-54.918	1.059	0.000
	Parking fee				0.013	0.004	0.002	0.176	0.000	0.000
Equation C (Change destination)	Intercept	-5.419	1.962	0.006	-5.950	0.682	0.000	-6.206	1.735	0.000
	Parking fee	0.013	0.007	0.086	0.015	0.003	0.000	0.020	0.007	0.003
Pseudo R-Square		Cox and Snell: 0.129 Nagelkerke: 0.204 McFadden: 0.138			Cox and Snell: 0.173 Nagelkerke: 0.227 McFadden: 0.132			Cox and Snell 0.317 Nagelkerke: 0.378 McFadden: 0.209		

Note: Significant at the 0.05 level. The reference category is: Keep using current transport mode.

- **Probability predictions**

Model 2 and model 3 are used to make probability predictions for the mode choice of interviewees. This is done by solving the multinomial logit equation for probability using a range of values for one particular variable using the estimated coefficients and intercept (see Table 3-23).

The sensitivity analysis shows that when people have to pay 100% parking fee, very few of motorcyclists (2%) and bicyclists (4%) change their current transport mode. Only 1% of motorcyclist and bicyclists are willing to change their destination.

However, when the parking fees double, people are more willing to change the current mode: 10% of motorcyclists are willing to shift to the bus, 2% shift to walk and 5% change their destination. The bicycle users are more sensitive to parking fee. When the fee increased to 200%, 18% of them are willing to change to shift to the bus, and 8% change their destination.

Parking pricing measures might have an influence on parking users, especially motorcycle and bicycle user group. It also reveals that there is the higher ability of motorcycle and bicycle users to shift to public transport or use non-motorised traffic (walking).

Table 3-23: Effects of parking fee on mode choice probability

	Motorcycle Users				Bicycle Users			
Parking fee level	Use current mode	Shift to bus	Shift to walk	Change destination	Use current mode	Shift to bus	Shift to walk	Change destination
20%	99%	1%	0%	0%	99%	1%	0%	0%
50%	98%	1%	0%	1%	98%	2%	0%	1%
100%	96%	2%	0%	1%	95%	4%	0%	1%
150%	88%	6%	2%	4%	88%	9%	0%	4%
200%	84%	10%	2%	5%	73%	18%	0%	8%
250%	71%	18%	3%	9%	52%	33%	0%	16%
300%	54%	28%	4%	14%	28%	45%	4%	24%

- **Scenario 2: Possible impact of parking fee and bus accessibility**

Case 3: Comparison among all parking users, commuters, and shoppers

Table 3-24 gives the results of the multinomial logit regression for travel alternative (use current mode, change to a bus, change to walk, and change the destination) on two factors of travel (parking fee and the walking time to the bus station). Generally, the results show that both factors have a significant influence on the willingness to change to a bus in three models. Results of other two alternatives (shift to walk and change destination) are not significant to make a conclusion.

Model 1 uses the parking cost and walking distance to bus station to examine the willingness to shift to the bus of all parking users. The higher parking fee generates expected positive coefficient (0.005). Longer walking distance to bus stations produces expected negative coefficient (-0.103), all with a high level of significance. It means that when the parking fees increase, parking users are more likely to shift to the bus, whereas at the longer walking distance to bus station, they are less likely to do so. Model 2, tested with commuters (0.008

coefficient of parking fee, -0.085 coefficient of walking distance), generates the same response. Model 3 with shoppers is not sufficiently significant to make a conclusion.

The coefficients for the first equation (shift to the bus) in two models indicate that with higher parking fee and shorter walking distance, commuter demand group is more willing to choose the bus.

Table 3-24: Estimated multinomial logit models of stated mode choice

Independent Variable		**Model 1: Pool of all parking users (N=924)**		**Model 2: Commuters Only (N=546)**		**Model 3: Shoppers Only (N=309)**	
		Estimated Coefficient	**Sig.**	**Estimated Coefficient**	**Sig.**	**Estimated Coefficient**	**Sig.**
Equation D (Shift to bus)	Intercept	-0.108	0.036	-1.153	0.040	2.094	0.013
	Parking fee	0.005	0.001	0.008	0.000	0.000	0.887
	Bus walking time	-0.103	0.000	-0.085	0.000	-0.136	0.000
Pseudo R-Square		Cox and Snell:	0.128	Cox and Snell:	0.128	Cox and Snell:	0.181
		Nagelkerke:	0.149	Nagelkerke:	0.170	Nagelkerke:	0.198
		McFadden:	0.069	McFadden:	0.098	McFadden:	0.081

Note: Significant at the 0.05 level. The reference category is: Keep using current transport mode.

- **Probability predictions**

The sensitivity analysis (see Table 3-25) shows that the combination of two factors, parking fee increase (150% level) and improvement of bus accessibility (from 30 minutes to 5 minutes), strongly influences the willingness to shift to the bus of parking users, especially the commuters.

When parking users have to pay 150% of parking fee (scenario 1), 13% of them are likely to shift to the bus. This probability is equivalent to the case of 150% parking fee level combined with 12 minutes walking time in scenario 2. With the same parking fee level, but the walking distance reduces to 10 minutes, more people (20%) are likely to shift to the bus. When the walking time reduces to 5 minutes, 44% of motorcycles users are likely to shift to the bus. The commuters have the same responses, at 150% of parking fee in scenario 1, only 10% of them are willing to shift to the bus. However, when bus stations are within 10 minutes walking time, another more 5% of them are willing to use the bus. When the walking time reduces to 5 minutes, 31% of commuters are willing to shift to the bus.

It is proved that the combination of two measures (increasing parking fees and improving bus accessibility) might have a stronger influence on travel mode choice comparing with the application of parking fee increase only. It also reveals that restricting private vehicle usage by parking fee increasing, on the one hand, and encouraging the utilisation of public transport system by improving bus accessibility, on the other hand - a “push and pull” measure - might provide better results in parking demand management.

Table 3-25: Effects of parking fee and bus walking distance on mode choice - Scenario 2

Parking fee level	Bus walking time	Pool of all users		Commuters Only	
		Use current mode	Shift to bus	Use current mode	Shift to bus
150%	30 minutes	99%	1%	99%	1%
150%	20 minutes	96%	4%	96%	4%
150%	15 minutes	93%	7%	94%	6%
150%	**12 minutes**	**87%**	**13%**	**90%**	**10%**
150%	10 minutes	80%	20%	85%	15%
150%	7 minutes	64%	36%	74%	26%
150%	5 minutes	56%	44%	69%	31%

Comparing with the effects of parking fee on mode choice probability in Scenario 1

Parking fee level	Pool of all users		Commuters Only	
	Use current mode	Shift to bus	Use current mode	Shift to bus
20%	97%	3%	98%	2%
50%	96%	3%	97%	3%
100%	92%	6%	96%	4%
150%	**87%**	**10%**	**92%**	**8%**
200%	78%	15%	87%	13%
250%	66%	23%	79%	20%
300%	51%	31%	67%	30%

Case 4: Comparison among car users, motorcycle users, and bicycle users

In model 2, which was tested with motorcycles users, parking fee increase produces the expected positive coefficient (0.009 for equation a, and 0.011 for equation b), while the improvement of bus accessibility generates the negative coefficient (-0.119 for equation a, and -0.041 for equation b). When parking fees are set higher, people are more likely to shift to bus or change to walk than to keep using their current transport mode. However, at the longer walking distance, commuters are less likely to shift to the bus (Table 3-26). The coefficients of variables in Model 1 (car users only) and Model 3 (bicycle users only) are not significant.

Table 3-26: Estimated multinomial logit models of stated mode choice

Independent Variable		**Model 2: Motorcycle Users (N=726)**		
		Estimated Coefficient	**Std. Error**	**Sig.**
Equation D (Shift to bus)	Intercept	-0.868	0.516	0.092
	Parking fee	0.009	0.002	0.000
	Bus walking time	-0.119	0.013	0.000
Equation E (Shift to walk)	Intercept	-4.606	1.190	0.000
	Parking fee	0.011	0.004	0.010
	Bus walking time	-0.041	0.024	0.092
Pseudo R-Square		Cox and Snell:		0.166
		Nagelkerke:		0.193
		McFadden:		0.092

Note: Significant at the 0.05 level. The reference category is: Keep using current transport mode.

- **Probability predictions**

The sensitivity analysis (see Table 3-27) again emphasizes that the combination of two factors, parking fee increase and improvement of bus accessibility, has a strong influence on the willingness to shift to the bus of parking users, especially the motorcycle users.

When motorcycle users pay at a level of 150% parking fee (scenario 1), 6% of them are likely to shift to the bus. This probability is equivalent to the case of 150% parking fee level combined with 15 minutes walking time in scenario 2. With the same parking fee level, but the walking distance reduced to 10 minutes, more motorcyclists (12%) are likely to shift to the bus. And when the walking time reduces to 5 minutes, 33% of them tend to shift to the bus.

The sensitivity analysis emphasizes that "push and pull" measures might be efficient in parking demand management.

Table 3-27: Effects of parking cost and bus accessibility on the probability of mode choice

Parking fee increase level	Bus walking distance	Motorcycle Users Use current mode	Shift to bus	Shift to walk	Travel to other locations
150%	30 minutes	91%	0%	1%	8%
150%	20 minutes	90%	2%	1%	8%
150%	**15 minutes**	**88%**	**4%**	**1%**	**7%**
150%	12 minutes	85%	7%	1%	7%
150%	10 minutes	80%	12%	2%	6%
150%	7 minutes	67%	25%	2%	5%
150%	5 minutes	60%	33%	2%	5%

Comparing with the effects of parking cost and bus accessibility on the probability of mode choice in Scenario 1

Parking fee increase level	Motorcycle Users Use current mode	Shift to bus	Shift to walk	Travel to other locations
20%	99%	1%	0%	0%
50%	98%	1%	0%	1%
100%	96%	2%	0%	1%
150%	**88%**	**6%**	**2%**	**4%**
200%	84%	10%	2%	5%
250%	71%	18%	3%	9%
300%	54%	28%	4%	14%

3.6. Summary

The chapter has reviewed different contemporary parking planning methods, then identified their advantages and disadvantages. A comprehensive process for parking planning and parking space management has been proposed for Asian developing cities. This process contains two major steps including the analysis of the general parking demand and the qualified demand at both micro and macro level.

The arrangement, dimensioning and development of parking space should be compatible with urban development. It means that parking planning concept should be part of the urban and

traffic development plans and transport planning. Focus should be placed on traffic and other urban aspects. Therefore, the zone-based parking planning concept has been introduced. Mobility characteristics, transport infrastructure and land use function of different zones have comprehensively been analysed.

The proposed parking planning especially focuses on the available data to define the objectives and assumptions of an urban development, type and volume of transport mode, the ability to conduct observation and counting survey, and an extensive analysis of mobility behaviour.

In Asian developing cities, rapid motorisation made the traffic demand forecast quickly obsolete. Two-step planning helps to overcome this difficulty. At macro-level, the parking analysis mostly utilises O-D traffic data within city zones to estimate type and volume of transport mode, and required parking spaces. Such kind of data are yearly collected. The process, therefore, can be time-saving and not expensive to be implemented. Then, the parking analysis at micro level helps to validate the planning model by analysing parking demand, parking behaviour, and parking characteristics at typical streets and land use types.

Additionally, the chapter has provided with a comprehensive understanding of the parking demand and the possible impacts of parking pricing on commuter mode choice in Hanoi, Vietnam.

It has investigated parking demand patterns, parking generation rates, parking occupancy and parking turnovers at different land-use types. The study reveals that parking infrastructure at office buildings are utilised least efficiently comparing with other land uses such as shopping malls, commercial buildings or condominiums. Therefore, it is necessary to reduce parking supply at the office buildings in order to shift the commuters from private vehicle to public transport.

The chapter has confirmed that parking pricing measures might help increase public transport use. With higher parking fees, parking users are more likely to shift to public transport. It also reveals that motorcyclists and bicyclists are more sensitive to parking fees than car users. To reduce private usage of vehicles, the commuters and the shoppers should be made to pay for their parking fees. Moreover, parking fees should be increased at central business districts. Time-based parking fee should be applied in combination with the location-based parking fee. Then, the expected number of people, especially motorcyclists, might shift to public transport.

The combination of “push and pull” measures, focusing on parking fee increase and bus accessibility improvement, may provide with better results. It is evident from data analysis that motorcyclist and bicyclists are more willing to shift to public transport than car users, especially when they have to pay more for parking. In addition to time-based and location-based parking pricing schemes, the bus network and services should be enhanced to improve accessibility to public transport.

The results of this section would be useful for transport planners and authorities to formulate effective parking policies to manage urban transport in developing countries. Parking policy has traditionally been supply-oriented. Results of the current study confirmed that emphasis should be shifted to a more market-oriented and demand-focused approach.

4. Parking Management Measures

Parking management measures can affect many different dimensions of travel behaviour in an attempt to make transport users switch to other transport modes or to distribute parking over a wider area (K. W. Axhausen & Polak, 1991a). This chapter aims to investigate various measures to solve parking problems in Asian developing countries. The study then goes further with the analysis on the need for a new parking management measure dealing with the unique phenomenon of illegal parking in Asian counties. A parking supply enhancement measure is recommended through the legalisation of illegal parking.

4.1. Demand-oriented measures

Generally, the primary impacts of parking management measures on parking demand are to avoid, to shift and to control that issue. These strategies mainly concern three major functions: infrastructure, regulations, and information and marketing. Table 4.2 lists the parking measures described in this chapter.

Table 4-1: Demand-oriented parking management measures

Strategies / Functions	AVOID Parking Demand	SHIFT Parking Demand	CONTROL Parking Demand
Infrastructure	• Unbundle parking;	• Re-locate parking lots to peripheral locations (Park&Ride);	• Shared parking; • Better utilise off-street parking by marketing;
Regulations	• Parking time restriction; • Parking location restriction; • Maximum parking requirements; • Commuter financial incentive; • Parking tax reform (commercial parking taxes, per-space parking levies)	• Improve parking enforcement and control; • Location-based parking pricing; • Time-based parking pricing; • Implement or increase fees.	• Parking duration restriction;
Information and Marketing		• Marketing for off-street parking facilities	• Parking information and guidance system (real-time parking information)

Source: Author's representation

Restrictive parking measures, such as time restriction and location restriction, are playing the key rules in order to reduce parking demand. Other supporting measures including unbundle parking and maximum parking requirement are suggested in condominiums, office building and commercial buildings.

To shift the parking demand, parking pricing and park and ride system are highly recommended. Parking pricing concerns location-based or time-based scheme used to limit the demand at peak period or in peak-demand areas. In the meantime, parking facilities should be relocated in the peripheral area to implement park and ride system. The commuter parking, therefore, can shift to the edges of city centres. The marketing for off-street parking facilities should be improved to shift the parking demand from on-street to off-street, then off-street

facilities are better utilised. Finally, parking enforcement and control should be regularly implemented to support and ensure the successful operation of other measures.

With the aim of controlling parking demand, parking information and guidance system are also of importance. Shared-parking is also recommended to better utilise off-street public facilities with various time-demands. Parking duration restriction is useful to control the length of on-street parking. It should be applied in combination with marketing so that surrounding off-street parking facilities could be exploited.

4.1.1. Measures to avoid parking demand

Regulation on parking restriction is the most effective measure since it directly limits the demand by location and by time. In addition, unbundle parking, maximum parking requirement, financial incentive, and parking tax reform are also useful.

- **Parking restriction**

Parking restriction mainly concerns time-restricted, duration-restricted, and location-restricted policies. Time-restricted parking policy is often used to deal with the peak-demand problems, especially in the city centre. Parking is restricted in certain periods of a day (morning and afternoon peak hours) or certain days in a week (weekdays). Duration-restricted parking policy is usually applied to limit the length of parking, especially on-street parking. This measure aims to prevent the blocking of long-term parking (residences or commuters) at streets. In the meantime, location-restricted parking policy directly diminishes the parking demand in certain locations in the cities. In many cases, parking is restricted in locations of special events (football matches, big performance, accidences or territories).

It is important to note that restrictive parking policies are always well-adjusted with public transport improvements.

The effects of restrictive parking policies on the development of city centres have been fully investigated in four cities Frankfurt, Zürich, Rotterdam, and Edinburgh (Martins, 2005). Parking demand measures were introduced prior to the introduction of restrictions on private parking and parking related to land uses. These measures have generally been introduced to guarantee an efficient use of public parking places (short-stay parking for visitors and shoppers) and to reduce the negative impacts on residents in areas with high demand. The measures have subsequently been used to limit the negative impacts of, and to increase the effectiveness of, restrictive parking norms for private parking. In other words, all four cities have used parking management to prevent commuters from using on-street and off-street public parking places.

- **Maximum parking requirements**

This new measure replaces the previous system (based on minimum parking norms) with a system based on maximum parking norms for a number of land uses, the most important of which are the office and retail sectors (Martins, 2005). The new policy relates the maximum norms to the proximity of competitive public transport systems, with the strictest norms for the areas around nodes of the train and light rail systems.

Minimum parking requirements for new office, commercial, and residential buildings have been in effect in many Asian developing cities for more than 20 years. It is now well-known

that such rigid compulsory technical standards are hardly accurate and often lead to the oversupply of parking, excess driving, and other costs to the society (G.Shaw, 1997; Lewandowski, Co-investigator, & Lewandowski, 2015; R. Wang & Yuan, 2013b). Minimum parking requirements are currently adopted in many Asian developing cities. Given high population density in such cities, the cost of an oversupply of parking may be higher than that in many other Western countries.

Two options for cities to enhance minimum parking standards are proposed. First, it may be feasible to combine a minimum parking standard with a maximum parking standard, especially in city centres. This has been implemented in cities such as London in the United Kingdom and Boston, Greenfield, Miami, Portland (Oregon), and Seattle in the United States (GTZ, 2010; Shoup, 2011; Weinberger et al., 2010). Through deliberately limiting the availability of parking in the urban core, cities can manage congestion levels and keep the urban core liveable, attractive, and walkable. Second, given careful planning and adequate enforcement of on-street parking rules, city governments may consider converting existing minimum parking requirements into suggestive standards, or even completely eliminating minimum parking requirements, as having been locally implemented in cities such as Portland, Oregon (Al-Fouzan, 2012). Developers will choose how many parking spaces they would build. Parking services reflect the value of the real estate. In this case, local governments may choose to provide more information about the benefits and costs of parking provision to guide parking supplied by individual decision makers. However, in the absence of pricing vehicle using externalities such as congestion, this free-market mechanism may still oversupply parking spaces because of the implicit social subsidies to driving. In this sense, it may be beneficial to use maximum parking requirements to adjust the free market outcome. In fact, to improve air quality by restricting driving, many cities of Frankfurt, Zürich, Rotterdam, and Edinburgh have shifted from minimum parking requirements to maximum parking allowances for new residential and commercial development (Martins, 2005).

- **Unbundle parking**

Unbundle parking refers to parking spaces which are rented separately from building space. For example, rather than paying $1,000 per month for an apartment with two parking spaces, renters pay $800 per month for the apartment and $100 per month for each parking space. This typically reduces parking requirements by 20%.

Parking can be unbundled in several ways. Facility managers can unbundle parking when renting building space. Developers can make some or all parking optional when selling buildings. In some cases, it may be easier to offer a discount to renters who use fewer than the average parking spaces, rather than charging an additional fee. For example, an office or apartment might be leased for $1,000 per month with two “free” parking spaces, but renters who only use one space receive a $75 monthly discount. Parking costs can be itemised in lease agreements to help renters understand the costs they bear and negotiate reductions.

Informal unbundling can be encouraged by creating a secondary market for available spaces. For example, office, apartment and condominium managers can maintain a list of residents who have excess parking spaces that are available for rent.

- **Financial incentive**

Financial incentives or disincentives are actions of tangible monetary value which either encourage employees or commuters to make use of a particular travel alternative or discourage them from some other course of action. These actions may have an obvious monetary value, such as a subsidy or parking fee. Alternatively, they may be of such a nature that a monetary value can be imputed, an example being the earning of points toward a tangible reward. There are many variations on how "money" can be used to influence travel behaviour.

Financial incentives have been used in many employer and institutional transport demand management actions (Morris et al., 2010). Shoup (1997) described the effects of cashing out employer-paid parking on the travel behaviour of workers of eight different firms in different central business districts in California. He found that cashing out reduced traffic congestion by reducing single occupancy vehicle use, vehicle emissions (fewer vehicle trips per employee per day), and gasoline consumption.

In parallel, employees are offered transit subsidies. Employers can reduce the cost of taking transit by offering prepaid or discounted transit passes to employees who agree to commute by transit. This benefit can vary from a modest share of the actual cost to full absorption of the cost, and instances have been observed where employees have been subsidised more than the actual fare being charged. Federal tax law allows employees to receive a transit subsidy of up to $230 per month (Morris et al., 2010) without incurring a tax liability for that benefit, while some states offer the employer a tax credit for paying such subsidies. Governments or transit agencies can supplement these subsidies through their own special programs that reward key customers or employers who provide substantial subsidies.

- **Parking tax reform**

Parking tax reform refers to the special parking taxes opposed to reduce total parking demand, therefore, create a disincentive to drive and raise revenue. These can include:

- Special property tax on parking facilities.
- Special sales tax on commercial parking transactions (for example, the city of San Francisco charges a 25% tax on commercial parking transactions).
- Special taxes on employee parking subsidies.

Parking taxes have the greatest effect on travel behaviour if they are paid directly by users (Higgins, 1992). Taxes on parking providers may reduce parking facility supply, but only if the supply is elastic and not required by minimum parking regulations.

Such taxes are government's revenue. They can be effective as part of an overall strategy to reduce total parking supply and manage vehicle use. Parking taxes can be considered a vehicle use fee, with revenues used to provide transportation services. Parking taxes offset other policies that under-price and under-tax parking, such as income tax exemptions for employee parking benefits.

However, there are some disadvantages. Parking tax reform requires a collection system, which increases transaction costs. Parking taxes tend to be opposed on motorists and businesses. They can be arbitrary or unfair and cause a competitive disadvantage to

businesses, particularly if only applied in certain geographic areas. They only affect travel behaviour if motorists pay the fee directly, or if taxes result in reduced parking supply.

4.1.2. Measures to shift parking demand

- **Parking pricing**

The relationship between parking supply and demand is captive to the dominant role of parking pricing (Kuzmyak et al., 2003). Parking pricing refers to direct charges for using a parking space. It has been widely shown in literature that parking pricing is a key feature of the urban traffic policy (Button and Verhoef, 1998; Verhoef et al., 1995), especially when the aim is to moderate commuting (Higgins, 1992; Shoup, 1997).

Even a relatively small parking charge can cause significant travel impacts and provide significant transport demand management benefits. Governments directly control prices for on-street parking, off-street parking at public facilities (offices, schools, parks, etc.), and municipal parking facilities. This often represents a significant portion of total parking, particularly in urban areas with parking problems.

Public policies can encourage pricing of privately owned parking. Governments can reduce the supply and increase the price of public parking, reduce parking requirements in zoning codes, and avoid tax policies that favour free parking. Businesses can unbundle parking so that consumers can choose how much parking they wish to pay for (Russo 2001). For example, under current practices, an apartment might be rented for $1,000 per month with two parking spaces. Unbundling means that the apartment alone is rented for $800, plus $100 for each parking space. This typically reduces parking demand by 10-30%.

Prices can be structured to achieve particular objectives. For example, more convenient parking spaces can be priced to favour customers and clients, with hourly rates, “First Hour Free” discounts, and two-hour maximums. Other parking can be priced to favour long-term parking users (commuters and residents), with discounted monthly rates.

Pricing is an efficient way to reduce parking demand, address parking congestion problems and support transport demand management objectives. Pricing of parking can be considered fairer than subsidised parking. Efficient parking pricing can provide numerous potential benefits including: (1) Increasing turnover of the most convenient spaces. This increases consumer convenience, facilitates deliveries, and reduces cruising for parking (searching for an unoccupied space); (2) Reducing the number of spaces needed to meet demand, reducing total parking costs, and allowing more compact development; (3) Encouraging longer-term parking users to use less convenient spaces (such as off-street or urban fringe), and encouraging travellers (particularly commuters) to use alternative modes when possible; (4) Reducing total vehicle traffic, traffic congestion, accidents, energy consumption and pollution emissions and (5) Generating revenue by assuring that users pay their share of municipal road and parking costs.

