TRANSIT-ORIENTED DEVELOPMENT ZONING INTENSIFICATION ASSESSMENT IN MALAYSIA: CASE OF KUALA LUMPUR MONORAIL

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Specially dedicated to my beloved father and mother, my dearest uncles and aunts
Your patience, sacrifice, and encouragement…
For making this day a reality.

To my supervisor
My friends and colleagues
Because of you, I grow stronger and tougher…
Will continue to challenge the uncertainty life of urban planning professions
Bravery and fearlessly.

To my Dharma master and venerable
Your kindness, love, and friendliness in Buddhist teaching…
Enlighten my life
Cultivating good values and not to do any evil.

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ABSTRACT

To promote greater urban sustainability, transit-oriented development (TOD) has been widely promoted as an urban policy in Malaysia. By recognising density as an important factor for TOD promotion, major Malaysian cities such as Kuala Lumpur has begun to incorporate such idea into its statutory zoning plan where the land parcels around the transit station are being intensify by allowing the market to deliver higher density development. However, how dense should it be? Many research has been largely focused on the minimal density or transit supportive density for cost-effective transit investment. Despite the fact that minimal density is essential for the economic feasibility of the transit investment particularly for TOD promotion in the low density suburban or new greenfield development setting, it may not sufficient to encourage most of the people to use transit. To address this concern, this research is aimed to examine the extent to what level of zoning intensification is appropriately dense for TOD using Kuala Lumpur monorail as a case study. Here, the study analyses a series of Kuala Lumpur monorail zoning intensification scenarios with the monorail capacity to identify the level of zoning intensification that could promote TOD significantly. The zoning intensification scenarios include the present early zoning intensification plan proposed by the draft Kuala Lumpur City Plan 2020 as well as the upzoning scenarios where this study suggest for transfer of development rights to address the weakness of the existing early zoning plan to restraint the future growth on the geographic space of weak transit influence. From the predicted potential monorail ridership results of Kuala Lumpur monorail zoning intensification scenarios, this study found that 60% upzoning is the preferable zoning intensification scenario for TOD promotion as the result show that it could fully capitalise the monorail capacity at various expected transit using rate by promoting most of the future growth to take transit. Drawing from the case study of Kuala Lumpur monorail, this research learned that an appropriate TOD station area density must strike a balance to benefit most of the future population and employment to take transit while compromise with the given transit capacity to ensure a fine quality of transit service for the community. It is hoped that the basic notion of this idea remains relevant to other Malaysian cities for TOD promotion in various context of the city that supported by diverse type of public transit services.

TABLE OF CONTENTS

LIST OF TABLES

Table **Page**

LIST OF FIGURES

Table **Page**

LIST OF ABBREVIATIONS

BRT	Bus Rail Transit
EPU	Economic Planning Unit
FAR	Floor Area Ratio
GDP	Gross Domestic Product
GIS	Geographic Information System
GHG	Greenhouse Gas
IRDA	Iskandar Regional Development Authority
ITDP	Institute for Transportation and Development Policy
JPBD	*Jabatan Perancangan Bandar dan Desa*
	(Federal Department of Town and Country Planning)
LRT	Light Rail Transit
SPAD	*Suruhanjaya Pengangkutan Awam Darat*
	(Land Public Transport Agency)
TOD	Transit-Oriented Development

CHAPTER 1

INTRODUCTION

1.1 Research Background

Cities in Malaysia are generally automobile focused. This phenomenon is reflected in the travel behaviour of the society itself. The nation has a very high proportion of private vehicle owning households (78%) (Khazanah Research Institute, 2014) and private vehicle ownership is at an alarming level with about 30 personal vehicles per 100 inhabitants, which is among the highest rates in the world (Gil Sander et al., 2015). The share of commuters taking public transportation in Kuala Lumpur, the national capital of Malaysia was merely documented at 16% (SPAD, 2013a), well below peer Asian cities such as Taipei, Singapore, Shanghai, Seoul, and Tokyo (Figure 1.1). Partly, an underlying driver for the high dependency on private vehicle is the inefficient horizontal spatial expansion of urbanisation in Malaysia. The physical form of the three largest cities of Malaysia (Kuala Lumpur, Johor Bahru, and Penang) is consistently one of dispersing and reduced density (Abdullah et al., 2009). Malaysia's largest urban areas, Greater Kuala Lumpur region has grown rapidly in built-up areas than the population in the past two decades, with resultant emergence of urban sprawl and declining density (Figure 1.2). Consequently, this has resulted in various serious economic and environmental threats to Malaysia. For the case of Kuala Lumpur, the World Bank reported that the cost of traffic congestion during the morning peak hours is equally to the income losses of USD$ 3.0-5.5 billion annually or 1.0-1.8% of Malaysia's gross domestic product (GDP) (Gil Sander et al., 2015). Additionally, the

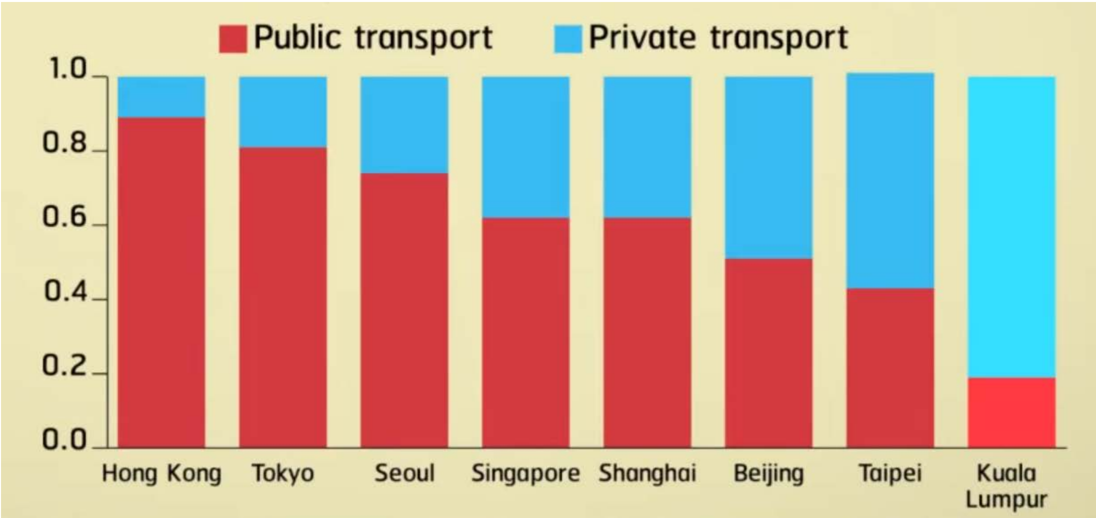
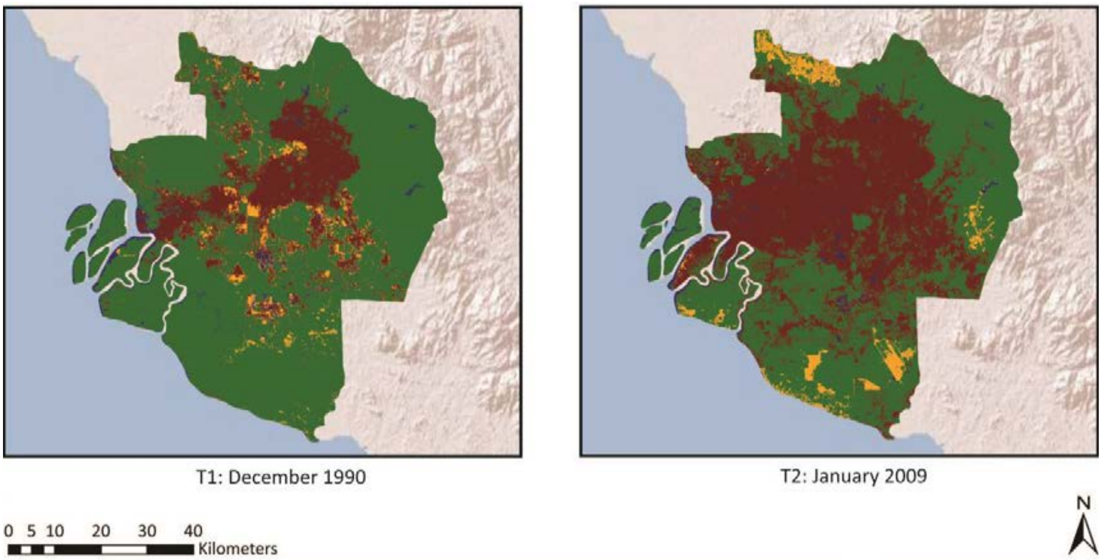


Figure 1.1: The position of Kuala Lumpur public transport modal shares in Asian cities, 2011. (Source: Gil Sander et al., 2015)



Measure	T_1	T_2	Annual Change (%) T_1-T_2
Population	3,079,200	5,969,300	3.55
Vegetated Area (sq km)	3245.24	2404.49	-1.36
Urban Area (sq km)	621.01	1555.23	7.92
Population Density	4,958	3,838	-1.34

Figure 1.2: The growth of built-up area of Greater Kuala Lumpur exceeded population growth. (Source: Gil Sander et al., 2015)

greenhouse gases (GHG) emissions generated from the transportation sector of Kuala Lumpur is found to be the second largest sector after building sector, representing 37% of the total GHG emissions profile of Kuala Lumpur (Kuala Lumpur City Hall, 2018).

The issue confronting the urban development as expressed above does not limit in Malaysia, similarly to many other cities across the world (Newman and Kenworthy, 2015). To address this challenge, built environment experts and scholars are often emphasis and suggest for transit-oriented development (TOD). TOD is an urban planning and design concept associated with the principle of New Urbanism or Smart Growth that calls for the urban growth to primarily concentrate around transit station (Figure 1.3) (Newman and Kenworthy, 1999; Carlton, 2007). At the local level, TOD stress for the high quality compact built form around the transit station area district to accommodate fairly dense population and employment (Figure 1.4) (Calthorpe Associates, 2012; Santasieri, 2014; Duany Plater-Zyberk & Co., 2014). It is believing that by encouraging more people to live and work within the geography advantage of close proximity to transit stations, more people are expected to travel using foot and transit for their daily destinations in comparison to their personal vehicle. In fact, various studies have proven that households from TOD are found to be low level of amount in private vehicle ownership (Zegras, 2010), fewer vehicle trip (Cervero and Arrington, 2008; Zamir et al.,2014; Ewing et al., 2016) and reduced vehicle-miles travelled (Zegras and Hannan, 2012). As a result, it helps cities to reduce private vehicle dependency and solve traffic congestion issues as well generate various environmental, economic and social benefits for better urban sustainability (Reconnecting America and the Centre for Transit-Oriented Development, 2007).

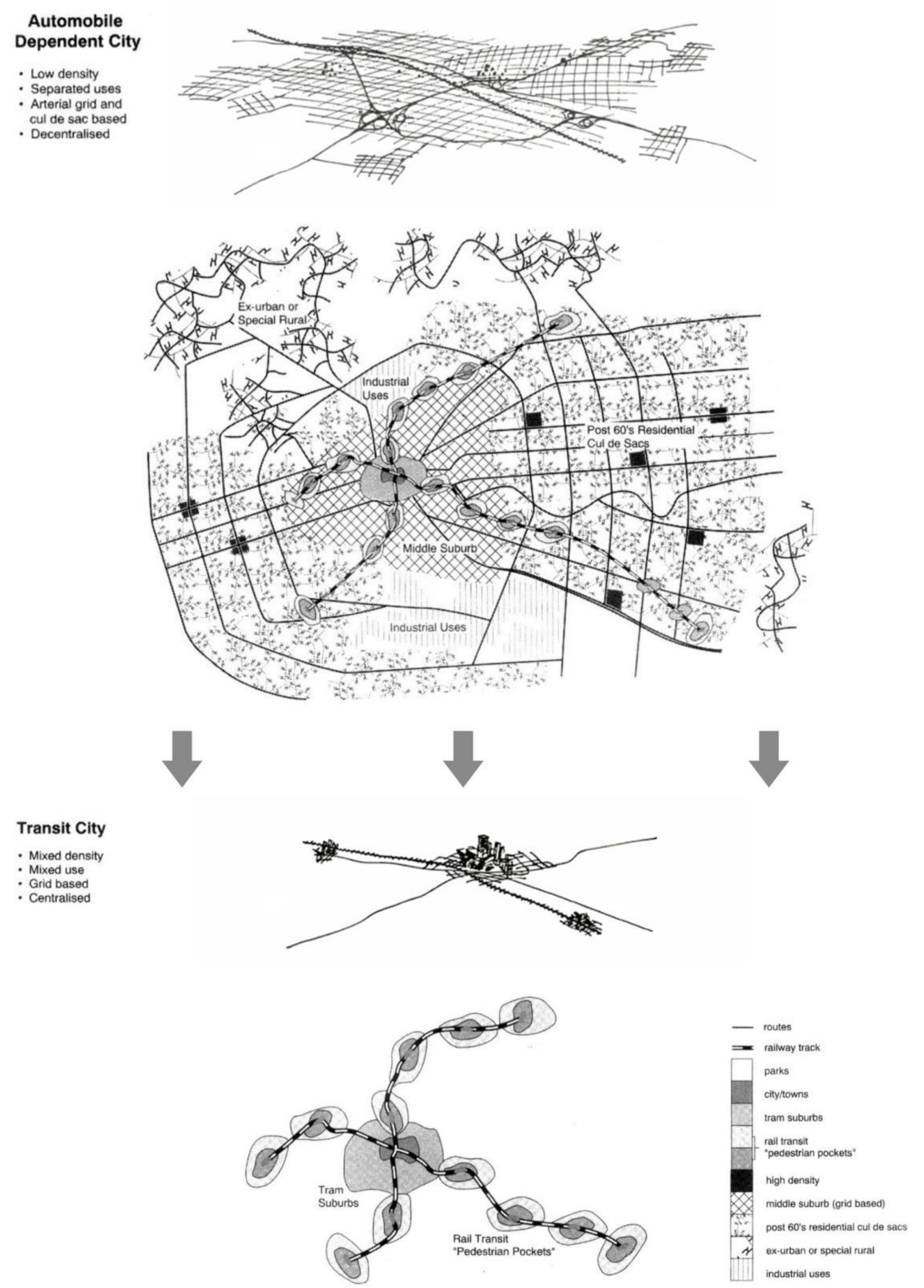


Figure 1.3: A visualisation of a regional TOD approach to structure low density automobile dependent city into high density transit oriented city. (Source: Adopted from Newman and Kenworthy, 1999; Roseland,1998)

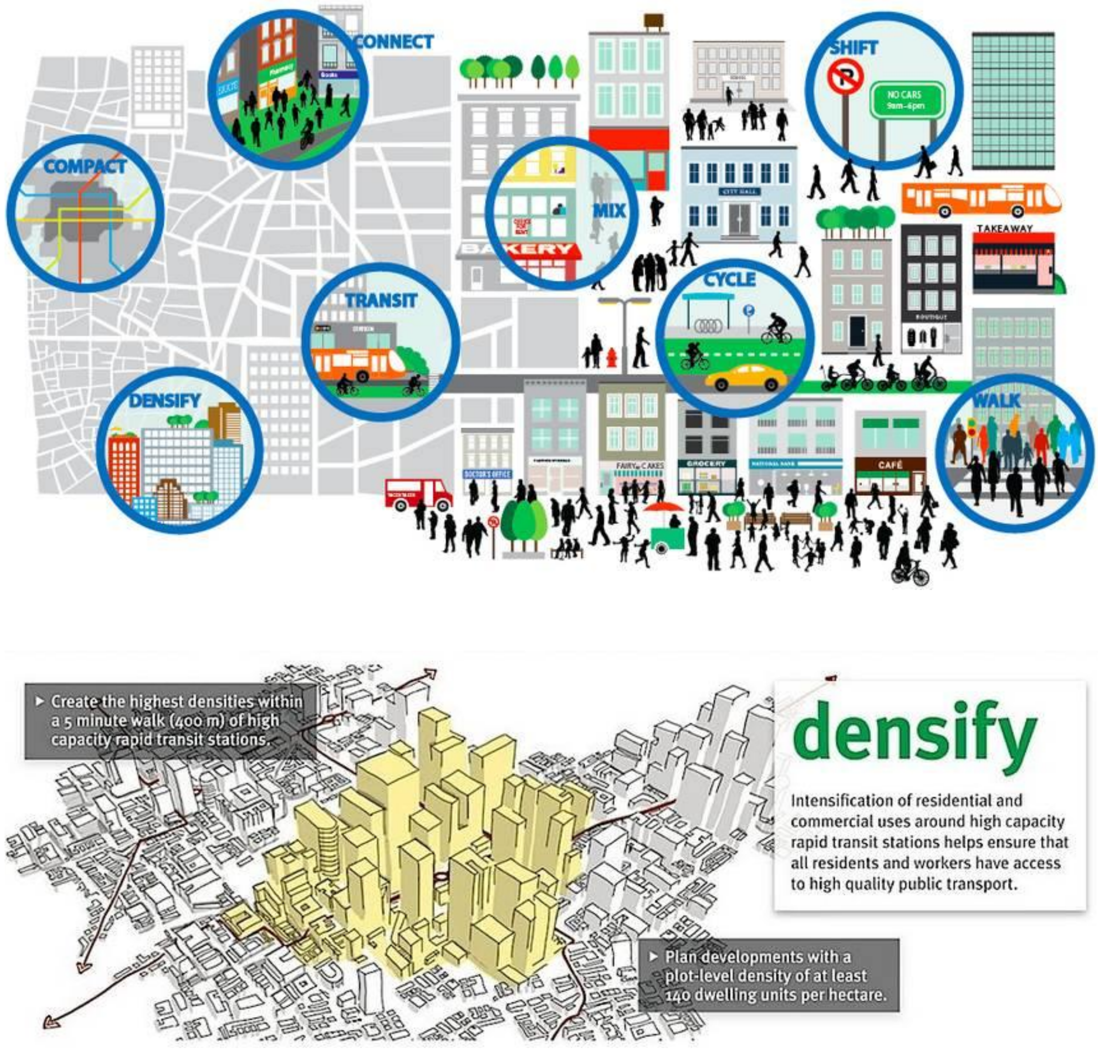


Figure 1.4: Density is one of the core principles of TOD. (Source: ITDP, 2014)

Additionally, the increase of the people anticipated from the TOD to take transit also contributes in generating ridership demand and resources that make frequent, dependable, and efficient transit possible through increased the fare box revenue streams and efficient public funding (Guerra and Cervero, 2011). With the provision of the high quality and efficient transit service, this would further invite more people to take transit and reduced private vehicle dependency.

As a response to the issues of high dependency on private vehicle and urban sprawl for sustainable urban development, TOD has gained attention in Malaysia too. The efforts of promoting TOD into the cities of Malaysia can be observed in the principal nationwide urban policies at national level by the Federal Department of Town and Country Planning (JPBD) (currently known as PLANMalaysia) [i.e. National Physical Plan (JPBD, 2005) and National Urbanisation Policy (JPBD, 2006)]. Due to the TOD concept is relatively new, the progression of TOD adoption among the Malaysian cities remain slow. At present, a major city such as Johor Bahru has indicated their interest to incorporate TOD into their city level policy (Khazanah Nasional, 2006). Meanwhile, Kuala Lumpur, the national capital city of Malaysia, has begun to take their strong early action to integrate TOD with their city plan and further translated it into zoning plan in regulating their urban development to embrace TOD (Kuala Lumpur City Hall, 2013). Additionally, the central government is also paying strong attention and commitment to reform the mass urban public transportation system aiming in Malaysia to achieve a 40% target model share for public transport in the urban areas by 2030 (SPAD, 2013b). A huge amount of national budget has been prioritised and allocated to develop the mass urban public transportation infrastructure in the major cities of Malaysia (EPU 2010; 2015). Specifically, Greater Kuala Lumpur, a metropolitan consist of Kuala Lumpur and its adjacent cities, is currently building new mass rapid transit, light rail transit (LRT), monorail and bus rapid transit (BRT) which expected to be completed within the coming 20 years (SPAD, 2013a). In the meantime, Johor Bahru in Southern Peninsular Malaysia also ambitions to implement BRT and a rapid transit system with Singapore (IRDA, 2014). Up in Northern Peninsular Malaysia, Penang also plans to put in place integrated LRT, monorail, BRT and tram networks (Penang State Government, 2016).

The physical public transportation infrastructure development offers good opportunities for the realisation of TOD in these major cities. The location theory of the modern urban economic model predicts that the transit stations from the transit infrastructure would improve the accessibility of the surrounding environment, leading to higher land values, stimulate real estate activity as well as attracting higher density development around transit station (Alonso, 1964; Isard, 1965; Mills, 1967; Muth, 1969). This implies that with the introduction of transit infrastructure system could facilitate TOD, as the theory suggest that the intense urban development pattern of the city by natural forces of the market would self-organised around transit stations. However, many studies found that claiming on the transit infrastructure as a tool to induce the TOD urban form is a faulty strategy. Schueltz et al. (2018) investigate the implication of zoning for TOD in the Los Angeles Metropolitan have found that the growth of the station area is affected by zoning regulation. They reveal that even with the strong market demand, the development of the station area may constraint with restriction by the conventional auto-oriented low density zoning regulation. The finding is compliment with researchers who seek to investigate on the developers' perception of TOD (Levine and Inam, 2004; Guthrie and Fan; 2016). They have found that the motivation of the developers to build dense and compact real estate projects are often hindered by the conventional low density zoning regulation. In addition, the numerous results from the research studies of the examination on the effect of transit on land use have suggested that transit investment has not to lead to reliable patterns of increased density and call for the planning intervention on harmonising zoning regulation to support TOD is necessary (Loukaito-Sideris and Banarjee, 2000; Pacheco-Raguz, 2010; Hurst and West, 2014; Lee and Sener, 2017; King and Fischer, 2018). Therefore, these studies informed us that to implement TOD is far beyond than a simple provision of transit infrastructure and technology solely itself. More essentially, it is important to consider transportation and land use integration approach. Furthermore, to encourage TOD, the existing conventional low-density zoning around the station area is needed to be improvised and intensified into a higher density zoning to allow dense development to take place.

Zoning is an urban planning instrument for the city government to regulate the urban development to meet the desired goals and the public good (World Bank, 2014; Amirtahmasebi et al., 2016; Salat and Olivier, 2017). It establishes a framework includes a set of specifications regarding form, intensity, and activity on each individual land parcel within the city. The development permission can be only granted if the given proposal is a complement to the zoning regulation. Historically, the conventional zoning regulation was a reaction to the severe threats which overcrowding posed to public well-being in the 19th century where the Industrial Revolution begin in major cities of most western countries such as London, Paris, Berlin and New York (Hirt, 2012; Hall, 2014) (Figure 1.5). The conventional zoning regulation was designed to decentralise the urban growth and promote low density development with the positive purpose of improving amenities as well as minimising health and safety hazard. The conventional zoning is a widely planning practice around the world includes Malaysia and the exercise remains till present as the contemporary urban planning see the private vehicle as a liberating force to be accommodated in cities (Rudlin and Falk, 2009). As such, zoning practice in Malaysia can be clearly observed from the growing trend of low density suburban expansion along the primary highways that are automobile oriented (Figure 1.6). The conventional low density zoning is part of the root cause for the pressing issues of unhealthy urban sprawl and high dependent on private vehicle. Often, it received attacks and criticises by numerous experts as an irrelevant approach for the cities in modern age today (Jacobs, 1992; Calthorpe; 1993; Newman and Kenworthy; 1999). Specifically, in the context of TOD, the current conventional low density zoning regulation is not capable of guiding new development towards the creation of compact and higher density built environment, as it does not permit so. As stated earlier, in order to enable TOD, the conventional low density zoning around the station area is needed to be review into be high density zoning.

Figure 1.5: The early zoning regulation was initiated to address the overcrowding issues of rapid urbanisation in major western cities during the Industrial Revolution in the 19th century. (Source: van der Werf et al., 2016)

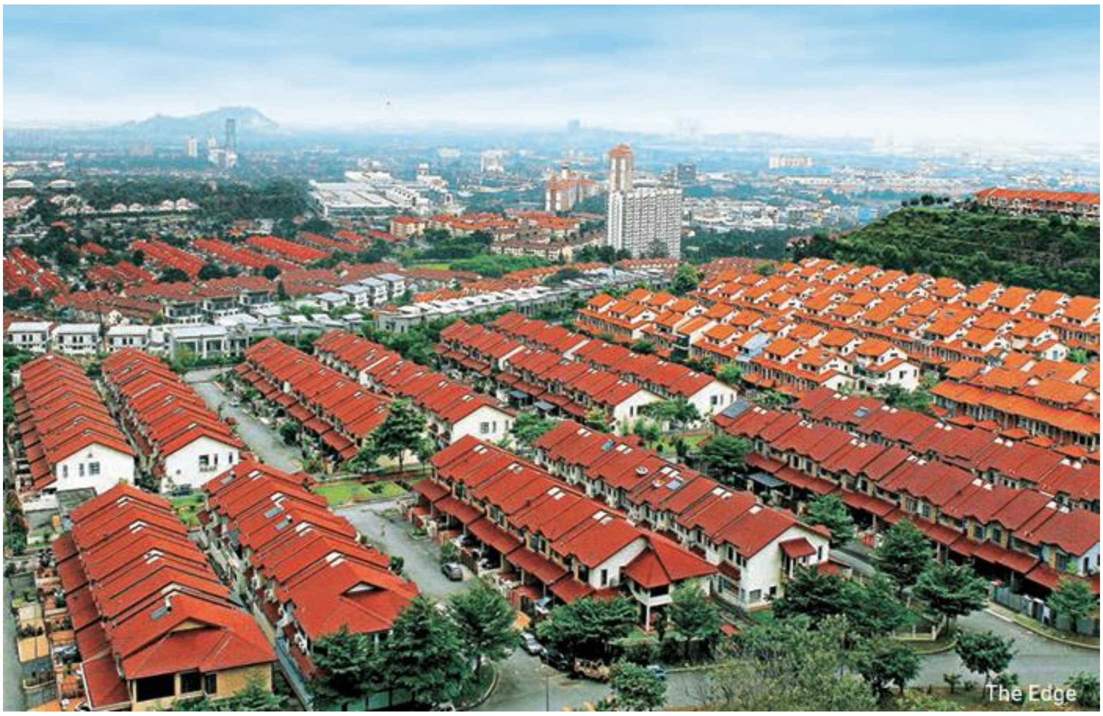


Figure 1.6: An aerial view on the typical low density suburban neighbourhood in the urban landscape of Malaysian cities. (Source: The Edge, 2015)

By having the understanding to recognise the importance and necessity of improvising conventional low density zoning regulation to higher density zoning regulation to promote compact and dense development around the station area is good but simply insufficient to deliver TOD. Going beyond this generality to a specific amount is never easy. The question is how dense should it be? Particularly in the form of quantitative measure as the mechanism of zoning regulation for the density control is mostly objective based that outline specific rules in terms of density (i.e. dwelling unit/land area or population/land area) for residential development, while floor area ratio (FAR) for commercial and industrial development.

To answer the question above, this research justifies that the density zoning of station area should consider the transit capacity. As suggested by the literature, the designated density of the TOD zoning regulation around the station is needed to be tailored to the amount of transit capacity could accommodate (Calthrope, 2012; ITDP, 2014). Given that the permitted station area density is lower than the designated transit capacity, it generates fewer revenue and makes delivery of convenient and efficient transit more expensive. Meanwhile, if the permitted station area density is higher than the designated transit capacity, it leads to the issues of congestion or overcrowding. Therefore, to determine an appropriate station area density is crucial. This is to prevent the issues of poor transit service quality (reliability and comfortability), thus ensuring transit to become or remain a viable alternative to the competitive private vehicle. Consequently, a mismatch of station area density over the transit capacity would discourage community to take transit, defeating the purpose of higher density TOD zoning formulation (i.e. getting motorists to switch to trains and buses).

At present, station area density recommendations from the transit-supportive guidelines can be found from North American Cities (e.g. City of Waterloo et al., 2017). However, these guidelines have several weaknesses. First, the practices are tending to set on the geography context of greenfield and suburban setting (Yang and Pojani, 2017). Second, the discussion of these station area density guide is limited to the viable threshold for providing the minimal density recommendation to support the cost effectiveness of transit investment. Therefore, these guides are not relevant and inadequate for the context of a fairly dense urban environment where major cities of Malaysia often build and expand their urban mass transit system. More importantly, experts do not agree with station area density recommendation from these guidelines as such suggestions are not based on the widely acceptable research findings (Cervero et al., 2004). It is clear that relying on these transit-supportive guidelines for the information of station area density may not sufficient and certain to support the TOD zoning formulation.

Perhaps, in response to the inquiry of station area density and transit capacity, it is necessary getting back to basic notion on how station area density influence ridership. Since ridership determines the scale of transit capacity, thus by having a good understanding of the quantitative relation between station area density and ridership is important. Without a proper knowledge between the connection on station area density and ridership, it poses a challenge for cities to translate the subjective TOD idea into the quantitative dimension of zoning plan formulation (setting density and floor area ratio permission) which could provide a meaningful regulatory control and guide for the land development around the station area to support TOD. Particularly, to what extent the station area density zoning intensification effort is appropriately or optimally considered as dense for transit capacity. For that reason, this research aims to investigate the quantitative relationship of station area density and ridership which can potentially apply for the zoning formulation assessment for TOD promotion. Based on these findings, this research adopts them to evaluate the early TOD zoning intensification efforts of Kuala Lumpur city, specifically for the case of monorail as demonstration purposes to provide lessons for benefiting other Malaysian cities in TOD promotion. Nonetheless, there are several research challenges are identified. More detail discussion can be found in the next section.

1.2 Problem Statement

As this research is an attempt to understand the quantitative relationship between station area density and ridership and demonstrate the TOD zoning intensification assessment, it comes with a lot of challenges. These are:

(i) Little Work on the Quantitative Relation Between Station Area Density and Ridership Has Generalised for Practices

With the strong attention and increasing recognition of TOD by cities and researchers globally, the TOD related studies have grown steadily over the past two decades after the TOD concept was coined by Calthorpe (1993). Among the most popular research theme of TOD, is the investigation of the built environment, socioeconomic and transit service characteristics in relation to the ridership at the station area environment. Commonly, these research employ statistical approach to develop multiple regression model where ridership as the dependent variable while the independent variables consist of sub-components from the built environment, socioeconomic and transit service characteristics. Density in terms of the number of population and employment within the station area is part of built environment characteristics for such model. As the model explain the dependent variable of ridership from a set of independent variables in a very straightforward procedure, hence it is widely known as direct ridership model (Cervero, 2006). It is important to take note that direct ridership model is a complementary response to the limitation of traditional four-step travel demand model (trip generation, trip distribution, mode split, and trip assignment) in ridership prediction. Researchers argued that the traditional four-step travel demand model mainly focuses on the regional movement of private vehicles and insensitive to capture the improvement effect from TOD that often takes place at the local finer geographic scale of transit station area (Cervero, 2006; Zuehlke, 2007; Gutierrez et al., 2011). Therefore, the traditional four-step model is not capable to provide a reliable ridership prediction for TOD and the direct ridership model is emerged to address this gap.

For this moment, this study found that there are at least 29 empirical studies are related to direct ridership models (more details see Section 2.1). Despite of a substantial amount studies are available; their findings are merely representing their individual empirical case respectively. There is a lack of concerted effort on this topic to date has generalised across studies or helped make sense of differing results. The previous research attempt, a remarkable meta-analysis by Ewing and Cervero (2010) on the travel and built environment synthesis have revealed that the weighted average elasticity of transit use with respect to population and employment density is recorded at 0.07 and 0.01. These results imply that a 100% increase in population and employment density would cause an increase in transit use at 7% and 1% respectively. However, their finding may not appropriate for this research, as these results were based on a pool study conducted at the city wide context. Without the generalisation, readers have glimpses of many trees rather a panoramic view of this complex and rich forest of research.

(ii) Varying Definition of Transit Catchment Area

From the discussion of early sections, it is learned that the immediate environment of a transit station is a matter for higher density zoning promotion to support TOD. Nevertheless, to what degree is the suitable size area around the transit station where the dense development should have promoted. Rationally, it should be close to transit station where it eases people access by walking for transit service or in the way round the other services around the station. As beyond a certain distance, transit is unlikely to influence people to use the service (Kolko, 2011; Guerra et al., 2012). For this research context, knowing the area defined within a specific distance from a transit station is important to provide effective TOD zoning intervention and TOD zoning intensification assessment since the built environment characteristics of the catchment area largely influence the transit ridership. Surprisingly, there is no consensus exists among practitioners or researchers regarding a uniform standard for catchment area size. For light rail transit system planning and rail-based TOD, the walking distance guidelines range from 300-900m in Canada with variation across cities, compared to 400-800m in the United States (O'Sullivan and Morall, 1996; Ewing, 1999; Canepa, 2007). For the common bus system, 400m walking distance is usually considered (Levinson, 1992; Ammons, 2001). Occasionally, 1,000m (1km) is also proposed (Newman and Kenworthy, 2006; Marks, 2016).

(iii) Inadequate Evidence on the Ability of Building Floor Space in Providing a Population and Employment Estimation on the Urbanised Station Area

As part of the research scope for this study is to demonstrate the assessment on the TOD zoning intensification of Kuala Lumpur city. For this purpose, the basic information on station area population and employment serves as an important input for the appraisal. To obtain the information of the station area population and employment, most TOD related studies have derived their data from the census tract or even block. The smaller geographical census unit is presented by the census bureau. However, generating station area population and employment information is never easy for Malaysian cities where detailed census data may not be readily available and may often be difficult to access. For example, the most detailed census data published by the Department of Statistics, Malaysia (2011a) for the capital city of Kuala Lumpur are at the census district level. On average, the geographic size of each census district of Kuala Lumpur has an area of 3,028 hectares. In comparison to the census tract or block in advance economies, these census districts are spatially too large and coarse for providing station area population and employment data. To overcome these issues, this study investigates the application of the building floor space as an alternative technique to estimate station area population and employment.