Prices can be structured to achieve various objectives, such as financing parking facilities, parking and transportation demand management, and to generate additional revenues (profits). Good pricing is particularly important for on-street parking with the most visible and convenient spaces. Maximum price for off-street parking should be used. If on-street parking is free orcheap, motorists will cruise around looking for an available space rather than paying

for off-street parking, resulting in parking and traffic congestion, and inefficient utilization of off-street facilities.

However, charging for parking incurs transaction costs, including equipment and administrative costs of collecting fees, and inconvenience to motorists. Pricing systems can be difficult to understand, inconvenient to use, and prices often seem arbitrary and excessive. It is considered unfair that some motorists must pay for parking while others are able to park for free or at lower prices. Although customers ultimately pay for free parking in the price of goods they purchase, it may seem fairer that they only pay if they make a purchase, shifting the risk from the consumers to the merchants.

Parking pricing concerns time-based parking pricing, where peak-time parking demand will be charged the highest fee, or location-based parking pricing, where the high-demand location will be charged the highest fee.

- **Park and Ride**

Park and Ride facility is a parking space with good connections to the public transport network where car drivers can park their cars and use public transport for some parts of their journey. This combination of public and private transport enables multimodal transport use (Santos, Behrendt, & Teytelboym, 2010). Park and Ride is viewed as one of the principal means of addressing transport problems in urban areas in the 1990s (Cairns, 1998).

The development of Park and Ride has significant geographical implications, influencing the distribution of land uses particularly on the urban-rural fringe and the relative catchment areas of settlements, as well as affecting travel patterns in both urban and rural areas (Cairns, 1998).

This scheme has been applied in many developed countries and cities as a means of transport demand management and has achieved some results. Among the countries are Germany (Topp, 1991a), the United Kingdom (Dijk & Montalvo, 2011; Hounsell, Shrestha, & Piao, 2011; Meek, Ison, & Enoch, 2009), Scotland (Cairns, 1998), the US (Duncan & Christensen, 2013), China (YE et al., 2009), Singapore (Seik, 1997a), Malaysia (Adnan, Alyia, Hamsa, & Azeez, 2012). Such system is specially implemented in historic towns and cities with limited road and parking space in the centre.

The provision of Park and Ride complements the restriction of parking supply in central areas. Parking demand could be met at suburban or peripheral locations where car travel generally does not aggravate problems of traffic congestion.

Strategic Park and Ride has the advantage of encouraging commuters to transfer from the private car to public transport and promoting the use of public transport generally. Park and Ride has been a key development in urban public transport in the 1980s. In particular, it has been viewed as a significant element in the design of a number of new light rail transit systems in North American cities (Duncan & Christensen, 2013; Duncan & Cook, 2014).

A number of features distinguish Park and Ride from other forms of public transport and make it attractive to motorists. The key element is the bus service. Most Park and Ride bus services operate non-stop between the Park and Ride car park and the town centres. The parking fees or bus fares typically are set at a level that is comparable with, or less than, parking charges in town-centre car parks, and usually cheaper than local bus fares for a similar length of the journey. These advantages outweigh the challenges motorists have to

face with bus services, namely longer journeys due to frequent stops, the high relative cost of use (compared with motorists' perceived costs which normally consist of only petrol and parking charges), and generally poor image.

In geographical terms, Park and Ride has a two-fold impact on urban areas. The provision of Park and Ride car parks results in changes in the spatial distribution of land uses, while in the long term Park and Ride has an impact on the delineation of urban employment, retail and tourist catchment areas. Park and Ride also affect the patterns and mode of travel in both urban and rural areas.

Park and Ride is used to encourage motorists to leave the car at a car park outside the central area and complete the journey by public transport. The development of Park and Ride has formed one element of broader strategies aiming at reducing car travel. It has complemented other policies including increased parking charges in central area car parks, limiting parking in new developments or promoting public transport, cycling and walking.

- **Marketing for off-street parking facilities**

Many studies reveal that customers, visitors and guests are in favour of on-street parking because of its convenience (Bonsall & Palmer, 2004; Petiot, 2004; Spiliopoulou & Antoniou, 2012; Teknomo, 1997; Waerden, Borgers, & Timmermans, 2006). Many commercial streets are blocked with motorcycles and cars. It is evidenced in previous studies that on-street parking is much preferred in Asian developing countries, even when there are sufficient off-street parking spaces (ITDP, 2010; P. A. Barter, 2011).

Therefore, the marketing for off-street parking facilities is necessary to redistribute parking demand and utilise both on-street and off-street parking facilities. User information refers to information for travellers about parking availability, regulations and price, and about travel options, such as walking, ridesharing and transit. Many parking problems root from insufficient user information. User information can be provided by signs, maps, brochures, websites, and electronic guidance systems. It is particularly useful if there is a perceived parking shortage, although spaces are actually available in an area.

4.1.3. Measures to control parking demand

Parking information and guidance system is the leading measure to control parking demand by providing enough information for the selection of parking location. This measure directly reduces parking searching time.

- **Parking information and guidance system**

Parking search time is one among the reasons leading to urban congestion. It was found to account for up to 25% of the total travel time (S. Hess & Polak, 1990). The time for parking search is lengthened due to a mismatch between travellers' parking intentions and parking supply. In many cases, this mismatch results from the travellers' lack of parking information. Thus, with improved source of information on parking system, parking congestion is expected to reduce (K. Axhausen et al., 1994).

The history of parking information and guidance system has witnessed a number of critical changes over the time. Parking Guidance and Information (PGI) system was the oldest and most widely used application in Europe and other countries in the early 1970's. Broadcast

information on parking was later added, though the information provided was occasional and seasonal. Smart parking management systems, typically provide real-time information via changeable message signs (CMSs) to motorist, have recently flourished in numerous European and Japanese cities. In-vehicle route guidance appears to be the latest technological advance applied, reducing the vehicles miles driven both to reach the final destination, as well as to find the necessary parking space. However, the use of such newly-developed applications has still been limited in Asian developing countries.

With the application of those sytems, existing parking resources could be better utilised and search traffic could be reduced. They, therefore, are expected to better control parking demand.

- **Shared parking**

Shared parking means that parking spaces are shared by more than one user, which allows parking facilities to be used more efficiently. Shared parking is advantageous in the way that most parking spaces are only used part-time by a particular motorist or group. Many parking facilities have a significant portion of unused spaces, with utilisation patterns that follow predictable daily, weekly and annual cycles.

There are various degrees of shared parking. Parking can be shared among different buildings and facilities in an area to take advantage of different peak periods. For example, an office complex can share parking facilities with a restaurant or theatres, since offices require maximum parking during weekdays, while restaurants and theatres require maximum parking during evenings and weekends. On-street parking spaces locating in a busy, mixed-use urban area tends to be the most shared. Parking spaces could be shared among various employees at a particular worksite, among customers at a variety of businesses located in a mall. One facility could use another facility's parking lots at certain times, such as a tavern that allows its parking spaces to be used on Sunday mornings by attendees at a nearby church. An assigned employee parking space is typically used about 2,000 hours per year, while an on-street parking space in a busy area often gets three times as much use. Based on the peak parking demand for different land use types (Table 4-3), efficient sharing of spaces can significantly reduce parking requirements.

Table 4-2: Peak parking demand for different land use types

Weekday Peaks	Evening Peaks	Weekend Peaks
Banks Schools Distribution facilities Factories Medical clinics Offices Professional services	Auditoriums Bars and dance halls Meeting halls Restaurants Theatres	Religious institutions Parks Shops and malls

Source: (Litman, 2016)

Parking can be shared relying on public parking facilities rather than having each building to provide private off-street parking since each public space can serve many users and destinations.

The concept of shared parking is well known. In many Asian developing cities, however, it is often discouraged by current planning practices. Conventional planning often reflects an assumption that communities want the greatest possible supply of parking provided at the lowest possible price. In most communities, it is required that each building or facility offers a minimum amount of off-street parking supply, basing on studies of peak-period demand. Transportation professionals and public officials often prefer generous, simple and consistent minimum parking standards because they are easy to administrate and minimise spill-over problems. All of these factors contribute to inefficient use of parking resources: many parking lots are seldom or never used, even during peak periods.

These practices are well established but are beginning to change, particularly in growing urban communities. Communities increasingly aim to encourage infill development, use of alternative modes and reduce the portion of land that is paved.

Shared parking can reduce parking facility costs (including aesthetic and environmental impacts), allow greater flexibility in facility location and site design, and encourage more efficient land use. Marshall, Garrick and Hansen (2008) found that low-speed urban streets with on-street parking tended to have lower traffic speeds. However, motorists could find it less convenient and automobile travel might be increased if it increases total parking supply.

4.2. Supply-oriented measures

There are many measures to manage and control parking supply. They can be categorised into three major groups including: (1) improve existing parking capacity, (2) increase parking supply, and (3) manage parking supply (Table 4-4).

Redesigning existing parking facilities, using car stackers and mechanical garages are seen as key to improving existing parking capacity. Redesigning existing parking facilities aims to increase the number of spaces in existing parking facilities by using currently wasted areas (corners, edges, undeveloped land, etc.) and sizing a portion of spaces for motorcycles and compact cars. Stackers and mechanical garages with lifts and elevators can significantly increase the number of vehicles that can be stored in a particular area. Pedestrian improvements can help create more pedestrian-friendly streetscapes and neighbourhoods, therefore, improve the accessibility to the parking facilities.

Increasing parking supply means building more parking facilities. This measure is strongly supported by minimum parking requirements. It enables minimum off-street parking requirements in zoning regulations and development policies, and raises these minimums as needed to accommodate growth in parking demand. Supporting measures should be considered to increase on-street parking. They include designing streets with parking lanes, converting traffic lanes to parking lanes, or converting parallel to angled parking. Those measures minimise restrictions for on-street parking. In small commercial centres, on-street parking may provide most of the parking supply.

Parking facility management involves improving enforcement and using flexible parking requirements. The enforcement is significant to reduce illegal parking, especially on-street parking. Flexible parking requirements involve developing minimum parking requirements and taking into account specific geographic, demographic and management conditions.

Table 4-3: Supply-oriented parking management measures

Strategies / Functions	IMPROVE Existing parking capacity	INCREASE Parking supply	MANAGE Parking facilities
Infrastructure	• Redesign existing parking facilities; • Pedestrian improvements	• Increase on-street parking	
Regulations	• Car stackers and mechanical garages;	• Minimum parking requirement; • Subsidize off-street parking	• Improved enforcement; • Access management; • More flexible parking requirements
Information and Marketing			• Control use of parking passes

Source: Author's representation

4.2.1. Measures to improve existing parking capacity

This involves strategies that result in efficient use of existing parking facilities and increasing occupancy rates or load factors. Performance based parking refers to pricing designed to rationally allocate parking supply (Shoup, 2008).

This measure can be a quick, cost-effective and flexible approach to solve parking problems. It supports transport demand management objectives, and most strategies reflect market principles. Some strategies improve consumer services and transport choice. However, it may require new planning and administrative structures. It may be less convenient to users than increasing parking supply. Below are specific measures to encourage more efficient use of existing parking capacity.

- **Redesign existing parking facilities**

This measure aims to increase the number of spaces in existing parking facilities by using currently wasted areas (corners, edges, undeveloped land, etc.) and sizing a portion of spaces for motorcycles and compact cars. Small size stalls (275 square feet) require about 20% less space than average stalls (325 square feet). Up to 25% of spaces can typically be sized for compact vehicles, resulting in a 5% increase in total parking capacity compared with all spaces being average size. Motorcycle parking can sometimes be located in an area that is too small for automobiles.

This measure can be an inexpensive way to increase capacity. However, its potential is usually limited. Current trends are toward larger parking spaces due to increasing average vehicle size and requirements for disabled vehicle parking. It may affect user convenience or involve paving green-space. It may also involve additional repainting and repaving costs.

- **Pedestrian improvements**

Pedestrian improvements cover paths and sidewalks, shortcuts, covers and shade, crosswalks, and address security concerns. New urbanism design principles can help create more

pedestrian-friendly streetscapes and neighbourhoods, therefore, improve the accessibility to parking facilities.

This measure increases the range of parking facilities that can serve a destination and creates a safer, more pleasant experience for users. It can be part of an overall program to improve pedestrian conditions and encourage alternative transportation. However, it requires financial and land resources. The implementation may require new planning and funding practices, particularly for improvements on private property, and for creating new shortcuts.

- **Car stackers and mechanical garages**

Car stackers and mechanical garages use various types of lifts and elevators to increase the number of vehicles that can fit in a parking structure. They can nearly double the number of vehicles that can be parked in a given area.

They are a flexible way to address growing demand for parking spaces at relatively low construction cost and no additional land requirements. However, the equipment needs high investment cost and operating costs (although usually less than building additional structured parking). It is only suitable for parking structures with attendants. Since it increases the time required to park and retrieve vehicles, it is unsuitable for many types of vehicles (vans and trucks).

4.2.2. Measures to increase parking supply

Increasing parking supply means to have developers or governments build more parking facilities. This is a well-accepted solution supported by existing planning practices and might be applied in peripheral areas where parking supply is not really stressful. It tends to be politically popular. It minimises transaction costs because un-priced parking is usually income tax exempt; therefore, it is financially attractive. It is considered fair since an average consumer bears their share of parking facility costs.

However, it costs developers, businesses or governments hundreds of dollars per space in annualised costs, increasing business overhead costs and taxes that are ultimately borne by consumers. It represents a subsidy to driving and is unfair to people who drive less than average. In many cases, it encourages driving, which increases traffic congestion, crashes and environmental impacts. Furthermore, it creates low-density, automobile-dependent land use patterns, a less pedestrian-friendly environment, and discourages infill development.

- **Minimum parking requirements**

Minimum parking requirements mean to establish minimum off-street parking requirements in zoning regulations and development policies, and raise these minimums as needed to accommodate growth in parking demand. It is helpful to coordinate such requirements among jurisdictions in a region in order to avoid conflicts.

This is a common way to increase parking supply. It is easy to implement in most communities by adjusting existing zoning codes and development policies. Generous minimum parking requirements for new construction can be justified because it is usually much more expensive to add parking capacity later. However, it imposes high economic and environmental costs, adding thousands of dollars per space to development costs. It is slow to implement and so cannot solve immediate parking problems. It is inflexible and standard

parking requirements do not necessarily represent demand at a particular site (Shoup, 1999a). It is unfair to people who use less parking than average. It places the full cost of solving parking problems on new development, even if parking problems result from a shortage of parking at existing facilities. It discourages new, infill development, which can contribute to urban blight, and reduces housing affordability.

- **Increase on-street parking**

Increase on-street parking means to design streets with parking lanes, convert traffic lanes to parking lanes, or convert parallel to angled parking. This measure minimises restrictions for on-street parking. In small commercial centres, on-street parking may provide most of the parking supply.

This measure helps on-street parking to be convenient, visible and cost efficient. It is a form of shared parking, with each space serving many destinations, and so tends to have a high load factor. It does not require access lanes, and so uses less land per parking space than off-street parking. It is relatively inexpensive. On-street parking can provide a buffer between pedestrians and vehicle traffic. Converting parallel to angled parking increases capacity (it can almost double the number of spaces), and make parking faster and easier (Edwards 2002).

However, only a limited amount of curb parking can be provided in an area. It often involves trade-offs with traffic lanes, bike lanes, sidewalk space, and other uses of street space. Parallel parked cars are a hazard to cyclists, particularly if lanes are narrow. Under some conditions, angled parking increases the rate of collisions, although it tends to reduce their severity.

- **Subsidise off-street parking**

Subsidise off-street parking means to use public resources to build parking facilities. This can include direct government funding, free or discounted land provided to developers, tax exemptions and other favourable tax policies, and public parking facilities incorporated into public-private-partnership projects.

It is advantageous in the way that public parking is supplied where it is most desired from a community perspective. Furthermore, governments can control when and where parking supply is added. Nevertheless, it tends to be expensive and represents a public subsidy for driving. It is slow to implement (planning and constructing new parking facility can take years). It is inflexible, resulting in expensive structures that have few alternative uses if expected demand does not occur.

4.2.3. Measures to manage parking facilities

Parking facility management and design can affect convenience, comfort, security and aesthetics. Design and management standards can address various problems and help achieve transport and land use objectives. This management can address a variety of problems and provide a variety of benefits. However, it may increase costs. Below are some specific parking facility management and design improvements.

- **Improved enforcement**

On-street parking is highly preferred in many Asian developing cities because of its convenience and being almost free. Therefore, people are likely to park illegally on the street

and find ways to avoid parking regulations and charges if there is no police enforcement. Effective enforcement is critical.

Parking enforcement must be frequent, fair and friendly. It is important to have sufficient signs and notices for motorists to know what is required to park, how to pay, and the punishment for violations. Parking enforcement officers should be professional and courteous, offering information and assistance to people who have problems. Fines must be high enough to enforce proper parking behaviour, without being so high that they seem excessive.

- **Access management**

Access management refers to the improved coordination between roadway design and land use to reduce traffic problems. It tends to convert automobile-oriented strip development into more clustered development with fewer driveways and improved pedestrian connections between sites. This allows shared parking and improves travel choices.

It can result in more efficient use of parking facilities and provide other benefits, including reduced congestion and crashes, improved transportation choice, more efficient land use, and improved streetscape aesthetics. However, it requires additional administration and enforcement activities, and it may impose costs on government and businesses.

- **More flexible parking requirements**

This involves developing minimum parking requirements that more accurately reflect a site's parking demand, taking into account specific geographic, demographic and management conditions (ULI 2000; Millard-Ball 2002; Kodransky and Hermann 2011). For example, minimum parking requirements can be higher in more automobile-oriented locations and lower at locations that are more accessible. Current parking standards tend to reflect parking demand in automobile dependent, suburban sites with un-priced parking, and so tend to be excessive in areas with better travel options, mixed land use, priced parking or other transport demand management strategies (Shoup 2002). Special efforts may be required to develop variable parking requirements that are politically and administratively acceptable.

  - Consult stakeholders to identify specific concerns related to variable parking requirements.
  - Establish standard methods to determine the minimum parking requirements at a particular site, based on defensible research.
  - Establish Transportation Management Associations that offer parking brokerage services so facilities with excess parking capacity can sell, lease or trade it to others. This allows all building owners to benefit from flexible parking requirements, not just developers of new facilities.
  - Develop ways to evaluate results and correct spill-over problems or increased future demand. For example, there could be requirements that if a lower level of parking supply proves inadequate, developers will be required to implement additional TDM strategies or build additional parking facilities in the future.

Flexible standards are more efficient and fair than inflexible parking requirements. However, it may require new planning and administrative responsibilities. It may be abused if applied inconsistently. Some planners and developers may consider them unfair.

- **Control use of parking passes**

Parking passes for motorists are not often carefully controlled. For example, an employee may be given a parking pass for official business trips, but use the pass for personal purposes. City officials who are given a parking pass for unlimited use of all public parking facilities may use it for personal errands.

More careful control of parking passes can reduce inappropriate use of parking facilities. Written guidelines should be enacted to define who may receive complementary parking passes and under what circumstances they can be used. Managers responsible for distributing such passes should be made aware of their full cost to an organisation. Each agency or group can be limited in the total number of passes they may distribute. Passes should be limited to specific users, types of trips, areas, or times and vehicles. For example, a pass can be limited to a particular vehicle, and not transferable to family and friend's cars. The distribution of parking passes must be regularly audited.

This measure helps to reduce the inefficient and unfair use of parking passes, thus reduce total parking demand. It also sets an example that parking is a valuable resource that should not be provided free.

4.3. The need for a new parking management measure

- **The widening supply-demand gap and the problem of illegal parking**

Available data in Chapter 3 show that the gap between supply and demand in parking in Hanoi has enlarged. Many parking management policies have been implemented. Expanding off-street parking supply in Daoli and other parts of the city centre, for example, has been suggested by several officials as an important policy goal (ITDP, 2010). More parking policies have been applied, such as, reducing or eliminating parking minimums, establishing maximum requirements, formalizing existing practice regarding on-street parking, charging for on-street parking using the latest payment technologies, increasing existing parking charges, eliminating parking spaces on walkways and in setbacks, directing more cars to off-street parking through improved information and promotion of underground facilities for public use, and reducing or abolishing parking standards for buildings. However, to date, the gap betwwen parking supply and demand is still large.

Another burning issue in large Asian developing countries, especially in big cities, is illegal parking. Most of the illegal parking lots appear in core city centres in Asian developing cities due to parking scarcity. For instance, illegal parking lots are popular in Hanoi Old Square Area (Vietnam) and are operated by private actors (Truong & Friedrich, 2016). As the case of Jakarta, where illegal parking lots are dominated by organised thugs and they make money from the illegal parking business, Jakarta Transportation Agency pointed out that the city had lost at least Rp 200 billion (US$17.03 million) in potential income from illegal parking (*The Jakarta Post*, 2014). In Taipei, illegal motorcycle parking has blocked the pedestrian walkway and shopping arcades in many road sections. In order to create a more comfortable zone for pedestrians, the Taipei City government began to clear away illegally parked motorcycles (*Taipei Times*, 2000). Particularly, it is found that the motorists more prefer to have on-street parking. Motorcycles usually park on the pedestrian sidewalk in Taiwan and Vietnam. In Malaysia, motorcycles usually park on the pavement of the street and most often will have designated parking bays (Hsu, Sadullah, & Dao, 2003).

There are several reasons for this alarming situation. First, parking supply has been insufficient. Second, police enforcement has been low. Third, on-street parking is much preferred than off-street parking.

Uniquely, illegal parking not only includes vehicles parking illegally but also illegal parking places.

- **Problem of illegal parking places**

The construction of public parking lots has developed slowly and cannot keep up with the demand. Therefore, many illegal parking places have been created in urban are of Asian developing countries. Owners of these parking places take parking fees from users although they do not have official permissions and often do not fulfil any standard. In many cases, the users might not even notice that they are parking illegally.

This type of parking, on the one hand, has negative impacts such as unplanned land use and private appropriation of public spaces but, on the other hand, it can contribute to overcoming deficiencies in parking supply. In such urban areas, consequently, illegal parking by some means helps to solve the problem of parking scarcity. In any case, possibilities for illegal parking deteriorate the discipline of citizens and drivers and disentitle transport authorities to control traffic and travel demand.

- **A new measure for parking supply enhancement**

Considering such unique traffic situation and parking problem in Asian developing cities, the study explores the idea of legalising illegal parking to manage and control this problem.

Solutions to control the problem of illegal parking should be considered in both long-term and short-term perspectives. For a long term approach, private vehicles should be restricted through adequate traffic demand management measures. Parking management strategies should be used as a major instrument to decrease automobile dependency and to support the shift to public transport. At the same time, the public transport system should be comprehensively improved. As different urban zones represent their own traffic features, parking management strategies throughout the city should be adjusted accordingly.

In short-term, while the public transport system cannot immediately be improved to fully serve the traffic demand, the parking supply enhancement measures are required to solve the issue of illegal parking. Legalisation of illegal parking opportunities (para-parking) could be beneficial for many parties involved: parking space users having legal parking possibilities, public authorities having a possibility to finance and control parking facilities, and private entrepreneurs offering private parking space. The issues of how and to what extents illegal parking should be legalised is discussed in Chapter 5.

4.4. Summary

The study reviews research on parking management policies internationally and takes an in-depth analysis of recommended parking management measures for Asian developing cities. Those cities have unique traffic situation with high motorisation rate, high preference for private vehicles, and limited investment in transport infrastructure. Additionally, the parking behaviour is also unique, with the high preference of on-street parking, willingness to walk in

short distance, and high willingness to park illegally because of low enforcement. Therefore, appropriately contextual parking management measures are recommended.

Generally, parking management measures are categorised into two groups, including leading group – significantly contribute to the parking management objectives, and supporting group - strongly assistance to the leading group. Demand-oriented measures are categorised as avoiding, shifting and controlling the parking demand. Supply-oriented measures are characterised by improving existing parking capacity, increasing parking supply and managing parking facilities.