With the research results from the regression analysis of Lwin and Murayama (2009) and Biljecki et al. (2016) suggested that building floor space has a strong, positive, and linear correlation with the population. This study found that the total building floor space within a particular geographic area has a meaningful association with the number of the population in the area. Based on their findings, it also implies that a greater amount of building floor space provides a clue of larger numbers of the population. Conversely, a lesser amount of building space signifies smaller numbers of population in a given location. In fact, previous studies are found in the building floor space experiment for a fine geographic scale population estimation (Lwin and Murayama 2009; Alahmadi et al., 2013;2016). Lwin and Murayama (2009) use building floor space and the census tract to build an empirical weighting model to map the population distribution at the scale of the building. Alahmadi et al. (2013;2016) estimate the population size of a neighborhood by using building floor space and the block level empirical statistical model of inhabitants per dwelling unit. However, applying these approaches to the station area in cities of developing countries remains difficult. This is because the detailed census and local statistic data in the earlier section are seldom available in developing countries. Thus, no realistic empirical model can be established for these cities to transform building floor space into the population. In addition, the existing studies are mainly focused on the residential building floor space for population estimation in the context of a relatively homogenous housing environment. However, efforts on the research extension into non-residential building floor space (e.g., commercial, institution, and industrial) for employment estimation and the environment of an urban setting where the transit development that tends to take place is rarely discussed.

1.3 Research Aims and Objectives

In response to the significant but under-researched topic of TOD promotion for pursuing greater urban sustainability in Malaysia, this research aims to investigate the quantitative relationship between station area density and ridership with the view for empirical demonstration towards a better TOD zoning formulation. Based on the problem statement mentioned above, several research gaps have been identified to provide study focus with regard to achieving this research aims. Towards the end, this research will fulfil the following objectives:

(i) To establish the quantitative effect size between density and ridership in the context of the station area via empirical literature and provide a generalised conclusion;

(ii) To examine the walkable catchment area for transit station that is likely to draw most ridership for the effective TOD zoning;

(iii) To investigate the application of building floor space as an alternative technique to estimate population and employment at the finer geographic scale of the station area for TOD promotion in the context of the urbanised environment; and

(iv) To evaluate the early zoning intensification effort of Kuala Lumpur Monorail for drawing the idea of appropriate zoning intensity to benefit TOD promotion.

1.4 Research Framework

This research thesis contains five chapters (Figure 1.7). Beginning with this chapter, it introduces the background issues and the need to improvise zoning regulation in relation to TOD promotion, the research gaps, aims and objectives that outline this research. Chapter Two reviews the empirical studies of direct ridership models with the focus on the quantitative relationship between station area density and ridership. The findings draw from this section will serve as an input for the TOD zoning assessment of Kuala Lumpur Monorail in Chapter Four. Further, it examines the appropriate walkable catchment area for transit station to set the geographic dimension of station area for the subsequent empirical studies of building floor space analysis for station area population and employment estimation (Chapter Three) as well as TOD zoning assessment (Chapter Four). Chapter Three validates the reliability of using building floor space for station area population and employment estimation. More importantly, Chapter Three tries to have a better understanding of the uncertainty of building floor space model by identifying the meaningful margin of error in station area population and employment estimation. Building on the findings derived from its preceding two chapters, Chapter Four assesses the early zoning intensification efforts of Kuala Lumpur for the case of Kuala Lumpur Monorail to serve as the demonstration. Finally, Chapter Five summarises the findings from literature reviews (Chapter Two) and empirical studies (Chapter Three and Four); concludes on the TOD zoning for Kuala Lumpur Monorail to provide lessons for benefiting TOD zoning formulation and promotion in Malaysian cities, and recommends possible future research directions in the topic.

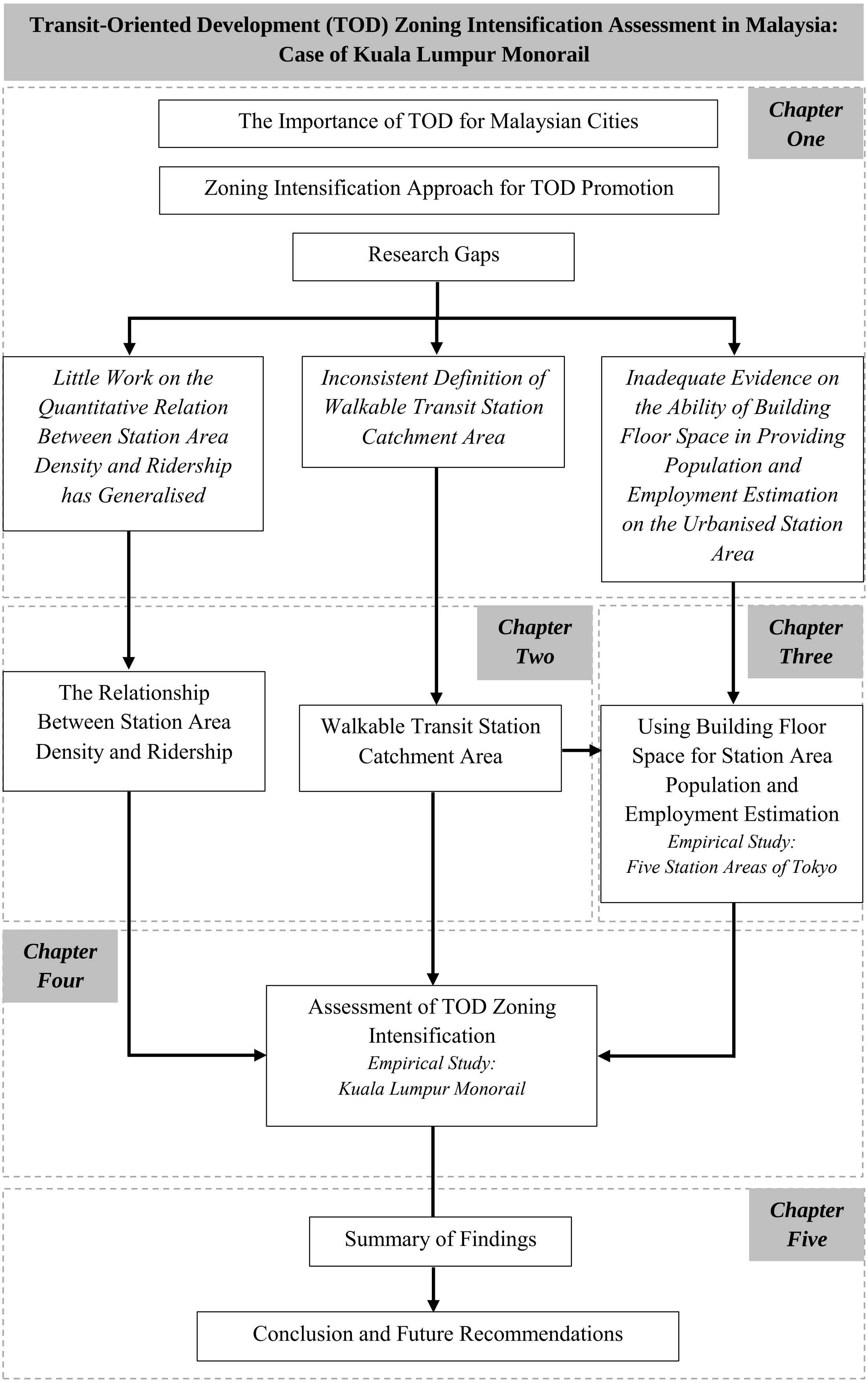


Figure 1.7: An overview of the research framework

CHAPTER 2

UNDERSTANDING TRANSIT-ORIENTED DEVELOPMENT

2.1 The Relationship Between Station Area Density and Ridership

A considerable body of empirical studies has investigated the links between ridership and the station level characteristics of the built environment, socioeconomic and transit service. Presently, at least a total of 29 relevant empirical studies (Parson Brinckerhoff Quade & Douglas, Inc., 1996; Chu, 2004; Kuby et al., 2004; Cervero, 2006; Chow et al., 2006; Lane et al., 2006; Estupinan and Rodriguez, 2008; Lin and Shin, 2008; Cervero and Murakami, 2009; Cervero et al., 2010; Sohn and Shim, 2010; Loo et al., 2010; Gutierrez et al., 2011; Sung and Oh, 2011; Cardozo et al., 2012; Blainey and Mulley, 2013; Chan and Miranda-Moreno, 2013; Currie and Delbosc, 2013; Dill et al., 2013; Duduta, 2013; Zhao et al., 2013; Zhang and Wang, 2014; Zhao et al., 2014; Durning and Townsend, 2015; Fang, 2016; Liu et al., 2016; Iseki et al, 2018; Islam et al., 2018; Vergel-Tovar and Rodriguez, 2018) have been identified from the recognised peer-reviewed journal and reliable institution for this research subject across the cities of Asia, Australia, Europe, North America and South America region (see Table 2.1).

In general, these studies perform the statistical analysis using multiple regression model to understand how do these local factors could influence ridership. The multiple regression model estimates ridership as a function of built environment, socioeconomic and transit service characteristic in the following basic form:

$$R_i = f(BE_i,\ SE_i,\ TS_i), \varepsilon_i$$

where R_i is the ridership of station i, BE_i a vector of built environment variables of ridership i, SE_i a vector of socioeconomic variables of ridership i, TS_i a vector of transit service variables of ridership i, and ε_i is a random error term. Alternatively, a similar model can be restated as the following common expression:

$$\mathrm{y} = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \cdots + \beta_k X_k + \varepsilon$$

where y is the dependent variable of station level ridership, $X_1, X_2, X_3, \ldots X_k$ represent independent variables of the built environment, socioeconomic and transit service characteristic respectively, $\beta_1, \beta_2, \beta_3, \ldots \beta_k$ are the coefficients, α is the constant term, and ε is the unobserved random error.

Table 2.1: A summary of the existing direct ridership empirical model

			Parson Brinckerhoff Quade & Douglas, Inc. (1996)	Chu (2004)	Kuby et al. (2004)	Cervero (2006)	Chow et al. (2006)	Lane et al. (2006)	Estupinan and Rodriguez (2008)	Lin and Shin (2008)	Cervero and Murakami (2009)	Cervero et al. (2010)	Loo et al. (2010)	Sohn and Shim (2010)	Gutierrez et al. (2011)	Sung and Oh (2011)	Cardozo et al. (2012)
		Study Area	11 Cities in United States and 2 Cities in Canada	Jacksonville, United States	9 Cities in United States	11 Cities in United States and 2 Cities in Canada	Broward, United States	11 Cities in United States	Bogota, Columbia	Taipei, Taiwan	Hong Kong, China	Los Angeles, United States	Hong Kong, China / New York, United States	Seoul, South Korea	Madrid, Spain	Seoul, South Korea	Madrid, Spain
		Transit Type	Light Rail / Commuter Rail	Bus	Light Rail	Light Rail	Bus	Light Rail / Commuter Rail	Bus Rapid Transit	Mass Rail Transit	Mass Rail Transit	Bus Rapid Transit	Mass Rail Transit	Mass Rail Transit	Mass Rail Transit	Mass Rail Transit	Mass Rail Transit
		Sample Size (*N*)	261 / 550	2,568	268	225	716	348 / 868	68	46	51	69	79 / 406	251	158	214	190
		Coefficient of Determinant (*R-squared*)	0.536 / 0.343	0.54	0.54	0.771	0.516	0.47 / 0.84	0.45	0.709	0.746	0.952	0.59 / 0.74	0.634	0.753	0.779	0.567
Dependent Variable (y)		Average Weekday Boarding			•						•		•	•			
		Average Weekday Alighting														•	
		Average Weekday Total Rider (sum of boarding and alighting)															
		Daily Boarding	•	•		•		•	•			•					
		Daily Total Rider (sum of boarding and alighting)								•							
		Weekly Boarding															
		Monthly Boarding													•		•
		Boarding / Vehicle Kilometre															
		Passenger Mile Travelled															
		Daily Working Trip					•										
Independent Variables ($X_1, X_2, X_3, \dots X_k$)	Built Environment	Population Density	•		•	•	•	•	•	•	•	•	•	•	•		•
		Employment Density			•		•	•		•		•	•	•	•		•
		Walkability (block size, intersection density, …)					•		•	•		•		•	•	•	•
		Land Use Diversity				•		•	•	•	•		•	•	•	•	•
		Hotel/ Restaurant/ Hospital/ University												•			
		Centrality (distance to downtown)	•		•	•		•			•		•	•		•	
		Sidewalk Attributes			•		•										
		Perceived Attributes (safety, amenity, …)							•								
	Socioeconomic	Ethnicity Composition		•			•										
		Age		•													
		Income	•				•	•		•							
		Poverty Level		•			•										
		Rate of Employment							•								
		Renter Household			•												
		Car Ownership	•	•		•	•	•		•			•				•
	Transit Service	Route Coverage/ Density							•							•	
		Level of Service (capacity, frequency, …)		•		•	•	•	•			•		•		•	•
		Fares													•		
		Parking Space (vehicle, bicycle, …)	•		•	•		•		•		•	•		•		
		Number of Bus Connections/ Stops/ Lines	•	•	•	•	•	•			•	•	•		•	•	•
		Station Attributes (facilities, years of operation)		•	•							•	•	•			
		Station Typology (terminal, transfer, …)	•		•	•		•		•	•	•	•	•			

Table 2.1: Summary of the existing direct ridership empirical model (Continued)

			Blainey and Mulley (2013)	Chan and Miranda-Moreno (2013)	Currie and Delbosc (2013)	Dill et al. (2013)	Duduta (2013)	Zhao et al. (2013)	Zhang and Wang (2014)	Zhao et al. (2014)	Durning and Townsend (2015)	Fang (2016)	Liu et at. (2016)	Iseki et al. (2018)	Islam et al. (2018)	Vergel-Tovar and Rodriguez (2018)
		Study Area	Sydney, Australia	Montreal, Canada	Australia, Europe, and North America	Portland / Eugene-Springfield/ Jackson, United States	Mexico City, Mexico	Nanjing, China	New York, United States	Nanjing, China	5 Cities in Canada	Boston, United States	State of Maryland, United States	Washington D.C., United States	Ahmedabad, India	7 Cities in Latin America Countries
		Transit Type	Mass Rail Transit	Mass Rail Transit	Bus Rapid Transit, Light Rail Transit	Bus, Light Rail Transit	Bus Rapid Transit / Mass Rail Transit	Mass Rail Transit	Mass Rail Transit	Mass Rail Transit	Light Rail, Commuter Rail	Bus Rapid Transit, Light Rail Transit, Commuter Rail	Light Rail Transit, Mass Rail Transit	Mass Rail Transit	Bus Rapid Transit	Bus Rapid Transit
		Sample Size (*N*)	307	65	101	7,214 / 1,400 / 250	51 / 84	55	117	55	342	298	73	84	151	120
		Coefficient of Determinant (*R-squared*)	0.925	0.679	0.83	0.69 / 0.62 / 0.53	0.51 / 0.54	0.979	0.786	0.958	0.81	0.822	0.812	0.486	0.17	0.695
Dependent Variable (y)		Average Weekday Boarding						•		•		•				
		Average Weekday Alighting														
		Average Weekday Total Rider (sum of boarding and alighting)		•												
		Daily Boarding					•		•		•		•			•
		Daily Total Rider (sum of boarding and alighting)				•										
		Weekly Boarding	•													
		Monthly Boarding													•	
		Boarding/ Vehicle Kilometre			•											
		Passenger Mile Travelled												•		
		Daily Working Trip														
Independent Variables ($X_1, X_2, X_3, \dots X_k$)	Built Environment	Population Density	•	•	•	•	•	•	•	•	•	•	•	•	•	•
		Employment Density	•	•	•	•		•	•	•	•		•	•	•	
		Walkability (block size, intersection density, …)		•		•		•		•	•	•	•		•	•
		Land Use Diversity		•		•					•		•		•	•
		Hotel/ Restaurant/ Hospital/ University						•		•						
		Centrality (distance to downtown)	•	•		•	•	•		•	•			•		•
		Sidewalk Attributes														
		Perceived Attributes (safety, amenity, …)														
	Socioeconomic	Ethnicity Composition				•							•			
		Age	•	•		•					•		•			
		Income	•	•		•			•		•		•			•
		Poverty Level		•		•										•
		Rate of Employment									•					
		Renter Household									•		•			
		Car Ownership	•	•	•	•							•			
	Transit Service	Route Coverage/ Density		•			•		•							
		Level of Service (capacity, frequency, …)	•	•	•	•							•			
		Fares		•	•						•			•		
		Parking Space (vehicle, bicycle, …)	•			•		•		•	•		•	•		•
		Number of Bus Connections/ Stops/ Lines	•	•			•	•		•	•		•	•		
		Station Attributes (facilities, years of operation)														
		Station Typology (terminal, transfer, …)		•		•	•	•	•	•	•		•	•		

The primary interest of this research on the existing pool of empirical regression models is in the station area population and employment density, it can be often found as part of the sub population in the built environment independent variables. The coefficient of the multiple regression model describes the mathematical relationship between each independent variable and the dependent variable. It represents the mean change in the dependent variable for one unit of change in the independent variable while holding other independent variables in the model constant. This property of holding the other variables constant is crucial because it allows us to assess the effect the given independent variable in isolation from the others. Therefore, to understand what is the effect of station area population and employment density on ridership, this research mainly interested in the regression coefficient of station area population and employment density independent variable. By holding the other independent variables constant, this study specifically extracts the coefficient of the station area population and employment density independent variable from these empirical regression models so that the relationship between ridership can be established.

Despite the great number of empirical studies, deriving their profound findings for this research context remains a challenge. It is observed that there is an inconsistency definition of the dependent variable (ridership) and dissimilarity of independent variable specifications has been developed for analysing ridership across the current studies. Further, a repeated duplicated article with a similar analysis is also found. By simply adopting results from these empirical studies without any precaution measure would lead to serious mistake and fault finding. Therefore, in order to obtain a better result for benefiting this study to synthesis a generalise conclusion on the quantitative relationship between station area density and ridership with the view for matching TOD zoning formulation to transit capacity, this study carefully reviews these literatures systematically. Attention is paid on the subject matters of dependent variable definition, underspecified model (omitted variable bias) and regression coefficient p-values for the statistical output interpretation on the existing studies.

It is interesting to note that there is as much as ten kinds of station level ridership dependent variable can be noted on the existing studies. They are (i) average weekday boarding (Kuby et al., 2006; Cervero and Murakami, 2006; Loo et al., 2010; Sohn and Shim, 2010, Zhao et al., 2013; 2014; Fang, 2016); (ii) average weekday alighting (Sung and Oh, 2011); (iii) average weekday total rider (Chan and Miranda-Moreno, 2013); (iv) daily boarding (Parsons Brinkerhoff Quade & Douglas, Inc., 1996; Chu, 2004; Cervero, 2006; Lane et al., 2006; Estupinan and Rodriguez, 2008; Cervero et al., 2010; Duduta, 2013; Zhang and Wang, 2014; Durning and Townsend, 2015; Liu et al., 2016; Vergel-Tovar and Rodriguez, 2018); (v) daily total rider (Dill et al., 2013); (vi) weekly boarding (Blainey and Mulley, 2013); (vii) monthly boarding (Guetirrez et al., 2011; Cardozo et al., 2012; Islam et al., 2018); (viii) boarding/vehicle kilometre (Currie and Delbosc, 2013); (ix) passenger mile travelled (Iseki et al., 2018); and (x) daily working trip (Chow et al., 2006). Among the variation of station ridership dependent variable, this study found that that the average weekday boarding could offer more meaningful implication on the common metric of transit capacity that measured in passenger per hour per direction (pphpd). Average weekday boarding is the mean counts on the number of passengers entering the station in the working days. Without the presence of weekend (off-peak period), average weekday boarding provides a better ridership counts for peak traffic period (Kuby et al., 2004). The peak hour passenger boarding has been consistently highlighted as an important aspect needed to be fulfilled by the standard transit capacity and quality of service manual (Kittelson Associates, Inc. et al., 2013). Therefore, we do not find much advantage of using the other nine definitions of station level ridership dependent variable for this research. For that reason, this study emphasises on the empirical studies with the dependent variable of station level average weekday boarding.

The underspecified model is the condition where the regression equation missing one or more relevant independent variables. In the domain of statistics, it is technically known as omitted variable bias (Wooldridge, 2009). By excluding the relevant independent variable(s) in the multiple regression model, some part of their effect might mistakenly attribute to the existing independent variable(s). Therefore, it yields biased coefficient outcome and biased prediction of the response (Clarke, 2005; Antonakis et al., 2014; Abdallah et al., 2015). For more detail information of the omitted variable bias, a further illustration is available in Appendix A. In this research context, the problem of underspecified model would cause the regression coefficient of station area population and employment density to be misleading as it unable to reflect the true effect on ridership in the complex reality where in fact the ridership tends to be affected by other factors too. Based on the existing empirical studies, it is noticed that a few studies are mainly relying on the single dimensional set of independent variables (i.e. built environment). Fang (2016) conducted a simple regression analysis using density and average block size on the average weekday boarding of 298 transit stations in Boston, United State. While Islam et al. (2018) studied the relationship of built environment characteristic with the monthly boarding of bus rapid transit station in Ahmedabad, India. Both of these studies are not adopted in this research. Additionally, for the repeated similar empirical case study for Hong Kong from Cervero and Murakami (2009) and Loo et al. (2010), this research gives a favour on the results of Loo et al. (2010). By comparing the independent variables, the regression model of Cervero and Murakami (2009) contains less independent variables than Loo et al. (2010) with the absence of employment density, car ownership, parking space, and station attributes. This suggests that the regression model of Cervero and Murakami (2009) as an underspecified model. Even the model of Cervero and Murakami (2009) has a relatively decent coefficient of determinant (R-squared) value recorded at 0.746 than the R-squared from the model of Loo et al. (2010) that reported at 0.59, which indicating that the model of Cervero and Murakami (2009) gives a better goodness-of-fit in explaining most of the variability of the station level average weekday boarding (dependent variable). However, it does not mean that the regression coefficient from the model of Cervero and Murakami (2009) is reliable than the model of Loo et al. (2010). Stock and Watson (2003) pointed out that that a high R-squared does not mean that there is no omitted variable bias, while a low R-squared does not imply that there is necessarily an omitted variable bias. Therefore, to minimise the problem of the underspecified model, we do not include the empirical study of Cervero and Murakami (2009) for this study.

As aforementioned, the regression coefficient of the independent variable explains how it affects the dependent variable. The p-value for the coefficient is a result derived from the null hypothesis test that indicates whether these relationships are statistically significant. In other words, evidence to conclude that there is a correlation between the given independent variable and dependent variable. A low p-value (<0.05) signifies that the null hypothesis rejection. The independent variable that has a low p-value is likely to be meaningful and worthwhile because changes in the value of the given independent variable are related to changes in the dependent variable. For that reason, this study verifies the p-value of the station area population and employment density independent variable from the current empirical studies. This research does not keep the regression coefficient from the empirical studies that are not statistically significant as this will lead to a distorted result. Under this condition, this study avoids accepting the regression coefficient of station area population density independent variable from the empirical study by Sohn and Shim (2010) in Seoul, South Korea. The correspond high p-value from the regression model of Sohn and Shim (2010) documented at 0.281 (Table 2.1), imply that the regression coefficient of station area population density independent variable of their study is proven to be statistically not significant. Hence, it is inappropriate to consider it in our study.

It is unexpected to found that the content from the empirical regression model by Zhao et al. (2013) is repeated again in Zhao et al. (2014), yet, their data and results are contrasting with each other. For the case of duplicated articles by the identical author(s) on a similar empirical study using the alike methodology, we have a preference for their recent publication for this study. As we suspected that the author(s) have revised and incorporated their up-to-date data for improving new results in their latest publication. Based on this notion, the findings from the study of Zhao et al. (2014) is selected for this research. An overview of the systematic review of the existing empirical studies for this research is shown on the following page.

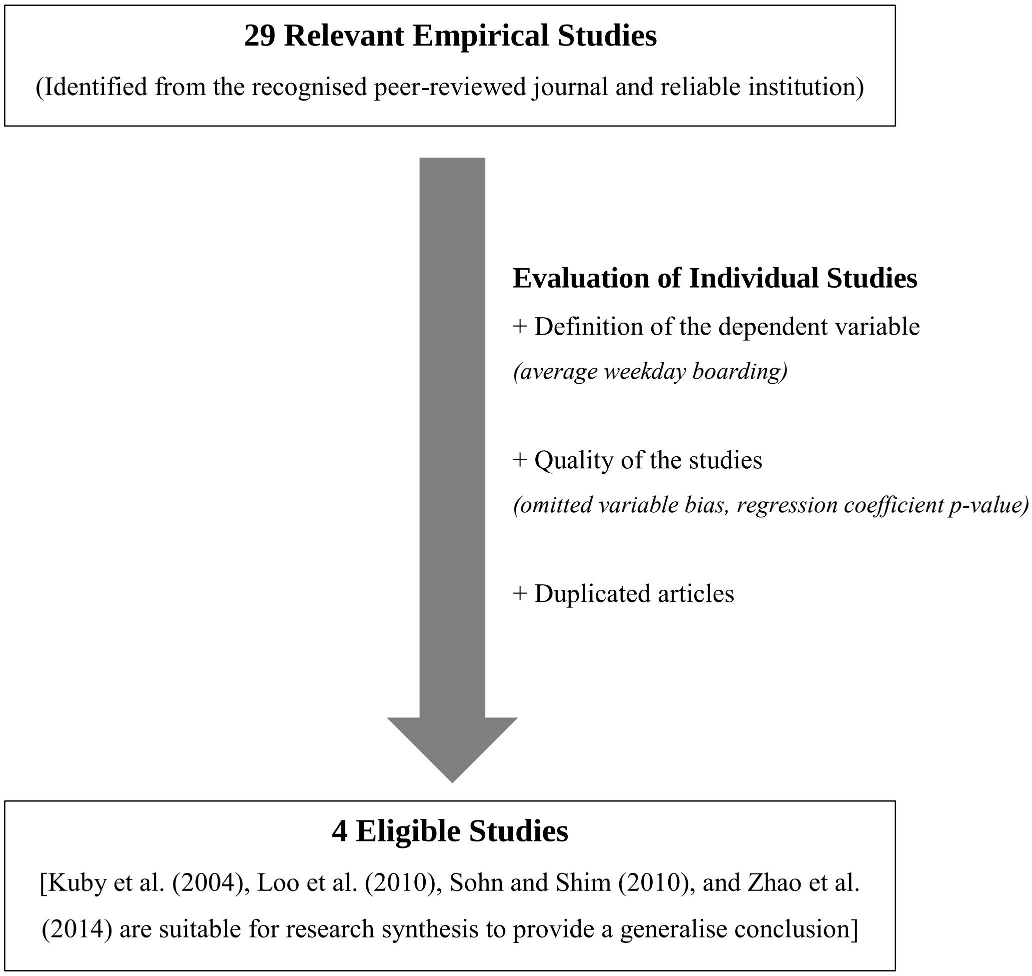


Figure 2.1: The literature review protocol of this research on the current empirical investigations between ridership and station level characteristics of the built environment, socioeconomic and transit service.

Table 2.2: Summary of the relationship between station area density and ridership from the eligible empirical studies.

Author(s)	Study Area	Transit Type	Sample Size (*N*)	Coefficient of Determinant (*R-squared*)	Station Area Density (Average)	Interaction Between Station Area Density and Ridership	
						Population	Employment
Kuby et al. (2004)	9 Cities in United States	Light Rail Transit	268	0.54	Pop./hectare: 12 Emp./hectare: 32	Increase of 9.2 passengers (daily weekday boarding) for every 100 population increment. *(p-value: 0.04)*	Increase of 2.3 passengers (daily weekday boarding) for every 100 employment increment. *(p-value: 0.02)*
Loo et al. (2010)	Hong Kong, China	Mass Rail Transit	79	0.59	Pop./hectare: 364 Emp./hectare: 222	Not Available.	Increase of 20 passengers (daily weekday boarding) for every 100 employment increment. *(p-value: 0.01)*
	New York, United States	Mass Rail Transit	406	0.74	Pop./hectare: 204 Emp./hectare: 195	Increase of 23 passengers (daily weekday boarding) for every 100 population increment. *(p-value: 0.00)*	Increase of 8 passengers (daily weekday boarding) for every 100 employment increment. *(p-value: 0.00)*
Sohn and Shim (2010)	Seoul, South Korea	Mass Rail Transit	251	0.63	Pop./hectare: 698 Emp./hectare: 176	Not significant. *(p-value: 0.28)*	Increase of 18.7 passengers (daily weekday boarding) for every 100 population increment. *(p-value: 0.00)*
Zhao et al. (2014)	Nanjing, China	Mass Rail Transit	55	0.96	Pop./hectare: 126 Emp./hectare: 69	Increase of 9.0 passengers (daily weekday boarding) for every 100 population increment. *(p-value: 0.04)*	Increase of 12.5 passengers (daily weekday boarding) for every 100 employment increment. *(p-value: 0.00)*

NOTE: Pop. = Population. Emp. = Employment.

By considering all the above circumstances on the existing literatures evaluation, this study found that four empirical studies (Kuby et al., 2004; Loo et al., 2010; Sohn and Shim, 2010; Zhao et al., 2014) are satisfied and eligible for the research synthesis to produce a generalise conclusion for the quantitative relationship between station area density and ridership. The regression results of the four eligible empirical studies are summarised in Table 2.2.

Collectively, the evidence from the four empirical studies provides us with interesting quantitative insight on how station area density of population and employment could affect ridership. Two separate sets of our synthesis findings drawn from this research are illustrated in Figure 2.2 and 2.3. For the purpose of effective discussion, the value of the quantitative effect of station area density on ridership for this research synthesis has been rounded to zero decimal number. In general, the results show the tendency of higher station area density for stronger influence on the number of average weekday boarding. The effects of station area population density over ridership is observed at the range of 9-23 (Figure 2.1). The strongest effects of station area population density over ridership is observed in New York, where 23 passenger boarding is expected for every 100 population increment (Loo et al., 2010). In contrast, the model of Kuby et al. (2004) in nine cities of United States (Baltimore, Boston, Buffalo, Cleveland, Los Angeles, Philadelphia, Pittsburgh, Portland, Sacramento, San Diego, and St. Louis) indicate that 9 passenger boarding for a similar amount of population increment. It is unexpected that the higher average station area population density of large metropolitan of Nanjing, China (126 populations per hectare) (Zhao et al., 2014) has a fairly similar magnitude of effect on ridership to the lower average station area population density in general cities of United States (12 populations per

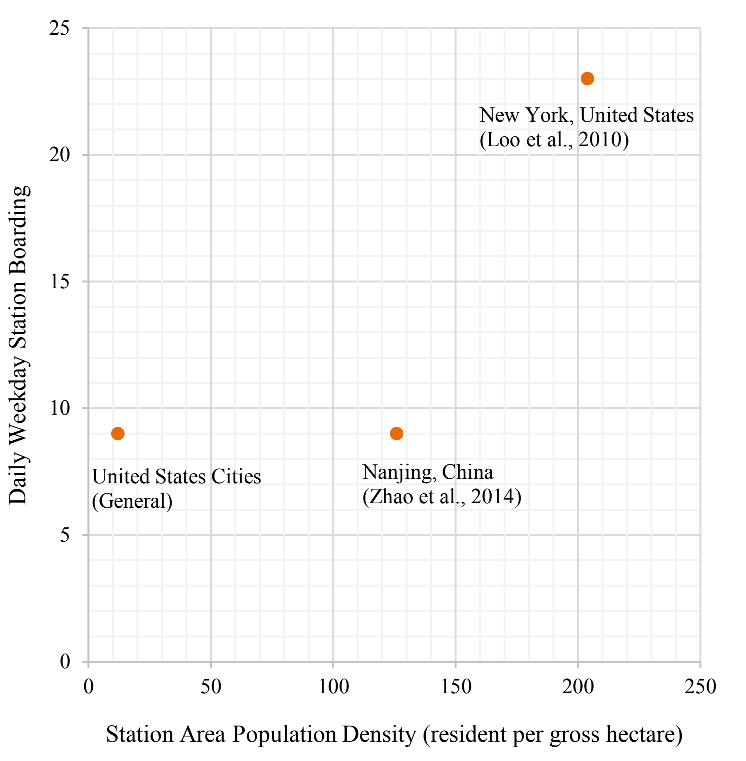


Figure 2.2: The relationship between station area population density and ridership (for every 100 population increment).

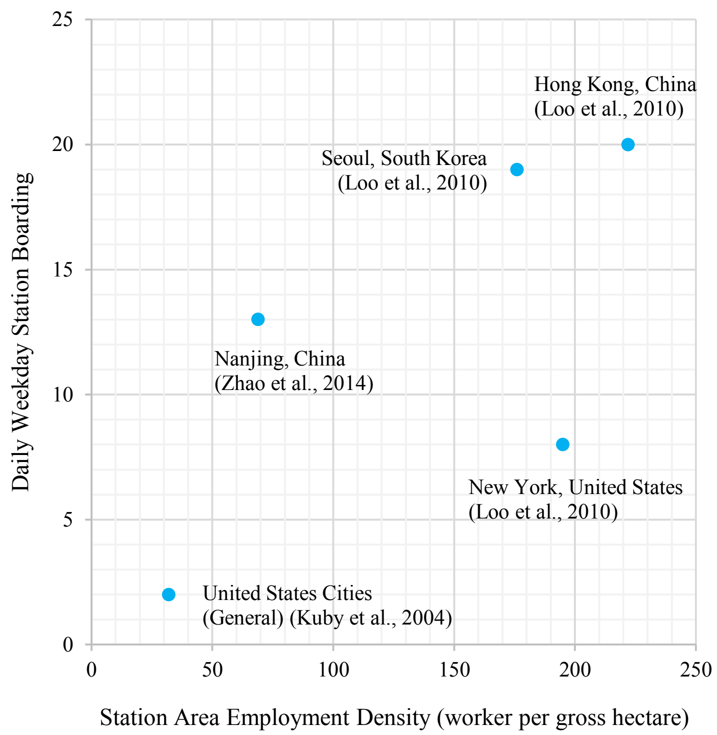


Figure 2.3: The relationship between station area employment density and ridership (for every 100 employment increment).

hectare) (Kuby et al., 2004). A possible reason for this could be due to the stronger walking and bicycle cultures over the transit use for non-work trips (e.g. school trip, shopping trip, and social-recreational trip) in Nanjing, China (Li et al., 2017). Therefore, the station level ridership in Nanjing, China is less sensitive to the effect of station area population density.

Meanwhile, in term of the relationship between station area employment density and ridership, the effect is noticed at the range of 2-20 (Figure 2.2). The strongest effect of station area employment density over ridership is observed in Hong Kong, where an increase of 20 passenger boarding is predicted for every 100 employment increment (Loo et al., 2010). Again, the smallest effect is noted from the study of Kuby et al. (2004) over 268 stations across nine cities in the United States. Their result shows that an increase 2 passenger boarding is expected for every 100 employment increment. The integration of the evidences from these four empirical studies surprise us that New York, United States with a relatively higher average station area employment density (195 workers per hectare) to Hong Kong, China (with 222 workers per hectare) and Seoul, South Korea (176 workers per hectare) give smaller effect on ridership. It is too early for this study to explain why this particular effect at this moment. Nevertheless, based on our observation, we suspect that such situation could be distorted by the geographical location of the transit station samples over the city level employment density pattern (see Figure 2.4, Figure 2.5, and Figure 2.6). In general, it can literature that the employment centres for Hong Kong are intensely clustered evenly across 79 transit station samples in the city. Whereas most of the intense employment centres for New York is highly centralised at the Manhattan district and beyond this geographic space it reduces significantly. The number of transit station samples located in Manhattan district is about 150 (Metropolitan Transportation Authority, 2018) while the rest 300 station samples are spread across another district of Brooklyn, Queens, The Bronx, and Staten Island with medium to low employment density. Therefore, a large number of station samples with lower employment density could absorb and normalise the higher effect of station area employment density on ridership in New York city.

More importantly, drawing from the results of this research synthesis, it provides us an informative insight that informs us about the influence size of station area density on ridership quantitatively. The effect of station area population density on the daily weekday station boarding is expected from the range of 9-23. At least, in the context of low station area population density (12 populations per hectare), 9 passengers of daily weekday boarding are expected for every 100 population increment. In the setting of high station area population density (204 populations per hectare), 23 passengers of daily weekday boarding are expected for every 100 population increment. In the meantime, the effect of station area employment density on the daily weekday station boarding is expected from the range of 2-20. For the case of low station area employment density (32 populations per hectare), 2 passengers of daily weekday boarding are expected for every 100 employment increment. At the high station area employment density environment (222 populations per hectare), 20 passengers of daily weekday boarding are expected for every 100 employment increment.

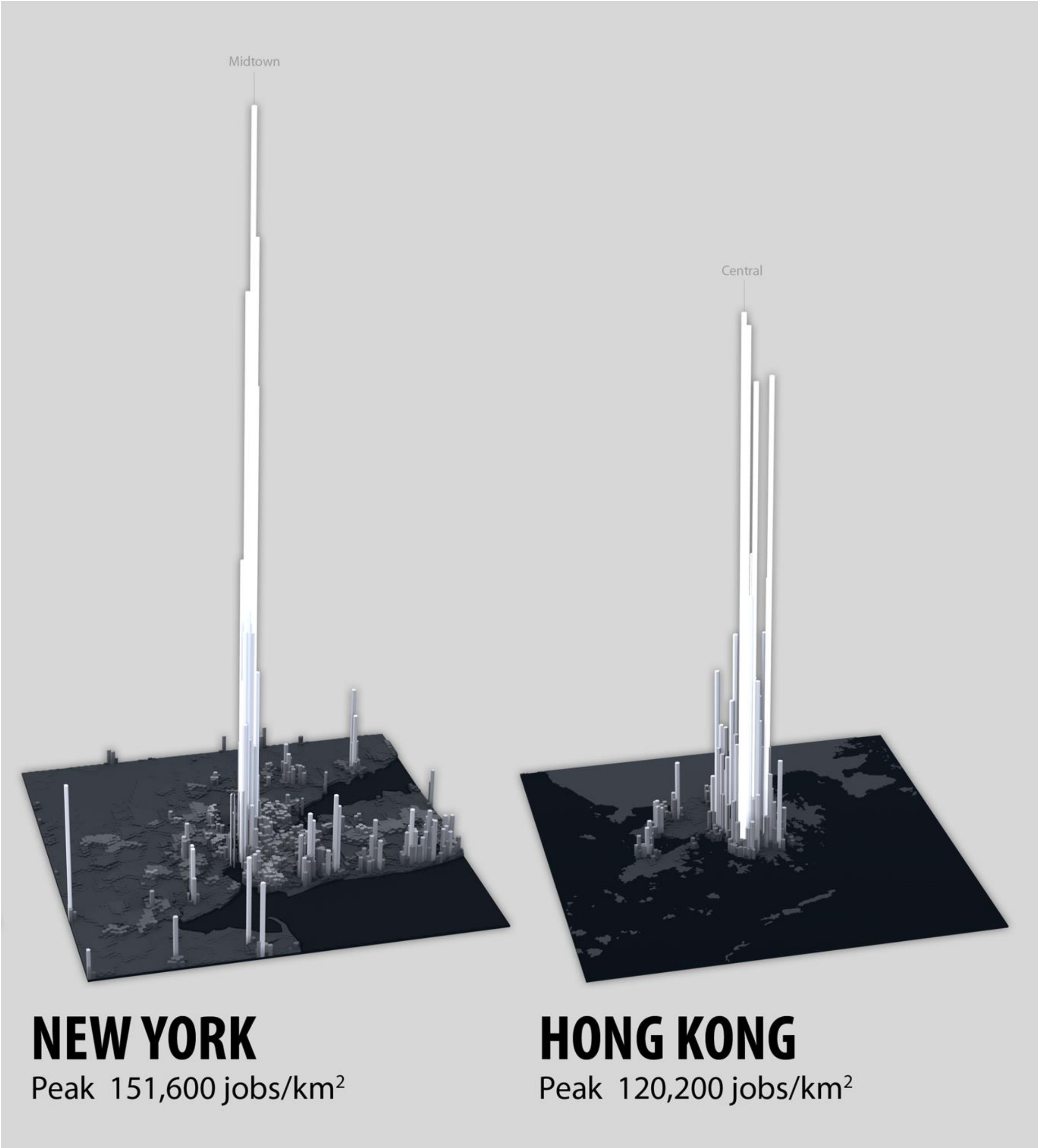


Figure 2.4: The city level employment density pattern of New York, United States and Hong Kong, China in 2013. (Source: Burdett and Rode, 2018)

Note: The total area of New York, United States is 1,213 square kilometres and Hong Kong, China is 1,106 square kilometres.

Figure 2.5: Mass rail transit routes and stations in Hong Kong, China.

(Source: Mass Transit Railway, 2016)

Figure 2.6: Mass rail transit routes and stations in New York, United States.

(Source: Metropolitan Transportation Authority, 2018)

2.2 Transit Catchment Area

Transit catchment area, sometimes being referred to transit service coverage area, is a measure of the geographic space around a transit station which offers close proximity for people to access the transit service. As many studies have found that most transit users access their transit service using foot, the size of the transit catchment area is typically justify based on the walking distance. In addition, the top priority is given to walking as it is considered as the fundamental and socially equitable form of travel mode for the general transit users (Hill, 1987; Wigan, 1995; Sandt et al., 2016). The further away people from the transit station, the less likely it is they will use transit. As the distance from a transit station increase, people feel reluctant to walk and most people would not consider transit as a viable option (Kolko, 2011; Guerra et al., 2012). Therefore, walking distance to transit station is an important factor of transit ridership and it is not surprising that the size of transit catchment area often decided based on the walking distance where most people are willing to walk to access the transit service.

Since the ultimate goal for TOD is to promote transit use, assigning TOD zoning intervention and prescription to the transit catchment area would give a more meaningful impact to attract people to take transit than to those areas that are further away. Nonetheless, how far people are willing to walk for transit use? And what is the appropriate size of transit catchment area? To date, interestingly there is no consensus exists among practitioners and researchers regarding a uniform size of the transit catchment area. The current general transit catchment area guidelines range from 300-900m in Canada with variation across cities, compared to 400-800m in the United

States (O'Sullivan and Morall, 1996; Ewing, 1999; Canepa, 2007). Establishing a standard transit catchment area is important for this research to ensure an effective TOD zoning intensification assessment as it could capture most of the transit users since the population and employment within the transit catchment area has a higher probability to take transit.

Despite of the varying transit catchment area suggestions, many studies of the transit users and walking travel behaviour related research found that the physical 400m (¼ mile) or 5 minutes of walking distance is common. In Melbourne, Australia about 75% of trips below 400m is walked (State of Victoria, 2010). Kolko (2011) found that the likelihood of residents and workers commute by using transit in California, United States falls by approximately half when comparing residents and workers within one-quarter mile (400m) of a transit station and those between one-quarter (400m) and one-half mile (800m) of a transit station (Figure 2.7). Gutierrez et al. (2011) conducted an analysis on the 17,000 Madrid Metro trips accessing station on foot reveal that both a number of travellers from home and employment have a decreasing trend with distance. Their distance-decay function illustrated that the number of daily trips/population and number of daily trips/employment falls drastically after 400m. For instance, in the 0-100m distance band, approximately 1.2 daily trips per worker are registered, but this value falls to 0.4 in the 400m and further reduces to 0.2 in the 800m.

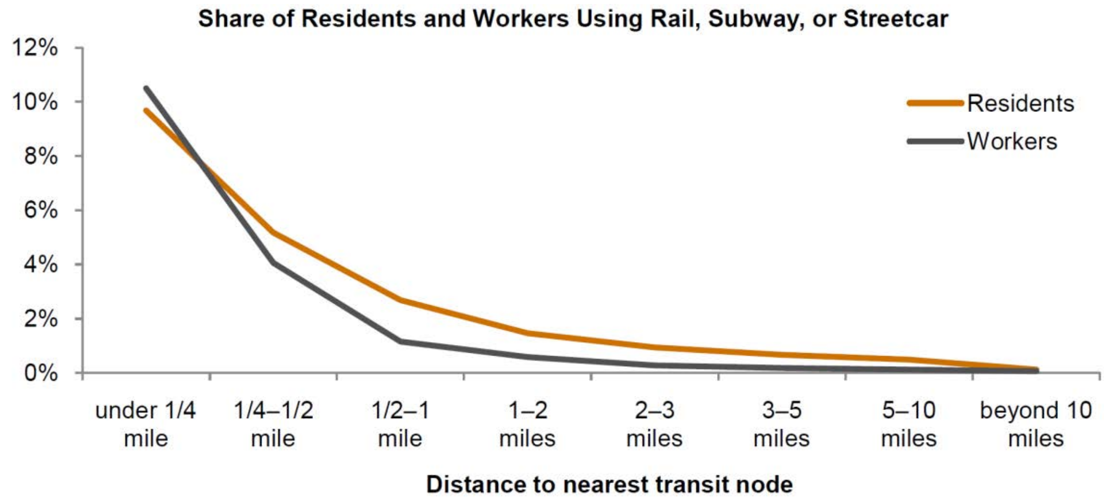


Figure 2.7: The tendency of using transit for both residents and workers falls dramatically after ¼ mile (400m) in California, United States. (Source: Kolko, 2011)

El-Geneidy et al. (2014) analysed on the detailed origin-destination transit survey data of Montreal, Canada have reported that willingness to travel on foot to access the transit varies on the basis of service type. They discover that the amount of passenger for intra-city transit service (bus and metro) suffer greatly after the access distance beyond 400m in comparison to inter-city transit serve (regional commuter train). Their findings complement to the model of walking distance to access transit services suggested by Vuchic (2005). He pointed out that the similar trend where the tendency of transit use deteriorates with the distance from the transit station particularly at 400m for street transit and metro in contrast to the regional rail where people willing to walk further. In the recent investigation on the non-motorised (walk and bicycle) accessibility to transit in Cincinnati Metropolitan Area, Zuo et al. (2018) found that at the trip origin of 400m distance to the transit station, it captures 65% of walking mode share in accessing transit service (Figure 2.8). While at the trip destination of 400m distance from a transit station, 75% of egress passengers using their foot to reach their destination can be observed (Figure 2.9).

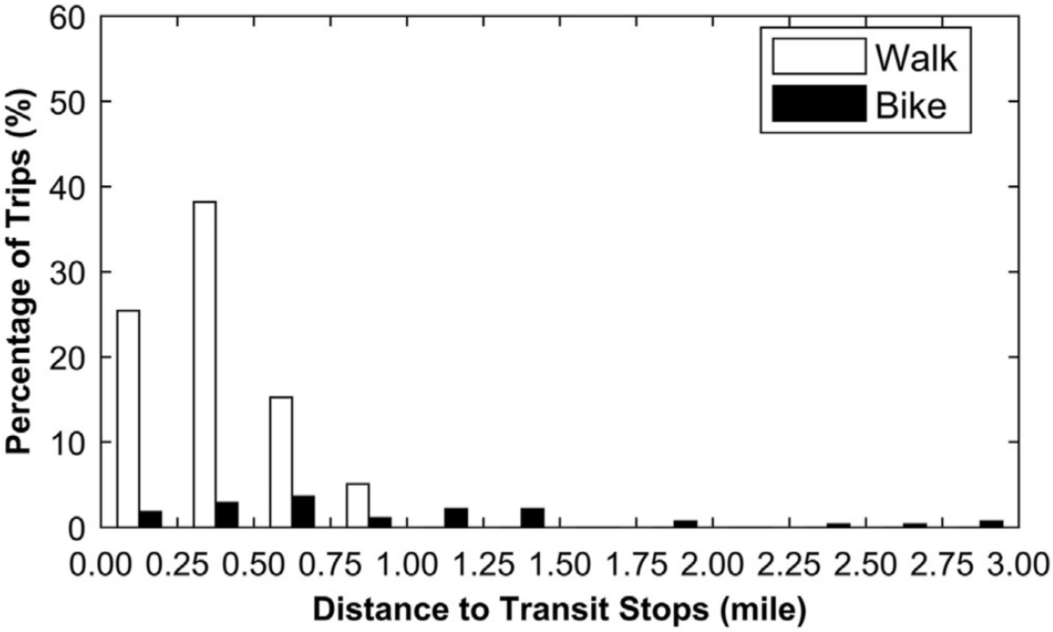


Figure 2.8: Distribution of travel distance of non-motorised transit access trips. (Source: Zuo et al., 2018)

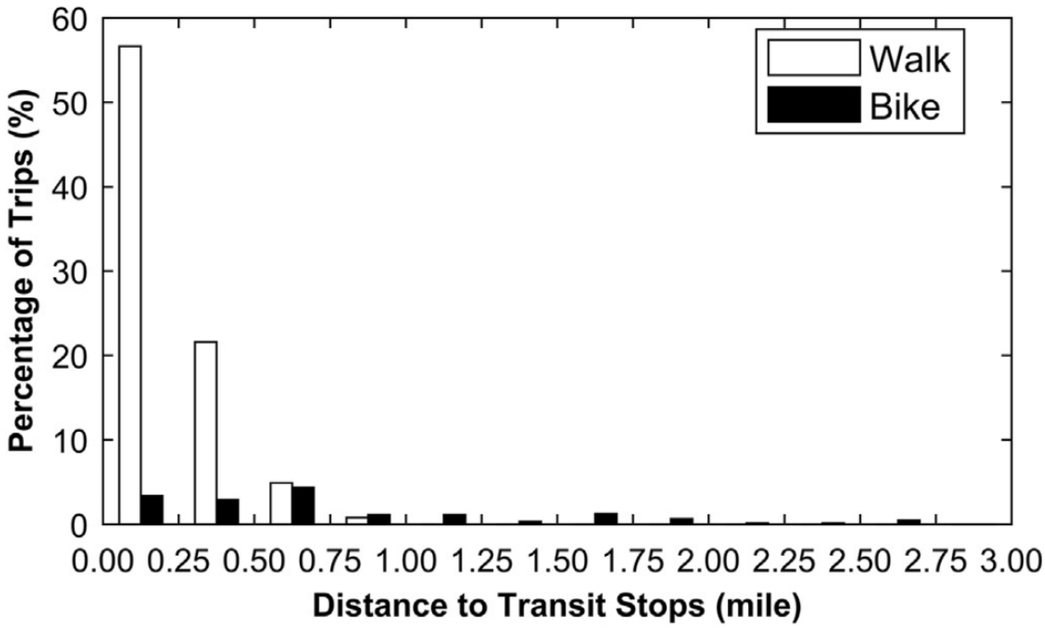


Figure 2.9: Distribution of travel distance of non-motorised transit egress trips. (Source: Zuo et al., 2018)

Further, more relevant to the current study context in terms of warm tropical climate, the urban mass transit catchment area study for the Bangkok, Thailand and Manila, Philippines, Wibowo and Chalermpong (2010) found that the mode access to transit is dominant by foot and most of this trip are noticed within the distance of 400m from station. Meanwhile, Diyanah et al. (2012) discovered that residents of different age groups from Putrajaya, Shah Alam and Sabak Bernam, Malaysia are willing to walk up to 400m.

Likewise, the outcomes from the studies of statistical analysis between the land use around the station and ridership do suggest for the complement support on the findings of 400m walking distance from the primary survey results of the transit users and walking travel behaviour related research above. To name a few, Guerra et al. (2012) examine the relationships between catchment area and transit ridership at 1,500 stations in 21 cities across the United States and indicate that land uses within a 400m radius have a stronger effect on transit ridership in comparison to 400-800m. Zhuang and Zhao (2014) investigated the land use effect on the ridership in Fukuoka, Japan for five different years (1985, 1993, 1998, 2003 and 2008) have revealed that the land use implication on ridership can be better explained in 0-400m than 400-800m distance band. Additionally, Tong et al. (2018) studied the land use characteristics around the 86 transit stations in Shenzhen, China has noted that the concentration of the facilities distribution is often intense within the density gradient curve of 100-400m.

While this study attempts to examine the appropriate dimension of walking distance to demarcate the transit catchment area from literature, it is important to note that the transit catchment area can be defined in the different form. Often, the transit catchment area is defined in the circular form using Euclidean distance or straight line geometry in all directions from the station to create a circle of the catchment area. Given that road networks do not emanate radially from transit stations; several researchers define transit catchment areas on the basis of road network distance in the diamond form (Horner and Murray, 2004; Andersen and Landex, 2008). Despite of the debate on diamond form of transit catchment area could be more realistic in explaining walking accessibility over the circular form of transit catchment area, researchers found that the similar walking distance presented by the different shape of catchment area methodology (i.e. radial or network) have little influence to explain the station level ridership (Guerra et al., 2012). They noticed that people tend to move along the space between buildings, parks, paths, and parking lots as opposed to the road network. Therefore, the radial form of the transit catchment area, the most readily available or easily modelled remains relevant for illuminating the transit users walking accessibility to the station to take transit.

Based on the research findings suggested from the above studies, it is appropriate and rational to justify that the geographic area around the station with 400m walking distance in the radial form as the standard transit catchment area.

2.3 Conclusion

Despite of the substantial amount of the profound empirical studies in these two decades have inspected the relationship between the station level ridership and the characteristics of built environment, socioeconomic and transit service, the systematic review of this study carefully chosen four eligible studies from a pool of 29 relevant studies to integrate their research findings to provide a generalise conclusion on the effect of station area density on ridership. Together, our research synthesis results indicate that the interaction of station area density on ridership is separately determined by the amount of inhabitant and employment who live and work around the station. The results indicate that the likelihood of higher station area density gives a greater prediction on the number of average weekday boarding at the station level. Influenced by the degree of density, the effect of station area population on the average weekday station boarding is expected at the range of 9-23 for every 100 population increment. In the meantime, the effect of station area employment density on the average weekday station boarding is expected from the range of 2-20 for every 100 employment increment. The findings from this section provide insightful information for the assessment of the TOD intensification in Chapter Four. In addition, build upon the consistent evidence from the literature, this study found that the 400m (quarter mile) circle is well-suited for the common standard of transit catchment area as people willingness to walk to transit has largely defined within this zone. It gives us some credence to use 400m circular form of transit catchment area to define the primary geographical unit of analysis for the subsequent study of this research in Chapter Three and Four.

CHAPTER 3

USING BUILDING FLOOR SPACE FOR STATION AREA POPULATION AND EMPLOYMENT ESTIMATION

3.1 Background

As part of a long-established custom, building floor space together with ancillary variables has been widely accepted in development planning studies (at both micro and macro levels) for forecasting the potential future population and employment implications for environmental, economic and social assessments. These studies' findings provide a basis for suggesting recommendations to mitigate possible anticipated consequences of development planning. Conner Holmes (2014) forecasts population and employment from the proposed Wilton Junction new township masterplan for land supply and infrastructure planning. The City of Calgary (2009) analyses the population and employment growth scenarios of the Brentwood Station Area potential development for mobility assessment. Japan International Cooperation Agency (2009) forecasts future population and employment of Kabul Metropolitan to analyse residential, commercial and industrial land supply to meet upcoming demand. These studies apply the planned building floor space from the city's proposed master plan to forecast future population and employment. Nonetheless, these development planning studies are more about future forecasting rather than current estimation, and their results are rarely validated. This may be due to the absence of proper references such as the census for them to check against. Therefore, there is not much of evidence on the efficacy of building floor space in providing a good estimation of existing population and employment of an urban area. Consequently, it becomes highly essential to systematically test and verify the use of building floor space for the urban area – in our case here, transit area – population and employment estimation. This is because an inaccurate station area population and employment estimations may lead to significant implications on financial and economic risks of transit-oriented development.

Based on our knowledge, in transportation studies, Priemus et al. (2008) found that rail passenger forecasts are often inaccurate and biased, with an average overestimation of about 106 percent. At this point, we could only presume that forecasts tend to be imprecise and overestimated to provide minimal risk measures, perhaps with a view to propping up transportation project proposals. Further, it is interesting to observe that there have not been unified variables being adopted by various studies on the building floor space approach for population and employment forecasting. We believe that by better rationalising and refining the present building floor space approach to incorporate additional variables in the transformation procedure, better estimations could be yielded. To test our hypothesis, we, therefore, evaluate the application of building floor space with different variables in the station area population and employment estimation. The specification of the model is illustrated in Section 3.2.

While this study attempts to estimate station area population and employment by using building floor space, it is worth noting that the application of remote sensing for population estimation at a finer geographic scale such as the individual housing and street block level is possible (Wang and Wu, 2010). Physical characteristics extracted from satellite imagery or aerial photographs have been used for deriving population data. As early as in the 1950s, Green (1956), Hadfield (1963), and Binsell (1967) estimated population based on simple dwelling counts from aerial photographs. With the advancement of high resolution remotely sensed imagery and processing technologies in modern days, building footprint (Ural et al., 2011), building rooftop areas (Hillson et al, 2014) and building volume (Wu et al., 2008; Qiu et al., 2010; Lu et al., 2011, Xie et al., 2015; Wang et al., 2016) are employed to estimate population. In addition to remote sensing, Biljecki et al. (2016) adopt a different approach of using a sophisticated detailed semantic 3D city model to generate population estimations. It is thus observed that to date approaches to population estimation have been well researched into but little has been done with respect to employment estimation. Since this study concerns both population and employment estimations of station areas, a slightly different approach needs to be explored.

3.2 Methodology

In order to compare the application of building floor space with different variables in population and employment estimation, we constructed four models using various combinations of variables. As the interaction between variables and models are multidimensional in this research, for that reason, the matrix diagram method is applied to aid our evaluation procedure on the performance of these building floor space models correspond to the set of variables. Matrix diagram method is a useful tool that allows complex relationship situation to be effectively analysed and visualised in a legible way (Eppinger and Browning, 2012; Kent, 2016). Importantly, it offers an advantage to look at specific combinations, determine essential factors and explain the relationships between results, causes and methods (Gunasekaran, 2001 and Asaka and Ozeki, 1990). The matrix diagram of this research as shown in Table 3.1, by the symbols, checkmark denotes the presence of a particular variable in the building floor space model and a cell with hyphen means a sign of absence.

Table 3.1: Different combinations of variables used for the experimentation of building floor space in station area population and employment estimations.

Variables	Model A		Model B		Model C		Model D	
	Pop.	Emp.	Pop.	Emp.	Pop.	Emp.	Pop.	Emp.
Gross Floor Space	✓	✓	✓	✓	✓	✓	✓	✓
Net-to-Gross Floor Space Ratio	-	-	-	-	✓	✓	✓	✓
Net Floor Space per Dwelling Unit	✓	-	✓	-	✓	-	✓	-
Household Size	✓	-	✓	-	✓	-	✓	-
Net Floor Space per Employee	-	✓	-	✓	-	✓	-	✓
Occupancy Rate	-	-	✓	✓	-	-	✓	✓

Note: Pop. = Population; Emp.= Employment

Among the four building floor space models, three models (A, B and C) were based on the existing forecasting studies (Table 3.2) whereas Model D was our proposed, refined, approach. In this way, we can directly compare the quality of estimations given by these models. For population estimation, we considered (i) gross floor space, (ii) net-to-gross floor space ratio, (iii) average net floor space per dwelling unit, (iv) average household size and (v) occupancy rate. On the other hand, (i) gross floor space, (ii) net-to-gross floor space ratio, (iii) average net floor space per employee and (iv) occupancy rate were taken into account for employment estimation.

Model A is a simple approach to estimating population and employment. The model pays no attention to the detailed features of building floor space (i.e. gross vs. net). Gross floor space is the basic total floor space within the building envelope while net floor space is the subset of gross floor space without including unoccupied public spaces such as corridors, stairways, washrooms, parking garages, utility rooms, and mechanical closets. Model A computes population estimation by translating residential gross floor space with net floor space per dwelling unit and average household size. For the case of employment estimation, Model A implies commercial, institution and industrial gross floor space directly with net floor space per employee. Meanwhile, Model B is fairly similar to Model A, with the exception of an additional variable of occupancy rate. Occupancy rate refers to a used space ratio compared to the total amount of available space.

Model C is a more advanced approach in population and employment estimation. Built upon the basic structure of Model A, Model C interprets gross floor space into population and employment with cautious consideration of both gross and net floor spaces. To convert the gross floor space into net floor space, a net-to-gross floor space ratio is applied in Model C. The gap between the net and gross floor spaces becomes increasingly noticeable from low-rise to high-rise buildings (Sev and Ozgen, 2009; Barton and Watts, 2013). Apart from the above, Model D is the most detailed approach that applies all relevant variables used in Models A, B and C. We applied these four models to estimate the population and employment of five station areas in Tokyo. The estimation results obtained from these models were then verified with the actual population and employment data reported in the census.

Table 3.2: Summary of modelling approaches and present population and employment forecasting studies using building floor space.

Modelling Approach	Author(s)	Study Area	Geographic Scale	Purpose of Study
Model A	Watson & Associates Economist Ltd (2017)	Waterloo, Canada	City-wide	To review the development charge with the forecasted public facilities to serve the new development.
	County of Riverside (2015)	Riverside County, United States	County	To appraise the population and employment growth from the general plan for socioeconomic, transportation, environment, public infrastructure and facility planning.
	SGS Economics and Planning (2014)	Parramatta, Australia	Precinct	To evaluate the implication of city centre master plan against the projected economic growth and housing demand.
	Connor Holmes (2014)	Wilton Junction, Australia	Township	To analyse the land use supply and infrastructure planning of the new township proposal to meet the future forecasted population and job demand.
	District of Mission (2010)	Mission, Canada	City-wide	To study commercial and industrial land availability to meet the future labour force demand.
Model B	Strategic Regional Research Alliance (2016)	Greater Toronto Area, Canada	Metropolitan	To examine the impact of regional express rail development on the jobs and housing growth around the transit stations.
	City of Woodland (1996)	Woodland, United States	Township	To evaluate the environment effects of potential population and employment growth from the general plan.
Model C	City of Calgary (2009)	Brentwood, Canada	Precinct	To assess the traffic impact of the station area redevelopment plan.
	Japan International Cooperation Agency (2009)	Kabul Metropolitan, Afghanistan	Metropolitan	To analyse the land use plan to meet the need for regional expansion.

3.3 Study Area and Data

To test the building floor space approach, we employed five station areas namely Toyosu, Etchujima, Tsukishima, Kachidoki and Kiba in Tokyo as our empirical case study (Figure 3.1). They were selected based on the presence of a considerable mixture of jobs and housing composition in the urban environment setting. For this study, they allow us to examine the application of building floor space in both population and employment estimations concurrently. Further, this is also suitable for the developing countries as their mass transit infrastructure investment are largely focuses on urban settlement. The size of each of these station areas is about 50 hectares, an area defined by the 400m Euclidean distance measured from the station (see Section 2.2). The numbers of population and employment obtained from the official census block for the five station areas are shown in Table 3.3. This information will be used as the basis to validate the estimation results.

Table 3.3: Population and employment of Toyosu, Etchujima, Tsukishima, Kachidoki and Kiba station areas.

Station Area	Population[1]	Employment[2]
Toyosu	13,989	21,116
Etchujima	5,166	4,556
Tsukishima	16,463	6,808
Kachidoki	14,934	8,124
Kiba	8,794	15,663

Source:

[1]Statistics Bureau of Japan (2015b)

[2]Statistics Bureau of Japan (2014)

Figure 3.1: An overview of the study area and its geographic location in Tokyo city.

The entire amount of gross floor space in each of our study area (as summarised in Table 3.4) is assembled from the gross floor space of each building located in the station area vicinity. To produce the building gross floor space, we derived them by means of the official Tokyo Metropolitan Government administrative GIS database that contains building polygon with attribute information of building footprint, number of building floor, gross floor space and classification of building use. Using GIS proximity tool, a total of 3,968 building polygons from five station areas are captured from the dataset for this study. As our research applies Euclidean distance principle, subsequently, not all building polygons are precisely fallen within 400m radius of station area buffer. To acquire the gross floor space for the building polygons that partially intersect at the perimeter of the station area, we relied on their weight (based on the proportion of the building footprint size area).

Table 3.4: Estimated total gross floor space of Toyosu, Etchujima, Tsukishima, Kachidoki and Kiba station areas.

Station Area	Estimated Total Gross Floor Area (sq. m)			
	Residential	Commercial	Institution	Industrial
Toyosu	578,098	631,139	20,442	3,389
Etchujima	281,239	123,472	20,442	13,800
Tsukishima	738,100	122,505	42,060	14,440
Kachidoki	775,820	208,320	69,910	25,159
Kiba	425,943	325,754	14,404	13,728

Thanks for the detail attribute documentation, where the amount of floor space per usage activity per building is well established by the city administration, we are able to distinguish and quantify the gross floor space variation of the mixed-use building of our study area. Else, we would refer on the robust technique of Greger (2015) by adopting building footprint area and number of building floor to generate the building gross floor space, as well as rely on the number of address point from the open access business directory to assign the usage fraction and approximate their respective gross floor space quantity in mixed-use building. In the GIS database, the identified apartment tower with ground-floor retail, both residential and commercial gross floor space will be extracted and sorted into two different groups. Nevertheless, we carried this procedure manually for every single mixed-use building polygon of our study area. It took us a while to complete the process for these five station areas because the multi-activity building is frequent in urban areas. Even with a few mistakes observed during our preliminary computation, particularly on the building polygon of high-rise building has resulted in a significant error in our station area population and employment estimation. Therefore, it should be done with caution. In view of applying this method for the cities of developing countries where their building use classification could not be as complex as our study area at this moment, we begin with four basic categories of floor space activity (i.e. residential, commercial, institution and industrial) for this research. Therefore, the given fifteen detail classification of building uses from the official data are reorganised into the aforementioned categories (see Appendix B). As agriculture, forestry and fishery building use is hardly ever notice in an urban setting when compared to the countryside, thus we do not include it in our study. An example of the improvised GIS building floor space data of Toyosu station area for this research is displayed in Appendix C.

Meanwhile, values of the variables for the five station areas' population and employment modelling were assumed to be similar to that of the Tokyo Metropolitan aggregate statistics. These data were obtained and adapted from official statistics, research studies, real estate market reports and guidelines. Net-to-gross floor space ratio for residential, commercial, institution and industrial buildings were set to the value of 0.75, 0.75, 0.75 and 0.90 respectively (see Table 3.5). In the building economic guides from Johnson (1990), the commonly accepted ratio for residential buildings (apartments) is 0.64, while that of commercial (retail and office) ranges between 0.7-0.8; institution (school, hospital, and library) between 0.55-0.76; and industrial between 0.85-0.93. Since the space efficiency of buildings in Tokyo is relatively higher than those in Western countries (due to the smaller parking space requirement), thus a higher value of net-to-gross floor space ratio from the guides are adopted. Average occupancy rates for Tokyo's residential, commercial, institution and industrial properties reported by the real estate market research were applied for our study area. For the case of net floor space per employee, these values were adjusted to the Japanese cities' context with reference to the employment density guide prepared by the British Homes and Communities Agency (2015). We recognise the size difference of working space between Tokyo and the cities of North America and Europe. Miller (2014) discovers the median net office floor space per worker in American cities to be about 25 sq. m, while in Japanese cities it is less than 15 sq. m. We considered the average net floor space per dwelling unit in Tokyo at 65 sq. m., with an average household size of 1.94 persons as documented by the Statistics Bureau of Japan (2015a) and Tokyo Metropolitan Government (2015).

Table 3.5: Data input for the population and employment estimation of five station areas in Tokyo in 2015.