Time and location restrictions are leading measures to avoid parking demand. Those are applied to limit the parking demand at peak periods and high-demand areas. Other supporting measures include unbundling parking and applying maximum parking in condominiums, office building and commercial buildings. In order to shift parking demand, parking pricing and park and ride system are key measures. Location-based or time-based scheme should be used to limit the demand at peak periods or in peak-demand areas. In the meantime, parking facilities should be relocated in the peripheral area to implement park and ride system. The commuter parking, therefore, can shift to the edges of city centres. Others supporting measures, for instance, marketing for off-street parking facilities should be improved to shift the parking demand from on-street to off-street, then off-street facilities are better utilised. Furthermore, parking enforcement and control should be regularly implemented to support and ensure the successful operation of other measures. Parking information and guidance system is significant in controlling the parking demand with the combination of other supporting measures, such as shared parking and parking duration restriction, to better utilise off-street public facilities.

Parking management measures significantly influence on not only parking demand but also the supply. Redesigning existing parking facilities, using car stackers and mechanical garages are seen as leading measures to improve existing parking capacity. Pedestrian improvements are suggested to create more pedestrian-friendly streetscapes and neighbourhoods, therefore, improve the accessibility to the parking facilities. In many cases, parking supply improvement has to be implemented by building new facilities and regulated by minimum parking requirements. It accommodates growth in parking demand. Another supporting measure is to increase on-street parking. Existing parking facilities could be better utilised by improving enforcement to reduce illegal parking and using flexible parking requirements to accurately reflect a site's parking demand.

However, given such parking management measures, the gap between supply and demand in parking is still large. Many illegal parking places have been created in Asian developing cities because the construction of public parking places has been slow and cannot keep up with the demand.

Considering the unique traffic situation and parking problem in Asian developing cities, the need for a new measure to deal with illegal parking problem is significant. The study initiates the idea of legalising illegal parking to manage and control this problem, in the context that public transport system take years to be able to fully serve the traffic demand. The questions of how and to what extent illegal parking should be legalised are discussed in the next chapter.

5. Development of the Para-parking Concept

In this chapter, the questions "How and to what extent illegal parking should be legalised" will be answered, giving the benefit for parking users, urban planning, and transport planning. Through reviewing previous researches, the current situation and trend of urban transport development in developing cities are identified and the role of parking management is investigated. Empirical surveys are conducted to examine the parking conditions, parking user's behaviour and the consequence of illegal parking spaces in Vietnam. Then, the requirements of para-parking (legalisation of illegal parking spaces) are formulated including the change process that involves parking authorities, parking operators, and parking users. An in-depth analyse is undertaken to look at opportunities, risks, and forms of para-parking and finally, a proposal for economic impact assessment of parking facility investment is given.

5.1. Definition of illegal parking places

Generally, there has not been a specific definition of the "illegal/irregular parking" or "parking violation" in the literature yet. Through some aspects described in traffic engineering (Roess et al, 2011), Code of Eddystone Borough (Pennsylvania, USA) (Borough Council, 1992), the term can be understood simply that it is the act of drivers stopping and parking their vehicles in a place restricted by law regulations or in an unauthorized manner. It is against the law virtually.

If looking more closely one could furthermore differentiate illegal parking places. This place is used illegally by individuals who offer it to parking users collecting parking fee. The users might not even notice that this is illegal.

Investigation into previous research as well as actual on-site data collected from the sites in this current study point to an alarming situation in most of Asian developing cities – illegal parking. This issue calls for immediate actions in the local contexts for its negative impacts to be avoided.

5.2. Para-parking concept and application

Given several parking demand management measures have been applied, the supply is still too low. Therefore, the concept of para-parking is firstly introduced in this study to provide a legal basis to manage illegal parking spaces. Additionally, the development of para-parking spaces will solve the problem of un-planned land-use in urban area, especially in core city centres.

5.2.1. Para-parking concept

In transport, the term of "para" was firstly seen in the concept of "para-transit". Para-transit is a transport concept, which was born in the mid-1960's to describe certain types of transport services which did not quite fit the conception of "transit" as that term was being traditionally employed. In common parlance as well as in professional literature "transit" came to be synonymous with public mass transport. The term is usually preceded by a qualifying adjective, as in mass transit, rapid transit, rail transit or bus transit; or by a combination of the above qualifier, as in rapid transit. With or without the qualifying words, however, the phrase

connotes a public transport system operating over fixed routes and on regular prearranged schedules (Rimmer, 1984).

The term "para-parking" is partly derived from "para-transit" to describe certain types of parking services which did not quite fit the conception of "parking" as that term was being traditionally employed.

Para-parking means to utilise a place "similar" to a parking lot by improving a private area to become a semi-private parking lot or by utilizing a public area to become a partly-public parking lot. Characteristics of para-parking are shown in Table 5-1.

Table 5-1: Characteristics of para-parking spaces

Aspects	Description
Forms	Semi-private parking (private parking facilities, private operating, public utilization); Partly-public parking (public parking facilities, private operating, public utilization).
Investor/Operator	Private financing, private operating; Public financing, private operating;
Location	Located in areas with high parking demand (residence, shopping, business area)
Parking Pricing	Market – oriented pricing (government might limit the ceiling price)
Guidance and Information System	Good provision of guidance and information system with internet-based form
Design Standards	Follow the minimum requirement of design standards (safety and security, lighting, entrance and exit gate…)

5.2.2. Transition process to legalise illegal parking

The objectives of the transition process are first to investigate the inter-relation between involved parties when they join together in parking business; secondly to explore a communication instrument for involved parties, and thirdly to design a change process to successfully legalise illegal parking.

To frame the transition process, the relation between parking management authorities, parking operators and parking users are investigated.

- **The empower-register relation between parking management authorities and parking operators**

Parking management authorities empower parking operators to provide parking service including the investment, setting the parking fee, collecting parking fee, providing the information system. It means that the private sectors or individuals can provide parking facilities as a business. To do so they have to register to parking management authorities, setting appropriate parking pricing scheme to ensure a reasonable profit. Parking authorities also could provide a communication instrument such as a parking information platform which helps to maintain the communication between involved parties: parking management

authorities and parking operators (register and approve); parking operators and parking users (service providers and service users).

Additionally, the parking facilities have to meet parking design standards and the enforcement to prohibit illegal parking should be guaranteed. Importantly, the parking facilities which are run by private companies or individuals can be developed in only some specific zones, to ensure positive impact on traffic demand management strategies. In order to get more operating revenue, private sectors can integrate other business in parking houses (automated vehicle cleaning machines, shopping malls, leisure and entertainment stops…). To reduce the parking fee, private sectors can get subsidies from local government relating to tax and free land.

- **The service provider – service user relation between parking operators and parking users**

Parking operators will provide the service and parking users will be service users, their business relation is maintained through the market. Such commercial parking is usually open to the public rather than serving specific buildings or clients. Parking operators have to ensure the accuracy of parking information system (availability, capacity and pricing scheme of parking facilities) and the security aspects such as who compensate for the damaged or lost vehicles.

Parking users can search for the availability, capacity, and parking fee of parking place through an information system. Parking users can give instant feedback to the quality of the parking service such as safety, security, physical condition which might be used as a reference to other users as well as a guarantee to service worth. They also can book and pay in advance the parking space that they intent to occupy. This will diminish the irregular payment. An important issue is that parking users are willing to pay market-based parking fee.

The summaries of the change process are illustrated in the Table 5-2 below.

Table 5-2: The requirements for change process

Policy change	Business change	Behaviour change
• Private sectors or individuals have to register with parking management authorities to provide parking business; • The parking facilities have to meet parking design standards; • The enforcement to prohibit illegal parking should be strongly enhanced; • The parking facilities can only be developed	• Private sectors or individuals can provide parking facilities as a business; • Private sectors can integrate other business in parking houses; • Parking operators provide an communication instrument such as an information system which helps to maintain the communication between involved parties; • Parking operators have to ensure the accuracy of parking information system (availability, capacity and pricing scheme of parking facilities); • Parking users can search for the	• The willingness that private sectors or individuals can provide parking facilities as a business (management authorities); • The willingness to change policy and providing support to parking business (management authorities);

in some specific zones; • Private sectors or individuals can set appropriate parking pricing scheme; • Private sectors can get subsidies from local government relating to tax and free land; • Parking operators have to ensure the security aspects, e.g. also pay for the compensation of damaged or lost vehicles.	availability, capacity, and parking fee of parking place through above information system; • Parking users can give instant feedback to the quality of the parking service such as safety, security, physical condition then it might be used as a reference to other users as well as a guarantee to service value; • Parking users can book and pay in advance for the parking space that they intent to occupy.	• The willingness to involve in parking business (private sectors); • The willingness to use the new parking service and willingness to pay new scheme of parking fee (parking users).

- **The framing of the change process**

Most important requirements relating to the relation between three key stakeholders are categorised into three groups, including policy change, business change and behaviour change. A framework has been built to show the relation of involved stakeholders to the sequence of chance and the acceptability to change (Figure 5-1).

Figure 5-1: The framework of the change process to legalise illegal parking

Three levels of involvement of key stakeholders are illustrated in the framework. At the highest level, parking management authorities are responsible for the policy change which providing the basic regulation for the legalisation of illegal parking. From that basis, parking operators (individuals or private sector) can involve in the parking business. From that point, parking business starts to change. After new parking business is set up, parking users have opportunities to change their behaviour on new parking form relating to parking search, book, and payment.

To investigate the acceptance to change, three level of willingness should be considered. At the first level, parking users' willingness to accept new parking services should be considered. Then parking operators' willingness to get involved in parking business has to be fully

understood. And finally, parking management authorities' willingness to change the policy and provide efficient supports for parking business should be measured.

5.2.3. The role of legal enforcement

Legalising illegal parking could create more official parking facilities and control unplanned land-use. However, the issue of illegal parking could hardly be resolved without strict enforcement of parking regulations. The lack of legal enforcement contributes to illegal parking in the roadway which hinders traffic flow and encourages users to seek these ''free'' spaces (Aoun et al., 2013).

With a very typical motorcycle-traffic-culture and a high preference of on-street parking, illegal parking in many Asian cities mostly occurs on the roadsides and the sidewalks. One significant aim of legal enforcement is to control on-street parking.

Controlling on-street parking has been believed to be crucial in many parking management strategies (Weant and Levinson, 1990). Limiting off-street parking in areas of high parking demand could lead to spill-over parking in local neighbourhoods. On-street parking control measures like residential permit parking could address such concern. Similarly, permitting short-term on-street parking during off-peak hours can provide more parking spaces for shoppers while ensuring maximum street capacity during peak hours and a tightened supply of long-term spaces. Enforcement is an important component of any programs aiming at allowing on-street parking at some certain time slots or for some groups and not others. Strict legal enforcement is often perceived to be essential for successful on-street parking programs (Weant and Levinson, 1990).

Experience in highly-motorised countries such as the UK and US indicates that road construction alone is not sufficient to solve traffic congestion in cities and that other policy measures such as high parking charges, strict enforcement of parking and traffic regulations, public transport development and high fuel taxes are equally important (Calthrop et al., 2000).

As in the case of Bangkok, the road network system consists of only 7% of the land area whereas in developed cities, 20%-30% of their land area is for road network. Current transport facilities in Bangkok fail to accommodate present traffic demand, leading to heavy congestions almost throughout the day. Most of the links in the network handle traffic in almost full capacity level during peak hours, creating bumper to bumper flow conditions. The capacity of available facilities is further reduced due to illegal road-side parking. Insufficient number of traffic police results in the lack of proper law enforcement and finally leads to chaotic traffic behaviour and inefficient usage of the facilities (Bhattacharjee, Haider, Tanaboriboon, & Sinha, 1997).

To implement on-street parking time restriction, many Asian cities have collected comprehensive data on all public parking spaces (on-street, lot, and garage) and the regulations that apply to each. The administrative data makes it possible to infer the occupancy and turnover rates of paid public parking (with electronic meters, including on-street parking). Through the enforcement of parking requirements and parking inventories, cities must come up with a reasonable number of private parking spaces, if not of their turnover and occupancy rates. Most cities commission internal and external studies on parking in particular neighbourhoods, with many of these studies collecting detailed data, by

block and time of day, on parking turnover and occupancy rates. Some trip diaries collect information on parking and satellite imaging generates data that can be used to estimate the land area devoted to surface parking (Arnott & Rowse, 2013).

Strict enforcement should be applied to control on-street parking. Charging a fee for parking is a primary means of controlling the use, which may be important to a shared facility in an urban location where parking is at a premium. Validated parking can be provided to hotel guests, shoppers and others. The rates will depend on a variety of land uses in the mixed-use development and the need to control parking. If parking is free, strict enforcement must be provided to control its use (Boroski, Faulkner, & Arrington, 2002).

The enforcement is needed to reduce the encroachment by "outside" parking users, especially in the dedicated resident parking areas where commuters and shoppers also search to park. Furthermore, it may be more difficult to identify and control unauthorised parking users in shared parking facilities than at a single use location. Certain areas of the facility may be closed at specific times to reserve space for various users, and enforcement may be required depending upon the situation.

In summary, the strict enforcement of parking regulations that control who, when, and how long vehicles may park at a particular location in order to prioritise parking facility use can be considered central in parking policies to reduce illegal parking. Without strong enforcement, the concept of para-parking would hardly be successful. It is significant to regulate vehicles to park at the right location in the right time and within the right duration.

5.3. Application for the case of Hanoi

As mentioned in section 3.4.5 in Chapter 3, on-street parking survey (see Appendix A) and the survey on illegal parking behaviour (see Appendix B) were conducted in three areas in Hanoi.

The on-street parking survey was conducted in July and August 2014. Thirty street sections were selected to represent major road network and distributed equally in three districts including Hoan Kiem (core city centre), Dong Da (developed area), Cau Giay (newly developed area). To determine on-street parking demand, parking counting surveys were conducted in two weeks. The first week was from 15th July, 2014 and the second week was from 25th August, 2014. Time of survey was from 5:00 AM to 23:00 PM. The collected data focused on physical conditions of streets and parking situation in the roadsides and the sidewalks.

A survey on illegal parking behaviour was conducted in November 2014. A total of 360 people were randomly selected in the streets and in parking facilities, then directly interviewed by the interviewers. The survey aimed to understand parking characteristics and the perception of illegal parking of parking users.

The characteristics of the survey area are illustrated in Table 5-3.

Table 5-3: Characteristics of survey area

Area	Districts included	Area (km^2)	Density (people/ km^2)	Traffic demand (total trip generation and trip attraction/day)
Old Square Area	A part of Hoan Kiem district	0.81	84,000	1,412,000
Developed Area	Ba Dinh, Dong Da, Hai Ba Trung	28.78	39,156	4,359,000
New Development Area	Tay Ho, Cau Giay, Bac Tu Liem, Nam Tu Liem, Thanh Xuan, Hoang Mai, Long Bien	222.20	19,682	4,539,000

Source: Synthesis from the General Statistics Office (2016) and Hanoi Department of Transport (2015)

5.3.1. Illegal parking phenomenon

It is found that for 80% of the roads surveyed illegal parking occurs. The illegal car parking occurs more frequently in New Development Area (Figure 5-2) whereas illegal motorcycle parking happens more regularly in Old Quarter Area (Figure 5-3). The reasons are mainly that people go for shopping and park their vehicles for very short time (less than 15 minutes). Then they tend to park in front of the shop to buy things and immediately go. In New Development Area, since the sidewalks are wide enough and people can easily park their cars, then the illegal car parking happen more frequently. Furthermore, it is important to notice that illegal parking occurred frequently due to the lack of police enforcement in every area in Hanoi.

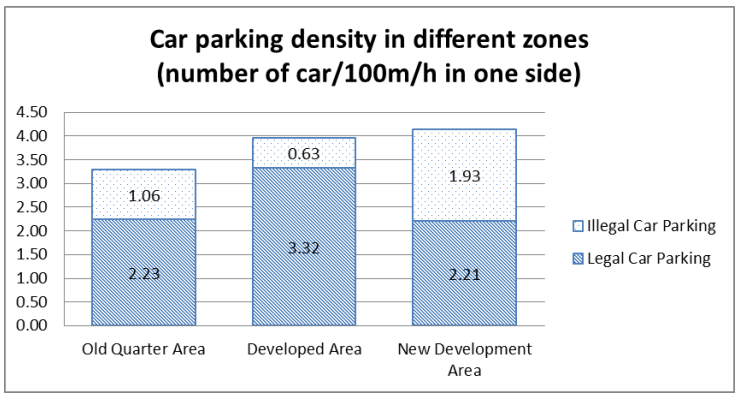

Figure 5-2: Car parking density

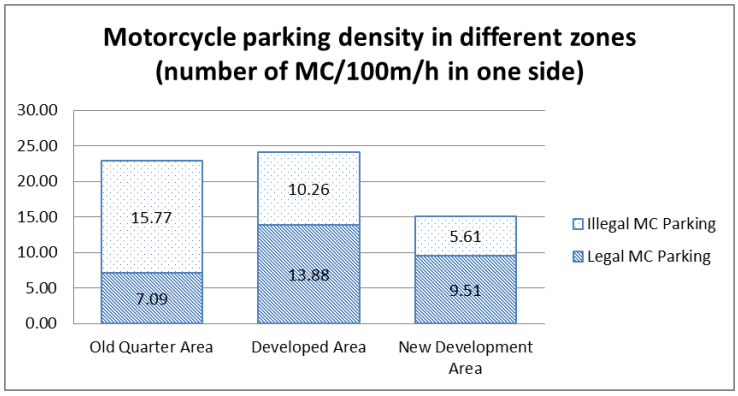

Figure 5-3: Motorcycle parking density

5.3.2. Walking distance

Figure 5-4 shows that 64% of respondents park their vehicles in front of their destinations. There is 18% of visitors walking shorter than 100 meters and the same percentage of people walking longer than 100 meters (18%).

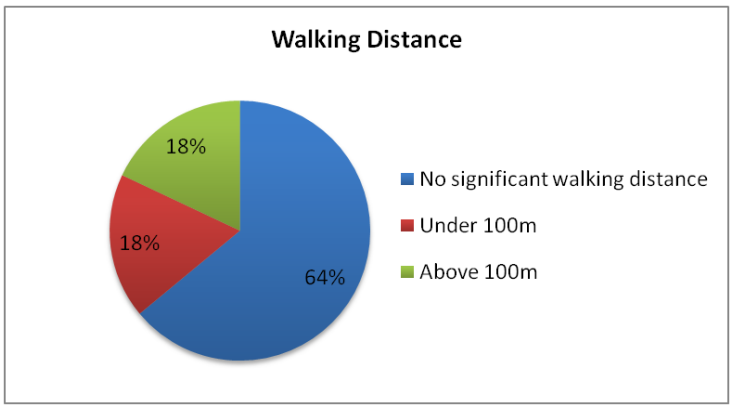

Figure 5-4: Average walking distance of survey group

5.3.3. Parking charge

Most of people (71%) do not pay any fee to park their vehicles on streets (Figure 5-5). About one-third (29%) of the total number of interviewees pay some money to be able to park their motorcycles on sites.

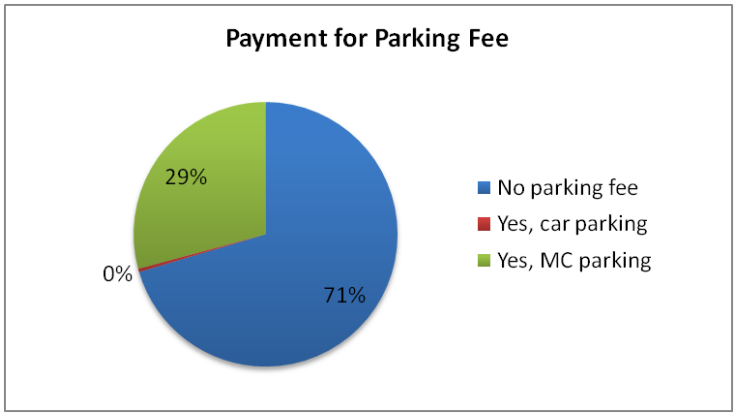

Figure 5-5: Payment for on-street parking

The parking fee is regulated at 3,000VND/motorcycle/turn in central area of Hanoi. However, the survey results show that most of parking users have to pay higher fee (Figure 5-6). The parking fee is especially high in the Old Quarter Area, where people have to pay even three times more than the regulated fee.

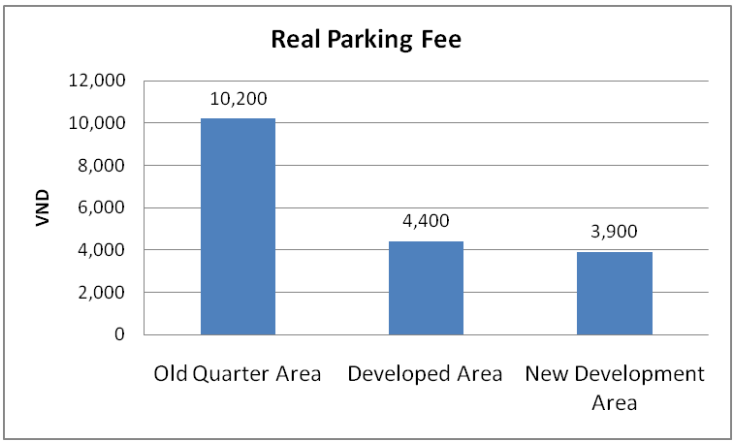

Figure 5-6: Real payment for off-street parking

The results of two surveys have shown the unique features of parking condition and parking user's behaviour of Hanoi, a typical city among Asian developing countries. These results are important to the framing of parking management strategies. Parking location preference and walking distance have been investigated to give the basis for future parking policies. Base on the analysis results, a new concept of para-parking is introduced in the next part.

5.4. Qualitative assessment of parking supply measure

Para-parking concept has been introduced to adapt with the unique traffic context of Asian developing countries. The aim of this new measure is to provide more official parking supply through the legalisation of illegal parking. In order to understand the possible impact of para-parking measure on local socio-economic situation and transport system, the study proposes an assessment structure. The evaluation is very initial and qualitative. A quantitative assessment, a cost benefit analysis model as an example, is suggested for further study.

5.4.1. Possible analysis structure and variables

Table 5-4: Possible structure of analysis

Variables	Scale of Analysis		
	National	**Regional**	**Local**
Benefit categories		Changes in environmental quality; Labour productivity	Walking time saving; Searching time saving; Congestion reduction; Time to access public transport; Accident and vehicle collisions; Changes in number of jobs created;
Cost categories	Public expenditures;	Regional public investment;	Investment cost; Operating costs; Maintenance cost; External costs (CO2, noise…)

Source: Author's representative

The possible analysis structure consists of three dimensions: the scale of the analysis, the type of variables used to assess the impacts and the duration that the impacts occur. Table 5-4 shows the relationships between the types of measured impacts and the level at which they are likely to be felt. Although the national and regional levels of impacts should be covered, the main focus is directed at the local impacts of parking infrastructure investment.

5.4.2. Spatial distribution of parking places in Hanoi Old Quarter Area

The area selected for this initial assessment is the Old Quarter Area (Figure 5-7). Hanoi Old Quarter, a common name of a longstanding metropolitan area located at the centre of Hanoi, belongs to Hoan Kiem district. Its total area is about 100 ha, with 76 streets of 10 wards. This area has very dense population and becomes the concentration of handicraft and trading activities, forming the traditionally specialized craft streets or merchant guild.

As a typical central business district in Hanoi, the Old Quarter Area usually attracts thousands of vehicles every day. Thus, the parking demand is extremely high. It has caused a tremendous pressure on the parking supply, which has still been small with total parking area of about 3,900 m2 contributed by approximately 13 controlled parking spots. They are small-scale parking spaces scattering in the area with limited capacity, except two parking spaces on Phung Hung Street.

Because of the supply-demand unbalance, spontaneous “vehicle-keeping services” have appeared without permission. Due to their limited owned land areas, it is difficult to serve the increasing demand. Therefore parking illegally on the street, including sidewalks and curbsides, has become common in the community. Improper behaviour has been supported by the regular and “immature” habit of “stop-and-drive” in shopping activities of visitors, the inattentive and loose enforcement, the unclear information of parking spaces, improper legal awareness of the community, and illegal parking fee at legal parking spaces.

The encroachment of the restaurants and retail shops as well as illegally parked vehicles in front of their building, often reduce the width of sidewalk and carriageway. In fact, the majority of the streets in the area have narrow sidewalks (<3 m in width and even no sidewalk) and roadways (about 7 m in width). So parking violation has caused serious problems such as traffic congestions, pedestrian inconvenience, and environmental pollution.

To solve the problem of parking scarcity, two different alternatives are being set. The first alternative is to build new public parking spaces; the second alternative is to develop the para-parking spaces.

- **Alternative one: The construction of new parking houses**

In this alternative, three new parking houses will be built in the edge of Old Quarter Area (Figure 5-8). The location and the capacity of parking houses are planned base on the proposal of Hanoi Parking Company. It is assumed that multi-level parking houses with each area of 500m^2 are built, having a parking capacity of 100 cars and 500 motorcycles each.

This alternative requires a big investment from public budget. New parking houses will fulfil the gap of parking demand and supply. In the case that parking users accept to park in new parking houses, it will help to reduce the traffic in Old Quarter Area since parking houses will work as P+R facilities. However, since the distance from parking houses to nearby shops is

long, there is the risk of resistance of parking users, and illegal parking might happen more frequently.

- **Alternative two: The development of para-parking spaces**

In this alternative, 43 on-street and 9 off-street para-parking spaces will be developed (Figure 5-9). The location of both on-street and off-street parking spaces are based on the on-site survey and observation, following below criteria:

(i) the distance between on-street parking spaces is about 200m on average which be suitable with the willingness to walk of parking users;

(ii) on-street parking spaces locate on the sidewalk, in two ends of the streets, serving mostly for motorcycle, with capacity of 40 to 50 motorcycles.

(iii) off-street parking spaces locate on the available free land of private houses (currently provided illegally), serving for both cars and motorcycles, with capacity of about 10 cars and 20 motorcycles.

This alternative will attract small investments from individuals or the private sector to develop parking business, to shift from illegal parking spaces to the legal ones (through the legalisation of illegal parking). Therefore, it will reduce the burden on public budget and effectively employ private finance resources. In this case, since para-parking spaces locate in many small areas then the searching traffic for parking will be minimized through the on-line parking information system. However, the traffic flow in second alterative might be denser than that in the first alternative.

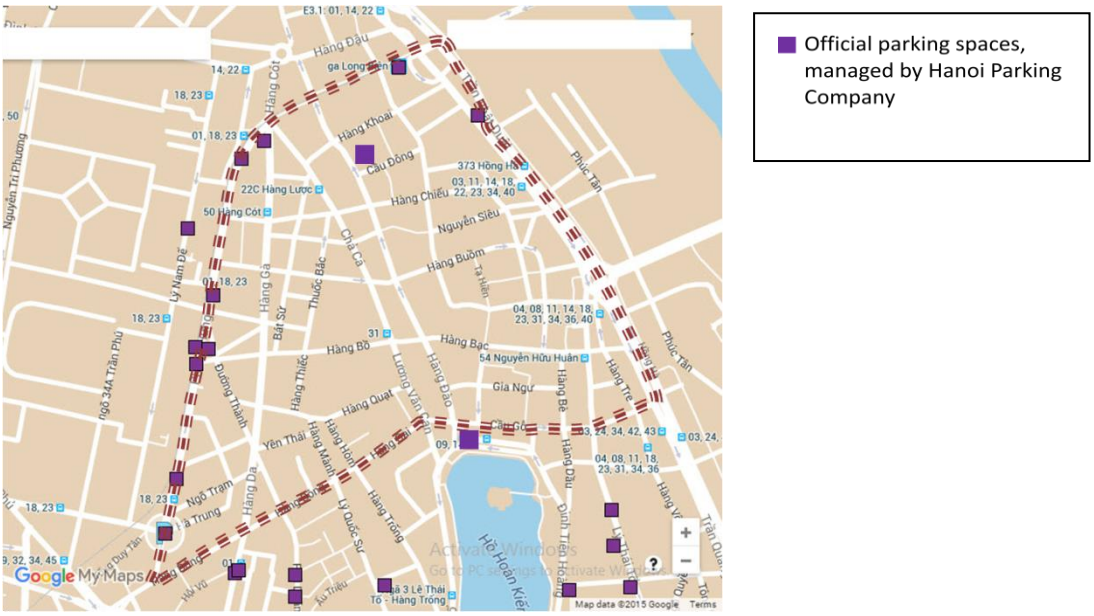

Figure 5-7: Existing location of offical parking spaces in Hanoi Old Quarter Area

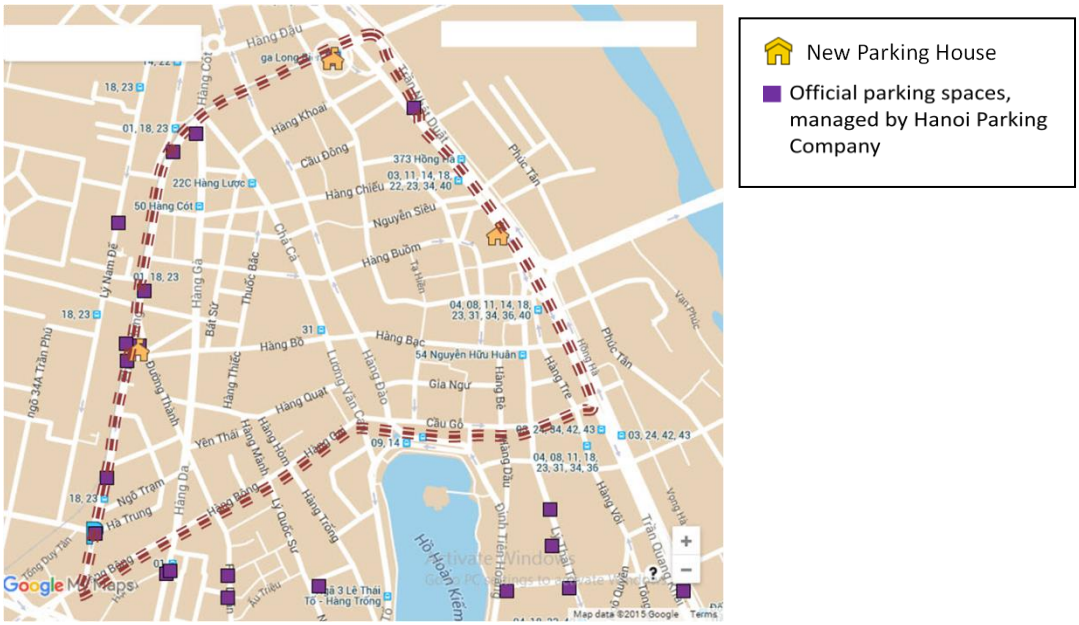

Figure 5-8: The location of new parking houses in Hanoi Old Quarter Area

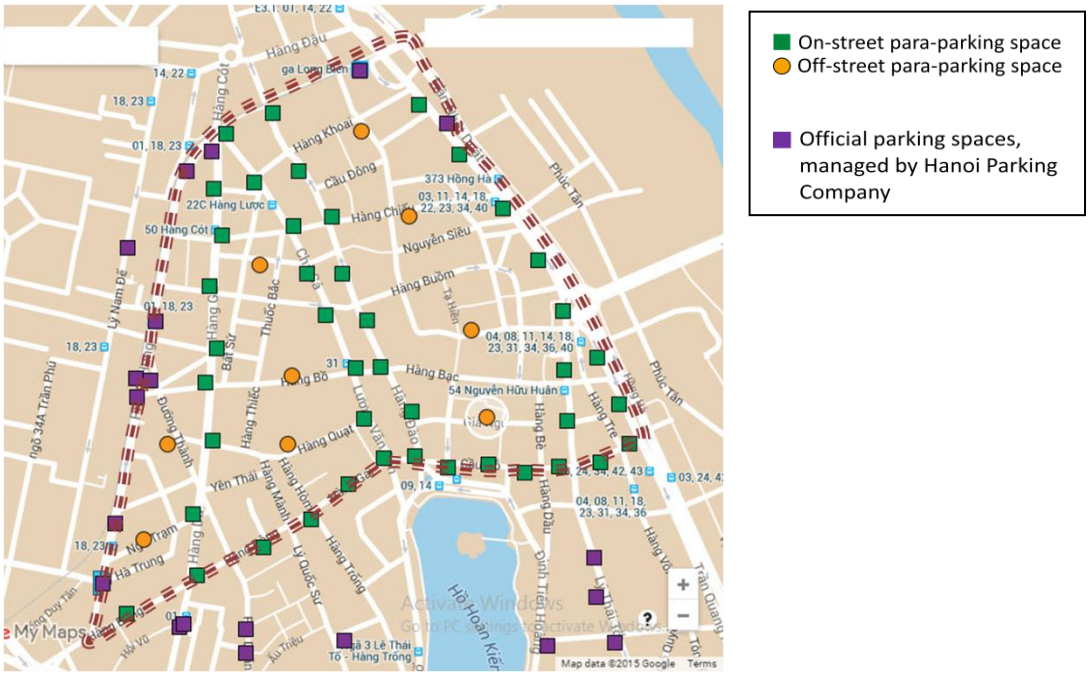

Figure 5-9: The location of para-parking spaces in Hanoi Old Quarter Area

The following variables are proposed to be integrated in analysis structure and the ability to have impact on different aspects of two alternatives (Table 5-5).

The walking distance from parking spaces to shopping streets are long in the first alternative, hence the enforcement to control illegal parking is strongly required. Additionally, the building of new parking houses is costly; it results in the high public investment. In the alternative two, para-parking spaces locate in many small areas thus the traffic flow within Old Quarter Area is denser.

Table 5-5: Variables integrated in the analysis structure

Variables	**Alternative 1: Build new parking houses**	**Alternative 2: Development of para-parking spaces**
Need of enforcement for legal parking	●	◐
Need for public investment	●	○
Reduction of traffic flows within the city	●	○
Increase in employment	◐	●
Land-use	●	○
Ability to manage supply	●	●
Ability to impact on traffic management	○	●
Legend: ● Strong impact ◐ Medium impact ○ Low impact		

Relating to the changes in employment, more changes will be made in alternative two since it require many more labours working as vehicle observers.

Land-use is also an important criterion to consider in two alternatives. The first alternative requires big free land to build parking houses where as the land used to develop para-parking spaces mostly utilised from current parking areas in the second alternative.

Both alternatives have direct influence on parking supply since they provide more legal parking infrastructure. However, the development of para-parking spaces in the second alternative is more dynamic and requires low public resources, and then it has higher ability to impact on traffic management.

Possible analysis structure and variables are recommended to assess the impacts of two alternatives of parking supply enhancement: to build new parking houses or to develop para-parking spaces. With the limitation of time and budget, the quantitative assessment has not been conducted within this study. It is suggested that a real data analysis will be conducted and measurable results will be shown in a further study, giving the evidence to conclude the practical role of para-parking concept in urban parking management.

5.5. Summary

The study has proposed a new concept of para-parking to solve the problem of illegal parking to accommodate unique context in Asian developing cities. It also positioned it as a core measure of parking management strategies for short and medium term based. This concept covers the definition, the pros and cons analysis, and the transition process to successfully legalise illegal parking. The quantitative assessment of economic impact is recommended for a later study, illustrating the applicability of para-parking concept and also position para-parking measure in parking management strategies in particular and in traffic management strategies in general.

Generally, the framing of para-parking concept is expected to enhance the legal parking supply to urban area of developing cities. It will particularly benefit transport planners to control unplanned land-use. Furthermore, successfully legalising illegal parking also allows new parking businesses in urban area while establishing reasonable pricing schemes and effective regulations.

6. Zone-based Parking Management Strategies

The parking situation and parking behaviour in Asian developing countries, as investigated in Chapter 2, call for pre-defined parking management measures, as recommended in Chapter 4. A strategy can be defined as an action plan which includes a bundle of pre-defined measures to improve a defined initial situation (Boltze & Fornauf, 2013). This chapter aims to develop parking management strategies to respond to the unique features of the local traffic conditions. Firstly, the need for parking zoning is highlighted, taking into account the mobility related aspects for specific urban areas. Secondly, indicators to divide zones for parking are recommended. Thirdly, zone-based parking management strategies are then formed and applied for the case of Hanoi. Finally, key differences of parking management between developed and developing countries are emphasised for the importance of this research outcome.

6.1. The need for parking zoning

Originally, zoning is implemented for spatial planning, land-use management and administrative control (Nel, 2016). One important component of land-use management is the control over the density or intensity of land uses to enable the planning and supply of basic service infrastructure. In addition, land use management is linked to administrative justice and transparency where appropriate processes are essential to inform communities of proposed developments. In practice, zoning is used to prevent new development from interfering with existing uses and/or to preserve the "character" of a community.

Zoning may include regulation of activities acceptable on particular areas (such as open space, residential, agricultural, commercial or industrial), the densities at which those activities can be performed (from low-density housing such as single family homes to high-density such as high-rise apartment buildings), the height of buildings, the amount of space structures may occupy, the location of a building on the lot (setbacks), the proportions of the types of space on a lot, such as how much landscaped space, impervious surface, traffic lanes, and whether or not parking is provided (Tsekeris & Geroliminis, 2013; Zammit, 2013).

In Germany, for instance, zoning includes an impact assessment with specific green-space and compensation regulations and possible regulations for building design. The way that individual planning systems incorporate zoning into their regulatory regimes is similar. For example, in the state of Victoria, Australia, land-use zones are combined with a system of planning scheme overlays to account for the multiplicity of factors that impact on desirable urban outcomes in any location (Tsekeris & Geroliminis, 2013).

6.1.1. Types of zoning

Traditionally, zoning is a technique of land-use planning - a tool of urban planning used by local governments to regulate the use, the form, the design and the compatibility of development. Legally, a zoning plan is usually enacted as a by-law with respective procedures. In some countries, e. g. Canada (Ontario) or Germany, zoning plans must comply with upper-tier (regional, state, provincial) planning and policy statements.

Zoning describes the authority’s control over the use of land and buildings. Areas of land are divided into zones within which various uses are permitted. There is a great variety of zoning

types, of which Euclidean zoning, performance zoning, and incentive zoning are the most popular.

- **Euclidean zoning**

Euclidean zoning, also known as single-use zoning, is a tool of urban planning that controls land uses in a city. The earliest forms of Euclidean zoning were practiced in New York city in the early 1900s, to guide its rapid population growth from immigration (Grieson, 1980; Urban, Ohls, & Weisberg, 1974). Land uses were divided into residential, commercial and industrial areas, now referred to as zones or zoning districts in cities.

Euclidean zoning has been the dominant system of zoning in much of North America since its first implementation (Hall, 2007). The predictable model for dividing land use patterns generated by the Euclidean system has been associated with a number of problems in land use planning in the United States and elsewhere. Single-use zoning is a basic model that has not evolved to create appropriate solutions for the increasing complexity of social, political and environmental challenges in cities (L. Martínez, Viegas, & Silva, 2007).

Problems with Euclidean-style zoning policy include urban sprawl, urban decay, environmental pollution, racial and socioeconomic segregation, negative economic impacts and an overall reduced quality of life (Hall, 2007). Euclidean zoning represents a functionalist way of thinking that uses mechanistic principles to view the city as a fixed machine. This conception contrasts the view of the city as a continually evolving organism or living system.

- **Performance zoning**

Performance zoning can be used as an alternative to land-use zoning. Instead of determining land use and densities, performance zoning sets standards for impacts and measures the performance of the development against those impacts, permitting the integration of activities and land uses provided that they meet the required standards (Baker, Sipe, & Gleeson, 2006; Connor, 1981). Initially the criteria were based on environmental management measures such as carrying capacity, safety thresholds, environmental quality and the extent of impervious surfaces and open space or floor area ratios. Now criteria may include traffic generated, noise levels, and hours of operation of the activity (Baker et al., 2006). South African town planning schemes use both land use zoning as well as density controls based on the number of units per defined area or floor area ratios. In many cases performance zoning has come to be used alongside – or as part of – land-use zoning as it was found to be inadequate on its own (Zammit, 2013). Performance zoning was able to maintain environmental standards, but not improve them (Jaffe, 1993).

An assessment conducted by Eggers (1990) in Fort Collins, Colorado (USA) indicated that while performance zoning did have positive effects such as improving the quality of development, limiting environmental impacts, improving the links to and utilisation of infrastructure and facilitating mixed land uses, it resulted in far greater costs to developers, due to the complexity of the applications. Baker et al. (2006) concurred that performance zoning as applied in the USA, Queensland (Australia) and New Zealand increased the costs for developers and municipalities alike. Furthermore, due to the nature of the performance criteria, additional skills such as environmental management and anthropology (cultural awareness) are required to assess the applications. The complexity of the system thus places a

heavy administrative burden on local authorities. Not only being costly, it is also a time consuming process.

Although performance zoning is designed to promote greater environmental sustainability, it can also be used to achieve other goals such as equity (e.g. inclusionary housing) or improved design and the aesthetics of an area. Performance zoning also meets the criteria for investor confidence and transparency, but with greater flexibility.

- **Incentive zoning**

Incentive zoning, also known as density bonus, is a fairly recent land-use practice. While zoning is concerned with avoiding negative externalities between land uses and works, incentive zoning allows developers to build at higher density in exchange for the provision of social and environmental amenities such as parks, open-space areas, schools, and affordable housing. Hence, mutual business interests drive incentive zoning. Construction and development interests are required to either build or finance public infrastructure but derive tangible benefits from building and selling at higher densities (Sagalyn, 1997). This growth management technique is based on incentives because the price at which the local government buys each amenity is the amount of bonus provided to the developer. Hence, incentive zoning entails the determination of optimal pricing of social infrastructures in exchange for density bonuses. The determination of the optimal price, however, is difficult to achieve. Local governments can only recognise if an incentive is sufficient to engage the developers in the transaction, not if it exceeds the optimal price. Additional social costs are imposed when "too much" bonus is given to developers.

Two conflicting hypotheses regarding the distributive consequences of incentive zoning are derived from this discussion. On one hand, because incentive zoning imposes the provision of social and environmental infrastructure by developers, it can be argued to be the product of the police power of the state. As such, businesses would oppose the implementation of this policy tool because it imposes a cost on land development and construction. On the other hand, it can also be argued to be more flexible than other land-use controls, such as development moratoria or building caps. Given its potential increased benefits to builders and developers, it may not induce the kind of opposition one would expect from stricter regulations.

Without density bonuses, many communities would find it hard to obtain essential amenities without incurring more expenses. Commission-only governments are in better condition to claim credit and take political advantage from delivering social and environmental amenities that are highly valued by their constituents.

6.1.2. Transport and land use interactions – Mobility zoning

Urban zones differ widely in terms of transport circumstances. Transport and land use are part of a retroactive feedback system where they influence each other. Changes in transport technology, investment and service characteristics can alter overall accessibility levels as well as the relative accessibility of different locations. Land-use changes also affect activity patterns. Of special importance are the changes in trip generation, both for passenger and freight. Trip patterns may change in a number of ways, such as the number of trips, the timing of trips, their origin or destination, the mode, and trip chaining. These changes in travel demand strongly influence the development of new transport infrastructure or services. As

such, the interactions between transport and land use are often referred as a "chicken-and-egg" conundrum (Moore & Thorsnes, 1994). When considering land use in an urban area, certain basic functions are usually found in all cities. The total urban area usually consists of both developed and undeveloped areas.

There has also been much debate over land-use patterns on transport, especially the proposition that urban planning policy can reduce the use private cars. Thus in recent years there has been criticism of the low-density suburban development that is typical in North American and Australian cities and of the difficulties of providing viable public transport in such dispersed urban areas (Kenworthy & Hu, 2002).

However, this debate in the West may not be particularly relevant to most cities in Asia. In these cities, high urban densities (generally higher than European densities) seem a fact of life. The challenge is how to implement transport arrangements appropriately in the local contexts.

Such issues call for further investigation into Asia where both the urban form and transport conditions are different from those in North America, Australia and Britain. The need is made more urgent when arguments from the Western-oriented debates have started to be adopted in Asia and poorer countries. Empirical evidence of impacts on travel and land use is presented in the following part.

- **Accessibility**

The distribution of accessibility in a city, which is strongly influenced by the transport system, influences location decisions and land-use patterns (Hansen, 1959). In simple terms, accessibility is a measure of the ease with which people and goods can reach a location and is an attribute of the location. The impacts of a given change in transport patterns on development patterns depend on many factors, including the state of the land market, regulations on land-use changes, and how much the change actually affects accessibility patterns. The land-use impact of a particular new piece of transport infrastructure is likely to be strongest in cities where accessibility is “a scarce resource”, due to the lack of infrastructure or congestion (Leinbach, 1995; Pooler, 1995). Low accessibility by motorised vehicles (due to congestion and low-quality transport links) seems to be a feature in Asian cities. Therefore, transport patterns and infrastructure will probably be key influences on Asian urban development patterns, even in the absence of active land-use planning measures.

Conceptually, accessibility is central to transport planning. Linking origins with destinations to create flows is the fundamental task of travel demand models. Understanding how urban form combines with the transport system to provide accessibility to activities and how people respond to accessibility in both their location and activity/travel choices is central to this travel demand forecasting process. An integrated approach to the modelling of location choice and travel behaviour is required.

- **Public transport availability**

The impacts of light rail, subway and commuter rail lines and stations on residential density, employment density, or property values have been reported (Badoe & Miller, 2000; Curtis & Scheurer, 2010; Geurs & van Wee, 2004; Moore & Thorsnes, 1994). Three main points associated with integrated urban modelling are focused.

First, not many land-use impacts of bus systems have been mentioned in research. Bus routes can change on a month-to-month basis. Bus lanes can generally be converted to general traffic usage with minimal effort. Further, such systems can provide high levels of accessibility, which, in turn, influences location and travel choice. However, they are assumed to be unlikely to stimulate major land development decisions (Newman & Kenworthy, 1996).

Second, urban form evolution operates on a time scale of decades. Short-run impacts are inevitably negligible and short-run responses need not be indicative of long-run impacts. Practical difficulties exist, however, in long-run empirical studies. Simply being able to observe a system over a very long period of time is a major undertaking. Over the long run many factors change, making unambiguous determination of the public transport system impact difficult, if not impossible.

Finally, it is emerged from the review that transport in general and rail public transport in particular, is a facilitator of development. Curtis (2008) built a compelling case that public transport investment was "one piece of the puzzle" in land-use development.

- **Automobile ownerships**

Households in higher density neighbourhoods tend to own fewer vehicles; and households owning fewer cars tend to use public transport more and generate less vehicle miles travelled (Schimek, 1996a,b; Kockelman, 1997; Cevero, 1996; Messenger and Ewing, 1996).

The role of auto ownership within the overall transport – land use interaction is often overlooked. This may reflect the assumption that auto ownership in many is so high and so pervasive that it ceases to be an interesting explanatory (or policy) variable. It may also result from the view that auto ownership is just one more socio-economic descriptor of trip-makers.

In our view, these assumptions significantly underestimate the extent to which auto ownership decisions are connected to the transport – land use interaction. In particular, auto ownership is a critical "intermediate link" between household location choices (where to live, where to work) and their subsequent activity/travel decisions. Households who choose to live and/or work in low density suburban areas will probably be "auto-oriented". They tend to have a high auto ownership level and use cars to make most or all of their trips. Households who live and work in denser communities may opt to own fewer cars (e.g., only one instead of two or more). Once a household decides to own, say, one car less, it by necessity is committed to driving less and using other modes of travel (public transport, walk) more. Thus, as in the public transport service case previously discussed, a proper specification of the urban form - travel demand interaction requires including auto ownership as an endogenous component of the system.

- **Socio-economic factors**

Socioeconomic factors such as income, age, gender, occupation, etc., have a significant impact on travel behaviour (Peat Marwick & Mitchell, 1975; Schimek, 1995; Loutzenheiser, 1997). Two points concerning the role of socio-economic factors within integrated urban models are then made.

First, it is the interaction between socio-economics and urban form which is central to the understanding and modelling the decision making of people on location and travel. Different people will respond to different density levels and urban designs in different ways. It is,

therefore, not a question of "which is more important", density or socio-economics, in explaining behaviour. Rather, it is a question of understanding how behavioural responses to changes in density, etc., will vary by socio-economic characteristics.