Variables	Residential	Commercial	Institution	Industrial
Net-to-Gross Floor Space Ratio	0.75[1]	0.75[1]	0.75[1]	0.90[1]
Occupancy Rate	0.96[2]	0.98[2]	0.98[2]	0.97[2]
Net Floor Space per Employee (worker per sq. m)	-	20[3]	35[3]	50[3]
Net Floor Space per Dwelling Unit (unit per sq. m)	65[4]	-	-	-
Household Size (residents per dwelling unit)	1.94[5]	-	-	-

Source:

[1]Adapted from Johnson (1990, p. 155);

[2]Adapted from Association for Real Estate Securitization (2017) and Savills (2017);

[3]Adapted from the Homes and Communities Agency (2015) and Miller (2014);

[4]Adapted from the Ministry of Land, Infrastructure, Transport and Tourism (2016); and

[5]Adapted from the Statistics Bureau of Japan (2015a) and Tokyo Metropolitan Government (2015)

3.4 Results and Discussion

We carried out the experiments and benchmarked them against actual governmental census data. The results show a large degree of differences between the accuracy depending on the models and the variables considered. The results of the experiments are presented in Table 3.6. As what we expected, the smallest mean absolute percentage error is observed in our proposed detailed Model D, registering a difference of 9.51% for population estimation and 16.30% for employment estimation. However, it is surprising to note that Model C is only slightly less accurate than Model D. It seems that occupancy rate does not add much value to the model. This could be due to the higher tenancy level in our study area, which gives rise to negligible effects on the results. Likewise, a similar trend can be observed between Model B and Model A, both without input on the occupancy rate. This finding lends support to estimations in station areas with high tenancy level while occupancy rate data are not available.

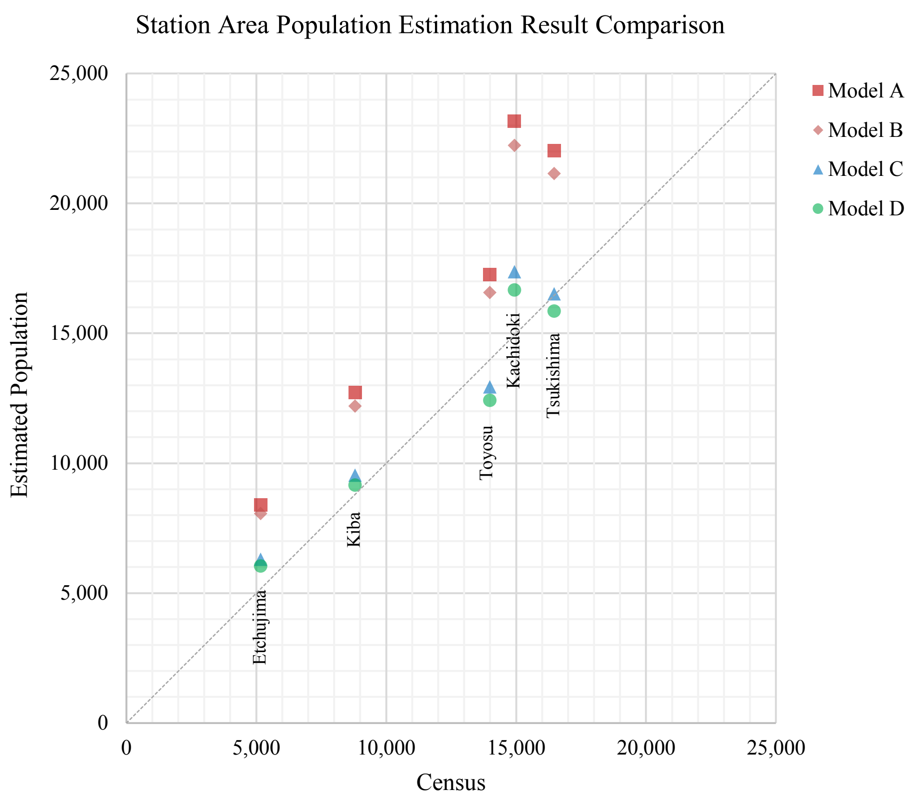
Table 3.6: Tokyo's five station areas' population and employment estimation accuracy assessment results.

Station Area	Model A		Model B		Model C		Model D	
	Pop. (%)	Emp. (%)	Pop. (%)	Emp. (%)	Pop. (%)	Emp. (%)	Pop. (%)	Emp. (%)
Toyosu	+23.34	+52.53	+18.41	+49.48	-7.50	+14.45	-11.20	+12.16
Etchujima	+62.48	+54.38	+55.98	+51.23	+21.86	+16.70	+16.99	+14.31
Tsukishima	+33.81	+11.86	+28.46	+9.59	+0.36	-15.46	-3.66	-17.19
Kachidoki	+55.05	+58.99	+48.85	+55.75	+16.29	+20.17	+11.64	+17.71
Kiba	+44.56	+8.37	+38.78	+6.18	+8.42	-18.46	+4.08	-20.11
Mean Absolute Percentage Error (%)	43.85	37.23	38.10	34.45	10.89	17.05	9.51	16.30

Note: Pop. = Population; Emp.= Employment

'+' and '-' represent over-estimation and under-estimation respectively

Further, it is noted that the mean absolute percentage errors from Models A and B are much higher than Models C and D. Scatter plots from Figure 3.2 also display that in most cases the station area population and employment estimations from Models A and B deviate much further from the actual census data. Models C and D yield better estimations over that of Models A and B because they consider the net-to-gross floor space ratio. The variable helps to exclude unoccupied common spaces such as the lobby, corridor, utility room and garage which are not related to net floor space per dwelling unit and net floor space per employee. Thus, the net-to-gross floor space ratio provides a significant improvement in the estimations over the models without such information. This finding suggests that a net-to-gross floor space ratio is necessary for the building floor space model to achieve accurate estimations of population and employment. Interestingly, while the net-to-gross floor space ratio is crucial, it appears that there is inconsistent performance across the five station areas. In comparison to Models C and D, Model B is noted with good employment estimation for Tsukishima and Kiba station areas even without the information on net-to-gross floor space ratio. In this study, it is premature for us to explain the reason why in this particular model lesser data yielded better results because all errors (induced by quality of input data, homogenous assumptions for all entities in our study area, etc.) have been aggregated in a single number that cannot be decomposed. A potential way to investigate this phenomenon is to attain fine grade local statistics data for the model as well as conducting more case studies to obtain the mean error.



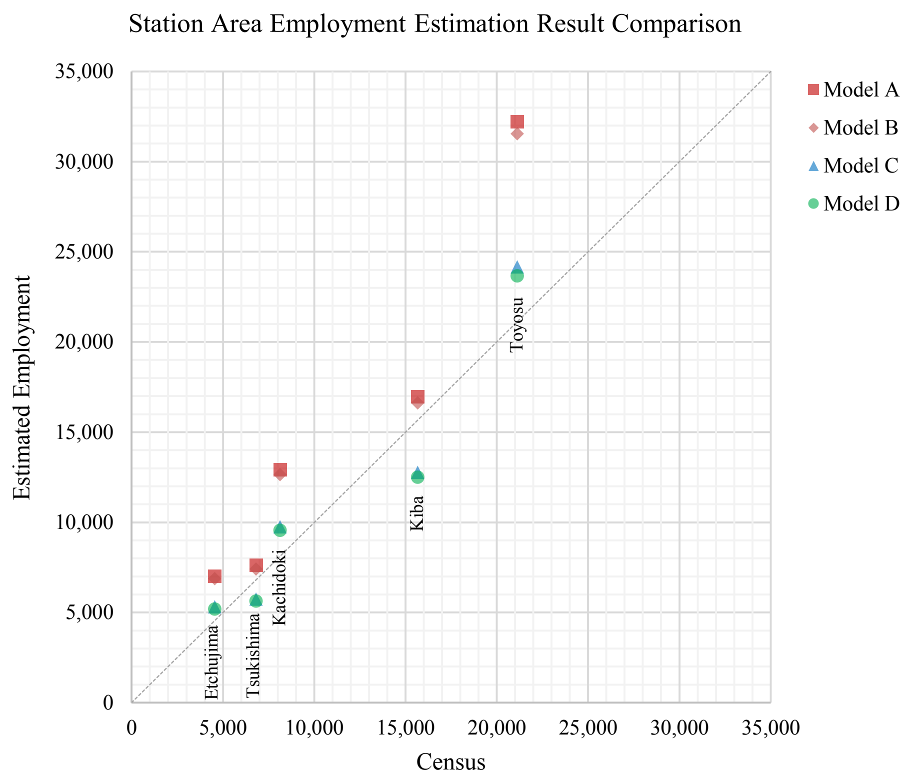


Figure 3.2: Scatter plots of the estimated counts versus census-based counts: population (top) and employment (bottom).

In most cases, we notice that employment estimations tend to suffer from higher discrepancies over the population estimation. A possible reason is that the variation among the working space configuration (office, retail, finance, restaurant, entertainment, hotel, education, healthcare, manufacturing, storage, etc.) is far more wide-ranging and complex than housing space pattern (apartment, detached, studio, etc.). We were expecting that these errors would be absorbed within the statistical variations of different entities in the station area, but it turned out otherwise. This indicates that by simply generalising such diverse characteristics of working space into the three broad categories of commercial, institution and industrial is insufficient. Thus, future studies may consider improving the model by further expanding and refining the employment building floor space classification.

Compared to the related work on finer scale population estimation in urban settings by using remote sensing, the finer building floor space approach (Models C and D) provides a closer approximation of population, recording mean absolute percentage errors at 10.89% and 9.51% correspondingly. By comparison, the accuracy assessment of population estimation by Wang et al. (2016) with building volume for the sub-district registers an error of 16.46%, while the error of population estimation at half size of artificial blocks (an artificial block consists of twenty census blocks) via building volume and census block level housing statistics by Wu et al. (2008) is documented at 15%. Using building volume associated with the spatial autoregressive model, census block level population estimation by Qiu et al. (2010) yields an error of 23.74%. At the neighbourhood level, Xie et al. (2015) observe their population estimation error at 33.12%. This gave us another additional interesting insight itself that using building floor space (m^2) could achieve better estimation than building volume (m^3). We think that building volume is incapable to isolate the internal void space such as atrium and be aware of the lower ground floor in the building. As a consequence, given a similar set of the building (with identical function and geometry), the building volume may produce a different result as compared to building floor space. However, it should be noted that building floor space may not always superior to building volume. For instance, building volume approach has the automated computation advantage over the manual extraction of building floor space approach to eliminate the possible human error.

Drawing on the results from the above studies, it may be suggested that considering building floor space together with the additional information of building morphology (net-to-gross floor space ratio and net floor space per dwelling unit), density coefficient (net floor space per employee), demographic attribute (household size) and real estate statistics (occupancy rate) is capable of providing satisfactory population estimation. Due to the fact that the employment estimation study is relatively uncommon, we are unable to evaluate the accuracy of our employment estimation from building floor space and provide any valuable discussion yet.

3.5 Conclusion

This chapter explores the application of the building floor space approach for station area population and employment estimation. We demonstrate this method using five station areas in Tokyo that are characterised by jobs and housing diversity. The findings from this chapter indicate that under certain circumstances, building floor space can offer a good estimation of population and employment. As detailed census data are rarely available in most developing countries, it is hoped that this approach can serve as a potential tool to provide important station area population and employment information for built environment professionals to support transit oriented development. More importantly, for the purpose of this research we identified that the Model D of building floor space approach is considered as the best among other models we examined in terms of accuracy. Therefore, we would apply the building floor space (Model D) to estimate the station area population and employment in our empirical case study in Chapter Five later. Further, learning from this chapter we take note on the possible highest and lowest error that might expect for building floor space (Model D) is documented at +16.99% and -11.20% for station area population estimation meanwhile +17.71% and -20.11% for station area employment estimation.

CHAPTER 4

TRANSIT-ORIENTED DEVELOPMENT ZONING INTENSIFICATION ASSESSMENT OF KUALA LUMPUR MONORAIL

4.1 Background

Kuala Lumpur is a national capital of Malaysia and one of the major economic and cultural growth centre in Asia. The size of Kuala Lumpur is about 242 square kilometres with a population of 1.67 million (2010) and gross domestic product (GDP) RM 84,852 million (2010) (Figure 4.1).

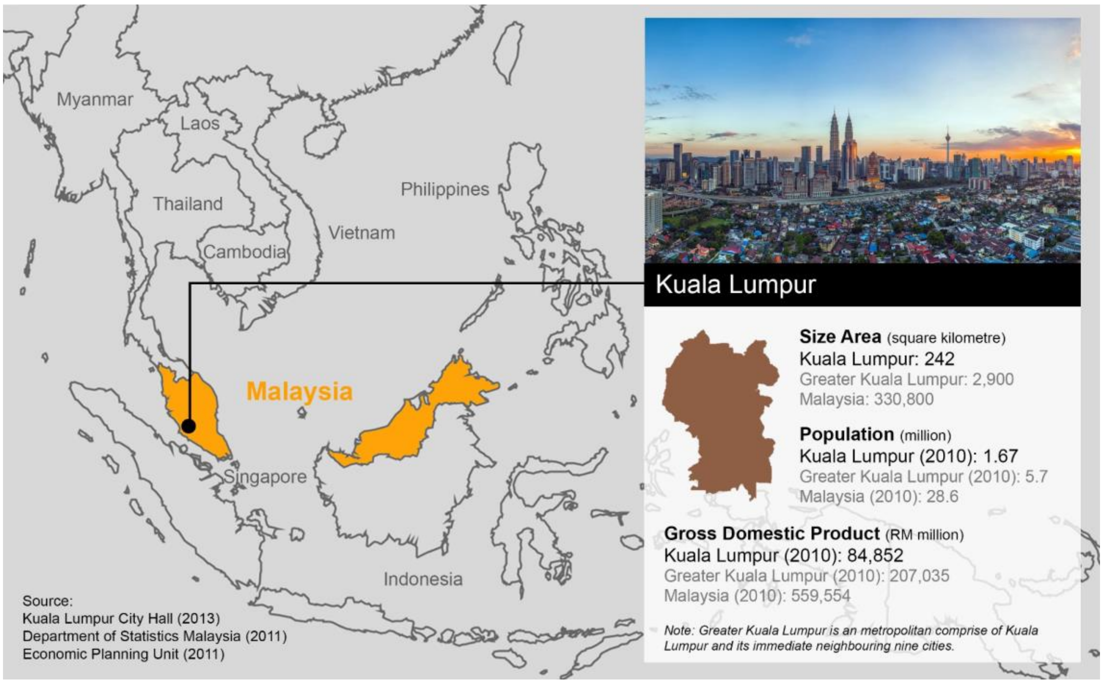


Figure 4.1: Basic profile and location of Kuala Lumpur city.

Like many similar practices from the other cities around the world, the urban development of Kuala Lumpur is governed by the statutory master plan. The official statutory master plan of Kuala Lumpur will be known as Kuala Lumpur City Plan 2020. The Kuala Lumpur City Plan 2020 is formulated under the provision of the Federal Territory (Planning) Act 1982 (Act 267) as a local blueprint for the 10-year city's development. By envisioning Kuala Lumpur towards a world class city, the plan outlines both strategic framework and development control mechanism to support Kuala Lumpur to achieve its vision. The development control mechanism of the Kuala Lumpur City Plan 2020 translates every strategic direction into the detail zoning provisions with regards to provide guidance on the development and use of land in Kuala Lumpur. It serves as an important urban planning and design instrument for Kuala Lumpur City Hall, the administrator of Kuala Lumpur to regulate and manage the physical development of land through development control processes and procedures. Development permission of any plot of land will be granted if only if the proposal is properly compliance with the designated land use zone, development intensity and design guideline prescribed in the Kuala Lumpur City Plan 2020.

The preparation of the Kuala Lumpur City Plan 2020 was beginning back in 2005, the first draft of the plan was unveiled in 2008 and the second draft in 2013. Although it was meant to become official, the document remained as a draft until today. Considering the tremendous change of local and global economy trend over recent decades, driven by disruptive technologies (e.g. artificial intelligence and big data, autonomous vehicles, Uber, etc…), demography, socioeconomic, real estate and housing development has led the Kuala Lumpur to step back and review the Kuala Lumpur City Plan 2020 before making it officially gazette and adoption for Kuala

Lumpur. The plan was prepared with the involvement of intensive public participation. In Malaysia, public participation is necessary for every master plan preparation accordingly to the Town and Country Planning Act 1976 (Act 172). Any planning documents have to be publicly displayed and open for comments from the citizens, at the local level like Kuala Lumpur City Plan 2020 is the most rigorous as it covers the use of privately owned land.

As the national premier city of Malaysia, Kuala Lumpur often takes a lead role in experimenting various innovative planning and design concept to improve its' urban sustainability and continuously kept their competitiveness on par with other cities in the global context. In this research context, Kuala Lumpur is among the first few cities in Malaysia, has placed a serious commitment on TOD by incorporating the TOD concept into its master plan. In the draft Kuala Lumpur City Plan 2020, the land around the station area has been revised to received zoning intensification to accommodate the future population and employment growth of Kuala Lumpur. To our knowledge, the zoning formulation of draft Kuala Lumpur City Plan 2020 is mainly limited to the benchmarking approach. Benchmarking compare and imitate on the best practices of TOD, which aspire to be similar like the target TOD from other cities. A major constraint of benchmarking is that while it helps Kuala Lumpur to position themselves, yet it remains inadequate in formulating optimal TOD zoning intensification to be tailored with respect to the transit capacity in the local context where we discussed in the Chapter One. At present, to translate the quantitative concept of TOD into the quantitative dimension of TOD zoning intensification with the limitation of knowledge on the connection between station area density and ridership poses a great challenge for Kuala Lumpur to deliver a meaningful TOD. Here, based on our research synthesis on the generalised effect of station area density on ridership from Chapter Two (Section 2.2), we apply them to assess the early effort of zoning intensification of Kuala Lumpur by using Kuala Lumpur Monorail as our case study with the view to demonstrate a better way of intensifying zoning for TOD promotion.

4.2 Zoning and Transit-Oriented Development in Kuala Lumpur

According to the draft Kuala Lumpur City Plan 2020, Kuala Lumpur city has seven major classifications of land use zone: residential, commercial, mixed use, industrial, institution, green areas, and others (see Table 4.1). Within each of these general categories are more narrowly defined divisions. For example, there are four kinds of commercial zone namely (i) Local Commercial, (ii) Commercial, (iii) Major Commercial, and (iv) City Centre Commercial. Additionally, every single land use zone has been assigned with intensity regulation based on its local context. The Residential 1 land use zone refers to the residential developments of 4 persons per acre up to a maximum of 40 persons per acre. More detail descriptions on the land use zoning of Kuala Lumpur city is available in Appendix D. As zoning is an instrument for the city to guide the development of land, it specifies all plot of lands in the city which certain use and intensity are permitted. To provide an illustration, a Residential 3 land use zone can only be allowed for the residential type development with the density of 160-400 persons per acre, or else, no development right can be granted upon the application and approval until such condition is fulfilled. Apart from the intensity, the land use zone often contains dimensional requirements such as building set-back, plinth area, and to a certain extent design guideline of architecture and landscaping

Table 4.1: Summary of land use zoning and intensity control of Kuala Lumpur.

Major Land Use	Land Use Zone	Permitted Plot Ratio (Max)	Permitted Density (Max)	Remarks
Commercial	City Centre Commercial	1: 10	-	
	Major Commercial	1: 9	-	
	Commercial	1: 8	-	
	Local Commercial	1: 7	-	
Mixed Use	Mixed Use	1: 10	-	Residential at least 60% of total gross floor area
	Mixed Use Industry	1: 4	-	Maximum allowable commercial 30% of total gross floor area
Residential	Residential 1	-	40 persons per acre	4 – 40 persons per acre
	Residential 2	-	120 persons per acre	48 – 120 persons per acre
	Residential 3	-	400 persons per acre	160 – 400 persons per acre
	Traditional Village	-	-	-
	Establishing Housing	-	-	Remain as per current density
	Public Housing	-	400 persons per acre	-
Industrial	Industry	1: 2	-	-
	Technology Park	1: 2	-	-
Institution	Institution	1: 8	-	-
Green Areas	Public Open Space	-	-	-
	Private Open Space	-	-	-
	Forest Reserve	-	-	-
Others	Public Facilities	-	-	-
	Transportation	-	-	-
	Infrastructure and Utility	-	-	-
	Cemetery	-	-	-

standards are imposed. Since these regulations give no significant implication on our research concern with regards to the intensity of land use zone, they are not further elaborated in this study.

The mechanism of development intensity adopted by the zoning plan in Kuala Lumpur city relies on density and plot ratio. The regulation of density is applying for residential land use zone while the plot ratio is imposing for the land use zone category of mixed use, commercial, industrial and institution. Density is a numerical measure of the number of residents to the size of the piece of land upon which it is built. In the meanwhile, plot ratio refers to the ratio of the total gross floor area of building(s) over the total size area of that given plot of land. The terminology of plot ratio varies between countries. Plot ratio is known as the floor space ratio in Japan and United States. In India, the floor space index is used. In this research, it is important to note that both density and plot ratio set the limits on the building size, indirectly it also limits the number of people that a building can hold. By giving the permission for a greater designated density or plot ratio in land use zoning, it allows developers or land owners to build more units on a given area of land, thereby a large amount of people is expected. The illustrations of the intensity mechanism of land use zone are available in Figure 4.2 and Figure 4.3.

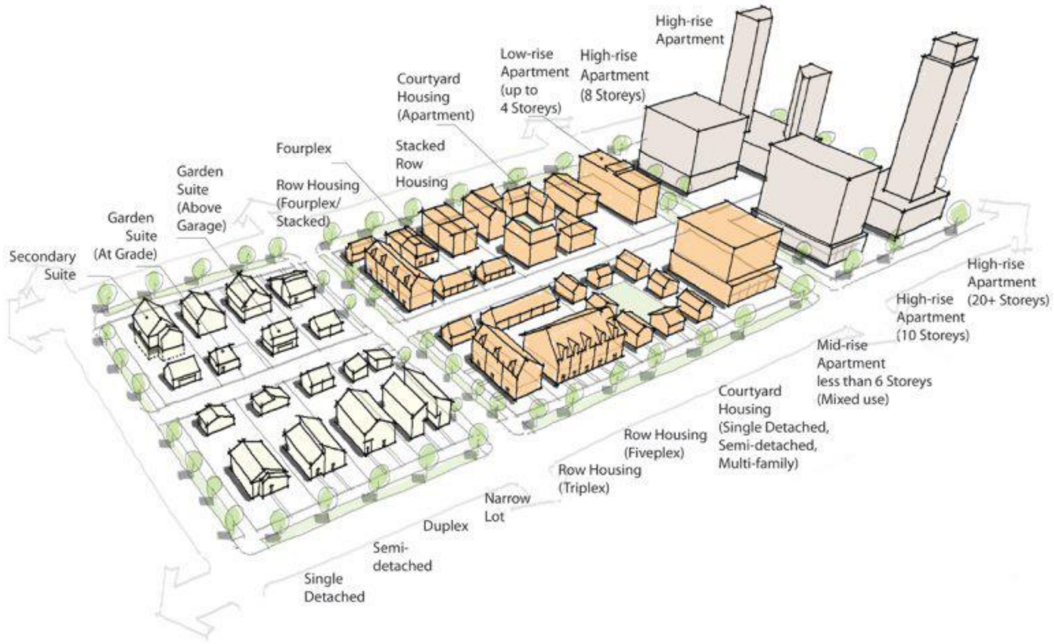


Figure 4.2: An image of the possible housing size variation could have resulted from the density control specified by the residential land use zone in draft Kuala Lumpur City Plan 2020. Lower left: Residential 1 land use zone (low density residential zone of 4 – 40 persons per acre). Middle: Residential 2 land use zone (medium density residential zone of 48 – 120 persons per acre). Upper right: Residential 3 and Public Housing land use zone (high density residential zone of 160 – 400 persons per acre).

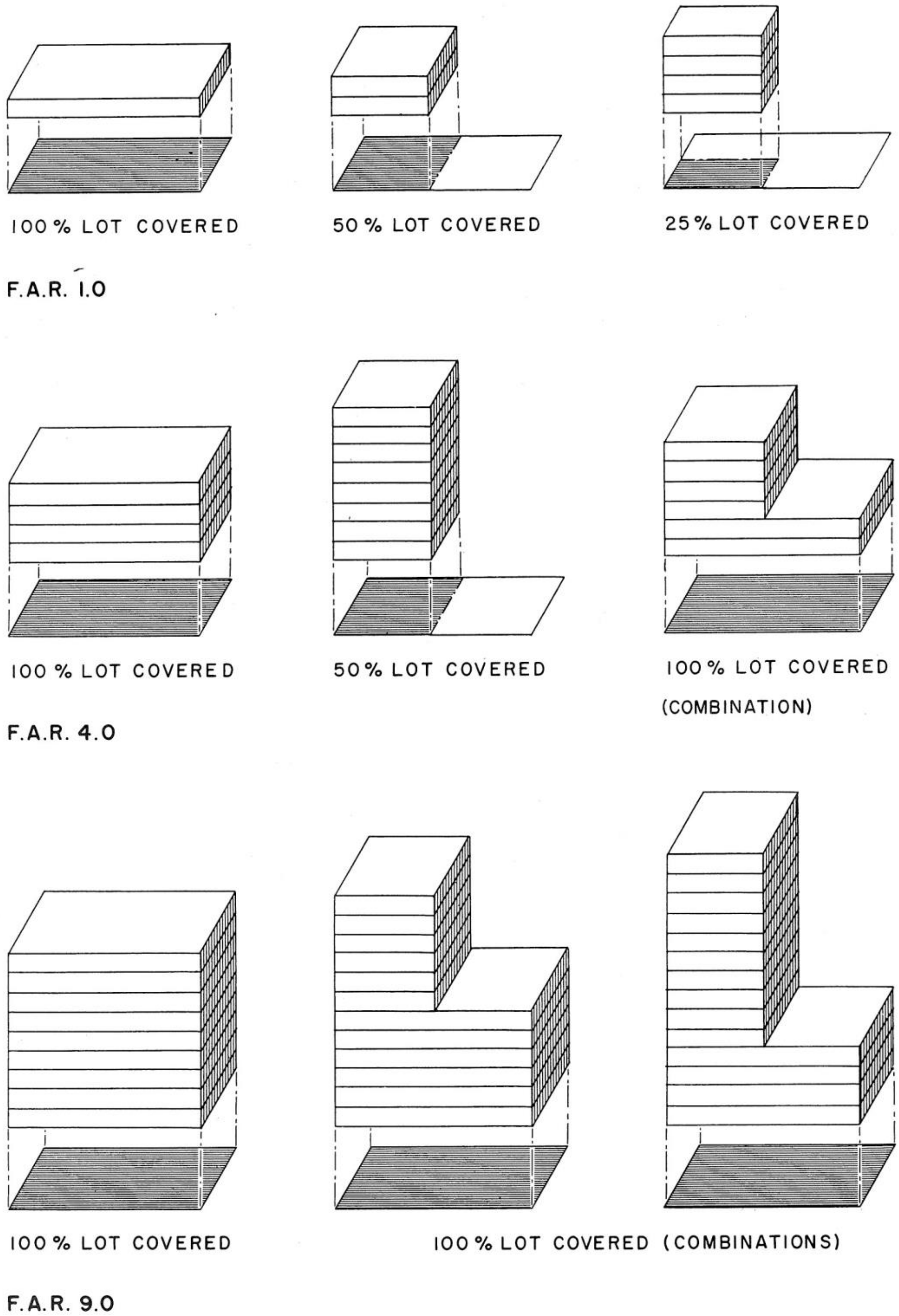


Figure 4.3: A diagram explains the plot ratio or floor area ratio as the ratio between the total gross floor area of a building and the area of a building plot. A land use zone with higher plot ratio, it allows for greater building size development. The illustrations show that even building form may vary, nevertheless they represent a similar total gross floor area.

For the purpose of promoting TOD, Kuala Lumpur city recognised the importance of the density as one of the key principles of TOD. The notion of the importance on higher density environment around the station area towards the creation of TOD has been incorporated in the zoning plan formulation. From the draft Kuala Lumpur City Plan 2020, one can notice that the early land use zoning proposal for the land with geographical proximity around all the total 59 stations of Kuala Lumpur city allows for intense development than the existing. For an instance of Cheras Station, the existing medium intensity of industrial and residential land use activities received new land use zoning where intense developments are allowed (Figure 4.4). These new land use zones include Mixed Use (max permissible plot ratio of 1:10), Mixed Used Industry (max permissible plot ratio of 1:4), Major Commercial (max permissible plot ratio of 1:9), Commercial (max permissible plot ratio of 1:8) and Residential 3 (max permissible density of 400 persons per acre).

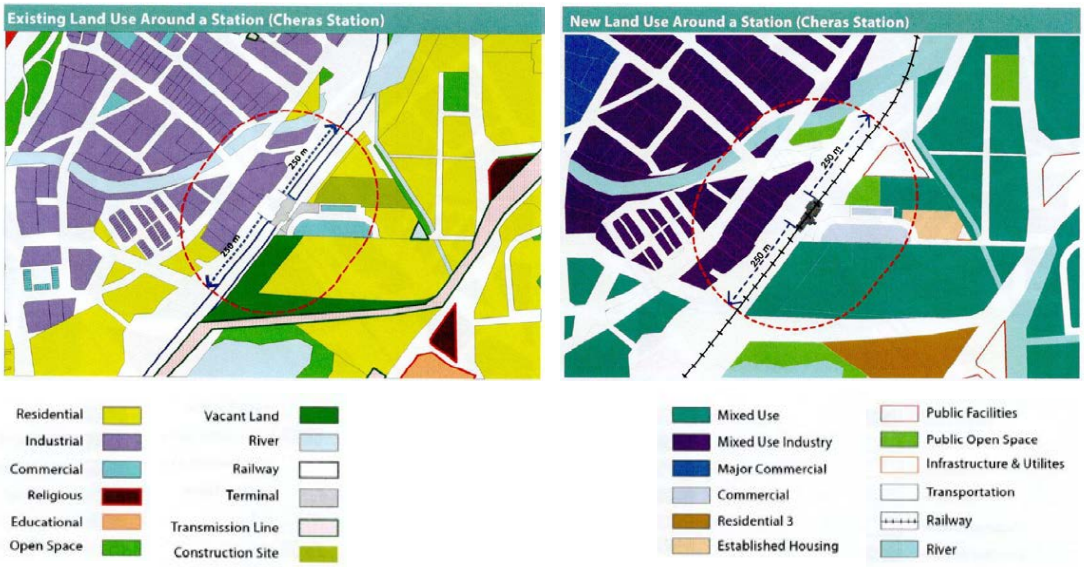


Figure 4.4: The image on the left shows the existing of land use around Cheras station and the image on the right illustrated the new early proposed land use zone around the similar station by the draft Kuala Lumpur City Plan 2020.

It is interesting to note that on top of the underlying land use zone determines the development right which we have discussed so far, the draft Kuala Lumpur City Plan 2020 introduces overlay planning control of transit planning zone to further improve the integration of station area environment with transit. The transit planning zone is a district of 250m circular area measured from the station intended to set out additional incentives (Figure 4.4). Any plot of land/ part of the land that falls within transit planning zone with the underlying land use zone of commercial, residential, mixed use industrial, institutional will be given an additional density or plot ratio bonus on top of the maximum permissible density or plot ratio we stated earlier. The incentive only serves to those proposed developments with pedestrian linkage to/from the station and provision of high quality public space for safe and walkable pedestrian environment. The amount of the density and plot ratio incentive is defined by the Kuala Lumpur City Hall on a case by case basis. Without much reliable hint on these incentives, this research mainly considers the underlying land use zone into the zoning intensification assessment for the case study of Kuala Lumpur monorail.

4.3 Kuala Lumpur Monorail Station Areas

To evaluate the implication of zoning intensification effort from Kuala Lumpur, this study specially focused on the Kuala Lumpur monorail station areas as their geographic environment essentially situated in the bustling central district of Kuala Lumpur (Figure 4.5, 4.6 and 4.7). Kuala Lumpur monorail station areas are served by the monorail, ranked as the busiest urban rail system with 2.915 million annual ridership per kilometre (Ministry of Transport Malaysia, 2015). The monorail system spans 8.6 kilometres connects 11 station areas with the capacity of 2,556 passengers per hour per direction (pphpd) (as of the year 2012). It covers KL Sentral, an integrated public transportation hub of Kuala Lumpur in the south and Titiwangsa, urban neighbourhood in the north. The detailed characteristic of existing activities, early designated land use zoning, estimated number of population and employment, and ridership information for every station areas of Kuala Lumpur monorail is elaborate on the following page. The description on the individual Kuala Lumpur station areas can be read together with several statistics indicated in Figure 4.8 and 4.9. The existing land use activities and early land use zoning proposal for Kuala Lumpur monorail station areas are generated from the authorised Kuala Lumpur City Hall administrative geographic information system (GIS) dataset. Whereas, the station level ridership information of Kuala Lumpur monorail is obtained from the official urban public transport survey conducted by the Land Public Transport Commission, Ministry of Transport Malaysia. The number of population and employment for Kuala Lumpur monorail station areas is estimated by using the station level building floor space where it derived from the Kuala Lumpur administrative GIS dataset and land use intensity prescription in the early zoning plan (detail procedure is available in section 4.4.1).

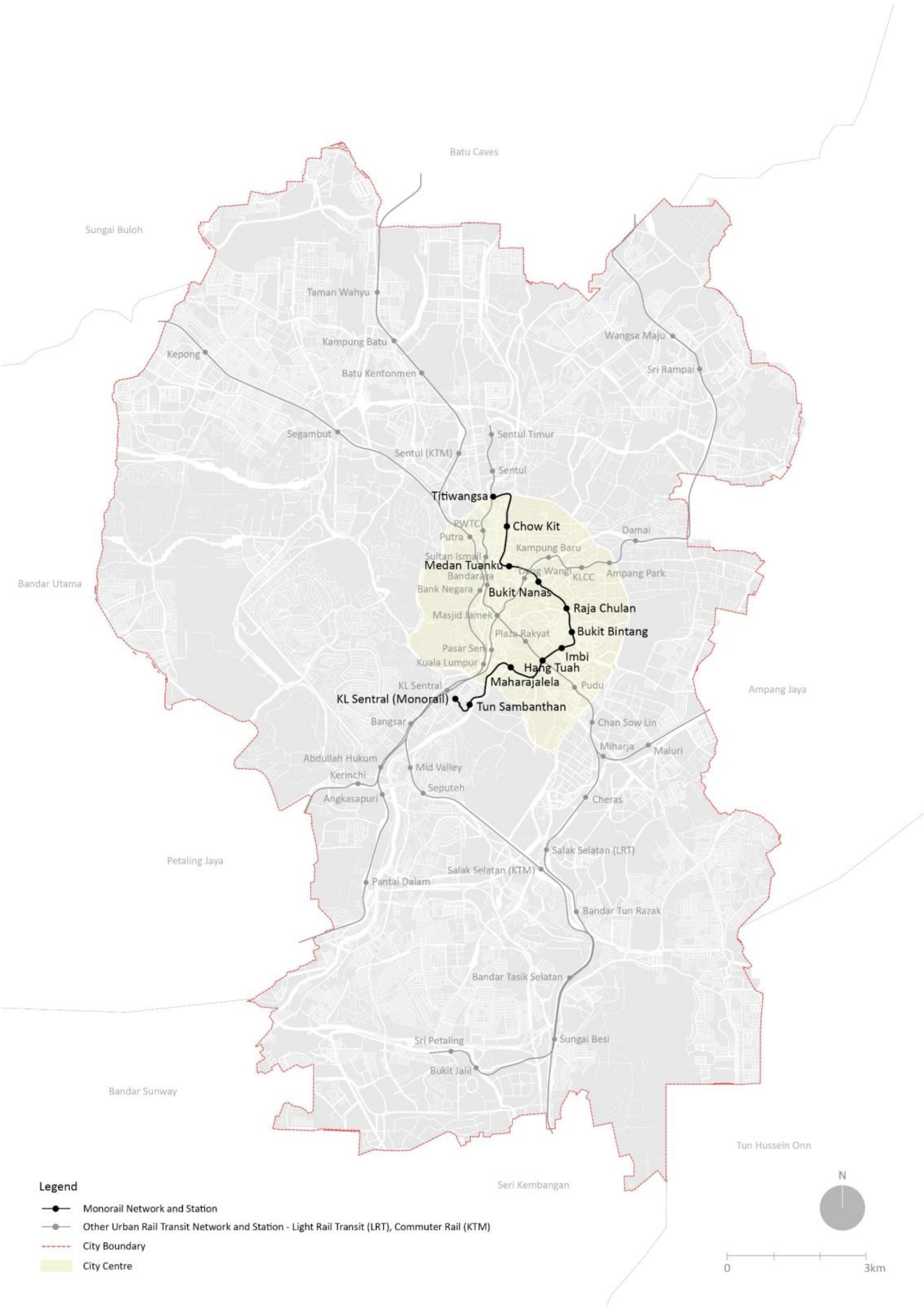


Figure 4.5: Geography context of monorail station areas in Kuala Lumpur.

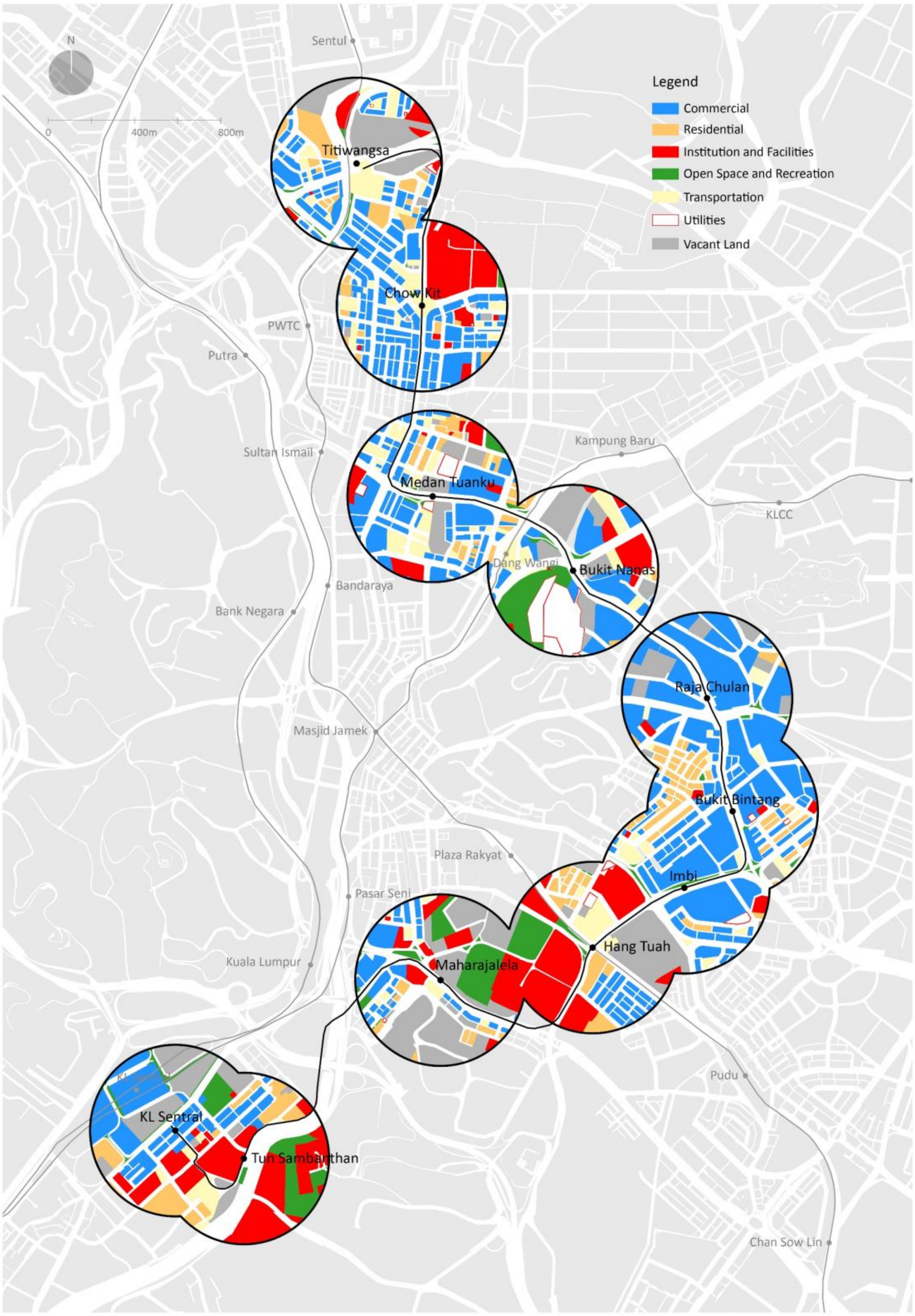


Figure 4.6: Existing land use activities of Kuala Lumpur monorail station areas in 2012.

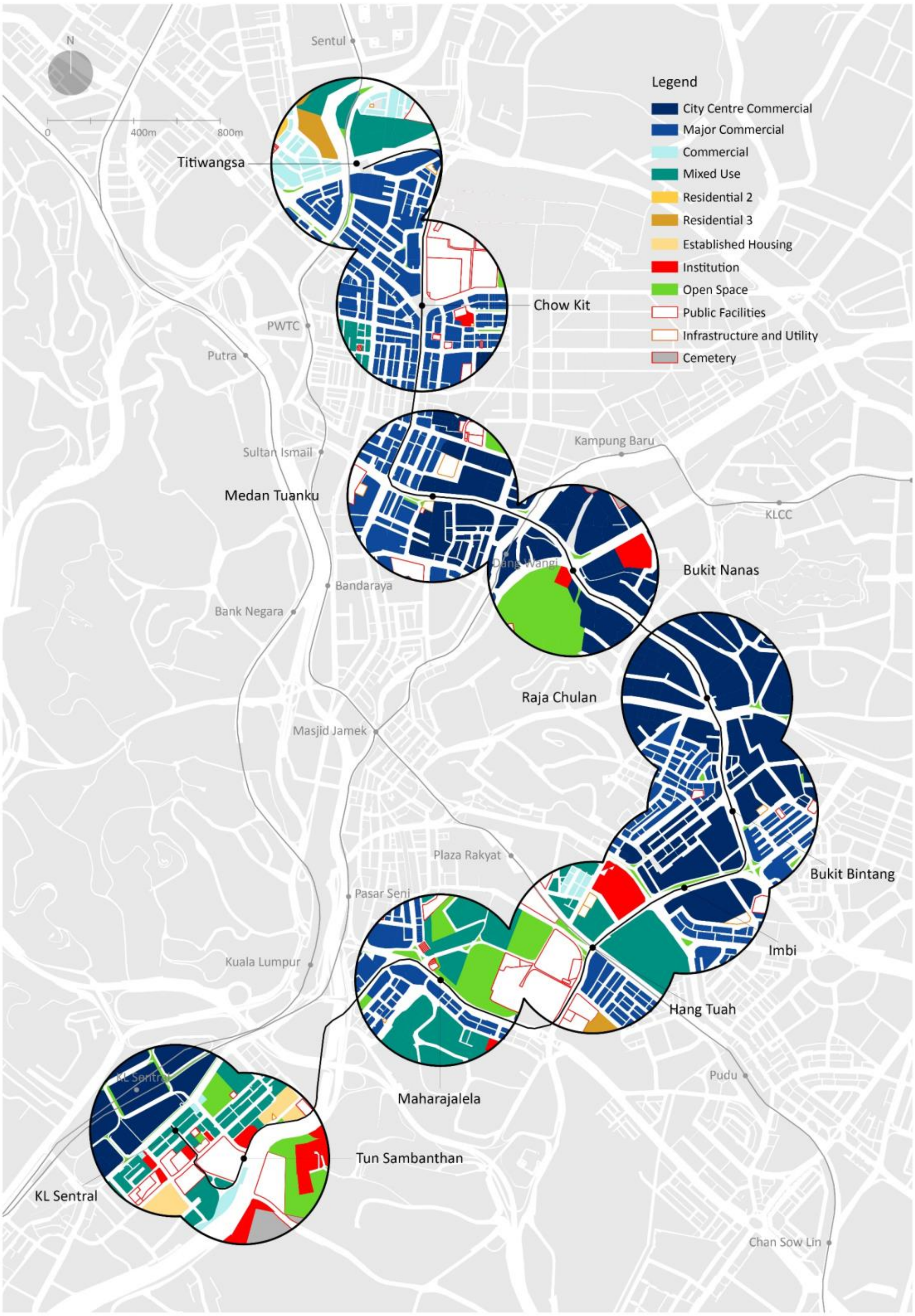
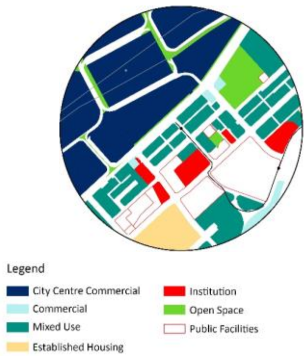
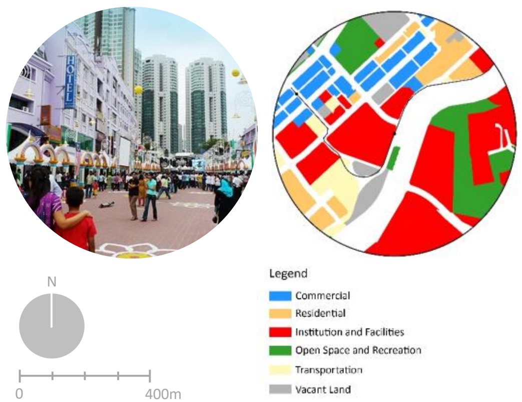
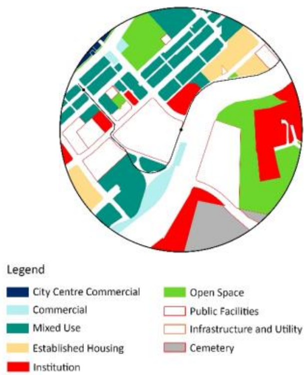
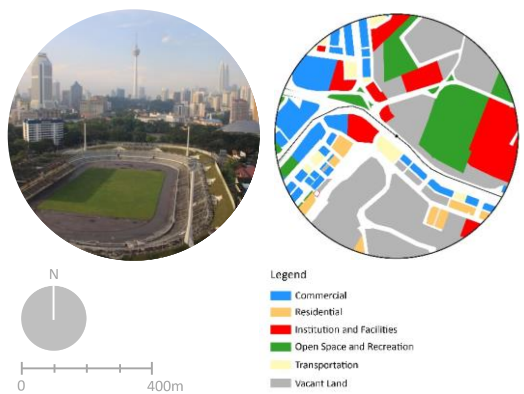
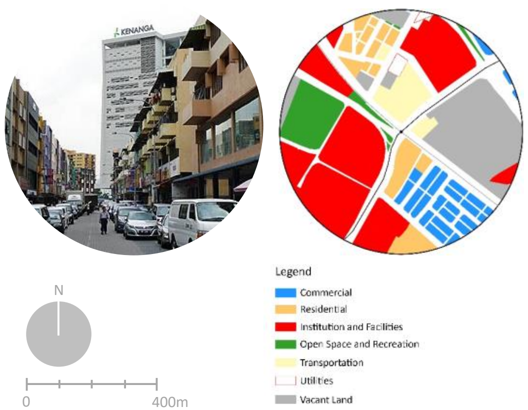


Figure 4.7: Early designated land use zoning of Kuala Lumpur monorail station areas.

<table>
<tr><th colspan="2">Station Area</th><th>Description</th></tr>
<tr><td colspan="2">1. KL Sentral</td><td rowspan="2">KL Sentral the is the main intermodal public transit hub and gateway to Kuala Lumpur. With good connectivity, major business and commercial activities can be found around this area. The existing estimated number of population and employment in KL Sentral is documented at 5,960 and 15,738. The early designated zoning proposed by the draft Kuala Lumpur City Plan 2020 for KL Sentral includes city centre commercial and mixed use zone. The intensity for both of this zone is permitted for the highest maximum plot ratio 1:10. In the proposed zoning setting, the number of population and employment in KL Sentral would expect the increase to 10,424 and 57,823 respectively. The existing average weekday boarding per peak hour of KL Sentral station for inbound is recorded at 733. As the outbound journey of monorail terminates at KL Sentral station, hence, KL Sentral station does not receive any boarding and onboard passenger. Instead, outbound monorail passengers have to alight from this station.</td></tr>
<tr><td>Existing

</td><td>Early Zoning

</td></tr>
<tr><td colspan="2">2. Tun Sambathan</td><td rowspan="2">Tun Sambanthan is an urban neighbourhood with local retail and popular as the cultural district for art and religious related activities. The existing estimated number of population and employment in Tun Sambanthan is documented at 6,647 and 4,117. The early designated zoning proposed by the draft Kuala Lumpur City Plan 2020 tried to further strengthen Tun Sambanthan as an urban neighbourhood with mixed use zone and enhancing the cultural value by applying institution zone on the existing building and land of cultural organisations. The intensity for mixed use and institution zone is permitted for the highest maximum plot ratio at 1:10 and 1:8 respectively. In the proposed zoning setting, the number of population and employment in Tun Sambathan would expect the increase to 15,059 and 18,557 respectively. The existing average weekday boarding per peak hour of Tun Sambanthan station for both inbound and outbound is recorded at 84.</td></tr>
<tr><td>Existing

</td><td>Early Zoning

</td></tr>
</table>

Station Area		Description
3. Maharajalela		Maharajalela is a home for several national stadiums which serve as the main venue to hold both national and international celebrations and sports events. Some commercial and retail activities are available in Maharajalela, most of them are linearly situated next to the major road. The existing estimated number of population and employment in Maharajalela is documented at 1,556 and 9,012. The early designated zoning proposed by the draft Kuala Lumpur City Plan 2020 introduces major commercial and mixed use zone to Maharajalela. The intensity for major commercial and mixed use zone is permitted for the highest maximum plot ratio at 1:9 and 1:10 respectively. In the proposed zoning setting, the number of population and employment in Maharajalela would be expected to significantly increase to 27,131 and 45,513 respectively. The existing average weekday boarding per peak hour of Maharajalela station for inbound is recorded at 27 and outbound is 88.
Exiting 	Early Zoning 	
4. Hang Tuah		Hang Tuah is an urban neighbourhood comprised of public housing with local retail and education institutions. The existing estimated number of population and employment in Hang Tuah is documented at 6,159 and 5,749. The early designated zoning proposed by the draft Kuala Lumpur City Plan 2020 for Hang Tuah includes major commercial, mixed use zone, and residential 3 zone. The intensity for major commercial and mixed use zone is permitted for the highest maximum plot ratio at 1:8 and 1:10 respectively. While the maximum allowable density for residential 3 zone is 400 persons per acre. In the proposed zoning setting, the number of population and employment in Hang Tuah would expect the increase to 16,906 and 29,887 respectively. The existing average weekday boarding per peak hour of Hang Tuah station for inbound is recorded at 1,596 and outbound is 416.
Existing 	Early Zoning 	

<table>
<tr><th colspan="2">Station Area</th><th>Description</th></tr>
<tr><td colspan="2">5. Imbi</td><td rowspan="3">Imbi is a shopping and tourist attraction district with a cluster of large department stores and retail malls. The existing estimated number of population and employment in Imbi is documented at 1,426 and 26,723. The early designated zoning proposed by the draft Kuala Lumpur City Plan 2020 for Imbi includes city centre commercial, major commercial and mixed use zone. The intensity for city centre commercial, major commercial and mixed use zone is permitted for the highest maximum plot ratio at 1:10, 1:9 and 1:10 respectively. In the proposed zoning setting, the number of population and employment in Imbi would expect increase to 5,243 and 55,650 respectively. The existing average weekday boarding per peak hour of Imbi station for inbound is recorded at 117 and outbound is 264.</td></tr>
<tr><td>Existing</td><td>Early Zoning</td></tr>
<tr><td>
</td><td>
</td></tr>
<tr><td colspan="2">6. Bukit Bintang</td><td rowspan="3">Bukit Bintang is a popular shopping, entertainment, and fashion district of Kuala Lumpur. The existing estimated number of population and employment in Bukit Bintang is documented at 4,293 and 25,509. The early designated zoning proposed by the draft Kuala Lumpur City Plan 2020 for Bukit Bintang is mainly city centre commercial and major commercial zone. The intensity for city centre commercial and major commercial is permitted for the highest maximum plot ratio at 1:10 and 1:9 respectively. In the proposed zoning setting, the number of employment would have expected two fold to 61,289. Without any mixed use or residential zone, the number of population in Bukit Bintang would expect to decrease to 0. The existing average weekday boarding per peak hour of Bukit Bintang station for inbound is recorded at 78 and outbound is 420.</td></tr>
<tr><td>Existing</td><td>Early Zoning</td></tr>
<tr><td>
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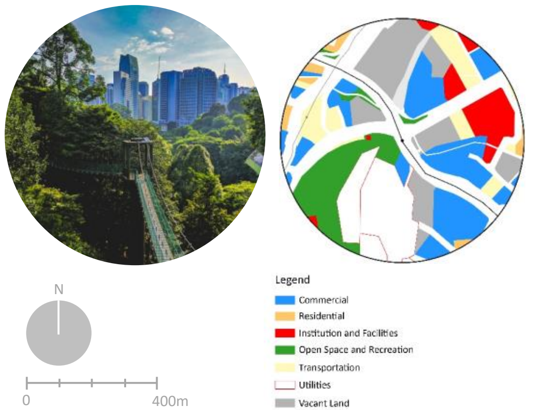
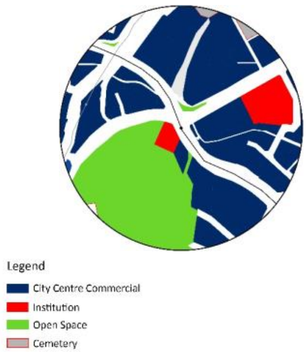
</td></tr>
</table>

<table>
<tr><th colspan="2">Station Area</th><th>Description</th></tr>
<tr><td colspan="2">7. Raja Chulan</td><td rowspan="2">Raja Chulan is the busiest central business district of Kuala Lumpur with major finance and office towers. It is 15 minutes walking distance away from the Kuala Lumpur Twin Towers. The existing estimated number of population and employment in Raja Chulan is documented at 2,305 and 44,946. The early designated zoning proposed by the draft Kuala Lumpur City Plan 2020 for Raja Chulan is mainly city centre commercial and major commercial zone. The intensity for city centre commercial and major commercial is permitted for the highest maximum plot ratio at 1:10 and 1:9 respectively. In the proposed zoning setting, the number of employment would have expected two fold to 96,509. Without any mixed use or residential zone, the number of population in Raja Chulan would expect to decrease to 0. The existing average weekday boarding per peak hour of Raja Chulan station for inbound is recorded at 26 and outbound is 76.</td></tr>
<tr><td>Exiting

</td><td>Early Zoning

</td></tr>
<tr><td colspan="2">8. Bukit Nanas</td><td rowspan="2">Bukit Nanas is part of the central business district of Kuala Lumpur with one of the popular landmark of Kuala Lumpur Tower and Bukit Nanas tropical rainforest reserved (the oldest gazetted forest in the country). The existing estimated number of population and employment in Bukit Nanas is documented at 665 and 15,994. The early designated zoning proposed by the draft Kuala Lumpur City Plan 2020 for Bukit Nanas is mainly city centre commercial and forest reserve zone. The intensity for city centre commercial is permitted for the highest maximum plot ratio at 1:10. In the proposed zoning setting, the number of employment would have a significant increase to 70,594. Without any mixed use or residential zone, the number of population in Bukit Nanas would expect to decrease to 0. The existing average weekday boarding per peak hour of Bukit Nanas station for inbound is recorded at 53 and outbound is 201.</td></tr>
<tr><td>Existing

</td><td>Early Zoning

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<table>
<tr><th colspan="2">Station Area</th><th>Description</th></tr>
<tr><td colspan="2">9. Medan Tuanku</td><td rowspan="2">Medan Tuanku is an office and commercial district situated next to the central business district of Kuala Lumpur. The existing estimated number of population and employment in Medan Tuanku is documented at 1,783 and 29,145. The early designated zoning proposed by the draft Kuala Lumpur City Plan 2020 for Medan Tuanku includes city centre commercial and major commercial. The intensity for city centre commercial and major commercial is permitted for the highest maximum plot ratio at 1:10 and 1:9 respectively. In the proposed zoning setting, the number of employment would have expected three fold to 83,434. Without any mixed use or residential zone, the number of population in Medan Tuanku would expect to decrease to 0. The existing average weekday boarding per peak hour of Medan Tuanku station for inbound is recorded at 68 and outbound is 78.</td></tr>
<tr><td>Existing

</td><td>Early Zoning

</td></tr>
<tr><td colspan="2">10. Chow Kit</td><td rowspan="2">Chow Kit is a bustle market district of Kuala Lumpur. The existing estimated number of population and employment in Chow Kit is documented at 1,958 and 23,179. The early designated zoning proposed by the draft Kuala Lumpur City Plan 2020 for Chow Kit includes major commercial and mixed use. The intensity for major commercial and mixed use is permitted for the highest maximum plot ratio at 1:9 and 1:10 respectively. In the proposed zoning setting, the number of employment would have expected a significant increase to 61,650. With some mixed use zone, the number of population in Chow Kit would be expected to grow slightly to 2,990. The existing average weekday boarding per peak hour of Chow Kit station for inbound is recorded at 101 and outbound is 610.</td></tr>
<tr><td>Existing

</td><td>Early Zoning

</td></tr>
</table>

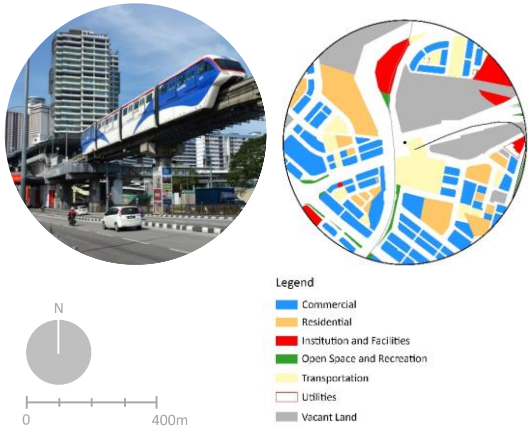
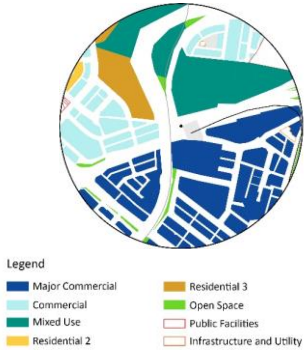
<table>
<tr><th colspan="2">Station Area</th><th>Description</th></tr>
<tr><td colspan="2">11. Titiwangsa</td><td rowspan="2">Titiwangsa is an urban neighbourhood situated at the northern fringe of Kuala Lumpur central district. The existing estimated number of population and employment in Titiwangsa is documented at 7,083 and 13,103. The early designated zoning proposed by the draft Kuala Lumpur City Plan 2020 for Titiwangsa includes major commercial, mixed use and residential 3. The intensity for major commercial and mixed use is permitted for the highest maximum plot ratio at 1:9 and 1:10 respectively. While the maximum allowable density for residential 3 zone is 400 persons per acre. In the proposed zoning setting, the number of employment would have expected to grow to 55,990. With the substantial amount of mixed use and residential zone, the number of population in Titiwangsa would be expected two fold to 16,072. The existing average weekday boarding per peak hour of Titiwangsa station for outbound is recorded at 698. As the inbound journey of monorail terminates at Titiwangsa station, hence, Titiwangsa station does not receive any boarding and onboard passenger. Instead, inbound monorail passengers have to alight from this station.</td></tr>
<tr><td>Existing

</td><td>Early Zoning

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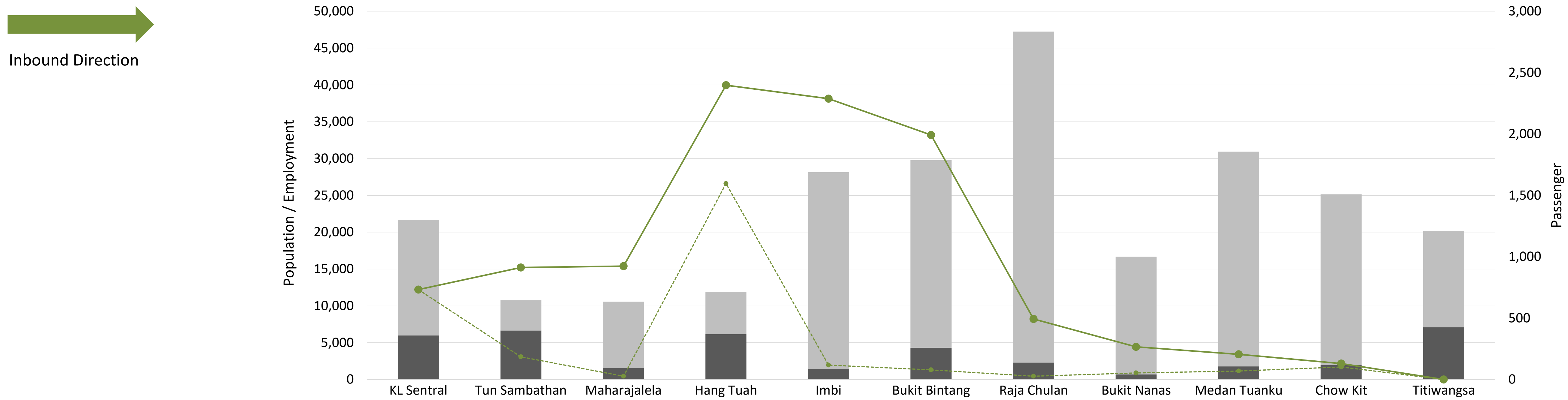
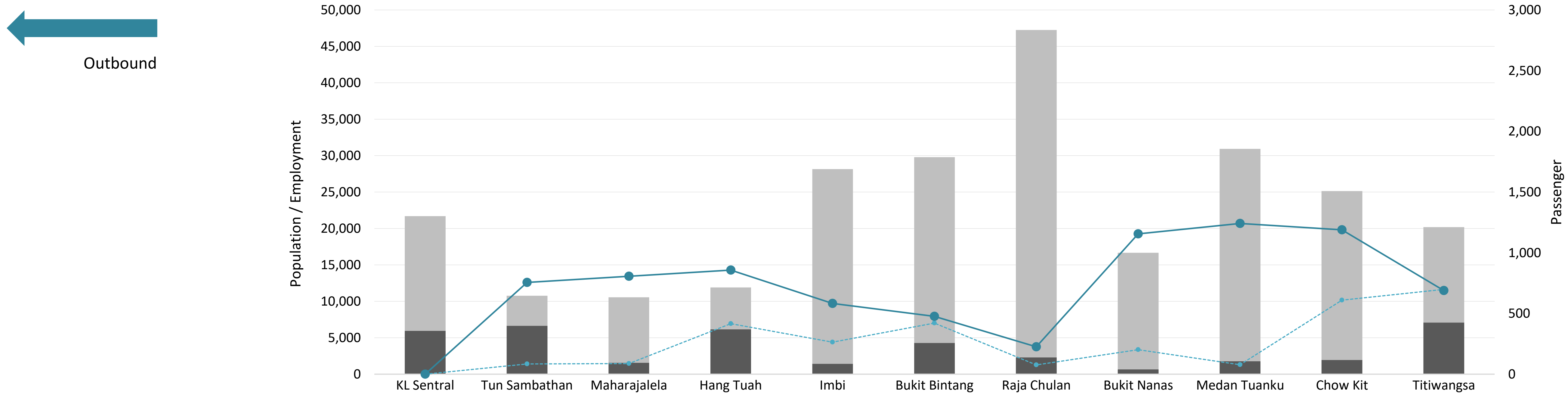
Figure 4.8: The estimated Kuala Lumpur monorail station area population and employment in 2012 and early zoning plan proposal.



	KL Sentral	Tun Sambathan	Maharajalela	Hang Tuah	Imbi	Bukit Bintang	Raja Chulan	Bukit Nanas	Medan Tuanku	Chow Kit	Titiwangsa
Employment (Existing)	15,738	4,117	9,012	5,749	26,723	25,509	44,946	15,994	29,145	23,179	13,103
Population (Existing)	5,960	6,647	1,556	6,159	1,426	4,293	2,305	665	1,783	1,958	7,083
Average Weekday Boarding per Peak Hour (Inbound)	733	184	27	1,596	117	78	26	53	68	101	0
Average Weekday Onboard per Peak Hour (Inbound)	733	912	923	2,398	2,288	1,992	493	266	205	130	0



	KL Sentral	Tun Sambathan	Maharajalela	Hang Tuah	Imbi	Bukit Bintang	Raja Chulan	Bukit Nanas	Medan Tuanku	Chow Kit	Titiwangsa
Employment (Existing)	15,738	4,117	9,012	5,749	26,723	25,509	44,946	15,994	29,145	23,179	13,103
Population (Existing)	5,960	6,647	1,556	6,159	1,426	4,293	2,305	665	1,783	1,958	7,083
Average Weekday Boarding per Peak Hour (Outbound)	0	84	88	416	264	420	76	201	78	610	698
Average Weekday Onboard per Peak Hour (Outbound)	0	755	806	857	582	477	226	1,155	1,242	1,189	689

Figure 4.9: Existing station level ridership of Kuala Lumpur monorail in 2012. (Top) Inbound refers to traffic movement of Kuala Lumpur monorail travel from KL Sentral towards Titiwangsa. (Bottom) Outbound refers to traffic movement of Kuala Lumpur monorail travel from Titiwangsa towards KL Sentral. More detail ridership information is available in Appendix E.

In spite of the fact that our study is mainly focused on the assessment of zoning intensification of Kuala Lumpur monorail station area, we are surprised to note that even draft Kuala Lumpur City Plan 2020 consider the idea of TOD into its early zoning plan proposal, the current efforts for zoning intensification largely extend beyond the 400m walkable station area (the primary transit influence area which we have discussed in Section 2.2) where walking to transit is unlikely. Figure 4.10 illustrates an example of geographic space further the 400m walkable station areas of monorail and other rail transit in Kuala Lumpur city centre where early zoning intensification plan allows for future growth. Given such circumstances, the new population and employment growth would be expected on the geographic space of weaker influence for people to take transit as the access to transit is difficult. As a result, the new population and employment of Kuala Lumpur city that will live and work in such geographic space may prefer to seek for a more convenient transport mode such as private vehicle or innovative disruptive transport service that reply on private vehicle like Uber and Grab. It would be worse if we consider this situation with the existing strong culture of car driving in Kuala Lumpur city (86% of dependency on private vehicle). Therefore, the present early zoning intensification proposal is inconsistent with the idea of TOD intended to promote more people to use transit.