Second, given the importance of socio-economic factors, it is imperative that they be explicitly represented within our modelling systems, and that models be sufficiently disaggregated to properly capture their effects. This implies that explicit representations of demographic and economic process should be included within model systems. One of the reasons why many advanced disaggregate modelling methods have not yet wildly been adopted within operational planning contexts is the inability to predict detailed socioeconomic attributes.

- **Mobility zoning**

In many Asian developing cities, zoning of cities is hierarchical, including districts, streets, and communities (Zhou, Huang, & Zhang, 2017). Traditional zone plans simply consider static aspects of the city, including geographic, economy, culture and historical features. They did not take into consideration the actual urban dynamics generated by people. Understanding the dynamics of urban areas, especially the mobility of people, is critical for traffic management of the city.

New zoning scheme focuses on new indicators that are considered determinants of mobility. It gives a better understanding of the mobility determinants. In doing so, the new zone is determined by the combination of the following: 1/ traffic demand (O-D traffic), 2/ population density, 3/ public transport accessibility, and 4/ type and function of land use and land price. The integration of these four indicators allows transport planners to picture the mobility within the region and to precisely identify the main zones of activities and traffic exchanges. These new indicators are used to measure the homogeneity within a zone, leading to zoning schemes that are more suitable for transport planning (Table 6-1).

Table 6-1: Indicators to divide mobility zoning

Indicators	**Roles in zoning**
Traffic demand (daily mobility)	• Have current and future impacts on local infrastructure • Influence on the traffic condition (congestion, mobility and accessibility) • Influence on environment quality: air, noise…..
Population density	• Influence on with trip generation/attraction
Public transport accessibility	• Ability to restrict private vehicle access • Ability to limit parking supply (parking requirement within the zones or near bus/metro stations
Type and function of land use and land price	• Ability to have free land for the new development of transport infrastructure • Investment cost to improve traffic infrastructure

Source: Author's representative

With this consideration, the borders of the mobility zones might cross frequently the administrative limits of the departments. Urban developments and activity interactions do not always follow the administrative divisions. The centroids of the zones may not be the administrative centres but the economic centres which are close to transport networks nodes.

6.1.3. Zoning for parking

Zoning for parking is reviewed as a historical process of public policy development. Zoning for parking was relatively rare among US cities before the Second World War (Ferguson, 2004). By 1969, however, virtually all US cities with populations exceeding 25.000 zoned for parking as their primary method of dealing with land-use problems associated with rising automobile ownership rates. A brief history of zoning for parking reveals that despite its continuing popularity, it has almost always been a controversial topic. Zoning for parking began as an occasional or piecemeal approach to resolving problems associated with growing automobile storage requirements. It gradually became the preferred method to ensure adequate parking space in an automobile-oriented society. It was first employed to address the unusually high parking requirements of more affluent neighbourhoods in higher density areas, but gradually grew to encompass most land uses in most urban areas of any size or location (Ferguson, 2004). Zoning for parking originally was a supply-side strategy, mostly in the form of parking generation rate.

In Asian developing cities, rapid motorisation calls for traffic management measures to limit private vehicle usage. Therefore, zoning for parking should be more demand-oriented. Zoning for parking is essential to fulfil the requirements of parking management as discussed in Chapter 2. Parking policies should align with overall transport policies; parking management policies should be specific to zones; and parking user groups should be differentiated to their parking demands.

It is found that different areas in a city have specific characteristics regarding population density, traffic demand and available infrastructure facilities. Some cities have successfully differentiated their measures to control the number of parking spaces by the zone-specific land development, public transport accessibility, and environmental requirements (Daganzo & Lehe, 2015; Dong et al., 2015; Zheng, Barbieri, Di Tommaso, & Zhang, 2016).

In Shanghai, parking lots are charged differently depending on which of the six levels of regions they are located in. In Nanjing, the old urban and other areas adopt different standards of parking supply for buildings, and region-specific charging strategies. In 2002, Guangzhou differentiated its urban zones by the planned density. Thus, different parking supply indexes are defined for each of the zones of density 1, 2, 3, and 4. The indexes generally increase outwards from the inside. This sufficiently reflects general planning requirements of vehicle parking in different regions during the urbanization process (Saksena et al., 2014).

Differentiated parking policies should be considered through parking zoning so that the parking resources can be reasonably shared and efficiently utilised. This will balance the parking supply and demand in different regions, and thereby helps to realize the strategic objective of transport, and supports normal and efficient running of all mechanisms in the city. Parking zoning been implemented to regulate parking supply, but has become more demand-oriented recently.

6.2. Indicators to define zones for parking

Traditionally, the proportion of urban should be based on the total population and the urban population that achieve similar levels of coverage and that reflect properly the division of the territory into urban and rural areas (Brockerhoff & Nations, 2004). However, because of the complexity and variety of situations in which the urbanisation process has taken place, this study focuses on new indicators that are considered determinants of mobility. These new indicators are used to measure the homogeneity within a zone, leading to zoning schemes that are more suited for transport planning and parking planning.

The indicators used to identify zones for parking are considered determinants of mobility. They are determined not only by the trips generation and distribution patterns, but is also constrained by other indicators including population density, public transport accessibility, land use and land value.

6.2.1. Traffic demand

Traffic demand indicators used for parking zoning mainly concern trip generation and trip distribution. The generation of trips from particular land uses in any particular city is the basis for most modelling in transport planning. This daily mobility data is also used for parking planning, specifically for the estimation of parking capacity.

High traffic demand mostly occurs in economic development areas with high population density, for instance, central business districts. Generally, higher traffic demand entails higher requirements of parking facilities in the area. Many traffic management measures, parking measures are part of, are applied to reduce traffic demand and parking demand.

6.2.2. Population density

The population density is one of the key factors for mobility assessment due to its high correlation with trip generation and trip attraction (L. M. Martínez, Dupont-Kieffer, & Viegas, 2010). Similarly, the work and study density is also a key determinant to mobility generation and attraction due to the importance of commuting trips in the total number of trips performed.

- **Residential density**

The significance of residential density in determining public transport usage (as well as the use of non-motorized modes of travel such as walk and bicycle) has been investigated in many research (Guoliang, 2006; McConnell, Walls, & Kopits, 2006; Tsekeris & Geroliminis, 2013; Zheng et al., 2016). The debate concerning the role of residential density in determining urban transport efficiency' or sustainability is one which has been on-going within the urban and transport planning communities for some time. The role of density as a direct explanatory variable with respect to public transport usage, auto vehicle miles travelled declines significantly within the statistical analyses once “other factors” such as socio-economic characteristics of the trip-makers, accessibility by mode to destinations, auto availability are accounted for.

- **Work and study density**

Work and study density is also a key determinant to mobility generation and attraction due to the importance of commuting trips in the total number of trips performed. Work and study

density impacts have been investigated to the same extent as the residential density case. The reported findings are quite consistent: increased employment concentrations do have significant impacts on public transport usage, walking and ride-sharing. These results tend to be applicable for CBDs and employment centres located near commuter rail stations (Ihlanfeldt, 2004; Jeong, 2006; A. Nelson, Dawkins, & Sanchez, 2004). This strong result is likely due to the more direct relationship among work and study density, the supply of public transport, and the levels of service for other modes. For instance, higher employment densities increase the chances of ride-share matches, higher density areas, particularly in CBDs, tend to have higher parking costs and/or walk times from parking.

Perhaps the single most important implication of these findings for integrated urban modelling is to reinforce the importance of the employment or activity centre end of the trip. There is a strong tendency in both theory and practice to focus on the residential side of the land-use problem. The spatial distribution of employment (and, more generally, out-of-home activities, both work and non-work related), however, may well be a much stronger "driver" of travel behaviour and transport supply options. It is also arguable that this aspect of land-use may be more susceptible to successful planning control.

6.2.3. Public transport accessibility

Many studies have explained the significant role of public transport accessibility in mode choices (Park, 2008; Rowe et al., 2012; Torres-montoya, 2014). The better public transport service is, the more people will use it. Private vehicles should be less used. Parking demand will be scaled down consequently.

Urban zones are different from one another in terms of parking characteristics and parking contradictions. The core city centres have unique features of excellent provision of public transport service. Therefore, those zones are traffic restricted areas in many Asian cities. The parking requirements for off-street parking facilities should be set at maximum level near stations of light rail, subway commuter rail lines and bus. In the meantime, on-street parking should be restricted or limited in such areas.

Other periphery zones have merely provision of public transport service. Therefore, they are categorised from traffic partly restricted to normal traffic area. Parking demand is not an issue since public lands are still available.

6.2.4. Land-use and land prices

The land-use pattern and land availability contribute to the ability to have free land for the new development of transport infrastructure. Meanwhile, the land price strongly influences the investment cost to improve traffic infrastructure.

Land prices significantly affect parking fees, especially in the long term. The effort to reduce transport cost, especially parking fee, is influenced by land for parking. Singapore offers a spectacular example of a place which has explicitly raised the price of private land in order to prevent an unmanageable rise in illegal parking (Seik, 1997b; Yuan, 1993). Some researchers place a strong emphasis on land prices (Cutter & Franco, 2012; Echenique, 2011; Moore & Thorsnes, 1994; Donald C. Shoup, 1997b; Thien Thu & Perera, 2011). Others have also focused on parking charges (D. C. Shoup, 1997; Donald C. Shoup & H.Pickrel, 1978).

There is also a debate over the importance of land prices to parking policy. Most critics of an emphasis on prices do not necessarily disagree that prices have an impact on parking demand patterns. However, some question the political feasibility of relying on pricing policy alone to achieve changes in urban transport behaviour and fear that an over-emphasis on pricing policy will cause a neglect of other complementary policies (Newman, Kenworthy, and Vintila, 1995).

Therefore, surface parking is more efficient if the price of land is relatively low. For a sufficiently high land price, the developer provides underground parking instead of surface parking. Given that land prices are typically high in downtown areas, it is not surprising that most parking bundled with office-commercial development in central business districts is structured parking. In contrast, low-density office-commercial structures with large surface parking lots such as shopping malls are mostly found in suburban areas where the price of land is lower.

6.3. Zone-based parking management strategies

Basically, parking management always starts where the balance between parking supply and parking demand is not equal and no extension of parking spaces is possible or desired. No additional parking space offer is created through the parking space management; the existing space is however used more efficiently. As discussed in Chapter 2, the principles of parking management are developed based on an in-depth analysis of parking challenges in Asian developing cities. It has been indicated that parking management policies should align with overall transport management policies; parking management policies are specific to urban zones; and different priority levels are set to different user groups regarding their parking demand. To ensure that parking policies align with transport policies, increasing the mode share of public transport and reducing motorisation are key requirements in the local context.

There is also an important question “Who should have higher priority to access the limited parking available?” Based on the travel characteristics and parking behaviour as investigated in section 4.1 and section 3.4.7, residents should be on top of the priority list. Residents should be given prioritised access to on-street parking and reduced rate access to off-street parking. Business visitors, tourists and shopper should be the next priority although they are expected to pay higher than residents. Commuters should be the last priority for access to on-street parking, because they are seen to contribute most to rush hour congestion. Consequently, the following aims are proposed: (1) Improving the parking space availability for residents of densely populated residential areas in inner city; (2) Facilitating the accessibility by car for suppliers and customers; and (3) Reducing the car traffic of employees and students commuters.

Differentiated parking measures should be considered through parking zoning so that parking resources can be reasonably shared and efficiently utilised. This will balance parking supply and demand in different regions, and thereby helps to realize the strategic objective of transport and supports efficient running of all mechanisms in the city. In Chapter 4, parking management measures have been studied and recommended to accommodate the unique traffic circumstance in Asian developing cities. Parking management measures concerns both parking supply and demand.

Based on the characteristics of each zone such as population density, traffic demand, land-use and land price, and the provision of public transport service, parking management strategies are diversified to fit with different urban zones. Prioritisation of different parking user groups are carefully considered, and then the recommendations for each user groups are proposed for each zone.

Generally, urban zones can be categorised into three groups, including traffic restricted area, traffic partly restricted area, and normal traffic area. The number of parking spaces depends on the type of area, for instance, its location, use mixture and use intensity, building form and roadside environments. The overall strategies for parking management are illustrated in Table 6-2.

Table 6-2: Zone-based parking management strategies

Traffic Restricted Area (commercial area)	**Traffic Partly Restricted Area (residential area, mixed residential-commercial area)**	**Normal Traffic Area (industrial area, spatial area)**
SHORT TERM		
• Avoid parking demand in some critical areas, combine with shift parking demand • Better use existing parking capacity. • Legalise illegal parking to manage and provide more official parking facilities	• Shift parking demand, better use existing parking capacity and increase parking supply in some areas. • Legalise illegal parking in some areas to manage and provide more official parking facilities	• Shift parking demand for certain time and area, better use existing parking capacity. • Increase parking supply to serve parking requirement
LONG TERM		
• Completely avoid parking demand • Better use existing parking capacity	• Avoid parking demand in some critical areas • Shift parking demand, better use existing parking capacity	• Shift parking demand for certain time and area, better use existing parking capacity.

Source: Author's representation

Features of traffic restricted areas include the highest population density, very high traffic demand, mixed and compact land-use, very high land price, and good provision of public transport services. Therefore, parking provision should only cover requirements of residents, service providers and suppliers. Para-parking concept should be utilised to accommodate the parking demand of shoppers, service providers and suppliers. The coverage of other parking requirements is limited.

Traffic partly restricted areas are characterised with high population density, high traffic demand, mixed and compact land-use, high land price, and medium provision of public transport services. Parking provision should fulfil requirements of residents, service providers and suppliers and partially cover requirements of other demand groups. Para-parking should be developed only in some areas, where high shopping parking demand but very limited parking supply.

Features of normal traffic areas are medium population density, medium traffic demand, single use area, very high land price, good provision of public transport service. The coverage of parking requirements is limited only in exceptional locations.

Specifically for each parking zoning, parking management concept is recommended in three dimensions and covers the following sub-concepts: spatial concept, time concept, and fee concept. Spatial concept should delimit into each area and should cover resident parking, parking with mixed use for a fee, delivery zones, and the parking areas among others. Time concept should cover the management time over the course of the day and management time over the course of the week. Fee concept should be differentiated by level according to the local circumstances. Low fee should be applied in areas with high use density and typical mixed parking of residents, commuters, customers, suppliers, visitors and business people. Average fee are better used in central locations with high parking space demand of residents, commuters, customers, suppliers, tourists and business people and good development with public transport means. High fee is recommended for central commercial areas with especially high parking space demand of residents, commuters, customers, suppliers, tourists and business people and good development with public transport means.

Consequently, parking management forms are recommended as in Table 6-3.

Table 6-3: Recommended parking management forms for urban zones

Demand Characteristics	Management Forms		Typical Implications
	Short Description	Parking Regulation	
Central business areas with especially high parking pressure, especially strong competition between user groups (e.g. residents, employees, customers, tourists) and possible very good local public transport development	Mixed parking regulations	• Parking time restriction by parking machine; • Legalise illegal parking to add more official parking; • Parking restriction for certain location with high parking pressure; • Maximum parking requirements for office buildings, commercial buildings, universities and colleges; • Redesign existing parking facilities; • Pedestrian improvements; • Car stackers and mechanical garages; • Improved enforcement; • Access management; • More flexible parking requirements.	• Relocation of commuter traffic and application of commuter financial incentive; • Develop para-parking to lower parking pressure; • Increased parking chances for residents and short-term parking users; • Reduced search traffic.
Areas in central locations, with high parking pressure, strong competition between user groups (e.g. residents, employees, customers) and good	Mixed parking regulations	• Parking time restriction by parking machine; • Legalise illegal parking to add more official parking; • Redesign existing parking facilities; • Pedestrian improvements;	• Relocation of commuters and application of commuter financial incentive; • Lower parking pressure; • Increased parking

local public transport development		• Car stackers and mechanical garages; • Improved enforcement; • Access management; • More flexible parking requirements; • Marketing for off-street parking facilities; • Parking information and guidance system.	chances for residents and short-term parking users; • Reduced search traffic.
Areas with high use density, parking pressure and competition between user groups (e.g. residents and employees)	Mixed parking regulations	• Parking time restriction by parking machine; • Redesign existing parking facilities; • Pedestrian improvements; • Car stackers and mechanical garages; • Improved enforcement; • Marketing for off-street parking facilities; • Parking information and guidance system.	• Relocation of commuter traffic; • Develop para-parking to lower parking pressure; • Increased parking chances for residents and short-term parking users; • Reduced parking space search traffic.
Afore-mentioned areas with large share of gastronomy/leisure use		• Shared parking • Redesign existing parking facilities; • Pedestrian improvements; • Marketing for off-street parking facilities; • Parking information and guidance system.	• Relocation of commuter traffic; • Increased parking chances for residents and short-term parking users; • Reduced search traffic; • Employee parking of the gastronomy and leisure facilities is relocated.
Marked retail use	Short-term parking (with loading zone)	• Parking duration restriction; • Redesign existing parking facilities; • Pedestrian improvements; • Marketing for off-street parking facilities; • Parking information and guidance system.	• Relocation of commuter and resident traffic (during the day); • Lower parking pressure; • Increased parking chances for customers; • Reduced search traffic; • Improved conditions for delivery traffic.
Condensed residential use with adjacent workplace concentrations or with adjacent visitor-intensive uses	Resident parking	• Restricted ban on stopping; • Time of validity depending on the uses; • Special parking ID card for residents.	• Relocation of commuters; • Increased parking chances for residents.

Source: Author's representation

6.4. Application for the case of Hanoi

Two surveys have been described in section 3.4.5 in Chapter 3. One is on parking conditions at 30 streets in three zones and the other on illegal parking behaviour with 360 interview participants in Hanoi. Results indicated that parking supply and demand vary in different zones in Hanoi urban area. The characteristics of surveyed areas are presented in Table 6-4.

Table 6-4: The characteristics of surveyed areas

Old Quarter Area	**Dong Da District (Developed Area)**	**Cau Giay District (New Development Area)**
• Area: about 0.81km²; • Very high density, about 96,000 people/km² (2016) • Total 76 streets; • City central of on-street shopping and commercial activities.	• Area 9.96 km²; • High density, with 41,165 people/km² (2016); • Total 74 streets; • Mix land use of on-street shopping, commercial area, hospital, universities.	• Area: 12.04 km²; • High density, with 20,931 people/ km² (2016); • Total 60 streets; • Mix land use of new residence areas, new office buildings, hospitals and universities.
Source: Decision No.70 BXD/KT-QH dated 30/3/1995 of the Ministry of Construction Note: The average density of Hanoi is 2.279 people/ km² (General Statistics Office, 2016)		

The map of three zones is shown in Figure 6-1.

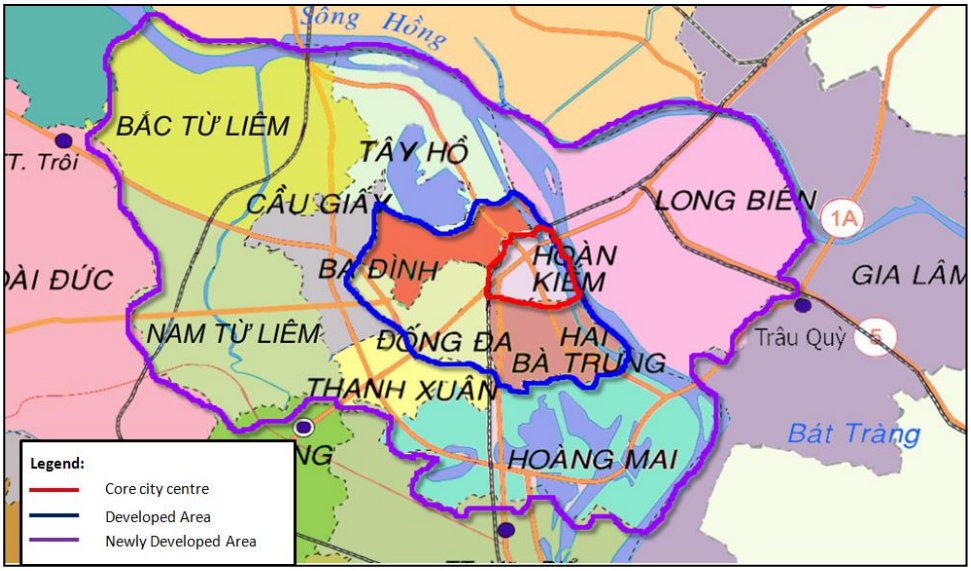

Figure 6-1: The boundaries of three zones in Hanoi

The main indicators investigated include road infrastructure, traffic volume, public transport system, trip purpose, and parking charge of parking users.

- **Road infrastructure**

There are 24% of surveyed streets being less than 7.0 meters wide (Figure 6-2). The streets with the large width of above 14.0 meters account for 12%. The total proportion of the streets with the medium/normal width from 7.0 to 10.5 meters and from 10.5 to 14.0 meters are 64% (in other words, each category got approximately 30% of all).

All of the streets have adequate sidewalks, but it is found that their widths are not homogeneous. Over a half of these streets have narrow footpaths which are less than 4 meters wide. Streets with above 5-meter-wide sidewalks account for 16% while the remaining 32% having the sidewalk width of 4 – 5 meters.

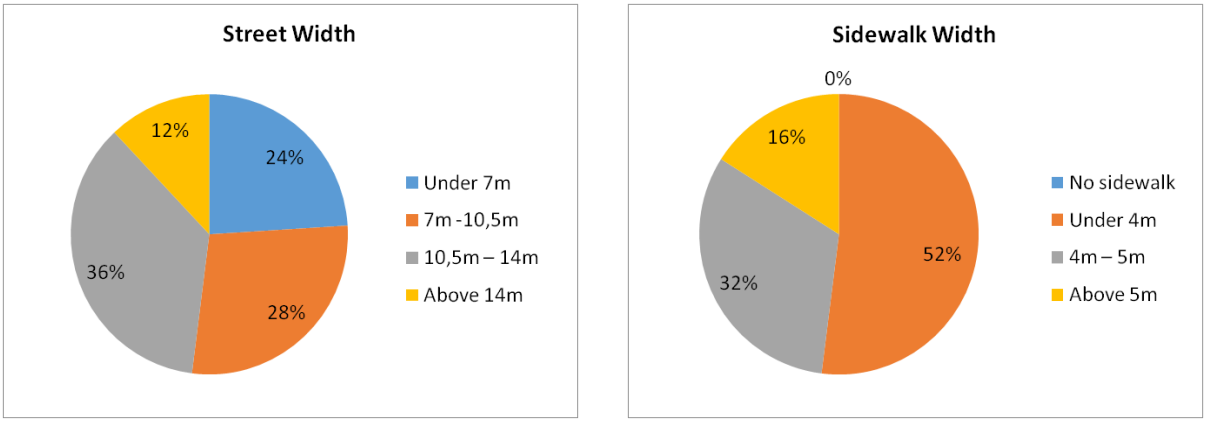

Figure 6-2: Street width and sidewalk width of surveyed roads

- **Public transport system**

Based on the research of Ngoc (2015), public transport in urban areas in Hanoi is not very good regarding network coverage. It is estimated that 82.3% of population in Hanoi centre live within 500 metres (a walkable distance) of a bus route (Table 6-5). However, the population in the centre area accounts for only 29.6% of the overall population in the cities. It means that public transport service is poorly accessible in the suburban areas.

Table 6-5: Spatial coverage from bus stop in Hanoi

Distance from the bus stop (m)	Area served (%)		Population served (%)	
	All-inclusive Hanoi area	Urban core	All-inclusive Hanoi area	Urban core
0 – 500 m	9.82	58.5	-	82.3
500 – 1000 m	10.68	21.4	-	10.5
1000 – 1500 m	9.09	11.0	-	4.1
1500 – 2000 m	6.11	5.7	-	1.0

Source: (Ngoc & Boltze, 2015)

Only 58.5% of the urban core area is covered by the public transport system. The service coverage percentages considerably fall down in the case of all-inclusive areas of Hanoi administrative boundaries because there is almost no public transport service in rural areas. Even with a maximum threshold of 1.000m distance, these figures only go up to 20.5% for the all-inclusive area coverage (Figure 6-3).

Network density represents the distribution of bus routes across zones passed by public transport route. It reveals the degree of consistency between residents and public bus routes. Contrary to network density, the route overlapping describes repetition of bus routes at a particular road segment. At a particular location, a higher route overlap implies a greater opportunity for direct trips, and a great chance to travel to numerous destinations. In the negative aspect, a high route overlap may increase traffic congestion.