Towards a meaningful TOD, the zoning intensification of Kuala Lumpur should be transit focused, mainly allow the high intensity permission on the walkable transit catchment area while restraint or prohibit the land parcels or zoning lots that do not belong to the walkable transit catchment area to receive any additional intensity growth. For this reason, we recommend transfer of development rights approach for Kuala Lumpur achieves this goal. Using transfer of development rights, Kuala Lumpur

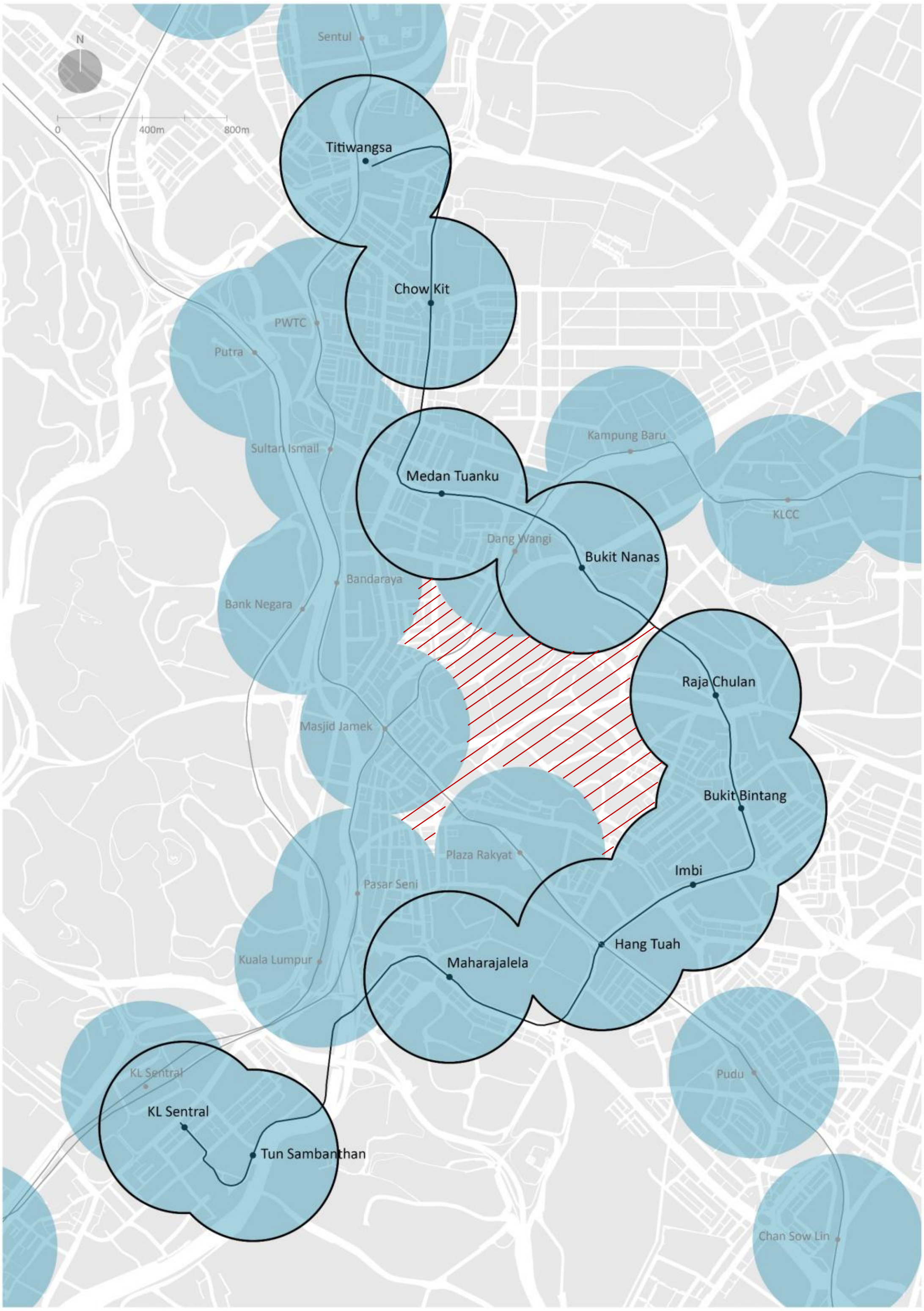


Figure 4.10: The hatched district is an example of geographic space where the present early zoning proposal allows the density increase beyond the 400m walkable station areas of monorail and other urban rail transit (blue coloured circular districts).

could downzoning the current proposed intensity on the land parcels or zoning lots located in the geographic space of weak influence from transit service (as sending area) and direct the development potential by upzoning to further intensify the present proposed intensity of station area (as receiving area) so that the zoning intensification proposal would encourage more people to take transit than private vehicle in the future (Figure 4.11). Through our analysis on the transit catchment area for monorail and other urban rail transit in Kuala Lumpur city centre, we found that the setup on geographic space of 400-600m from transit station is sufficient to defined as the sending area for transfer of development rights to mitigate most of the future growth to take place on the geographic space with weak influence from transit services (Appendix F). Figure 4.12 and 4.13 illustrate the existing land use activities and early zoning plan of Kuala Lumpur monorail station areas (400m from transit station) and its adjacent geographic space of weak transit influence (400-600m from transit station).

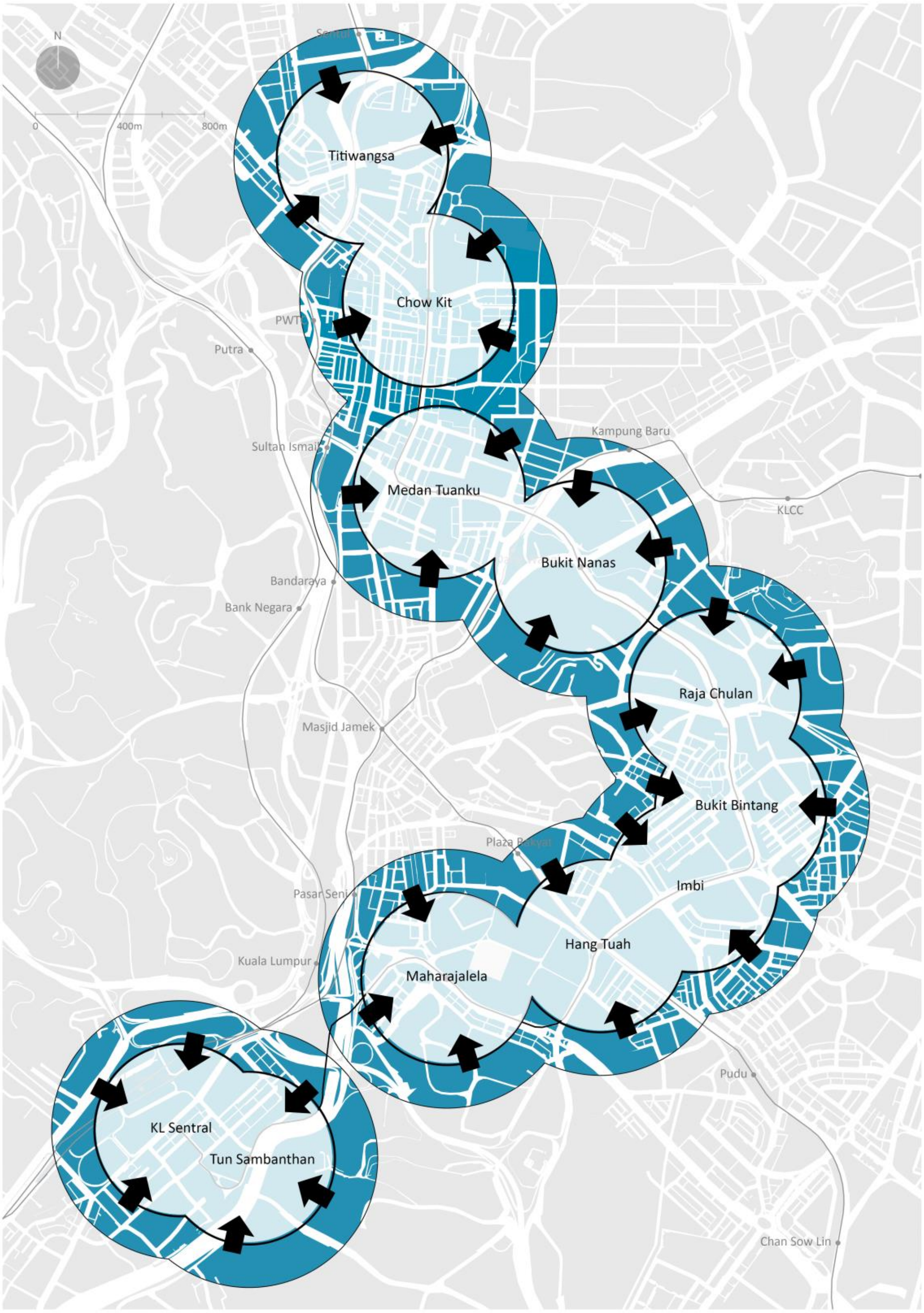


Figure 4.11: The suggestion for transfer of development rights to further intensify the early proposed zoning intensity of monorail station areas via the development potential transfer from the geographic space of weak transit influence.

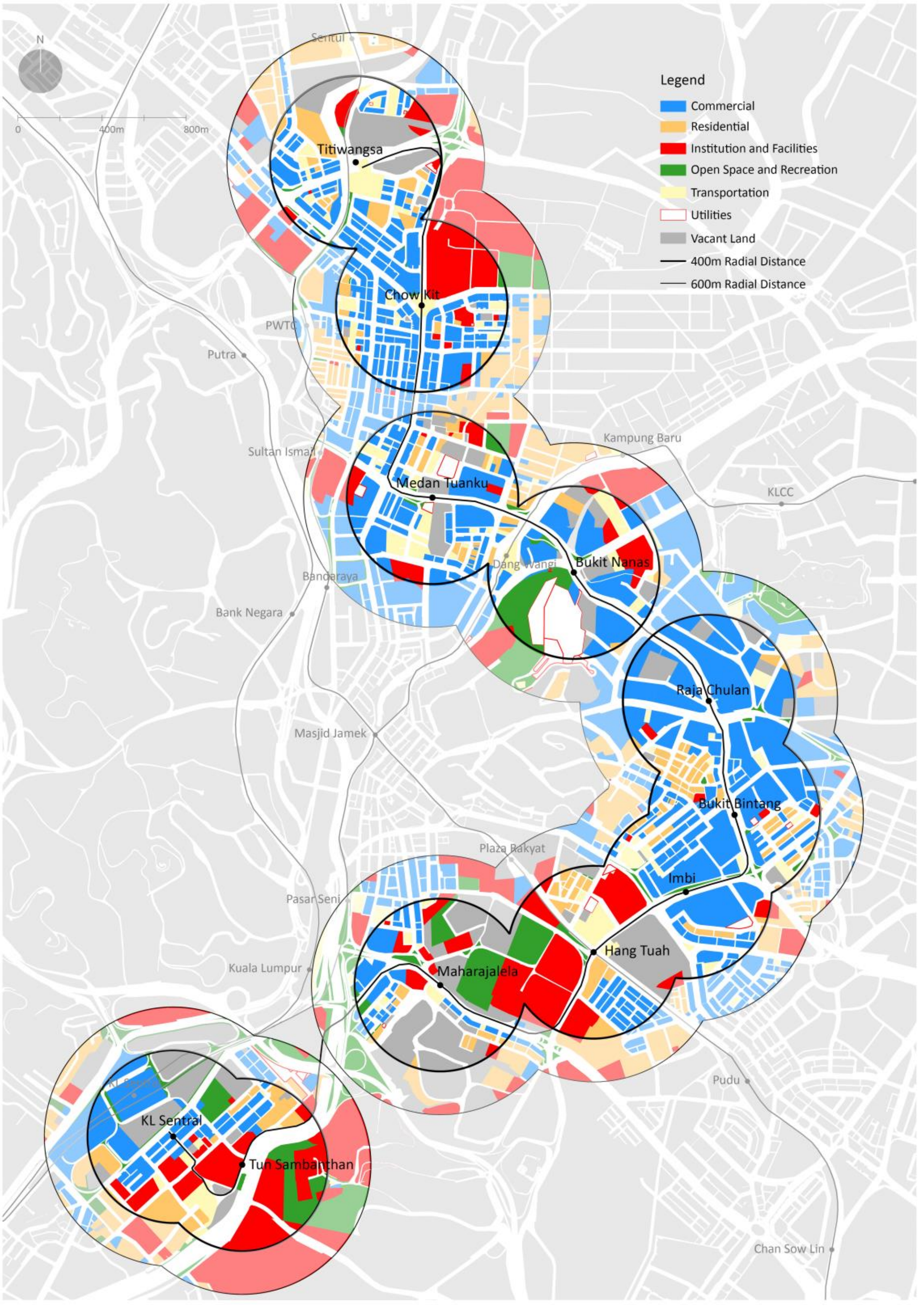


Figure 4.12: The existing land use activities of Kuala Lumpur monorail station areas (400m from station) and its adjacent region with weak transit access (400-600m from station).

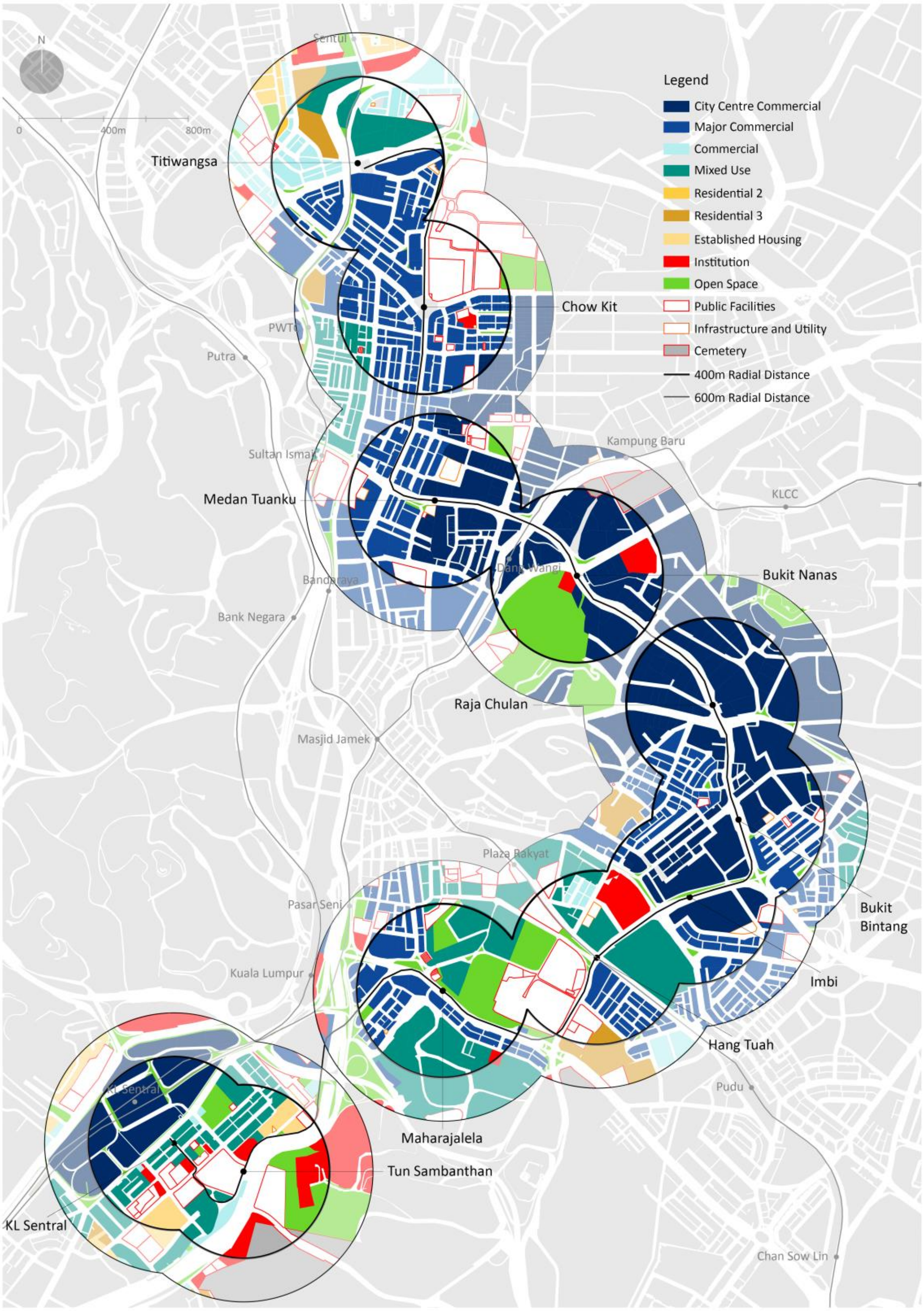
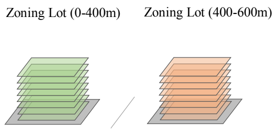
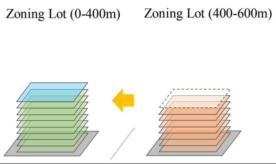
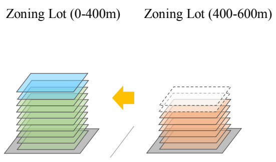
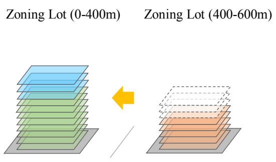
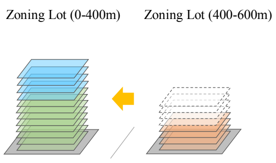
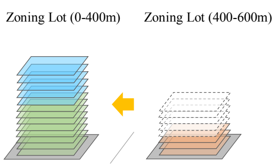


Figure 4.13: The early designated land use zoning plan of Kuala Lumpur monorail station areas (400m from station) and its adjacent region with weak transit access (400-600m from station).

However, to what extend the level of zoning intensification should the zoning plan propose is considering appropriate for TOD? To address this question, this study evaluates the zoning intensification efforts of Kuala Lumpur monorail in a series of upzoning scenarios (Table 4.2). The business as usual zoning intensification scenario represents the present early zoning intensification plan of draft Kuala Lumpur City Plan 2020 without any adoption of transfer of development rights. This scenario allows future growth on geographic space of weak influence from transit (400-600m) and mainly considers the early zoning intensification within the primary 400m walkable station area. The 20% upzoning is a zoning intensification scenario of present early zoning intensification plan with transfer of development rights where the primary 400m walkable station area (receiving area) would be given an additional +20% of development potential from its 400-600m geographic space (sending area) for further intensification. Under the 20% upzoning zoning intensification scenario, the future growth potential in the geographic space with weak influence to transit (400-600m from the station) would be reduced and restricted by 20%. The other four upzoning zoning intensification scenarios (40%, 60%, 80% and 100%) apply the similar principle of 20% upzoning zoning intensification scenario by further receive the increase of intensification magnitude on the primary 400m walkable station area while imply more restriction on the development potential in the geographic space of 400-600m. For the case of 100% upzoning zoning intensification scenario, it is a drastic measure where the primary 400m walkable station area will fully receive the future growth potential of the land parcels or zoning lots in the geographic space of weak transit influence (400-600m). In other words, the development potential for the geographic space of 400-600m from the station is completely restricted and identical land use intensity in the present would be maintained in the future.

Table 4.2: Zoning intensification assessment scenarios for Kuala Lumpur monorail case study.

Zoning Scenarios	**Description**
Business as Usual (Early Zoning Plan) 	It adopts the existing early zoning plan proposal. With no restriction on the future growth of 400-600m and it mainly considers existing zoning within the primary 400m walkable station area.
20% Upzoning 	The primary 400m walkable station area receives additional 20% of development rights from the geographic space of 400-600m. The future growth potential of the 400-600m from the station would be reduced and restricted by 20%.
40% Upzoning 	The primary 400m walkable station area receives additional 40% of development rights from the geographic space of 400-600m. The future growth potential of the 400-600m from the station would be reduced and restricted by 40%.
60% Upzoning 	The primary 400m walkable station area receives additional 60% of development rights from the geographic space of 400-600m. The future growth potential of the 400-600m from the station would be reduced and restricted by 60%.
80% Upzoning 	The primary 400m walkable station area receives additional 80% of development rights from the geographic space of 400-600m. The future growth potential of the 400-600m from the station would be reduced and restricted by 80%.
100% Upzoning 	The primary 400m walkable station area receives additional 100% of development rights from the geographic space of 400-600m. The future growth potential of the 400-600m from the station would be reduced and restricted by 100%. The existing land use intensity on the geographic space of 400-600m is expected to have remained.

4.4 Methodology and Data

In this study, we perform the assessment of TOD zoning intensification with the transit capacity. Figure 4.10 outlines the assessment framework of every zoning intensification scenario in this research. First, the early land use zoning proposed from the draft Kuala Lumpur City Plan 2020 for Kuala Lumpur monorail station areas is transformed into the building floor space and later the estimated station area population and employment for zoning setting. Given that the census data in Malaysia has a limitation in providing detail population and employment size at the local finer geographic scale of the station area, similarly, this study relies on the building floor space to estimate the existing station area population and employment. The building floor space for both the existing and zoning setting of the individual Kuala Lumpur monorail station area is derived from the administrative GIS dataset. More detail about Kuala Lumpur monorail station area population and employment estimation based on building floor space is discussed in Section 4.4.1.

Subsequently, the station area population and employment estimated for the zoning setting is set side by side with the existing station area population and employment to identify the station area population and employment growth implied by the proposed zoning intensification scenario. Founded on the findings on the generalised effects of station area density on ridership from Chapter Two, this research applies them in the present Chapter Four to translate the identified station area population and employment growth into the station level ridership growth of zoning setting (average weekday boarding). To allow the generalised effects between station area density and ridership to be fit with our study area in Kuala Lumpur, three possible

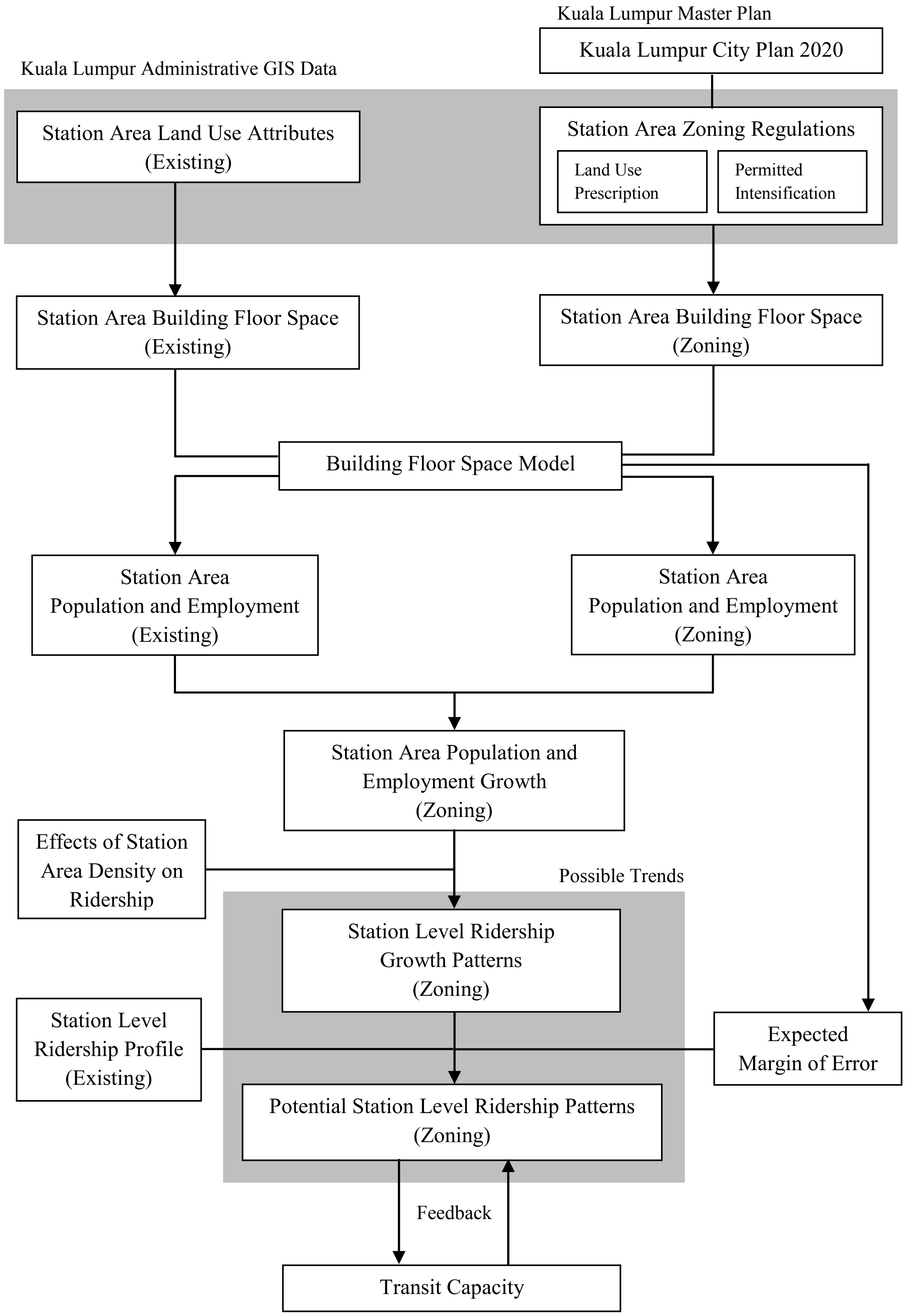


Figure 4.14: Overall TOD zoning intensification assessment framework for Kuala Lumpur monorail.

effects of station area density on ridership are adopted in this study. This is measures on the relative strength of effects from station area density on ridership. As a result, the station level ridership growth of every zoning setting for this study is presented three possible trends. Additional detail discussion on applying generalised effects of station area density on ridership for the context of Kuala Lumpur is available in Section 4.4.2.

Afterwards, the station level ridership growth trends of the zoning setting are added to the existing station level ridership in generating the potential station level ridership trends in zoning setting. Since the station area population and employment as discussed earlier are mainly based on the estimation from building floor space where inaccuracy could be unavoidable (see Chapter Three). For ensuring our potential station level ridership trends in zoning setting to be well prepare on this matter, we consider the expected errors we found from the Chapter Three where we apply building floor space for station area population and employment estimation in five station areas of Tokyo as the error bands on top of the three basic potential station level ridership trends of zoning setting. Further information about the procedure of including error bands of into the potential station level ridership trends of zoning setting is presented in Section 4.4.2. The results of the potential station level ridership trends for Kuala Lumpur monorail suggested from the zoning intensification scenarios are measure with the transit capacity for our research discussion.

4.4.1 Estimating Station Area Population and Employment Using Building Floor Space

The key finding from the early Chapter Three informed us that the building floor space is able to provide a reasonable station area population and employment estimation. Building upon this finding, the higher accuracy building floor space Model D from the Chapter Three is selected for our study in the present Chapter Four. Here, we repeated a similar procedure demonstrated in Chapter Three to generate the Kuala Lumpur monorail station area population and employment in both existing and zoning setting. The result is indicated in Figure 4.8, Figure 4.9, Figure 4.16 and Table 4.5.

Again, we define the geographic size of Kuala Lumpur monorail station area based on our finding of the 400m Euclidian distance as an appropriate walkable transit catchment area in Chapter Two. The entire amount of gross building floor space for every Kuala Lumpur monorail station area is derived from the official draft Kuala Lumpur City Hall administrative GIS database. Our estimation for the gross building floor space of the proposed land use zoning scenarios assumed that future development and market under the zoning setting would fully capitalise to take the advantage of maximum density or plot ratio permitted by the draft Kuala Lumpur City Plan 2020. Given that certain monorail station areas intersect with each other; this study applies mutually exclusive geography approach to avoid double counting of gross building floor space for station area population and employment estimation later (Figure 4.15). This approach is consistent with the evidence of an empirical study by Lane et al. (2006) found that the attributes of exclusive station areas (without overlapping of geography) explains ridership way better than the attributes of non-exclusive station areas (overlapping of geography).

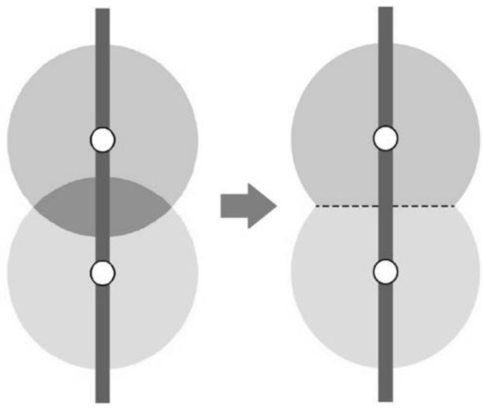


Figure 4.15: Transformation of the geography from intersected station areas into mutually exclusive station areas to address the challenge of double counting.

The estimated gross building floor space of existing and early zoning plan proposed by the draft Kuala Lumpur City Plan 2020 around the Kuala Lumpur monorail station area is displayed in Table 4.3. Meanwhile, the Kuala Lumpur city-level aggregate information for the variables of building floor space model to transform the gross building floor space into the population and employment is showed in Table 4.4. These data are obtained and adapted from the official statistics, research studies, real estate market reports, and guidelines. For the zoning intensification scenarios using the transfer of development rights to further intensify the station area from the early zoning plan, the estimated gross building floor space of a monorail station area from the would further receive additional gross building floor space growth from the 400-600m geographic space of monorail station.

Table 4.3: Estimated gross floor space around the Kuala Lumpur monorail station in 2012 and early zoning plan.

Station Area	Within 400m Distance from Station (Walkable)								Within 400-600m Distance from Station (Less Walkable)							
	Year 2012				Early Zoning Plan				Year 2012				Early Zoning Plan			
	Estimated Total Gross Floor Space ('000 sq. m.)				Estimated Total Gross Floor Space ('000 sq. m.)				Estimated Total Gross Floor Space ('000 sq. m.)				Estimated Total Gross Floor Space ('000 sq. m.)			
	Res.	Com.	Inst.	Ind.	Res.	Com.	Inst.	Ind.	Res.	Com.	Inst.	Ind.	Res.	Com.	Inst.	Ind.
KL Sentral	204	489	44	0	356	1,808	141	0	248	435	38	0	403	1,195	200	0
Tun Sambanthan	227	71	109	0	515	338	461	0	35	41	40	0	153	212	531	0
Maharajalela	53	260	60	0	928	1,467	34	0	129	201	81	0	851	1,142	674	0
Hang Tuah	211	122	114	0	550	835	243	0	332	194	31	0	368	622	28	0
Imbi	49	854	33	0	179	1,747	123	0	248	204	17	0	12	773	16	0
Bukit Bintang	147	826	13	0	0	1,996	11	0	109	231	2	0	164	938	2	0
Raja Chulan	79	1,462	12	0	0	3,154	0	0	210	821	2	0	0	2,265	84	0
Bukit Nanas	23	509	24	0	0	2,190	201	0	194	294	23	0	0	1,480	23	0
Medan Tuanku	61	894	101	0	0	2,684	73	0	42	1,036	35	0	110	1,878	35	0
Chow Kit	67	664	160	0	102	1,909	182	0	250	181	169	0	267	1,351	168	0
Titiwangsa	242	409	33	0	469	1,825	8	0	83	202	193	0	108	865	441	0

Note: Res. = Residential; Com. = Commercial; Inst. = Institution; Ind. = Industrial

Table 4.4: Data input for the population and employment estimation of Kuala Lumpur monorail station areas in 2012 and zoning setting.

Variables	Residential	Commercial	Institution	Industrial
Net-to-Gross Floor Space Ratio	0.85[1]	0.85[1]	0.75[1]	0.90[1]
Occupancy Rate	0.93[2]	0.90[3]	0.95[4]	0.90[4]
Net Floor Space per Employee (worker per sq. m)	-	25[5]	40[5]	50[5]
Net Floor Space per Dwelling Unit (unit per sq. m)	100[6]	-	-	-
Household Size (residents per dwelling unit)	3.7[7]	-	-	-

Source:

[1]Adapted from Johnson (1990, p. 155);

[2]Adapted from the Department of Statistics Malaysia (2011b);

[3]Adapted from the Valuation and Property Services Department Malaysia (2012), Rahim & Co Research (2011), Nabil Hussein (2011a, 2011b, 2011c), and Knight Frank (2015);

[4]Adapted from NAI Global (2009, 2011);

[5]Adapted from the Homes and Communities Agency (2015);

[6]Adapted from the Federal Department of Town and Country Planning (2014); and

[7]Adapted from the Department of Statistics Malaysia (2013).

4.4.2 Potential Station Level Ridership Scenarios

As highlighted in the Section 4.4, the assessment framework of TOD zoning intensification in our case study of Kuala Lumpur monorail station areas involves with the transformation of the identified station area population and employment growth implied from the proposed zoning intensification scenario into the station level ridership growth trends. Drawing from the findings of the generalised effects of station area density on ridership obtained in Chapter Two, we apply them to transform the station area population and employment growth into the station level ridership growth of the given zoning setting in the form of average weekday boarding. From the Chapter Two, it is noted that the effects of station area on ridership are influenced by the degree of a station area density. The generalised effect of the station area population on the average weekday boarding is expected from the range of 9 – 23 for every 100 population increment while the effect of the station area employment density on the average weekday boarding is expected from the range of 2 – 20 for every 100 employment increment.

For this study, we notice that the average station area population and employment density for Kuala Lumpur is expected at 138 and 108. Therefore, range value of 9 – 23 for every increment of 100 residents and 8 – 20 for every increment of 100 workers is adopted to transform the station area population and employment growth into station level ridership growth. In this range of values, we consider the three important possibilities weakest, moderate and strongest effects of station area density on ridership. At the weakest effect of station area density on ridership, we expected the average weekday boarding is 9 for every 100 population increment and

8 for every 100 employment increment. For the moderate effect of station area density on ridership, we consider the median value from the effect range, where we expected the average weekday boarding is 16 for every 100 population increment and 14 for every 100 employment increment. In the strongest effect station area density on ridership, we expected the average weekday boarding is 23 for every 100 population increment and 20 for every 100 employment increment. The above assumptions transform the station area population and employment growth into the station level ridership growth with three potential trends of optimistic, modest and pessimistic. For example, the KL Sentral station area population and employment growth of business as usual zoning intensification scenario are estimated at 4,464 and 42,085 respectively would expect the station level ridership growth (average weekday boarding) of 9,444 for the optimistic trend; 6,606 for the modest trend; and 3,769 for the pessimistic trend (the detail formula is available in Appendix G). Further, by adding the three possible station level ridership growth trends onto the existing station level ridership, the result suggests for the three potential ridership trends. Kuala Lumpur monorail station level ridership growth patterns implied from the zoning intensification scenarios is available in Appendix H (H1-H6).

Since the station level ridership growth is measured in the average weekday boarding while the existing station level ridership is measure in average weekday per peak hour boarding in both inbound and outbound direction. Therefore, translation is needed. First, we assign the station level ridership growth of average weekday boarding into average weekday per peak hour boarding with the assumption of seven peak hours are account for 60% of the total average weekday boarding. This assumption is based on the existing ridership statistical in 2012. Likewise, building upon the existing station level ridership pattern, we develop inbound and outbound boarding ratio to assign the station level ridership growth (average weekday per peak hour boarding) for inbound and outbound direction. The existing boarding ratio for inbound and outbound of Kuala Lumpur monorail station is listed in Appendix I. In the similar example as above, the KL Sentral station level ridership growth modest trend predicted at 6,606 average weekday boarding translate into 566 average weekday peak hour boarding. Given that the inbound and outbound boarding ratio for KL Sentral station is 1.00 and 0.00, this implies that the KL Sentral station level ridership growth (average weekday per peak hour boarding) (modest trend) for inbound is 566 in the meanwhile for outbound is 0. Together these results with the existing station level ridership of KL Sentral (inbound = 733 average weekday per peak hour boarding; outbound = 0 average weekday per peak hour boarding), the modest trend station level ridership of KL Sentral implied from the business as usual zoning intensification is 1,299 average weekday per peak hour boarding for inbound and 0 average weekday per peak hour boarding for outbound.

From the station level potential boarding ridership trends (average weekday per peak hour), we further transform them once more into the final outcomes of potential on-board ridership trends (average weekday per peak hour) by using the alighting proportion where we derived from the existing station level ridership (Appendix K). Additionally, for our readiness to understand the uncertainty, we consider the inaccuracy emerged from the building floor space model (Model D) on station area population and employment estimation, the anticipated uppermost and lowermost error from Chapter Three (see Appendix L) is integrated into every three key potentials on-board ridership scenarios as error bands.

4.5 Results and Discussion

The estimated population and employment around the Kuala Lumpur monorail stations suggested from the existing land use activities and early zoning intensification plan is illustrated in Figure 4.16 (for every station) and Table 4.5 (for entire monorail). The total potential population and employment growth suggested from the early zoning plan proposed by the draft Kuala Lumpur City Plan 2020 is expected to be 803,857 (Table 4.6). From this amount, we could notice that at the geographic space of strong influence of transit (400m walking distance from monorail station) the population and employment growth is expected at 53,990 and 423,681 respectively. Meanwhile, the population and employment growth at the geographic space of weaker influence from transit (400-600m from monorail station) is estimated at 27,942 populations and 298,244 employments correspondingly. From the above, the results from the early zoning plan suggested that 59% of future growth has a higher tendency to use transit whereas 41% of future growth has higher tendency to use private vehicle. As demonstrated in Table 4.5, with the proposed upzoning zoning intensification efforts of using transfer of development rights to further intensify present early zoning intensification plan for the geographic space of 400m walkable station area via the development potential of the geographic space of 400-600m from station, we can noticed that the number of estimated population and employment for the geographic space with higher accessibility to transit is increasing while the number of estimated population and employment located in the geographic space with lower accessibility to transit is reducing. It encourages more future growth has higher tendency to use transit than the present early zoning intensification plan proposed by the draft Kuala Lumpur City Plan 2020 (Table 4.6).

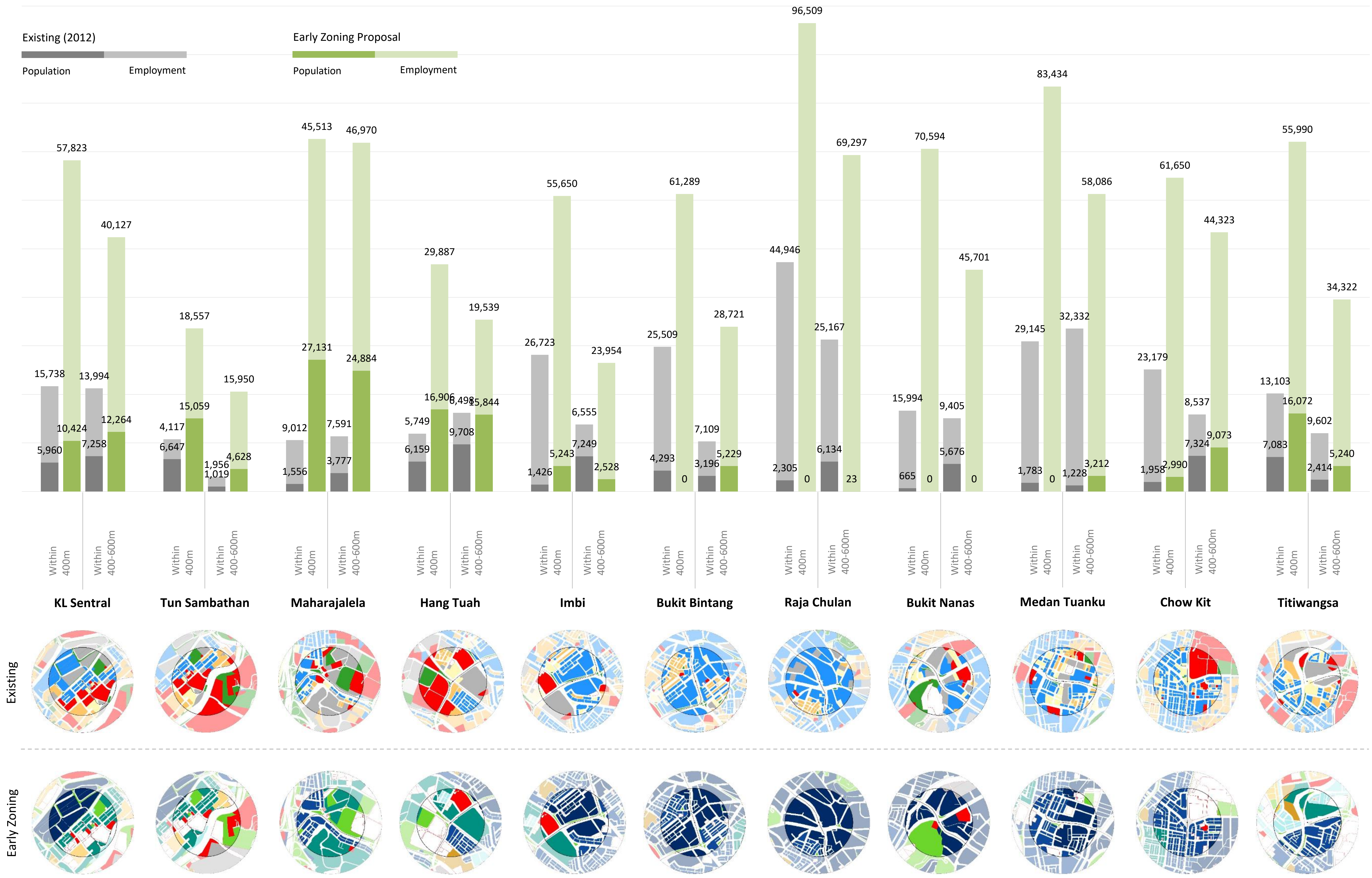


Figure 4.16: The implication of early zoning plan on the population and employment of Kuala Lumpur monorail station area (within 400m) and its adjacent region with weak transit access (within 400-600m).

Table 4.5: The estimated population and employment around the Kuala Lumpur monorail station implied from the zoning intensification scenarios.

Scenarios	**Geographic Space of 400m from Transit Station** (Higher Accessibility to Transit)	**Geographic Space of 400-600m from Transit Station** (Lower Accessibility to Transit)
Existing (Year 2012)	Population: 39,835 Employment: 213,215	Population: 54,983 Employment: 128,746
Business as Usual (Early Zoning Plan)	Population: 93,825 Employment: 636,896	Population: 82,925 Employment: 426,990
20% Upzoning	Population: 99,414 Employment: 696,545	Population: 77,337 Employment: 367,341
40% Upzoning	Population: 105,003 Employment: 756,194	Population: 71,748 Employment: 307,692
60% Upzoning	Population: 110,589 Employment: 815,842	Population: 66,160 Employment: 248,044
80% Upzoning	Population: 116,178 Employment: 875,491	Population: 60,571 Employment: 188,395
100% Upzoning	Population: 121,767 Employment: 935,140	Population: 54,983 Employment: 128,746

Table 4.6: The growth around the Kuala Lumpur monorail station suggested from the zoning intensification scenarios.

Scenarios	**Geographic space of 400m from the transit station** (Higher Accessibility to Transit)		**Geographic space of 400-600m from the transit station** (Lower Accessibility to Transit)		**Total Growth**	
	Numeric	Percentage (%)	Numeric	Percentage (%)	Numeric	Percentage (%)
Business as Usual (Early Zoning Plan)	477,671 (53,990 population) (423,681 employment)	59	326,186 (27,942 population) (298,244 employment)	41	803,857	100
20% Upzoning	542,909 (59,579 population) (483,330 employment)	68	260,949 (22,354 population) (238,595 employment)	32	803,857	100
40% Upzoning	608,147 (65,168 population) (542,979 employment)	76	195,711 (16,765 population) (178,946 employment)	24	803,857	100
60% Upzoning	673,381 (70,754 population) (602,627 employment)	84	130,475 (11,177 population) (119,298 employment)	16	803,857	100
80% Upzoning	738,619 (76,343 population) (662,276 employment)	92	65,237 (5,588 population) (59,649 employment)	8	803,857	100
100% Upzoning	803,857 (81,932 population) (721,925 employment)	100	0 (0 population) (0 employment)	0	803,857	100

Our ultimate research outcome of the predicted potential ridership trends of average weekday on-board passenger per peak hour of Kuala Lumpur monorail for inbound and outbound of every zoning intensification scenarios is illustrated in Figure 4.17 – 4.28. Instead of providing a single forecast, the assessment results of every zoning intensification scenario for this study are presented in the three variations of trends (optimistic, modest and pessimistic) together with its error band. Our purpose for this is to navigate a wide range of possible circumstances by conceiving the uncertainty (i.e. effects of station area density on ridership and inaccuracy of building floor space model in station area population and employment estimation) so that we could well prepare for the unexpected. Nevertheless, the existence of multiple possible trends should not confuse us to have a clear discussion, as this could overwhelm readers with excessive information and potentially distract readers from the implications of the main interaction analysis. Intentionally, among the three possible potential ridership trends of every zoning setting, our discussion would mainly emphasis on the optimistic potential ridership trend. The optimistic potential ridership trend particularly deserves our attention than the modest and pessimistic potential ridership trends in this study as it would allow us to suggest better measure to minimise contingencies and risks that could result in the quality of TOD and transit issues.

In general, the assessment results shows that the effect of all zoning intensification scenarios (optimistic ridership trend) for both inbound and outbound traffic movement of Kuala Lumpur monorail is anticipated to promote more people to transit than the existing ridership trend document in the year 2012. For the case of business-as-usual zoning intensification scenario on Kuala Lumpur monorail station areas, we may expect the highest on-board passengers (average weekday per peak hour) under the optimistic ridership trend rose to 4,042 pphd for inbound (at Hang Tuah station) (Figure 4.17) and 3,266 pphd for outbound (at Bukit Nanas station) (Figure 4.23). If we further consider upper bound error band of the optimistic ridership trend, the uppermost on-board passengers (average weekday per peak hour) for inbound would be anticipated at 4,330 pphd (at Hang Tuah station). In the meantime, for the upzoning zoning intensification scenarios (20% upzoning, 40% upzoning, 60% upzoning, 80% upzoning and 100 upzoning), with more development potential of land parcels or zoning lots from the 400-600m geographic space of weak transit influence being channel into the station area, we could observe a further increase of number of people are expected to use transit. It is important to note that among the zoning intensification scenarios, the business as usual zoning intensification scenario where it mainly adopts the existing early zoning plan, has the least implication for promoting number of people to take transit. Besides, as the scenario does not impose any transfer of development rights measure to restrict the density increase at the 400-600m geographic space of weak transit influence and channel it to the station area, it would allow most of future growth (41%) at higher tendency to take private vehicle (Table 4.6).

Our zoning intensification assessment results for the Kuala Lumpur monorail indicates that the first four zoning intensification scenarios (business as usual, 20% upzoning, 40% upzoning and 60% upzoning) are expected to increase the number of people to transit than that it would surpass the present 2-cars transit capacity of monorail could handle while below the planned 4-cars transit capacity of monorail. The peak of the uppermost on-board passengers for the optimistic ridership trend (average weekday per peak hour) for Kuala Lumpur monorail inbound movement

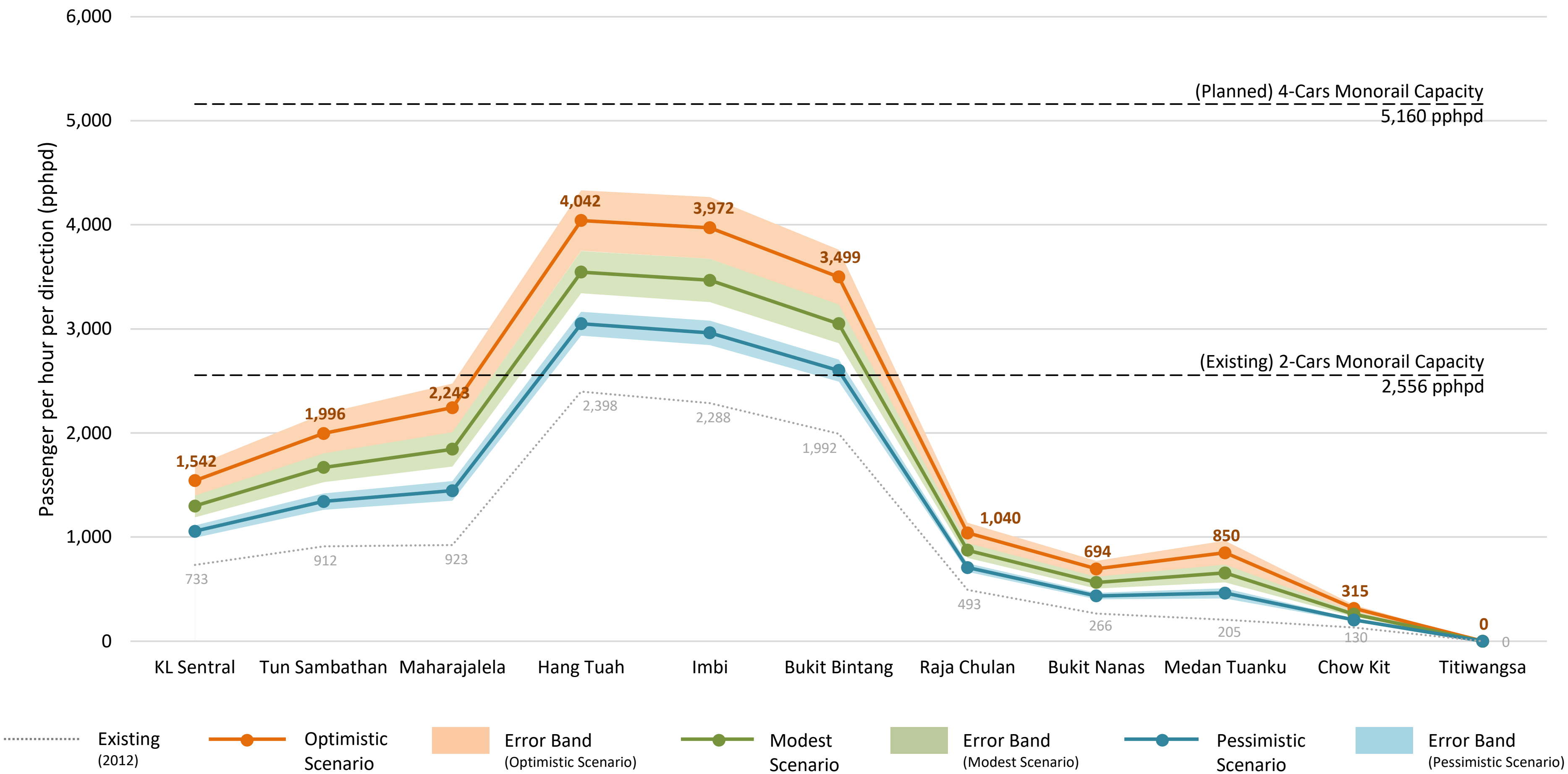


Figure 4.17: The effect of business as usual zoning intensification scenario (early zoning plan) on potential monorail ridership inbound traffic movement (average weekday per peak hour). More detail ridership information is available in Appendix M1.

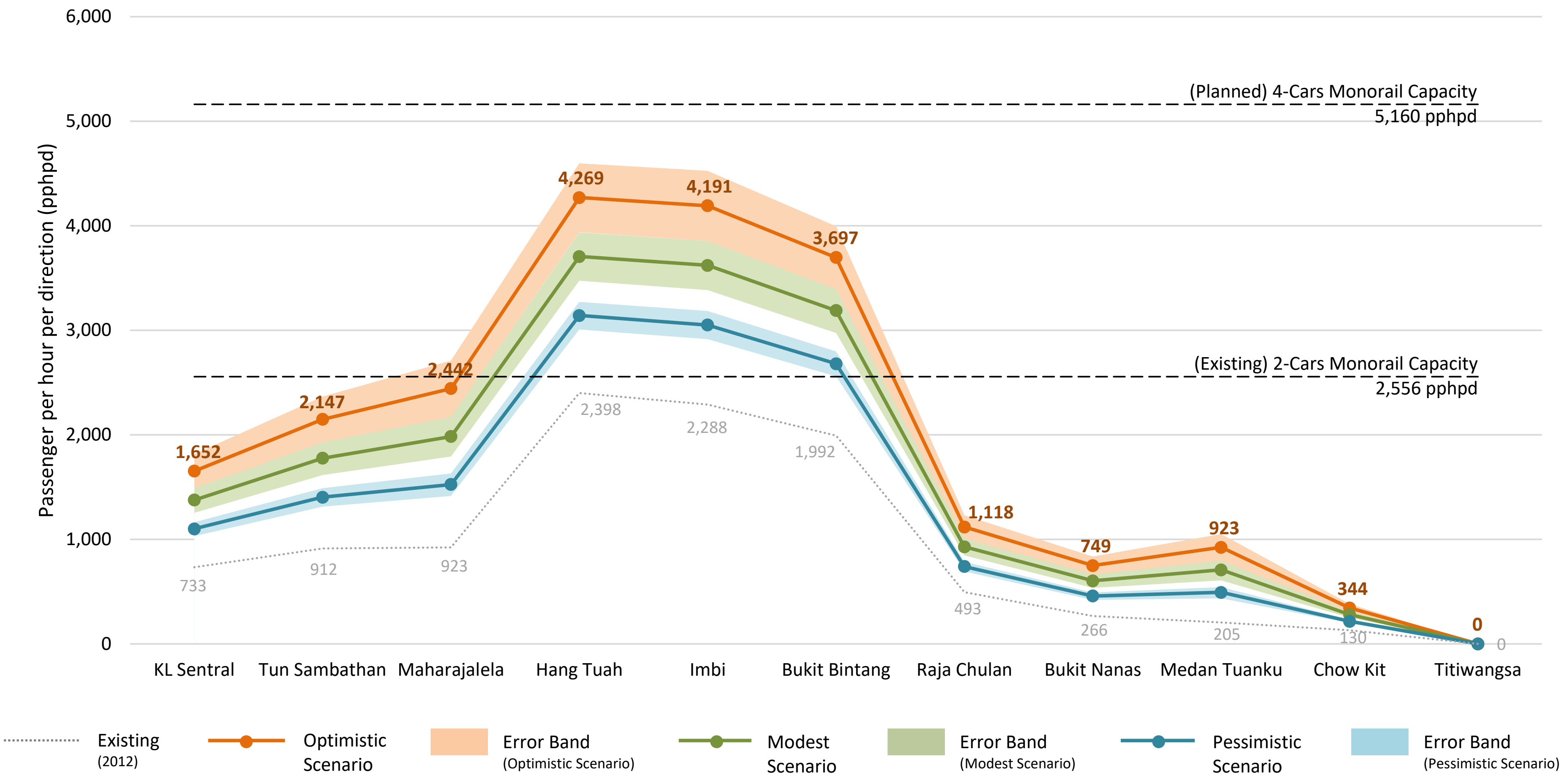


Figure 4.18: The effect of 20% zoning intensification scenario on potential monorail ridership inbound traffic movement (average weekday per peak hour). More detail ridership information is available in Appendix M2.

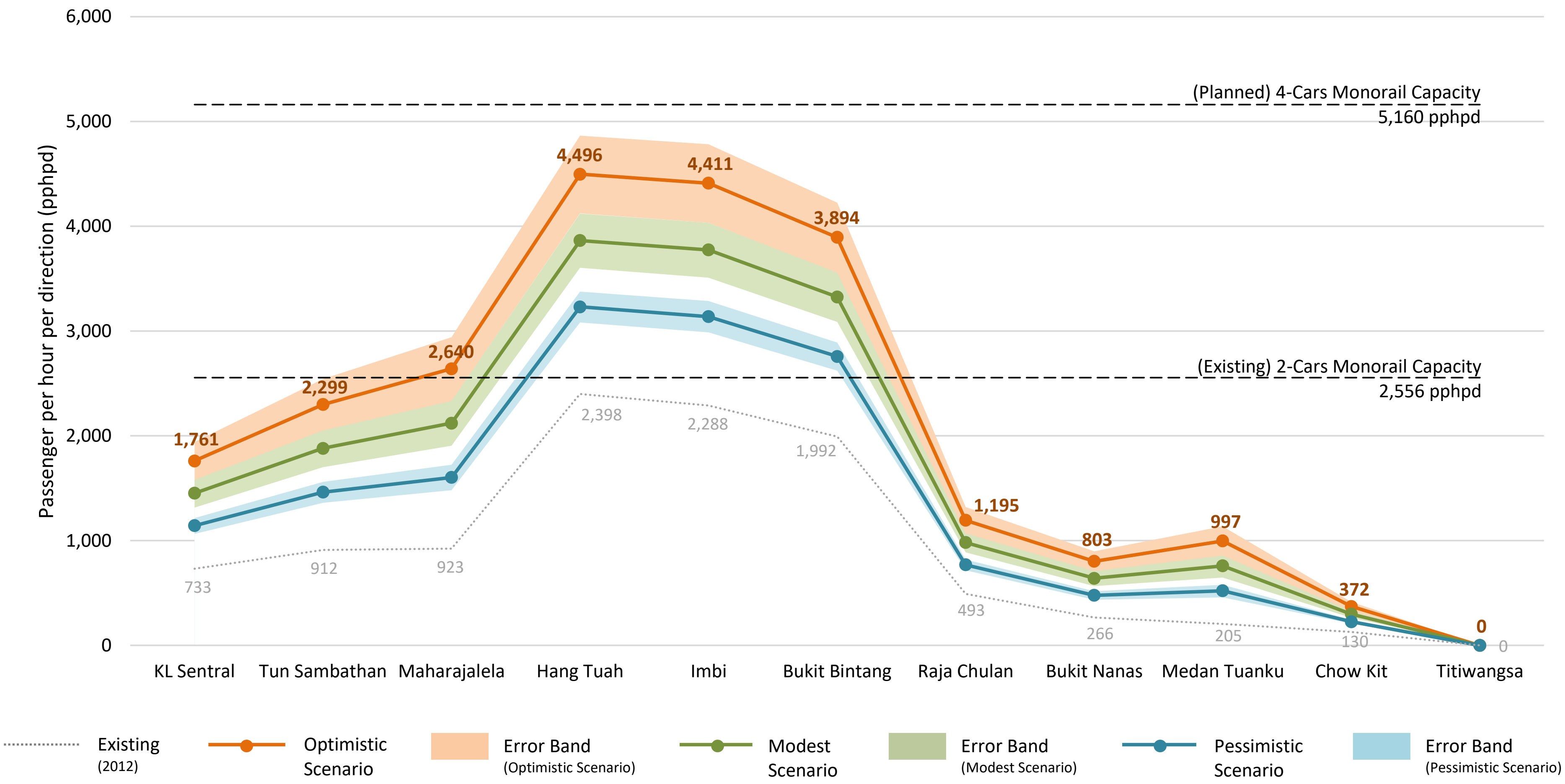


Figure 4.19: The effect of 40% zoning intensification scenario on potential monorail ridership inbound traffic movement (average weekday per peak hour). More detail ridership information is available in Appendix M3.

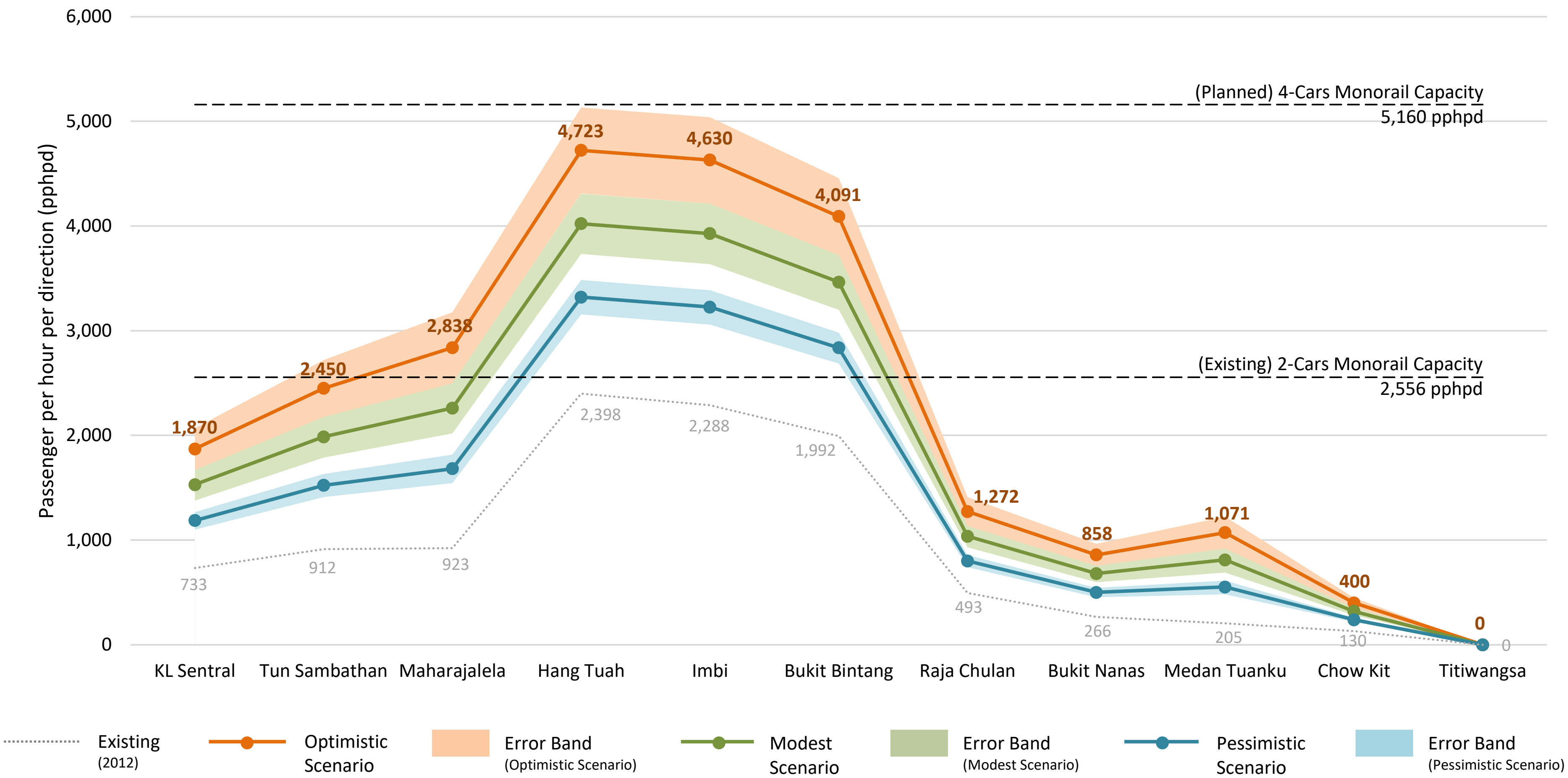


Figure 4.20: The effect of 60% zoning intensification scenario on potential monorail ridership inbound traffic movement (average weekday per peak hour). More detail ridership information is available in Appendix M4.

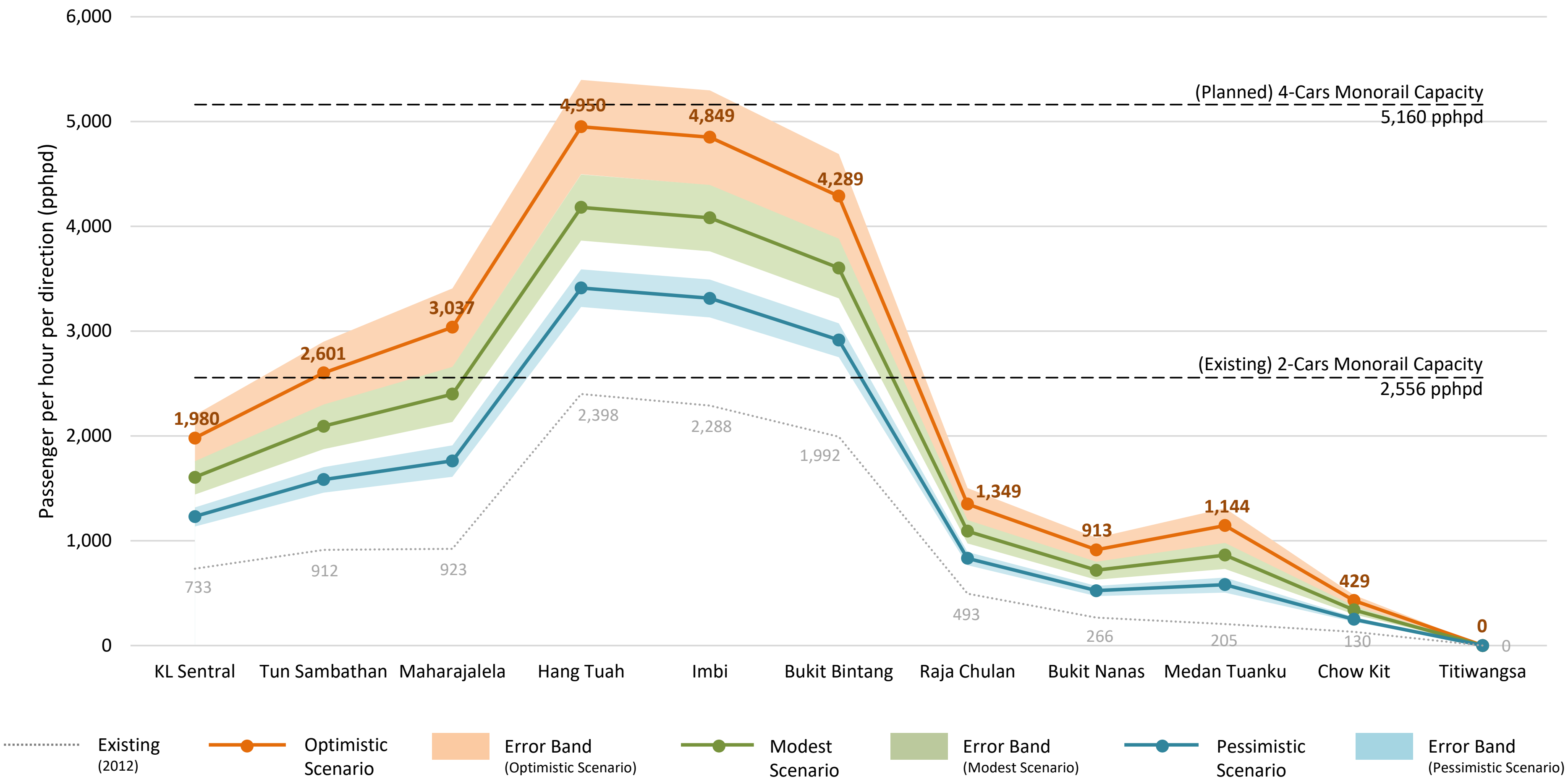


Figure 4.21: The effect of 80% zoning intensification scenario on potential monorail ridership inbound traffic movement (average weekday per peak hour). More detail ridership information is available in Appendix M5.