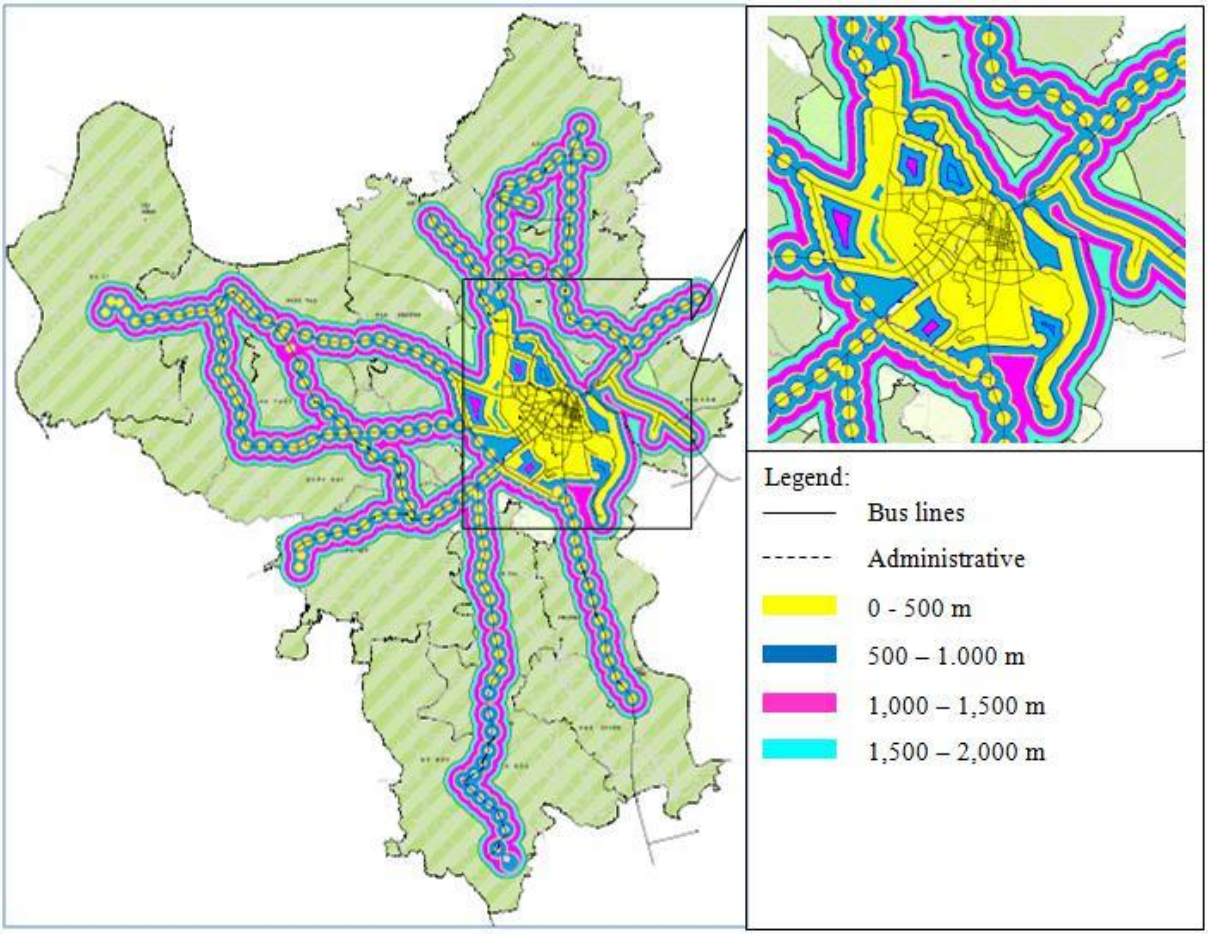

Figure 6-3: Coverage of public transport in Hanoi
Source: (Ngoc & Boltze, 2015)

Table 6-6 illustrates the public transport network density and route overlapping in Hanoi. The high network density is observed in the city centre (i.e. 10 urban districts). This number is reduced 11 times (0.35 km/km2) when considering all-inclusive areas of Hanoi. That points to a serious imbalance in the bus network between the urban and suburban areas.

The total length of bus network is 442 km, while the total length of bus routes in Hanoi is 1,407 km. Hence the corresponding route overlapping coefficient is equivalent to 3.18. This coefficient is relative compared to a maximum threshold of 5. However, the roads segments in city centre have a relatively higher route overlap. This implies that in Hanoi, except in main city hubs, there are considerably less opportunities for direct trips to numerous destinations by public transport.

Table 6-6: Network density and route overlapping in Hanoi

Criteria	Unit	Urban area	All-inclusive area
Total length of network	km	234	442
Total length of route	km	1,188	1,407
Network density	km/km^2	4.07	0.35
Route overlapping ratio	m	5.05	3.18

Source: (Ngoc & Boltze, 2015)

- **Trip purpose**

Going to work is the most important purpose in three surveyed areas. However, New Development Area witnesses the highest percentage of working trips of 62%, Old Quarter Area see the second highest percentage of 40%, and the percentage in Developed Area is 35% (Figure 6-4). Going home is the most important purpose in Developed Area, accounting for 19% of the total trip number. Both Old Quarter Area and Developed Area have the highest share of shopping trips of 21%. Business trips take only 3% in Old Quarter Area and 5% in New Development Area.

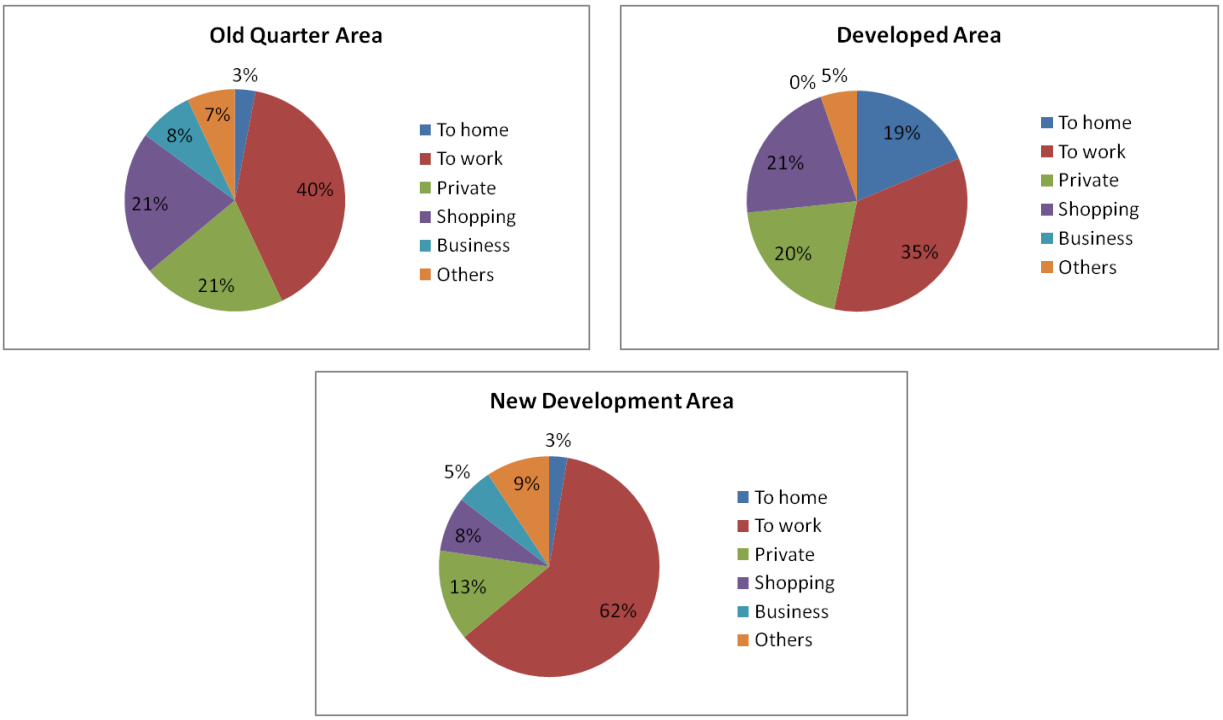

Figure 6-4: Trip purposes of interviewees

- **Parking charge**

As discussed in Chapter 5, the parking fee is set at 3,000VND/motorcycle/turn in central area of Hanoi. However, the survey results show that most of people have to pay higher fees (Figure 6-5). The parking fees are significantly high in Old Quarter Area, where people may have to pay three times higher than the regulated fee.

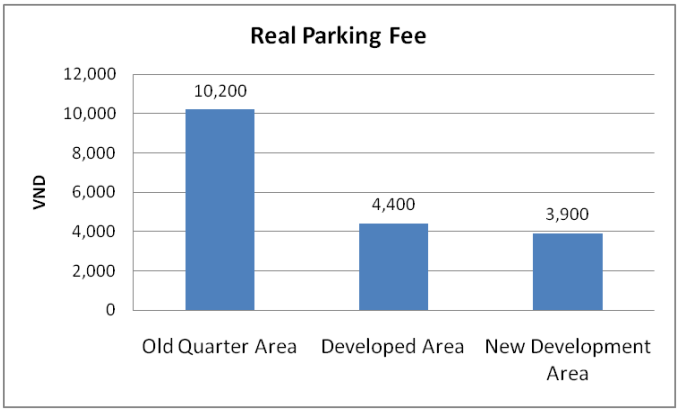

Figure 6-5: Real parking charge

Unique features of parking condition in three zones in Hanoi are withdrawn from the two surveys. It is found that parking demands are dissimilar in core city centre, developed area and newly developed area due to the differences in trip purpose, parking duration and parking supply condition. The characteristics of each area regarding population density, the land-use, traffic volume, and parking condition have been summarised and presented in Table 6-7.

Table 6-7: Summary of three survey zones in Hanoi

Zones	Land-use	Transport condition	Parking situation
Core City Centre	• Area: about 5.29km², accounts for 2% of total urban area of Hanoi; • Population accounts for 5.4% of total population of urban area; • Very high density, about 36,000 people/km² (2016) • City central of on-street shopping and commercial activities.	• This area takes only 2% of total urban area of Hanoi but accounts for 14% of traffic volume; • Public transport accounts only for 3% (DOT, 2016) • Vision toward 2030: public transport will account for 45%-55% in urban area	• Very high density of on-street parking; • Illegal parking vehicles and illegal parking spaces occurs regularly (100% of road survey); • Real parking fee is very much higher than regulated one (10 times); • A high percentage of people going to this area for shopping purpose (35%) with parking duration of 3-4 hours; for working purpose (21%) with parking duration 10-12 hours.
Deve-loped Area	• Area 52.78 km² accounts for 11% of total urban area; • Population accounts for 32.6% of total population of urban area; • High density, with 39,156 people/km² (2016); • Mix land use of central Gov. administrative offices, local Gov. offices, on-street shopping, commercial area, hospital, universities.	• This area takes 11% of total urban area but accounts for 42% of total trip;	• High frequency of on-street illegal car parking; • Many illegal car and motorcycle parking spaces in resident areas; • Private off-street parking being offered (office buildings, shopping malls, and leisure facilities);
New Develo pment Area	• Area: 264.11 km² accounts for 87% of total urban area of Hanoi; • Population accounts for 62% of total population of urban area; • High density, with 19,682 people/ km² (2016); • Mix land use of new residence areas, new office buildings, hospitals, and universities.	This area takes 87% of total urban area but accounts for 44% of total trip of urban area;	• High rise buildings for business, high-rise condominiums, provide very small amount of parking spaces (lower than minimum parking requirement); • Illegal parking occurs on street and public areas; • High percentage of people go to this area with working purpose (65%) with parking duration of 10-12 hours;

Source:
1. Transport development planning in Hanoi toward 2030 and vision toward 2050 (approved by Prime Minister in 2008);
2. Hanoi Department of Transport (DOT, 2016);
3. The on-street parking survey on 30 streets in Hanoi, research sponsored by the World Bank (2014).

Data analysis indicates that parking demands as well as the availability of parking facilities are dissimilar in different zones in Hanoi urban area. Zone-specific parking management schemes are important to fully capture the efficiency of traffic management.

Many studies in Asian developing cities have revealed that traffic management strategies in long term mainly include the limitation of private vehicles and the promotion of public transport system. Therefore, controlling parking demand is proposed to be the central measure of traffic demand management.

Such important measures as location-based parking fees and parking requirements are recommended. Parking fees should be set high and maximum parking requirements should be enacted in highly-demanded areas. Time-based parking fees should also be applied. Parking fees should be set at the highest levels in peak periods. Illegal parking should be closely monitored with improved police enforcement and law restrictions. Furthermore, based on the data analysed and international experience, Hanoi should properly apply parking management measures which are zone-appropriate. The overall parking management measures framed for specific zones in Hanoi are illustrated in the Table 6-8 below.

Table 6-8: Parking management measures framed for specific zones in Hanoi

Zones / Measures Group	Core City Centre	Developed Area	Newly Developed Area
Infrastructure	• Unbundle parking		• Park and Ride;
Technology	• Provision of parking information and guidance system	• Provision of parking information and guidance system	• Provision of parking information and guidance system
Regulatory	• Develop para-parking; • Maximum parking requirements; • Restriction parking base on location, duration, peak-hour	• Develop para-parking in some areas; • Minimum parking requirements for residents buildings; • Maximum parking requirements for public facilities (university, school, office)	• Minimum parking requirements;
Economy	• Location-based parking pricing; • Time-based parking pricing;		

- **Limit the parking in traffic restricted area at core city centre**

Parking demand in the core city centre is extremely high due to high traffic volume. Another big challenge is limited and costly land. Therefore, the ability to provide new parking

facilities is mostly feasible through the legalisation of illegal parking. Limiting private vehicles is the key traffic management measure in this area. Therefore, parking priority should be given to residents, service providers and suppliers. Other parking requirements should be kept limited. Parking demand could be constrained by applying maximum parking requirement to limit parking supply, banning parking on sidewalks in high traffic density streets, restricting parking during peak hours, applying time-limit parking and the highest level of the parking fee.

- **Combine two strategies of limiting parking and shifting parking in developed areas**

In developed areas, parking demand is high whereas land capacity is limited. However, these areas are characterised with wide streets and big sidewalks, hence on-street parking is feasible. An important issue is providing enough spaces for pedestrians. Moreover, there are many private parking spaces located in office buildings and shopping malls. Therefore, parking priority should be offered to residents, service providers. Para-parking might be developed in busy shopping streets to facilitate parking demand of shoppers. Requirements of other demand groups should then be partially covered. A significant parking management strategy is to shift the parking demand out of the core, especially at peak hours. This strategy is suitable for such trips as shopping or private purposes (visiting families and friends, leisure…). To implement, the following measures should be considered: applying maximum parking requirements for an office building or a shopping mall in high-density areas, applying minimum index for other sites; limiting on-street parking at peak hours in streets with high traffic volume, applying high parking fees, or deregulating parking fees at private parking spaces.

- **Effectively utilise current parking facilities, control the parking supply in newly developed areas**

In newly developed areas, parking demand is high at public authorities and office buildings, featuring long parking duration. Therefore, big parking spaces like high-rise parking houses or underground parking spaces should be developed. However, the maximum parking requirements should be applied to schools and universities to encourage students to use public transport. Additionally, parking fees for private parking spaces should be decided by parking operators in order to balance the supply and demand.

The proposed parking management strategies are expected to achieve the overall goal of traffic management in Hanoi. They include limiting motorisation, promoting public transport development, and attaining the long-term development of urban transport system. Through the application of effective parking management strategies, other urban transport objectives are potentially achieved.

6.5. Parking management - developing and developed countries

The aim of this discussion is to understand the key differences of parking management between developing and developed countries. That also helps to recognise the importance of above proposal (parking management strategies specific for Asian developing cities) among international parking studies.

Parking management is of importance in urban mobility in many developed countries, both in enhancing accessibility and in competing urban congestion. In modern "mobility management" parking is the largest single management tool (Knoflacher, 2006).

Parking management in such countries is based on the nature of urban transport development and motorisation. Car ownership and use have increased in many developed countries during the past five decades. As an example, Germany is one of the most highly motorised countries in the world. The rate of car ownership roughly doubled in Germany over 20 years (1960-1980), which forced German cities to undertake a range of measures to mitigate the adverse social and environmental impacts of car use (Pucher, 2014). Given the popularity of private cars, public policies have not even attempted to restrict car ownership. Instead, car use has been limited in such areas where it does the most damage like cities. In their efforts to balance the private benefits of car use with its social and environmental costs, German cities have shown that it is possible to maintain overall mobility levels while limiting car use in central areas and residential neighborhoods. The key to German transport policy has made car usage more difficult and expensive by parking policy (Topp, 1993). This measue is also combined with expanding and improving pedestrian, bicycling and public transport alternatives simultaneously with restricting car use.

As a major difference to Asian developing countries, public transport systems in developed countries have been provided with high-quality, well-integrated services, and large subsidies, therefore, have enabled them to offer regular riders. Consequently, such countries give their focus of parking management on developing and expanding park-and-ride facilities. This measure aims to attract those riders living in low-density areas outside of walking distance or convenient bus service from suburban rail, metro or LRT stations. In many German cities, the construction of additional park-and-ride facilities is viewed as crucial to retain those customers moving to the suburbs (Pucher, 2014).

This parking measure is similarly used in Singapore, where the development of public transport enables the expansion of many park and ride facilities (Seik, 1997a). The central objective of Singapore's Park-and-Ride Scheme has been to encourage more motorists to take public transport to work so as to alleviate traffic congestion in the CBD during peak hours. The same situation has been seen in Oxford, United Kingdom. Its bus-based Park-and-Ride Scheme, which has been established since 1974 and presently comprises over 3,000 parking spaces, is estimated to reduce daily radial traffic to its centre by about 10%, and at peak hours by 24% (Mingardo, van Wee, & Rye, 2015).

In order to reduce car ownership and use, parking in many developed cities has become more difficult and much more expensive. In most cities in Germany, for instance, the price of on-street metered parking increases considerably with proximity to the city center (Topp, 1993). The largest cities now charge for car parking in the center, roughly equal to the price of a round trip by bus, tram or metro. Most free, non-metered on-street parking has been eliminated, except for residential areas, where such parking is generally restricted to residents who purchase car decals entitling them to park in their own neighborhood (Mingardo et al., 2015). Moreover, special parking meters have been installed to prevent long-term parking by commuters in residential neighborhoods. In many German cities, the total number of car-parking places has been reduced. Additional parking facilities have been built outside the city

center, thus encouraging drivers to park their cars outside the center and walk or take public transport to the center.

Unlike Asian developing countries, parking management in developed countries have been revised significantly for car restriction and sustainable urban development. Most of developed cities have opened extensive car-free pedestrian zones, traffic-calmed residential areas and a network of bikeways that encourage walking and bicycling, generally complementing public transport use. Car use is restricted and parking supply is limited in cities, which makes car use more challenging in inner city areas.

Parking problems in the city centres in many developed cities, Germany is an example, are less severe. This is mainly beacause of high-quality public transport, less densely populated residents and the strong enforcement of parking regulations. This is a significant difference to Asian developing countries, where parking issues are serious in city centres because of parking shortage and low-quality public transport.

In developed countries, a popular parking problem is to find a cheap parking space in the direct vicinity of the drivers' destinations. The issues are much more severe for other street users: pedestrians are annoyed by cars parked on pavements, cyclists are annoyed by cars parked on cycle lanes, walking is impeded, getting out of the way through the carriageway is dangerous especially for children and elderly people, buses and trams are hindered, loading zones are blocked, and search traffic strains the streets in residential and mixed-use areas (Topp, 1991b).

Short-duration parking spaces are more prefered to be reduced in many developed countries. In his study, Topp (1993) revealed that a short duration parking space for customers and visitors was fivefold occupied compared with a resident's or employee's parking space. That means a fivefold car traffic generation if a parking space was transformed from long duration use by residents or employees to short duration by customers (Topp, 1993). More car traffic during times of day when capacity was not reached by traffic volumes (i.e. 10 am to about 3 pm, the evenings and Sundays) was not tolerable in large cities because of air pollution. Therefore, as Top (1993) recommended, the concept should be extended: more short duration spaces for customers instead of long duration spaces, provided that car traffic in total would not increase. That could be achieved, for instance, if five long-duration spaces for employees were transformed to one short duration space for customers and one long duration for residents and the rest changed into pavement, cycle lane, bus lane or space for a tree.

Following that concept, the Clean Air Programme for the City of Stuttgart prefers the reduction of short duration parking spaces to that of long duration (Pucher, 2014). The parking concept of the City of Frankfurt is based on a drastic reduction of employees' on-street parking and on a moderate parking supply for customers and visitors suited to the service quality of public transport in the area considered (Buehler & Pucher, 2012). Additionally, the fundamental goal of this parking concepts is an effective approach to giving selective preference to the necessary part of motor traffic and to elimitnating the unnecessary. This concept comprehends parking as a control figure of municipal transport policy. The parking supply is considered against current and future land uses, area and modal-split behaviour of people, motorisation and, vice- versa parking supply, is seen to be a major factor of modal choice.

The difference between parking policies in developed countries and those in developing countries substantially also lies in their influence on private parking garage. Normally, parking concepts using the usual instruments of parking management (parking prices in garages, parking meters, parking permits for residents) influence only the public parking volume, that is about one half of the total volume. In developed countries, the second half which is privately used are indirectly included into parking concepts. For instance, no on-street parking is provided for employees, not even for those who are car-bound because of handicaps, professional use of the car, or lacking public transport alternative. Any demand from this group which cannot be refused is to be covered by the employers on privately-used spaces.

The research of Pucher (2014) also indicated that there were close connections between public transport and total parking space amount. Therefore, all considerations should be about the compatibility of traffic within a city clash. Parking management in the public sector should be accompanied by an augmentation of private parking spaces. More and more cities in developed countries, such as Germany, are preparing changes of parking regulations in their regulations on parking requirements. At the moment, parking space limiting ordinances are known from eleven German cities (Pucher, 2014).

In summary, parking management is different between developing and developed countries regarding their objective of employment. Parking management in developed countries is used as a tool of mobility management for retricting car ownership and usage. Promoting park-and-ride system, reducing short-duration parking, and indirectly control private parking facilities are some of their focus. Those differences are mainly because of the disimilarity in urbanisation and motorisation. Specifically, the expansion of urban area is much faster and the population is much denser in developing cities than developed cities. Furthermore, high traffic demand but low investment in public transport system results in the rapid increase of private vehicles ownership and usage in developing countries. Parking mangement strategies developed specificly for developing countries and reflecting their unique context are necessary.

6.6. Summary

Parking management plays an important role in traffic management, especially in urban areas of Asian developing cities where high traffic density, limited land capacity and costly infrastructure investment are prominent features. Effective parking management strategies significantly contribute to solving such issues as rapid development of private vehicles, improper land-use planning, or reduced private investment in transport infrastructure. They are expected to enhance urban traffic system.

The study has proposed several solutions to solve current parking challenges in urban areas of Asian developing cities. The necessity of zones for parking is highlighted and the indicators to divide parking zoning are formed. Parking management strategies are diversified to fit with traffic restricted area, traffic partly restricted area and normal traffic area. Those strategies are based on differentiated characteristics of each zone. Prioritisation of different parking user groups are carefully considered, and then the recommendations for the coverage of requirements of each user groups are proposed for each zone.

The concept of zone-based parking has been deeply investigated. Zone-based parking management strategies are applied for the case of Hanoi. Data analysis from two surveys proves that parking demand as well as parking facility availability is dissimilar in different zones in Hanoi urban area. Unique features of parking condition in core city centre, developed area and newly developed area in Hanoi are withdrawn. Differences in trip purposes, parking durations and parking supply conditions are main reasons for those variations. Parking should be limited in traffic restricted area at core city centre. Two strategies of limiting parking and shifting parking in developed areas should be combined to utilise current parking facilities and control the parking supply in newly developed areas.

In summary, differentiated parking policies are considered through parking zoning to take the most advantage of current existing parking resources. The gap between parking and demand could then be gradually shortened and the strategic objectives of transport planning could be fulfilled, supporting the efficient running of all mechanism in the cities. Zone-based parking management strategies are recommended to city planners and transport developers to apply in Asian developing cities.

7. Conclusions and Recommendations

7.1. Summary of the research results

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

- **Parking challenges in Asian developing countries**

The parking problem has been analysed by examining the urban transport and parking condition, mainly focus on eight Asian developing cities (Bangkok, Guangzhou, Hanoi, Hochiminh, Jakarta, Kuala Lumpur, Manila, and Taipei) where a high level of private vehicle ownership and use is a distinct feature.

The results show that the chaotic parking situation and inappropriate parking management policies are two major challenges in developing countries.

Parking are troublous primarily because of: (1) Rapid motorisation and high dependence on private vehicle usage leading to high parking demand; (2) The dissimilarity in population density, traffic conditions, land uses and prices, parking demand and parking supply in different urban zones; (3) Unique parking behaviours relating to parking duration, parking searching time and walking distance; (4) Frequent occurrence of illegal parking due to the large gap between parking demand and supply and the lack of enforcement; (5) Low investment on parking facilities from central government; and (6) Lack of ITS application in parking information and guidance systems.

Challenges for parking management policies include: (1) Poor alignment between the parking policy and transport policies; (2) The unanswered question of whether parking should be a part of infrastructure system or a service; and (3) Rapid motorisation and its uncertain future development speed.

As a consequence, the principles of parking management have been set up to facilitate parking-related decision making. It has been yielded from data analysis that parking policy should align with the overall transport management policy and the urban development policy to ensure the liveability of the cities; parking policy should be made specific for individual urban zones due to their dissimilar characteristics; mutual effects of parking policies in neighbouring zones should be considered by implementing an area-wide parking management; parking demand should be analysed for specific user groups; qualified demand, which should be satisfied by the parking supply, should be distinguished from the general parking demand; different parking regulations should be used to prioritise specific user demand groups; the amount of parking supply should be controlled to ensure that not any parts of the supply remain unregulated; and illegal parking should be avoided by physical measures and strict enforcement of parking regulations.

- **Parking planning method**

The study has reviewed recent parking planning methods, then identified their advantages and disadvantages. Considering available data and the possibility for survey conducting, the study proposes a comprehensive process for parking planning and parking space management for developing cities. This process contains two major steps including the analysis of the general parking demand and of the qualified demand at both micro and macro level.

To estimate the general parking demand, secondary O-D traffic data of urban area of Hanoi (including 12 districts) are collected then distributed into zones. Then, the mode share coefficient and occupancy rate, which are analysed from off-street parking survey at four different land uses, are applied to estimate the volume of each mode into each zone. Subsequently, the share of trip purpose is used to calculate the volume of mode into different land-use types and parking turnover rate is applied to estimate the number of parking spaces required. In order to verify the method, the observation survey and counting survey at micro level – streets and buildings - are conducted at three typical streets at three zones in Hanoi to estimate parking inventory and analyse parking demand pattern.

To estimate the qualified demand, the regression model is used by conducting Stated Preference survey. A total of 311 people were interviewed to analyse parking behaviour changes under such impacts as the parking fees, the accessibility to public transport, covering different parking areas (office buildings, shopping malls, residences, etc.), and with different parking user groups (bicycle, motorcycle, and car).

- **Mobility-oriented parking management measures**

Measures for parking management in the urban area are consolidated based on the experience and research from developed countries. They are categorised into two major groups, including demand-oriented parking management measures and supply-oriented parking management measures.

Demand-oriented measures include proposed solutions to avoid parking demand, to shift parking demand, and to control parking demand. Each measure group is divided into leading measures and supporting measures. In order to reduce parking demand, restrictive parking measures, such as time restriction and location restriction, are playing the key rules. In the meantime, parking pricing and park and ride system are highly recommended to shift the parking demand. Parking information and guidance system is of central importance in controlling parking demand.

Supply-oriented measures are categorised into three major sub-groups including measures to improve existing parking capacity, measures to increase parking supply, and measures to manage parking supply. Aiming at improving existing parking capacity, increasing the number of spaces in existing parking facilities and using car stackers and mechanical garages are seen as leading measures. In order to increase parking supply, minimum parking requirements play as the key measure to accommodate growth in parking demand. Parking supply is better managed through improving enforcement and using flexible parking requirements.

Major attributes and application conditions of these measures are analysed to shed light on their advantageous and disadvantageous aspects. The parking management measures recommended for Asian developing cities include spatial, time, and fee relating ones.

- **New concept of para-parking**

Although many parking management measures have been applied, the gap between demand and supply is still large. The on-street parking survey in 30 streets in 3 zones in Hanoi urban area revealed that illegal parking occurred regularly (at more than 80% of survey streets). The interview survey with 360 people provided with an explanation. The shortage of parking

supply, the preference of short walking distance (less than 5 minutes walking), less parking searching time and poor police enforcement are main reasons for illegal parking. In order to reduce the parking supply and demand gap and better control the illegal parking situation, a new concept of para-parking is introduced.

The term "para-parking" is partly derived from "para-transit" to describe certain types of parking services which do not quite fit into the conception of "parking". Para-parking means to utilise a place "similar" to a parking lot by improving a private area to become a semi-private parking lot by the legalisation of illegal parking.

Through reviewing previous studies, the current situation and trend of urban transport development in developing cities are identified and the role of parking management is investigated. Empirical surveys are conducted to examine the parking conditions, parking user's behaviour and the consequences of illegal parking spaces in Vietnam. Then, the requirements of para-parking are formulated including the change process that involves parking authorities, parking operators, and parking users. An in-depth analysis is carried out to look at opportunities, risks, and forms of para-parking. Finally, a proposal for economic impact assessment of parking facility investment is given. The important question of "how and to what extent illegal parking should be legalised" is answered, giving the benefits to parking users, urban planning, and transport planning.

- **Zone-based parking management strategies**

Differentiated parking policies should be considered through parking zoning in order for parking resources to be efficiently shared and utilised. Parking zoning is expected to balance the parking supply and demand in different regions, and thereby helps to realise the strategic objectives of transport. Normal and efficient running of all mechanisms in the city is then supported.

The concept of mobility zoning originally covers the indicators to divide zones including traffic demand, public transport network, type and function of land use and land price, road network and road capacity.

Based on the characteristics of each zone, parking management strategies are diversified in accordance with traffic restricted areas, traffic partly restricted areas and normal traffic areas. Prioritisation of different parking user groups are carefully considered, and then the recommendations for each user groups are proposed for each zone.

- **Application of zone-based parking management in Hanoi**

The results from two surveys on parking condition at 30 streets in three zones and interviews with 360 people on parking users' behaviour in Hanoi have revealed that the parking demand and the parking facility availability are dissimilar in different zones in Hanoi urban area. Main indicators have been investigated including traffic volume, parking demand, parking duration, trip purpose and the willingness to walk and willingness to pay of parking users. Furthermore, the availability of parking facilities is also different in three zones. Therefore, it is not feasible to apply one parking management scheme for all areas. Such scheme could result in ineffective deployment of parking facilities and insufficient traffic management.

Limit the parking in traffic restricted area at core city centre

Parking demand in the core city centre is extremely high due to high traffic volume. Land is limited and costly, making it a challenge to increase the parking supply. Limiting private vehicles is the key traffic management measure in this area. Therefore, complete coverage of requirements of residents, service providers and suppliers, and the coverage of other parking requirements should be limited. The strategic parking management in this area should be limiting parking demand through the following measures: applying maximum parking requirements to limit parking supply, banning parking on sidewalks in high traffic density streets, apllying parking restrictions during peak hours, time-limit parking, and the highest level of the parking fee.

Combine two strategies of limiting parking and shifting parking in developed areas

Developed areas are featured with high parking demand and limited land capacity. However, there are also wide streets and big sidewalks in these areas. On-street parking is feasible to better utilise free spaces. An important issue is providing enough spaces for pedestrians. Moreover, there are many private parking spaces located in office buildings and shopping malls. Therefore, the prioritisation of different parking user groups should be complete coverage of requirements of residents, service providers and suppliers, partially coverage of requirements of other demand groups. A significant parking management strategy is to shift the parking demand out of the core, especially at peak hours. This strategy is suitable for shopping or private purpose trips. The following measures should be considered: applying maximum parking requirements for an office building and shopping mall in high-density areas (others can apply minimum index), restricting on-street parking at peak hours in streets with high traffic volume, applying a high level of parking fee, and deregulating parking fee at private parking spaces.

Utilise current parking facilities, control the parking supply in newly developed areas

In newly developed areas, the parking demand is high at public authorities and office building and is characterised with long parking duration. Therefore, big parking spaces such as high-rise parking houses or underground parking spaces should be developed. However, maximum parking requirements should be applied to schools and universities to encourage students to use public transport. Fees of private parking spaces should be decided by parking operators in order to balance the supply and demand.

7.2. Extended application of research outcomes to worldwide developing countries

Urban transport developments in developing countries have generally followed a similar path (Gwilliam, 2003). Shared trends include: (a) dynamic urban development processes, being led mostly by the private sector with high construction levels; (b) extensive urban sprawl, including peri-urban slums or decaying large housing estates and middle and upper class suburbanization; (c) increasing social segregation (e.g., gated communities for the rich and the middle classes); (d) rapid growth of motorisation; (e) inadequate and insufficient public transport systems; (f) chaotic traffic patterns with high car and motorcycle use and high environmental pollution levels; (g) poor infrastructure for pedestrians and cyclists; and (h) informality, inefficiency, and/or corruption in the formal planning system (Stead & Pojani, 2017).

In some ways, these trends are similar to those experienced earlier in “developed” countries. For example, mobility has greatly increased but cities have sprawled so much that accessibility has fallen for much of the population, especially the poor and the most vulnerable portions. Similarly, growth speed (through motorisation) has been offset by the scatter of the population and increased travel times and distances. Congestion is an obvious corollary of excessive travel demand relative to travel supply. Excessive travel does not only result in congested roads; it also leads to excessive emissions, increased traffic accidents, and increased energy use (Igwe, 2006).

These problems are magnified in developing countries due to the large size of cities and the frequent lack of resources. Many developing cities have experienced transformations towards increasing automobile dependence. Unpleasant conditions for pedestrians, high levels of pollution, treacherous road crossings, unsafe conditions for pedestrians and cyclists, inadequate public transport, and incessant traffic jams are popular (Hidalgo & Huizenga, 2013; Lohani, 2005).

Some public transport projects have yielded major socioeconomic benefits, reducing travel costs and times, accidents, and emissions. However, key challenges remain, including the competition between paratransit and motorcycles with formal public transport and the financial solvency of public transport operators (Hanaoka, 2013; Meszler, 2007; World Bank, 2011).

Many developing countries are struggling with sprawling and motorising megacities. There is an exponential increase in the number of cars on the roads and also large numbers of motorcycles, especially in Asia and Latin America (e.g., Brazil, China, Colombia, India, Indonesia, and Vietnam) (Stead & Pojani, 2017). Current motorisation rates surpass both the population growth rate and the urbanisation rate in some countries. The infrastructure is increasingly unable to cope with the huge growth in the traffic volume.

In terms of traffic flow, vehicle speeds and efficiency have decreased in almost all cities. Istanbul, Mexico City, Rio de Janeiro, and Moscow are now among the most congested cities in the world (Stead & Pojani, 2017). Moreover, parking continues to be free of charge in many urban areas, leading to a severe shortage of spaces, both on and off-street, and producing antisocial behavior such as parking on sidewalks or in green spaces.

Consequently, demand for parking space in urban areas is high. In many developing cities, for istance Tehran, Sao Paulo, Bogota, New Delhi, Mexico City, parking shortage has also become acute, especially in city centers, where jobs and activities are concentrated (Stead & Pojani, 2017). Most parking takes the form of open-air and low quality lots which are either free or cheap. Multistory garages are uncommon. For new residential development, planning regulations mandate a minimum of one parking space per unit. Usually, this rule does not apply to commercial, office, and industrial buildings, where the number of daily visitors is high. Consequently, commercial business districts (CBDs) are crowded with drivers searching for parking spaces or parked illegally in sidewalks and building entrances.

Those similar trends in urban transport development and parking challenges in worldwide developing countries call for effective solutions for parking planning, parking management, and illegal parking reduction. Therefore, the extended application of this research outcomes to those countries are promissing.

Firstly, the principles of parking management have been set as the fundamental for the decision on parking-related issues. As it is clearly stated in this study, that parking policy should align with overall transport policies and should specific for different urban zones, the mutual effects of parking policies in neighbouring zones should be considered through area-wide parking management, parking demand should be analysed for specific user groups, the qualified demand should be distinguished from the general parking demand, different parking regulations should be used to prioritise specific user groups, the amount of parking supply should be controlled to ensure that not any components of the supply are unregulated, and illegal parking should be reduced by physical measures and strong enforcement of parking regulations.

Similar to many Asian developing cities, a report of the World Bank (2013) stated that most Russian cities have not yet applied the concept of parking demand management in their transport strategies. Private car drivers are important constituents, and therefore local authorities are committed to accommodating their demands. Similarly to the addition of road capacity to increase vehicular throughput, municipalities regularly resort to providing more parking when faced with a mismatch between space supply and demand. The phenomenon is usually characterised as "shortage of parking supply" rather than "excess of parking demand" (World Bank, 2013).

Mexico city, Sao Paulo, Moscow and St. Petersburg have recently introduced parking charges and stricter enforcement (Ken Gwilliam, 2015; World Bank, 2015). These measures were introduced partly because those cities simply ran out of free parking spaces, especially in expensive central locations. They are also due to a changing attitude of both public officials and citizens, who are beginning to understand that parking demand management is a necessary urban transport policy tool.

It is clearly stated that comprehensive parking plans need to become part of strategic transport plans. Parking plans must include consideration of issues such as parking standards in new developments, management strategies of existing parking areas, appropriate fees for on-street and off-street, and enforcement measures. Furthermore, the merits of IT technologies in parking management go beyond the convenience in collecting fees. They enable experimentation to understand car users' willingness to pay for parking in order to inform policy.

Secondly, parking planning method has been proposed to accommodate the local traffic context of developing countries. The principle approaches of parking planning for developing cities are that the arrangement, dimensioning and development of parking space is compatible with urban development. It means that parking planning concept should be part of the urban and traffic development plans and transport planning. More attention should be paid to traffic and other urban aspects. Therefore, the zone-based parking planning concept has been introduced. The mobility characteristics, transport infrastructure, and land use function of different zones have comprehensively been analysed.

The proposed parking planning especially focuses on the available data to define the objectives and assumptions of an urban development, type and volume of transport mode, the ability to conduct observation and counting survey, and an extensive analysis of mobility behaviour.

In developing cities, rapid motorisation has made the traffic demand forecast quickly become obsolete. Two-step planning helps to overcome this difficulty. The parking analysis at macro-level mostly utilises O-D traffic within city zones to estimate the urban transport demand, type, and volume of transport mode. Then, the parking analysis at micro level helps to verify the planning by analysing parking demand, parking behaviour, and parking characteristics at typical streets and land use types.

Parking planning has a significant role to create a balance of interests between the claims of various demand groups. They include residents, employees, apprentices, students and pupils, customers, visitors and guests, service providers and suppliers. Parking space provision could affect the choice of destination and means of transport, the quality of the traffic flow and even the individual use of surface areas. The differerences between general parking demand and "qualified demand", therefore, have been made clear in parking planning. The size of the town is considered. Large cities or high-level centres have a good offer of public transport means. City centre areas and commercial areas near the city centre feature a large variety of use with a broad range of goods and services. Long distances on foot appear reasonable between the parking spaces and the destinations. The significance of the parking space offer for accessibility is to be put into proportion compared with the local public transport quality.

Furthermore, the types of area are cautiously considered since they take into account the various expectations of the demand groups, the various aims of parking planning and the various parking space offers.

Thirdly, a new measure of para-parking has firstly been introduced and seen as a key measure to control illegal parking. Illegal parking is not only a difficult issue in Asian developing cities but also a big challenge in Sao Paulo, Bogota, and Mexico city, where traffic users consume sidewalks for car parking (Hidalgo & Huizenga, 2013). Illegal parking on arterials and collector streets has also become ubiquitous in Russian cities, large and small (Gwilliam, 2003). For example, in St. Petersburg, it is estimated that about 20–50 % of the total road space in the historic core (about 8 km^2) is taken up by parked vehicles during peak hours. Residential parking is also a major issue as many socialist-era residential blocks have been built without parking provisions. Not only do parked vehicles reduce traffic flows, drivers also spend a great deal of time in search of parking spaces (World Bank 2013). Illegal parking constitutes an obstacle to traffic flow in the city center. Parking at, and in proximity of, public transport stops is prohibited but city rule is not effectively enforced and, therefore, often violated (World Bank, 2013).

Para-parking has been introduced to deal with illegal parking problem by legalising it to better manage it. Para-parking could contribute to overcoming deficiencies in parking supply. In any case, illegal parking deteriorates disciplines of citizens and drivers and disentitles transport authorities to control traffic and travel demand.

Solutions should be considered from both long-term and short-term perspectives and specifically for zones with different characteristics regarding population density, traffic demand, and available infrastructure facilities. For a long-term approach, private vehicles should be restricted through adequate traffic demand management measures. Parking management strategies should be used as a major instrument to decrease automobile dependency and to support the shift to public transport. In short-term, while the public

transport system cannot immediately be improved to fully serve the traffic demand, the parking supply enhancement measures might solve the obstacle of illegal parking. Among several supply enhancement measures, the legalisation of illegal parking opportunities (para-parking) could be beneficial for many parties involved: parking space users (having legal parking possibilities), public authorities (having a possibility to finance and control parking facilities), and private entrepreneurs offering private parking space (more chances to earn profits).

Finally, zone-based parking management strategies have been proposed to deal with parking unique challenges in developing countries. To keep up with rapid motorisation, urban road systems in many developing cities expanded radially rather than employing specific measures of traffic demand management (Gwilliam, 2003). In Tehran, local authorities are reluctant to introduce physical measures or pricing mechanisms to restrict car use. Motorists can park cheaply in central locations, or park for free on public sidewalks. In Mexico City, although parking meters have been installed in some central areas, planning regulations stipulate minimum rather than maximum parking provision for both residential and nonresidential land uses, a policy which also reflects continuing support for private car use. Parking continues to be free of charge in many urban areas in Istanbul, Mexico City, Rio de Janeiro, and Moscow, leading a severe shortage of spaces, both on- and off- street, and producing antisocial behavior such as parking on sidewalks or in green spaces (Stead & Pojani, 2017).

Experience in a number of countries, including Iran, Turkey, and South Africa illustrates that road construction may only reduce traffic congestion in the short term (Stead & Pojani, 2017). In the long run, extra capacity has fueled additional travel demand everywhere. In view of this evidence, professionals involved in urban transport policy and parking policy need to embrace the notion that they cannot build their way out of congestion. A turn of attitudes in parking policy is needed too, recognizing that free parking comes at a high cost.

With regard to general trends of urbanisation and motorisation, liveability in developing cities can be seriously threatened if no measures are taken. The study has clearly stated that urban transport demand need to be effectively managed by sufficient transport demand manegement, where parking management strategies should be of central attention. Parking management strategies should be specific to each urban zone, where traffic condition, parking situation and public resources are dissimilar. Parking resources could then be reasonably shared and efficiently utilised; illegal parking could be controlled; and the goal of sustainable mobility could be eventually achieved.

Zone-based parking management strategies are proposed to handle with the unique phenomenon of transport development in developing country context where rapid motorisation and high usage of private vehicles are key features. On the one hand, parking management strategies facilitate the reduction of automobile dependency. On the other hand, they promote the development of environment-friendly public transport and non-motorized transport.

7.3. Significance and limitations of the study

- **Significance of the study**

The unique features of Asian develoing countries regarding parking challenges, traffic situation and travel behaviour have been comprehensively analysed through typical selected cities. Base on that local context, this study has developed the principles of modern parking management strategies with all relevant measures and provided with recommendations on the parking planning methods.

The study has also proposed a new concept of para-parking to solve the problem of illegal parking in developing cities. It has also positioned para-parking as a significant measure of parking management strategies. This concept covers the definition, the pros and cons analysis, and the transition process to successfully legalise illegal parking. A qualitative economic impact assessment is proposed illustrating the applicability of para-parking concept and also positions para-parking measure in parking management strategies in particular and in traffic management strategies in general.

Generally, the framing of zone-based parking management and para-parking concept are expected to enhance the sustainable mobility in urban areas of developing cities. Furthermore, successfully legalising illegal parking also helps develop new parking businesses in an urban area while establishing reasonable pricing schemes and effective regulations.

The results of this study would be useful for transport planners and authorities to formulate effective parking policies to manage urban transport in developing countries.

- **Limitations of the results**

The study has examined parking challenges in Asian developing cities. Secondary data from eight Asian cities are selected for the evaluation process. The results are mostly evaluated by the author's own assessment without computerised tools. The valid data about parking conditions including parking supply and demand and illegal parking data in Asian developing cities are hard to collect. Some findings might be subjective and are limited in the sense that they reflect individual viewpoint and opinions.

The study has reviewed, compared and ranked most important parking management measures, then proposed a list of measures applicable in Asian developing cities. The transport situation, transport development trends, and the unique behaviour of Asian transport users have been cautiously considered. The qualitative assessment has been applied for the selection of measures that lack quantitative evidence.

The study has proposed a new concept of para-parking to solve the problem of illegal parking in developing cities and positioned it as a significant measure of parking management strategies. The impact assessment of para-parking measure is limited to a qualitative economic impact assessment. A full-scale of economic evaluation is hard to be carried out within the scope of a doctoral dissertation. Therefore, further studies are needed to confirm the results of economic impact assessment by quantitative evidence.

7.4. Recommendations for further studies

- **General recommendations**

For the application of parking planning method in other developing cities, mobility-related data should be cautiously considered, particularly in the area of O-D traffic data, vehicle ownership and usage, parking demand pattern, mobility behaviour, the characteristics of land use, and land type. It helps to ensure the quality of analysis at both macro and micro level and facilitate the proper implementation of the planning process.

For the application of parking management strategies, particularly the utilisation of location-based or time-based parking pricing, intelligent appliances are required, such as IoT (Internet of Things) automated parking systems or smart parking control systems. Opportunities for advanced technologies and smart appliances to be more widely applied are confirmed.

For the application of the para-parking concept, special focus should be made on the transition process to successfully legalise illegal parking, particularly a communication instrument for involved parties. The relation between parking management authorities, parking operators, and parking users should be fully investigated. There is an empower-register relation between parking management authorities and parking operators. Parking management authorities empower parking operators to provide parking service including the investment, the parking fee establishment and collection, the provision of the information system. Additionally, there is a service provider-service user relation between parking operators and parking users. Their business relation is maintained through the market.

- **Recommendations for Hanoi**

The following points should be focused for the successful application of parking management strategies in Hanoi:

Firstly, zone-based parking management strategies should be applied specifically to each zone. The mobility-related data have to be properly collected to define mobility zoning, which might be combined or separated from administrative boundaries.

Particularly in the core city centre (Ancient Quarter Area), traffic restricting strategies should be applied in the strictest mode. On-street parking should be abandoned. Location-based and time-based parking fee should be strictly applied. Maximum parking requirements are recommended for office buildings, shopping malls, and public administrative offices. Para-parking could be effectively used in this area with the supplemented parking infrastructure, changing from private land for public usage. With the application of internet-based platforms, parking information and guidance system will provide sufficient parking information for traffic users.

Additionally, in developed and newly developed areas, traffic-partly-restricted strategies should be applied. Specifically, residents, service providers, and suppliers should be firstly prioritised; maximum parking requirements are applied for office buildings and shopping malls in high-density areas; minimum index can be applied in other areas. Other regulations should be implemented, for instance, limiting on-street parking at peak hours in streets with high traffic volume, applying a high level of parking fees, or deregulating parking fees at private parking spaces.

- **Suggestions for further research**

Regarding the development and application of the para-parking concept, further quantitative assessment of economic impacts should be conducted to give a comprehensive understanding of such impacts in a socio-economic approach.

Further study should also be conducted on quantitative assessment of other parking management measures, such as time and location restriction parking measures, impacts in the areas of modal shift, parking location selection, or parking demand.

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List of Abbreviations

CBA	Cost Benefit Analysis
CBD	Central Business District
CMSs	Changeable Message Signs
EAR	Empfehlungen für Anlagen des ruhenden Verkehrs
FGSV	Forschungsgesellschaft für Straßen- und Verkehrswesen
GDP	Gross Domestic Product
HOV	High Occupancy Vehicle
ITE	Institute of Transportation Engineers
ITS	Intelligent Transport Systems
MSMEs	Micro, Small and Medium-sized Enterprises
O-D	Origin-Destination
OECD	Organisation for Economic Co-operation and Development
PGI	Parking Guidance and Information
PPP	Public Private Partnership
SME	Small and Medium Enterprises
SP	Stated Preference
SWOT	Strengths – Weaknesses – Opportunities - Threats
US	United States
VMS	Variable Message Signs

Appendix A. Survey on On-street Parking

A1. Survey Form

ROAD SURVEY FORM

Type of Survey Location	Location Name
Name of the street	
Location of roadsides/ sidewalks	From: To:
Is this road included in the list of 262 streets banned parking?	1. Yes 2. No
Is it a one-way or two-way road?	1. One-way 2. Two-way

I – Physical condition of the streets

Q1. Width of road (m):

1. < 7m
2. 7m -10,5m
3. 10,5m – 14m
4. > 14m

Q2. Width of each sidewalk (m):

1. No sidewalk
2. < 4m
3. 4m – 5m
4. > 5m

II - Roadside parking

Q3. What is parking status of the roadside (based on government regulations)?

1. Do not permit parking
2. Permit parking

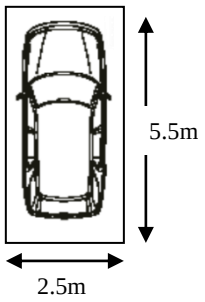
Q4. Do you observe any vehicle parking on the roadside?

1. No
2. Motorcycle parking only
3. Car parking only
4. Both car and motorcycle parking

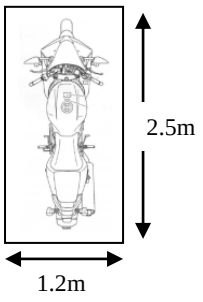
Q5. If this street is permitted for roadside parking, please estimate the total number of vehicles that can park in 500m length (based on the parking dimension of parking space for a car and a motorcycle as below)

1. Number of car: …… (car)
2. Number of motorcycle: …… (MC)

Dimension of parking space for a car



Dimension of parking space for a motorcycle



6. Count the current number of car parking in the roadside (each 500m length and each 30 minutes)
1. Legal car parking: …… (car) 2. Illegal car parking: …… (car)

Q7. Count the current number of motorcycle parking in the roadside (each 500m length and each 30 minutes)
1. Legal motorcycle parking: …… (MC) 2. Illegal motorcycle parking: …… (MC)

Q8. Observations of any other problems:
1. Vehicles cannot move smoothly 2. Prevent the vision of road users
3. Others:
-
-
-

III - Sidewalk parking

Q9. What is parking status of the sidewalk (based on government regulations)?
1. Do not permit parking 2. Permit parking

Q10. Is there any presence of separated line for parking on the sidewalk?
1. Yes 2. No

Q11. Is there any presence of signs that restrict parking or permit parking, the official parking fee?
1. Yes 2. No

Q12. Do you observe any vehicle parking on the sidewalk?
1. No 3. Car parking only
2. Motorcycle parking only 4. Both car and motorcycle parking

Q13. If this street is permitted for sidewalk parking, please estimate the total number of vehicles that can park in 500m length (based on the parking dimension of parking space for a car and a motorcycle as above)
1. Number of car: …… (car) 2. Number of motorcycle: …… (MC)

Q14. Count the number of car parking in the sidewalk (each 500m length and each 30 minutes)
1. Legal car parking: …… (car) 2. Illegal car parking: …… (car)

Q15. Count the number of motorcycle parking in the sidewalk (each 500m length and each 30 minutes)
1. Legal motorcycle parking: …… (MC) 2. Illegal motorcycle parking: …… (MC)

Q16. Observations of any other problems:
1. Pedestrians cannot move smoothly 2. 1,5 meter clearance is not present
3. Others:
-
-
-

A2. Survey Results

Counting number of vehicles parked legally and illegally on the road (both roadside and sidewalk)

1. Old Quarter Area				ROADSIDE				SIDEWALK				TOTAL			
No.	Name	Parking on the roadside is banned	Parking on the sidewalk is banned	Legal car parking	Illegal car parking	Legal MC parking	Illegal MC parking	Legal car parking	Illegal car parking	Legal MC parking	Illegal MC parking	Total car parking	Illegal car parking	Total MC parking	Illegal MC parking
1	Cau Go	x		0	1	0	15	0	0	150	8	1	1	173	23
2	Hang Duong	x		0	1	0	16	0	0	0	38	1	1	54	54
3	Hang Ngang	x		0	2	0	14	0	0	0	29	2	2	43	43
4	Hang Dao	x		0	1	0	22	0	0	0	34	1	1	56	56
5	Luong Van Can	x	x	0	0	0	42	0	0	0	199	0	0	241	241
6	Hang Can	x	x	0	0	0	38	0	0	0	107	0	0	145	145
7	Cha Ca	x	x	0	1	0	35	0	0	0	43	1	1	78	78
8	Tran Nhat Duat	x		28	16	0	10	0	0	54	59	44	16	123	69
9	Phung Hung			40	22	94	25	73	17	156	38	152	39	313	63
10	Hang Bong	x	x	0	4	0	14	0	5	0	223	9	9	237	237

2. Developed Area				ROADSIDE				SIDEWALK				TOTAL			
No	Name	No parking on the roadside	No parking on the sidewalk	Legal car parking	Illegal car parking	Legal MC parking	Illegal MC parking	Legal car parking	Illegal car parking	Legal MC parking	Illegal MC parking	Total car parking	Illegal car parking	Total MC parking	Illegal MC parking
1	Thai Ha	x		0	0	0	1	50	1	56	0	51	1	57	1
2	Chua Boc	x		0	0	0	0	0	0	188	6	0	0	194	6
3	Huynh Thuc Khang	x		0	0	0	0	43	2	95	18	45	2	113	18
4	Giang Vo	x		0	10	0	18	44	3	346	34	57	13	398	52
5	Ton Duc Thang	x	x	0	11	0	59	0	0	0	335	11	11	394	394
6	Xa Dan	x		0	14	0	23	0	9	800	0	23	23	823	23
7	De La Thanh	x		0	0	0	40	0	0	0	356	0	0	396	396
8	Truong Chinh	x		0	9	0	18	0	3	0	488	12	12	506	506
9	Duong Lang	x		0	1	0	21	350	0	0	299	351	1	320	320
10	Hao Nam			0	18	0	45	102	13	336	66	133	31	447	111
11	Hoang Cau	x		0	13	0	19	42	13	817	103	68	26	939	122

3. New Development Area				ROADSIDE				SIDEWALK				TOTAL			
No	Name	No parking on the roadside	No parking on the sidewalk	Legal car parking	Illegal car parking	Legal MC parking	Illegal MC parking	Legal car parking	Illegal car parking	Legal MC parking	Illegal MC parking	Total car parking	Illegal car parking	Total MC parking	Illegal MC parking
1	Cau Giay	x	x	0	5	0	4	0	4	71	3	9	9	78	7
2	Tran Thai Tong			19	0	0	0	7	3	162	2	29	3	164	2
3	Duy Tan			16	1	0	2	16	0	22	0	33	1	24	2
4	Hoang Quoc Viet	x		0	62	0	0	34	8	474	388	104	70	862	388
5	Nguyen Van Huyen			0	102	0	3	72	4	43	16	178	106	62	19
6	Nguyen Khanh Toan	x		0	14	0	0	0	3	153	23	17	17	176	23
7	Tran Duy Hung	x	x	0	18	0	30	0	15	0	301	33	33	331	331
8	Hoang Dao Thuy			147	31	15	22	18	12	358	35	208	43	430	57
9	Nguyen Phong Sac	x		0	5	0	0	2	0	129	14	7	5	143	14

Appendix B. Questionnaires on Illegal Parking Behaviour

INTERVIEW SURVEY FORM

Type of Survey Location	Location Name
Name of the street	
Location of roadsides/ sidewalks	From: To:
Is this road included in the list of 262 streets banned parking?	1. Yes 2. No
Is it a one-way or two-way road?	1. One-way 2. Two-way

I - General information of interviewee

Q1. Gender: 1. Male 2. Female

Q2. Age:

1) ❒ under 18
2) ❒ 18-24
3) ❒ 25-35
4) ❒ 36-50
5) ❒ 51-60
6) ❒ above 60

Q3. Occupation:

1. Office worker/Gov officer
2. Worker
3. Farmer
4. Small business/Self-employed
5. Univ. student
6. Pupil (primary to high school)
7. Seasonal worker
8. Housewife/Retired/Jobless
9. Other ( )

Q4. Trip purpose

1. To home
2. To work
3. Private
4. Shopping
5. Business
6. Others

Q5. Type of vehicle they use for current trip

1. Drive car/Passenger in car
2. Drive motorcycle/ Passenger of motorcycle
3. Drive electric scooter / Passenger of electric scooter
4. Drive electric bicycle / Passenger of electric bicycle
5. Bus
6. Walk

Q6. Frequency of visit to this area? ……..….(times/week)

II - Parking situation (not for bus users)

Q7. Where do you park?

1. On this street
2. On other street
3. Off-street

Q8. Walking distance

1. No significant walking distance
2. 10m – 50m
3. 50m – 100m
4. 100m – 200m
5. 200m – 500m
6. >500m

Q9. How much do you have to pay for parking fee (per hour/per turn)?
1. No parking fee 2. ……. (VND)
❒ Car parking ❒ Motorcycle parking

Q10. Do you know the regulated parking fee?
1. Yes, it is ……(VND) 2. No
Q11. Who pay for the parking fee?
1. I have to pay 2. Company pay
Q12. How long do you search for parking?
1. No searching time 2. …….. (minutes)
Q13. Do they know any other parking space available at this moment nearby?
1. No 2. Yes (on-street) 3. Yes (off-street)
Q14. If there is a parking space nearby, but less convenient, parking fee is cheaper; will you change to this parking location?
1. No 3. Yes (if walking distance 200m-500m)
2. Yes (if walking distance less than 200m) 4. Yes (if walking distance more than 500m)

III - User's opinion of on-roadside or on-sidewalk parking:

Q15. In your opinion, how much do you think about the following items when you decide to park your vehicle on the roadside/sidewalk?

List of items	Very unimportant	Unimportant	Neutral	Important	Very Important
1. Short walking distance to final destination	1	2	3	4	5
2. No parking fee	1	2	3	4	5
3. No searching time for parking	1	2	3	4	5
4. The awareness of illegal parking	1	2	3	4	5

Q16. In your opinion, how much do you think the roadside/sidewalk parking should influence on the following items?

List of items	Very unlikely	Unlikely	Neutral	Likely	Very likely
1. Influence on the convenience of pedestrians, they cannot move smoothly	1	2	3	4	5
2. Influence on the safety and security of pedestrians	1	2	3	4	5
3. Influence on the movement of traffic flow, causing traffic congestion	1	2	3	4	5
4. Influence on the movement of traffic flow, causing more traffic pollution	1	2	3	4	5

Q17. In your opinion, how important would the following measures be to better utilise the roadside/sidewalk parking?

List of items	Very unimportant	Unimportant	Neutral	Important	Very Important
1. The presence of signs that restrict parking or permit parking, and advise the official parking fee	1	2	3	4	5
2. The presence of separated line for parking on the roadside or sidewalk	1	2	3	4	5
3. Restricting illegal parking by effective enforcement	1	2	3	4	5
4. Increasing taxes and fees on motorcycle/car parking to encourage people using alternative modes (public transport)	1	2	3	4	5

Appendix C. Survey on Off-street Parking

C1. Counting Survey Form

PARKING VEHICLES – COUNTING SURVEY

Locations:…….… Name of surveyor: ……....
Time (Morning/Afternoon): …… DD/MM/YYYY: ……..

I. INFORMATION OF SURVEY LOCATION

1. Name of parking lot: 3. Parking area (m^2):

2. Type of parking vehicle (Car/MC/Both): 4. Capacity: Car: MC: Bicycle:

II. PARKING INFORMATION

Motorcycle

Number of motorcycles at the beginning of survey:

Time	Number of MC entrance (MC)	Number of MC exit (MC)	Time	Number of MC entrance (MC)	Number of MC exit (MC)
6:00-7:00			14:00-15:00		
7:00-8:00			15:00-16:00		
8:00-9:00			16:00-17:00		
9:00-10:00			17:00-18:00		
10:00-11:00			18:00-19:00		
11:00-12:00			19:00-20:00		
12:00-13:00			20:00-21:00		
13:00-14:00			21:00-22:00		

Car

Number of cars at the beginning of survey:

Time	Number of cars entrance (car)	Number of cars exit (car)	Time	Number of cars entrance (car)	Number of cars exit (car)
6:00-7:00			14:00-15:00		
7:00-8:00			15:00-16:00		
8:00-9:00			16:00-17:00		
9:00-10:00			17:00-18:00		
10:00-11:00			18:00-19:00		
11:00-12:00			19:00-20:00		
12:00-13:00			20:00-21:00		
13:00-14:00			21:00-22:00		

C2. Parking Duration Survey Form

PARKING DURATION SURVEY 6H-12H																									
No.	Plate Number	Time																							
		6:00 -6:15	6:15-6:30	6:30-6:45	6:45-7:00	7:00-7:15	7:15-7:30	7:30-7:45	7:45-8:00	8:00-8:15	8:15-8:30	8:30-8:45	8:45-9:00	9:00-9:15	9:15-9:30	9:30-9:45	9:45-10:00	10:00-10:15	10:15-10:30	10:30-10:45	10:45-11:00	11:00-11:15	11:15-11:30	11:30-11:45	11:45-12:00
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PARKING DURATION SURVEY 12H-18H

No.	Plate Number	Time																							
		12:00 - 12:15	12:15 - 12:30	12:30 - 12:45	12:45 - 13:00	13:00 - 13:15	13:15 - 13:30	13:30 - 13:45	13:45 - 14:00	14:00 - 14:15	14:15 - 14:30	14:30 - 14:45	14:45 - 15:00	15:00 - 15:15	15:15 - 15:30	15:30 - 15:45	15:45 - 16:00	16:00 - 16:15	16:15 - 16:30	16:30 - 16:45	16:45 - 17:00	17:00 - 17:15	17:15 - 17:30	17:30 - 17:45	17:45 - 18:00
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PARKING DURATION SURVEY 18H-22H

No.	Plate Number	Time																							
		18:00-18:15	18:15-18:30	18:30-18:45	18:45-19:00	19:00-19:15	19:15-19:30	19:30-19:45	19:45-20:00	20:00-20:15	20:15-20:30	20:30-20:45	20:45-21:00	21:00-21:15	21:15-21:30	21:30-21:45	21:45-22:00								
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C3. Survey Results

No.	Information	Location 1		Location 2	Location 3	Location 4	Location 5	Location 6	Location 7
		MIPEC-Commercial	MIPEC-Shopping	FPT - Office Building	CMC - Office Building	N03 Dịch Vọng - Low-income Condo	N02 Dịch Vọng - Low-income Condo	C6 Mỹ Đình - Commercial Condo	C3 Mỹ Đình - Commercial Condo
1	Number of upper-floors	25	25	17	20	17	13	19	19
2	Number of underground-floors (for parking)	2	2	1	2	1	1	1	1
3	Number of floors for office	20	20	15	15	15	12	17	17
4	Number of floors for shopping mall	5	5	-	-	-	-	-	-
5	Construction area per floor (m2)	1,500	1,500	1,500	1,690	3,000	1,200	2,600	1,300
6	Used area per floor (m2)	1,227	1,227	1,227	1,382	2,454	982	2,127	1,063
7	Total construction area (m2)	60,000	60,000	25,500	33,800	51,000	15,600	49,400	24,700
8	Total area for leasing (office/residence)(m2)	49,080	49,080	18,405	20,736	36,810	11,779	36,156	18,078
9	Parking area - underground (m2)	20,000	20,000	4,100	4,300	1,200	850	2,100	1,050
	Capacity	2,600	2,600	1,520	1,650	500	360	730	315
	1. Bicycle	200	200	100	100	-	-	150	75
	2. Motorcycle	1,800	1,800	1,400	1,500	500	350	500	200
	3. Car	600	600	20	50	-	10	80	40

10	Parking area - Outside (m2)	100	100		200	500	-	150	-
	Capacity	380	380	-	30	400	-	20	-
	1. Bicycle	50	50		-	100	-	-	-
	2. Motorcycle	180	180		-	200	-	-	-
	3. Car	150	150		30	100	-	20	-
11	Number of apartment per floor					24	10	16	8
12	Total number of apartment in the building					360	120	272	136
13	Total number of vehicles (Car+Motorcycle+Bicycle)	7,419	5,093	1,578	1,798	3,126	433	761	425
14	Number of vehicle/100m2 construction area	12.37	8.49	6.19	5.32	6.13	2.78	1.54	1.72
15	Number of vehicle/100m2 leasing area	15.12	10.38	8.57	8.67	8.49	3.68	2.10	2.35
16	Number of vehicle/apartment					8.68	3.61	2.80	3.13
17	Number of parking spaces/100m2 construction area	2.81	1.49	5.63	4.84	4.71	2.14	1.18	1.32
18	Number of parking spaces/100m2 leasing area	3.44	1.82	7.79	7.88	6.53	2.83	1.62	1.81
19	Number of parking spaces/apartment					6.68	2.78	2.15	2.40

Appendix D. Questionnaires on Travel Behaviour

TRAVEL BEHAVIOUR INTERVIEW SURVEY

Location:	Name of interviewer:
Name, phone number of interviewee:	DD/MM/YYYY:

I. GENERAL INFORMATION OF INTERVIEWEE

Q1. Gender:
(1) Male (2) Female

Q2. Age:
(1) under 18
(2) 18-24
(3) 25-35
(4) 36-50
(5) 51-60
(6) over 60

Q3. Academic level:
(1) Not attending school
(2) Primary/Secondary
(3) High school
(4) College
(5) University
(6) Master/PhD

Q4. Occupation:
(1) Officer/Gov.officer
(2) Worker
(3) Farmer
(4) Self-employed
(5) Student
(6) Pupil (primary to high school)
(7) Part-time employee
(8) Housewife/Retired/Jobless
(9) Other (_____)

Q5. Personal income:
(1) No income
(2) <3 mil.VND/month
(3) 3~6 mil.VND/month
(4) 6~10 mil.VND/month
(5) 10~20 mil.VND/month
(6) 20~30 mil.VND/month
(7) 30~40 mil.VND/month
(8) 40~50 mil.VND/month
(9) > 50 triệu mil.VND/month

Q6. Household income:
(1) No income
(2) <3 mil.VND/month
(3) 3~6 mil.VND/month
(4) 6~10 mil.VND/month
(5) 10~20 mil.VND/month
(6) 20~30 mil.VND/month
(7) 30~40 mil.VND/month
(8) 40~50 mil.VND/month
(9) > 50 mil.VND/month

Q7. What type of vehicle do you use for current trip?
(1) Bicycle
(2) Motorcycle
(3) Car
(4) Bus. Bus fare: ……(VND)
(5) Other (note):

Q8. Trip purpose
(1) To work
(2) To study
(3) Shopping/Entertainment/Dinning
(4) Other (note):

Q9. Trip length (km): …….(km)

Q10. Trip cost: …….(VND)

Note: The interviewer calculates the trip cost based on those assumptions:
1. Trip by motorcycle, average cost 2.000ND/km.

2. Trip by car, average cost 10.000VND/km.
3. Trip by bus, trip cost is equal to total bus fare.

Q11. Total trip duration (min): …….(min)

Q12. As part of total trip duration, time for parking + walking to destination: …….(min)

Q13. Parking charge:

(1) No parking charge, company paid
(2) No parking charge, as it is included in receipt
(3) No parking charge, as trip by bus/walking
(4) Have to charge. Parking charge: ……..(VND)

II. SCENARIO FOR FUTURE MODE CHOICE (A)

In order to manage the parking system in the city, the authorities will implement some parking policies to limit the usage of private vehicles in the future, for instance, increase the parking fee, and improve the quality of bus service. We would like to have your opinion regarding mode choice under the impact of certain parking policies.

Q14. Increase parking fee. Please select the option that most similar to your idea under the assumptions presented below:

Assumptions	Options
You have to pay for the parking charge (100%) List of parking charge: Motorcycle/Bicycle: 3,000VND/turn; 40,000 VND/month Car: 40,000VND/turn; 1,200,000VND/month	(1) Use current mode (2) Shift to bus (3) Shift to walk (4) Select another destination (if the trip purpose is shopping/entertainment/dinning)
Increase the parking fee to 200%	(1) Use current mode (2) Shift to bus (3) Shift to walk (4) Select another destination (if the trip purpose is shopping/entertainment/dinning)
Increase the parking fee to 300%	(1) Use current mode (2) Shift to bus (3) Shift to walk (4) Select another destination (if the trip purpose is shopping/entertainment/dinning)

Q15. Increase parking fee is combined with the improvement of bus service quality. Please select the option that most similar to your idea under the assumptions presented below:

Parking charge	Bus fare 6,000VND	Options
Parking fee is increased to 300%	Walking from home to bus station 15 min, walking from bus station to destination 15 min. Total walking time **30 min**.	(1) Use current mode (2) Shift to bus (3) Shift to walk (4) Select another destination (if the trip purpose is shopping/entertainment/dinning)
Parking fee is increased to 300%	Walking from home to bus station 10 min, walking from bus station to destination 10 min. Total walking time **20 min**.	(1) Use current mode (2) Shift to bus (3) Shift to walk (4) Select another destination (if the trip purpose is shopping/entertainment/dinning)
Parking fee is increased to 300%	Walking from home to bus station 5 min, walking from bus station to destination 5 min. Total walking time **10 min**.	(1) Use current mode (2) Shift to bus (3) Shift to walk (4) Select another destination (if the trip purpose is shopping/entertainment/dinning)

II. SCENARIO FOR FUTURE MODE CHOICE (B)

In order to manage the parking system in the city, the authorities will implement some parking policies to limit the usage of private vehicles in the future, for instance, increase the parking fee, and improve the quality of bus service. We would like to have your opinion regarding mode choice under the impact of certain parking policies.

Q14. Increase parking fee. Please select the option that most similar to your idea under the assumptions presented below:

Assumptions	Options
You have to pay for the parking charge (100%) List of parking charge: Motorcycle/Bicycle: 3,000VND/turn; 40,000 VND/month Car: 40,000VND/turn; 1,200,000VND/month	(1) Use current mode (2) Shift to bus (3) Shift to walk (4) Select another destination (if the trip purpose is shopping/entertainment/dinning)

Increase the parking fee to 200%	(1) Use current mode (2) Shift to bus (3) Shift to walk (4) Select another destination (if the trip purpose is shopping/entertainment/dinning)
Increase the parking fee to 300%	(1) Use current mode (2) Shift to bus (3) Shift to walk (4) Select another destination (if the trip purpose is shopping/entertainment/dinning)

Q15. Increase parking fee is combined with the improvement of bus service quality. Please select the option that most similar to your idea under the assumptions presented below:

Parking charge	Bus fare 6,000VND	Options
Parking fee is increased to 200%	Walking from home to bus station 15 min, walking from bus station to destination 15 min. Total walking time **30 min**.	(1) Use current mode (2) Shift to bus (3) Shift to walk (4) Select another destination (if the trip purpose is shopping/entertainment/dinning)
Parking fee is increased to 200%	Walking from home to bus station 10 min, walking from bus station to destination 10 min. Total walking time **20 min**.	(1) Use current mode (2) Shift to bus (3) Shift to walk (4) Select another destination (if the trip purpose is shopping/entertainment/dinning)
Parking fee is increased to 200%	Walking from home to bus station 5 min, walking from bus station to destination 5 min. Total walking time **10 min**.	(1) Use current mode (2) Shift to bus (3) Shift to walk (4) Select another destination (if the trip purpose is shopping/entertainment/dinning)

THANK YOU VERY MUCH FOR YOUR COOPERATION!