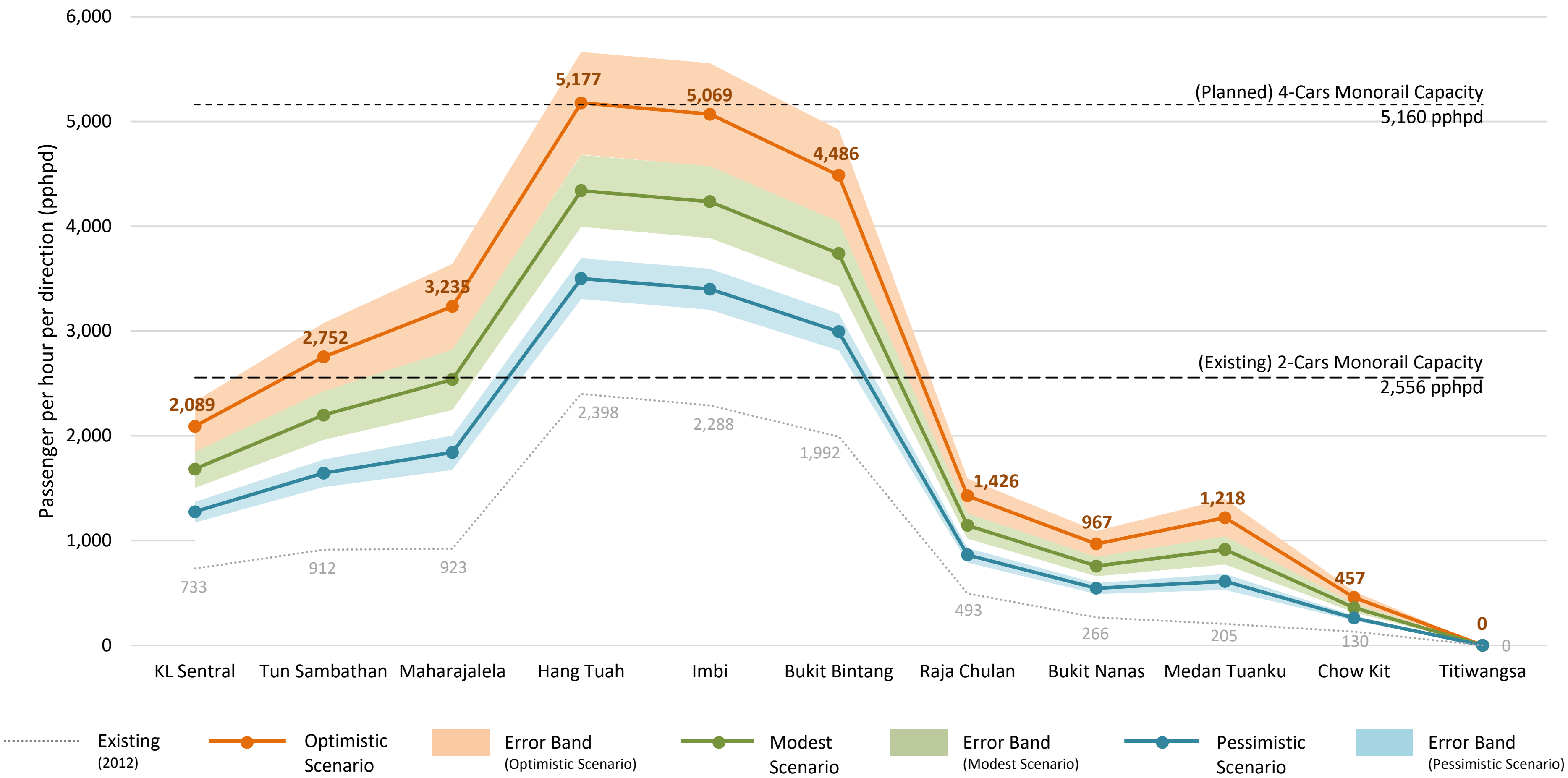


Figure 4.22: The effect of 100% zoning intensification scenario on potential monorail ridership inbound traffic movement (average weekday per peak hour). More detail ridership information is available in Appendix M6.

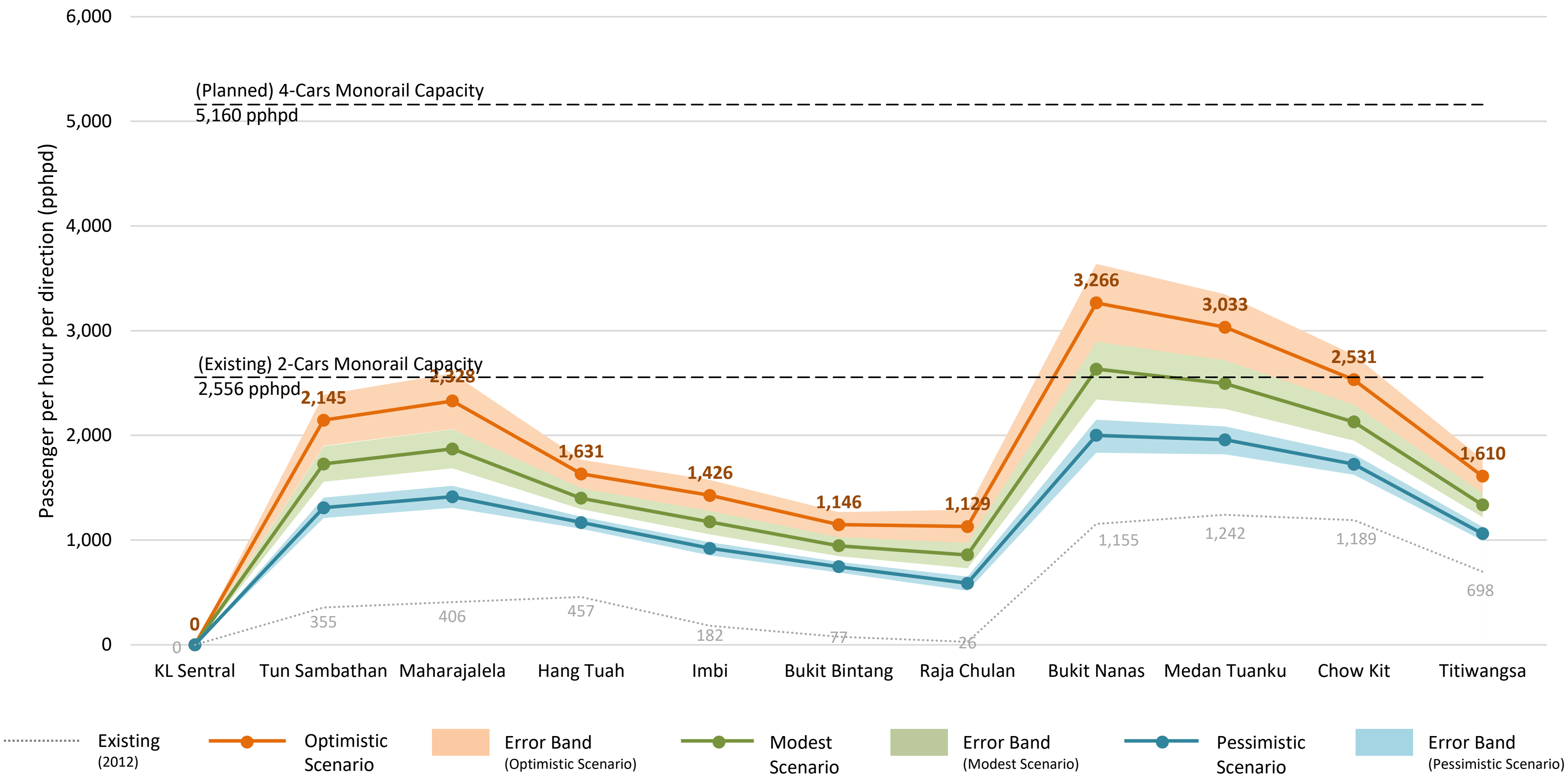


Figure 4.23: The effect of business as usual zoning intensification scenario (Kuala Lumpur early zoning intensification) on potential monorail ridership outbound traffic movement (average weekday per peak hour). More detail ridership information is available in Appendix N1.

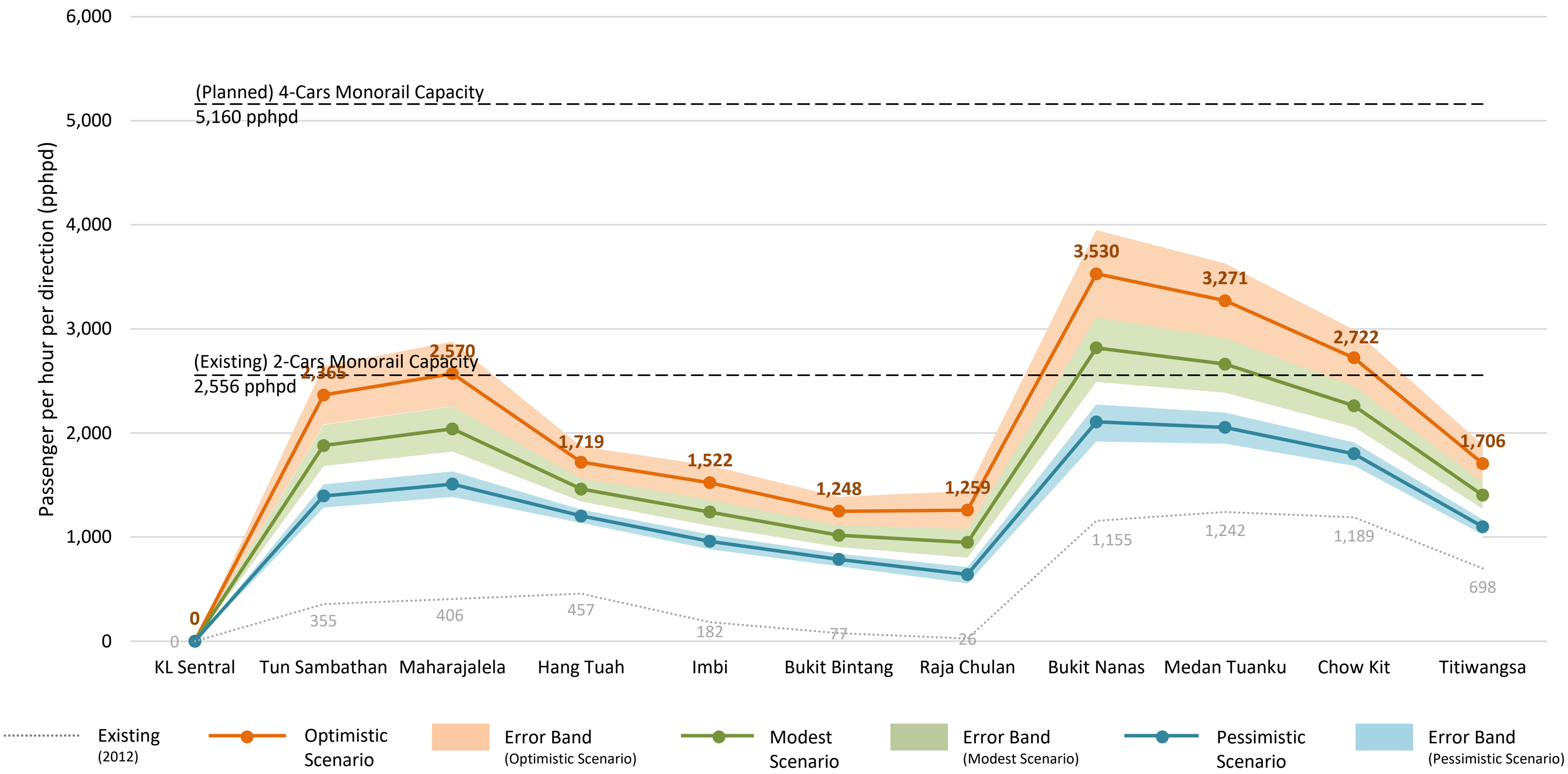


Figure 4.24: The effect of 20% zoning intensification scenario on potential monorail ridership outbound traffic movement (average weekday per peak hour). More detail ridership information is available in Appendix N2.

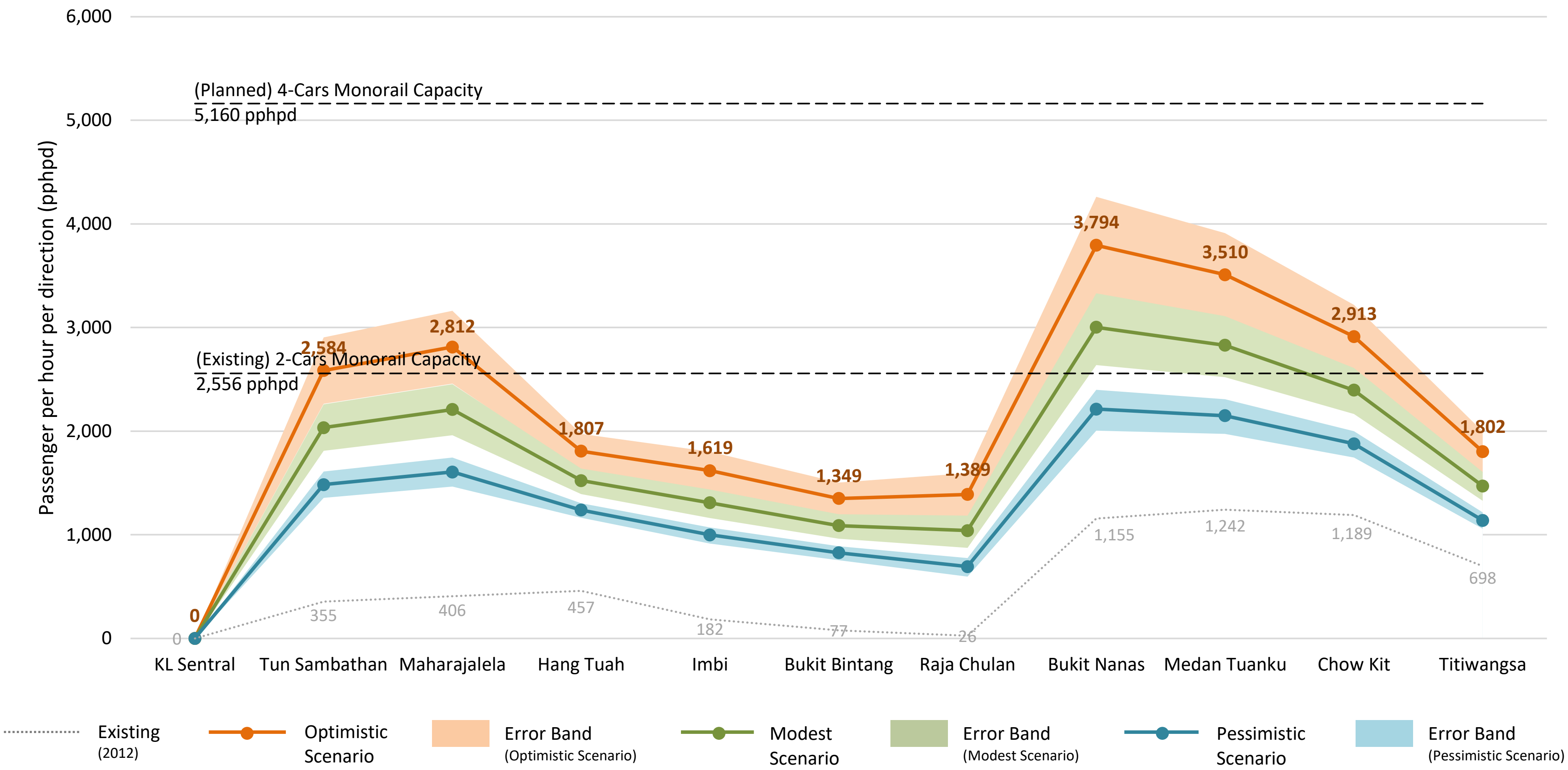


Figure 4.25: The effect of 40% zoning intensification scenario on potential monorail ridership outbound traffic movement (average weekday per peak hour). More detail ridership information is available in Appendix N3.

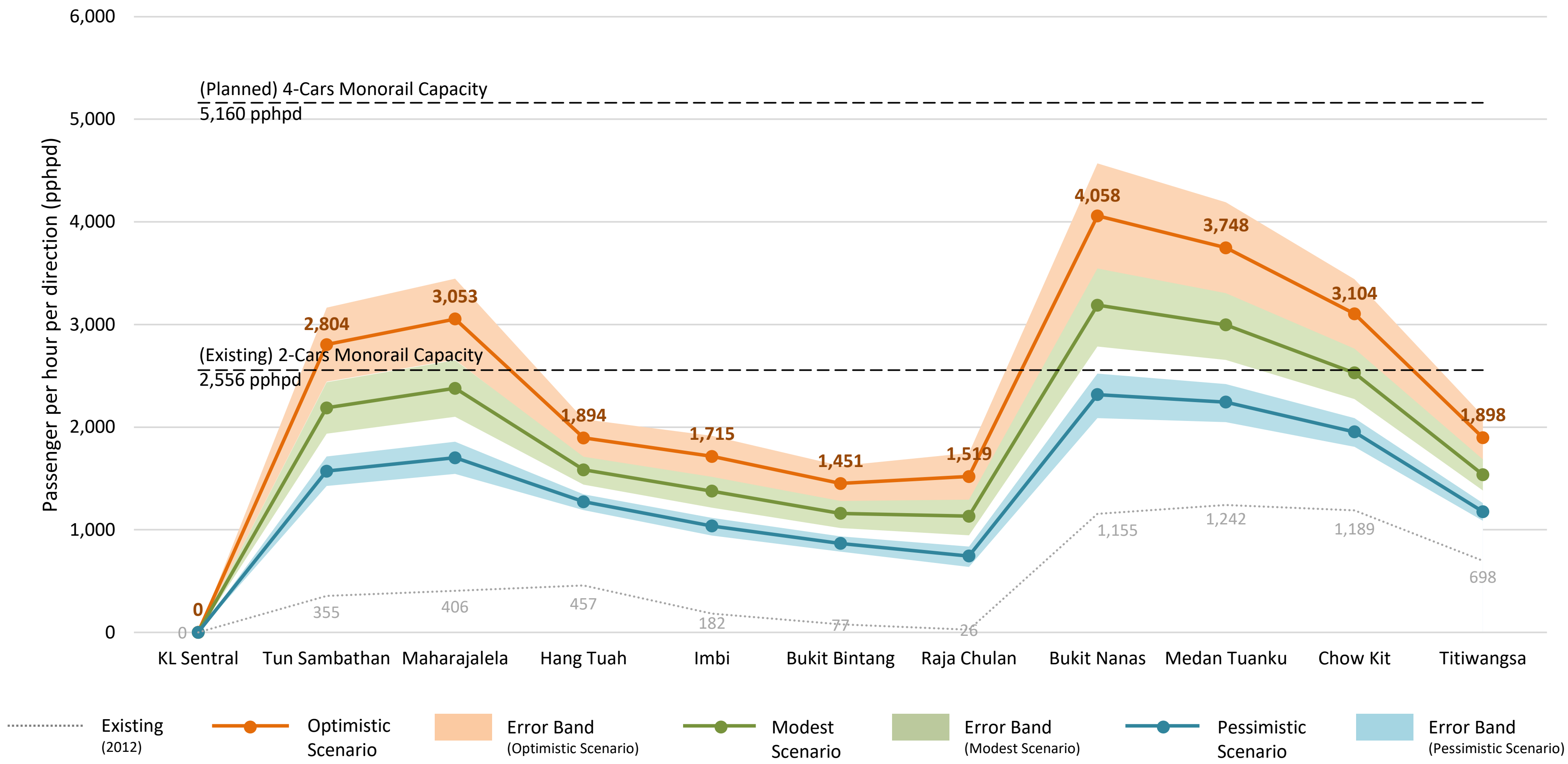


Figure 4.26: The effect of 60% zoning intensification scenario on potential monorail ridership outbound traffic movement (average weekday per peak hour). More detail ridership information is available in Appendix N4.

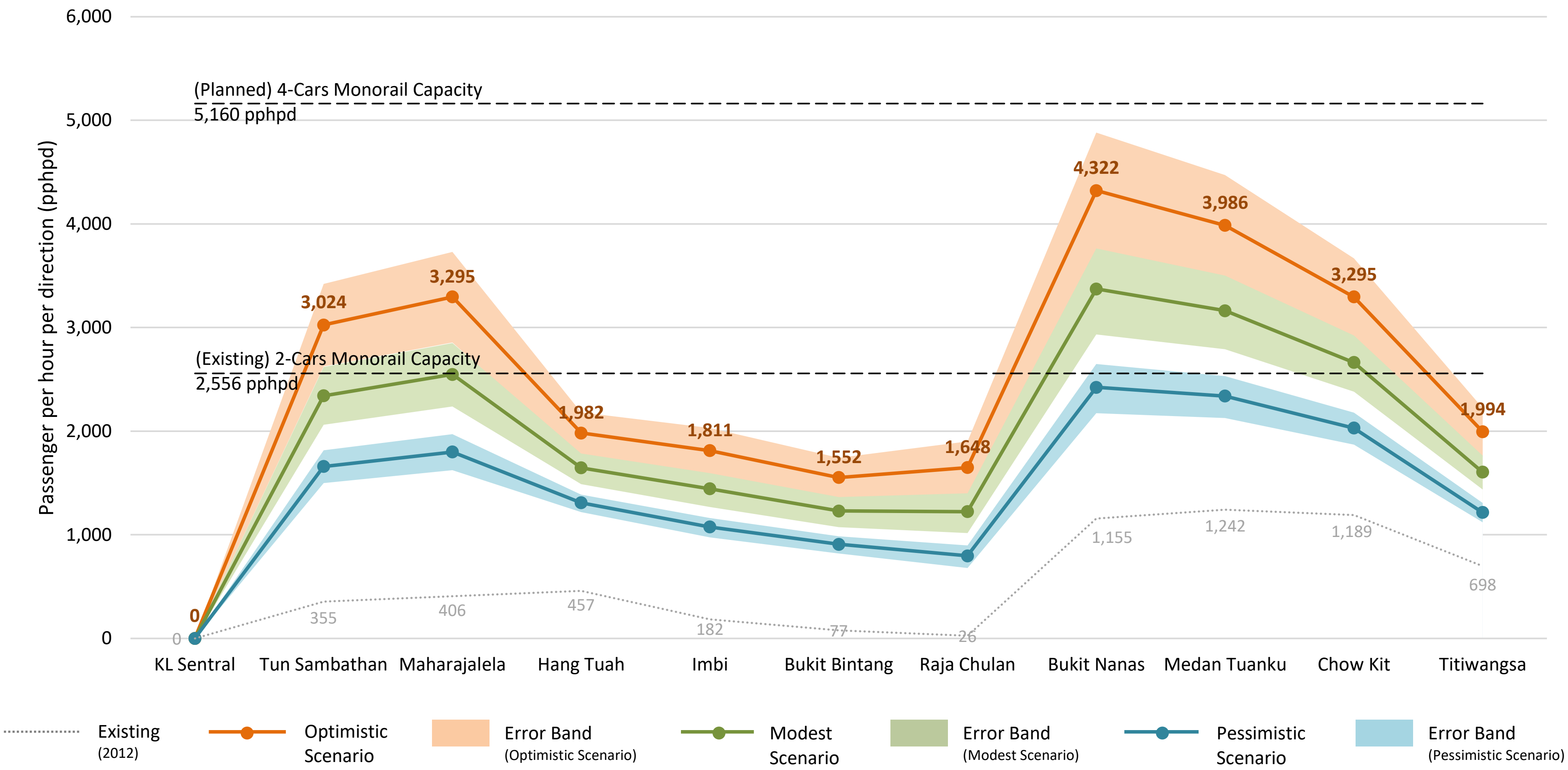


Figure 4.27: The effect of 80% zoning intensification scenario on potential monorail ridership outbound traffic movement (average weekday per peak hour). More detail ridership information is available in Appendix N5.

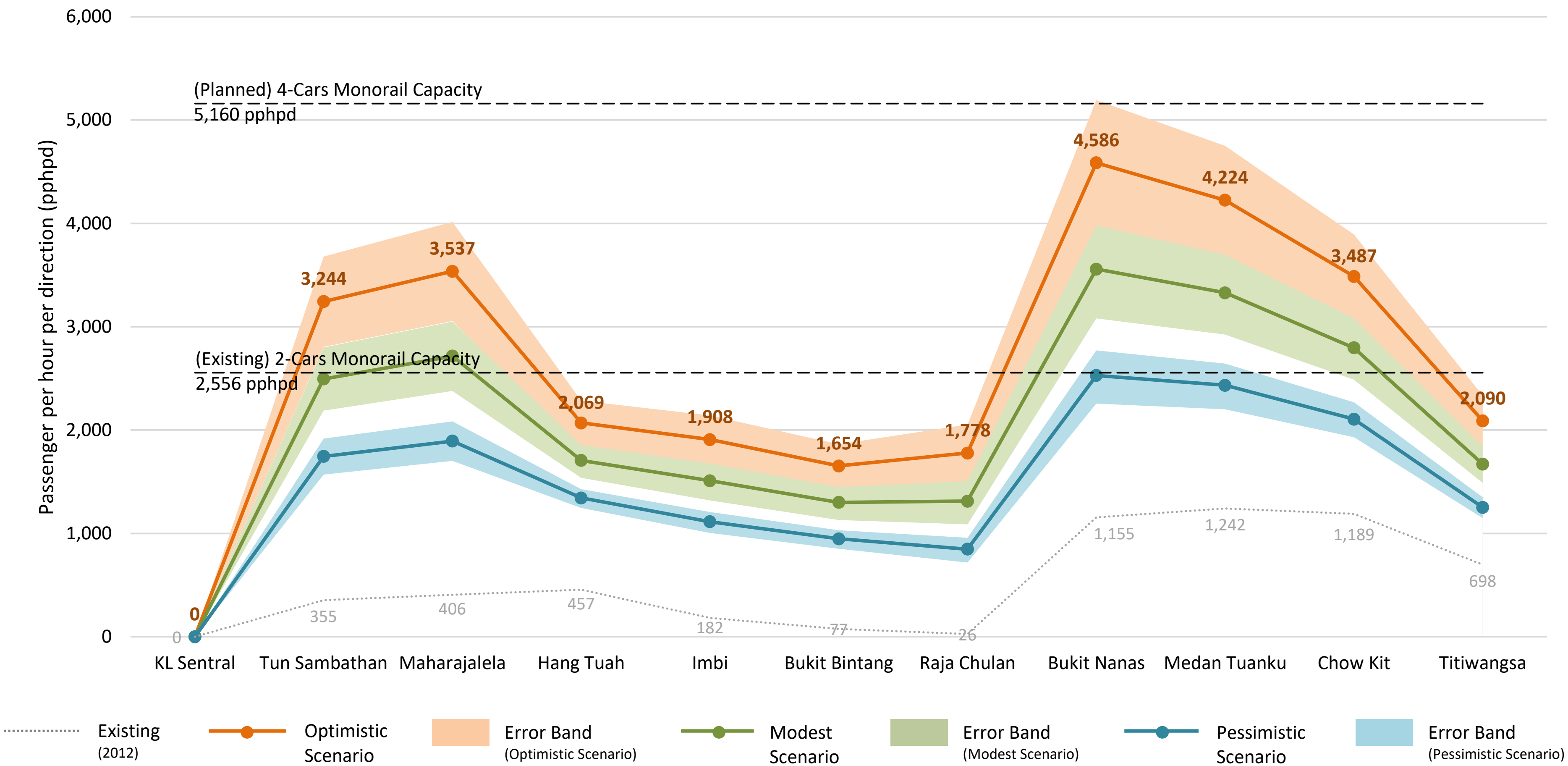


Figure 4.28: The effect of 100% zoning intensification scenario on potential monorail ridership outbound traffic movement (average weekday per peak hour). More detail ridership information is available in Appendix N6.

imply from these four zoning intensification scenarios are predicted at 4,330 pphd for business as usual zoning intensification scenario, 4,597 pphd for 20%upzoning zoning intensification scenario (Figure 4.18), 4,864 pphd for 40% upzoning intensification scenario (Figure 4.19) and 5,131 pphd for 60% upzoning intensification scenario (Figure 4.20). Meanwhile, the existing 2-cars monorail capacity and planned 4-cars monorail capacity is observed at 2,556 pphd and 5,160 pphd respectively. With the expansion of 4-cars transit capacity of monorail in mind, our analysis shows that it would be great for the zoning intensification to take the advantage of such transit capacity expansion to further intensify by receiving additional 60% upzoning over the business as usual early zoning intensification plan of monorail station areas. Consequently, this would encourage more people to take transit in the future than the other three zoning intensification scenarios (business as usual, 20% upzoning and 40% upzoning). In addition, by adopting 60% upzoning zoning intensification scenario, it would reduce the tendency of future growth (16%) to take private vehicle compared to the business as usual zoning intensification scenario (41%) (Table 4.6).

With beyond the zoning intensification of 60% upzoning, we are expecting that even more people to take transit and the potential ridership would higher than the planned 4-cars monorail transit capacity (5,160 pphd) could handle. In the 80% upzoning and 100% upzoning zoning intensification scenarios, the expected upmost on-board passengers for the optimistic ridership trend (average weekday per peak hour) for Kuala Lumpur monorail inbound movement is observed at 5,397 pphd (Figure 4.21) and 5,664 pphd (Figure 4.22) correspondingly. As discussed earlier in the Chapter One that ensuring station area population and employment density to tailored with transit capacity is important for a meaningful TOD development. Therefore, to adopt the zoning intensification scenario of beyond 60% upzoning, Kuala Lumpur city should consider themselves to plan for higher monorail transit capacity than what currently planned to accommodate the expected ridership. Based on the assessment results from our study, it is recommended that Kuala Lumpur city should consider at least 6-cars monorail transit capacity (7,716 pphd) to support the potential ridership from the zoning intensification scenario of beyond 60% upzoning. With this in mind, other monorail transit infrastructures such as station and structural foundation are a necessity to be expanded to meet the larger size of monorail transit and ridership. In view of the financial constraint in the expansion for transit capacity and infrastructure in the future, Kuala Lumpur should not adopt such level of zoning intensification for this moment as it does not compatible with the presently planned 4-cars monorail transit capacity. Otherwise, this would lead to overcrowding and making monorail transit less competitive to the private vehicle. Given a circumstance that Kuala Lumpur is afforded for 6-cars monorail transit capacity and infrastructure upgrade, our analysis shows that it could house for the expected number of people to take transit in the 100% upzoning zoning intensification or even much higher level of zoning intensification that this study has present. In this situation, Kuala Lumpur may think about to set-up more sending areas other than the present 400-600m geographic space of monorail transit stations to increase the transfer of development rights by further preserving the growth over the other geographic space that has disadvantage of transit access, so that most of the future growth of Kuala Lumpur is mainly concentrated within the walkable catchment area of transit station for promoting more people to take transit and ensuring a better TOD for Kuala Lumpur.

Nevertheless, it is important to note that the predicted potential ridership of Kuala Lumpur monorail from the zoning assessment scenarios demonstrated from this study so far is mainly considered the single facet effect of density and we would only induce and expect 20% of the future growth in the 400m walkable station area to take transit. Definitely, such amount is remaining insufficient for Kuala Lumpur city to promote TOD as most of the future growth (about 80%) would use private vehicle. This could be worse as the higher density environment is being promoted in the confined geographic space of station area where we could imagine for serious traffic congestion. Therefore, it is too early for us to conclude that 60% upzoning or 100% upzoning zoning intensification as good options at this moment as their result is primarily reflected from the situation where 20% of the future growth implied from the zoning intensification scenarios in the 400m walkable station area would expect to use transit.

In promoting TOD, Kuala Lumpur city would certainly be aiming for more future growth implied from the zoning intensification scenarios to use transit over the private vehicle. Given this circumstance, we would assume that the increase of density of Kuala Lumpur monorail station area would take place together with other built environment improvement such as better connectivity, mixed-use, higher quality of semi-public space and pedestrian friendly sidewalk as well as public transit policy. Therefore, we are expecting a higher proportion of future growth from zoning intensification scenarios to use transit. Apart from the current assessment result on the anticipation of 20% future growth in taking transit (see Figure 4.29, assemble from the Figure 4.17 – 4.21), this study further extends its analysis to further consider three additional consequences 40%, 60% and 80% of the future growth from the zoning intensification scenarios of Kuala Lumpur monorail to use transit. Since we have not seen any cities in the world where all of its community takes transit in their travel, thereby 100% expectation does not include in this study. Additionally, as the previous discussion has noticed that the predicted potential Kuala Lumpur monorail ridership for outbound traffic movement implies from the zoning intensification scenario is lower than the inbound traffic movement, thereby the discussion of this study for the additional analysis is mainly focused on the predicted potential monorail ridership of the inbound traffic movement.

The predicted potential monorail ridership from these three additional consequences on the zoning intensification scenarios for Kuala Lumpur monorail is demonstrated in Figure 4.30, 4.31 and 4.32. For the zoning intensification scenarios with 40% target future growth to use transit (Figure 4.30), the predicted peak of the error band of uppermost on-board passengers for the optimistic ridership trend (average weekday per peak hour) for Kuala Lumpur monorail inbound movement are anticipated at 6,131 pphpd for business as usual zoning intensification scenario, 6,646 pphpd for 20% upzoning zoning intensification scenario, 7,161 pphpd for 40% upzoning zoning intensification scenario, 7,676 pphpd for 60% upzoning zoning intensification scenario, 8,191 pphpd for 80% upzoning zoning intensification scenario and 8,706 pphpd for 100% upzoning zoning intensification scenario. Given that the 6-cars monorail transit capacity is available and assumed to be 7,740 pphpd (1.5 times of the planned 4-cars monorail transit capacity at 5,160 pphpd), the results show that among the 60% upzoning zoning intensification scenario offer the greatest TOD advantage, capitalises the most of its transit capacity to allow more people to use transit than other zoning intensification scenarios (business as usual, 20% upzoning and 60% upzoning).

Even 80% upzoning and 100% upzoning zoning intensification scenarios with 20% target future growth to use transit (which we discussed earlier) can be supported by the 6-cars monorail transit capacity (Figure 4.29), yet the expected number of people in total future growth to use transit from those scenarios is lower than the 60% upzoning zoning intensification scenarios with 40% target future growth to use transit. The Table 4.7 illustrates the proportion of expected transit users in the total growth from the zoning intensification scenarios with its respective percentage target of future growth in 400m walkable station area to use transit. The proportion of expected transit users in the total growth from these zoning intensifications can be observed at 18%, 20% and 34% correspondingly. While with beyond the 60% upzoning zoning intensification, a larger 8-cars monorail transit capacity is needed to accommodate a higher level of potential ridership demand to ensure the higher quality of monorail service for maintaining monorail as an attractive choice for the community to travel in the city centre. However, it is important to note that with the 8-cars monorail transit capacity, the zoning intensification scenarios with 60% target future growth of transit use (Figure 4.31) (in exceptional of the business as usual zoning intensification scenario) would in fact perform better in the TOD promotion than the zoning intensification scenarios of beyond 60% upzoning that has the 40% target future growth. For that reason, 60% upzoning is the greatest among the zoning intensification scenarios for the 40% target of future growth to use transit in TOD promotion.

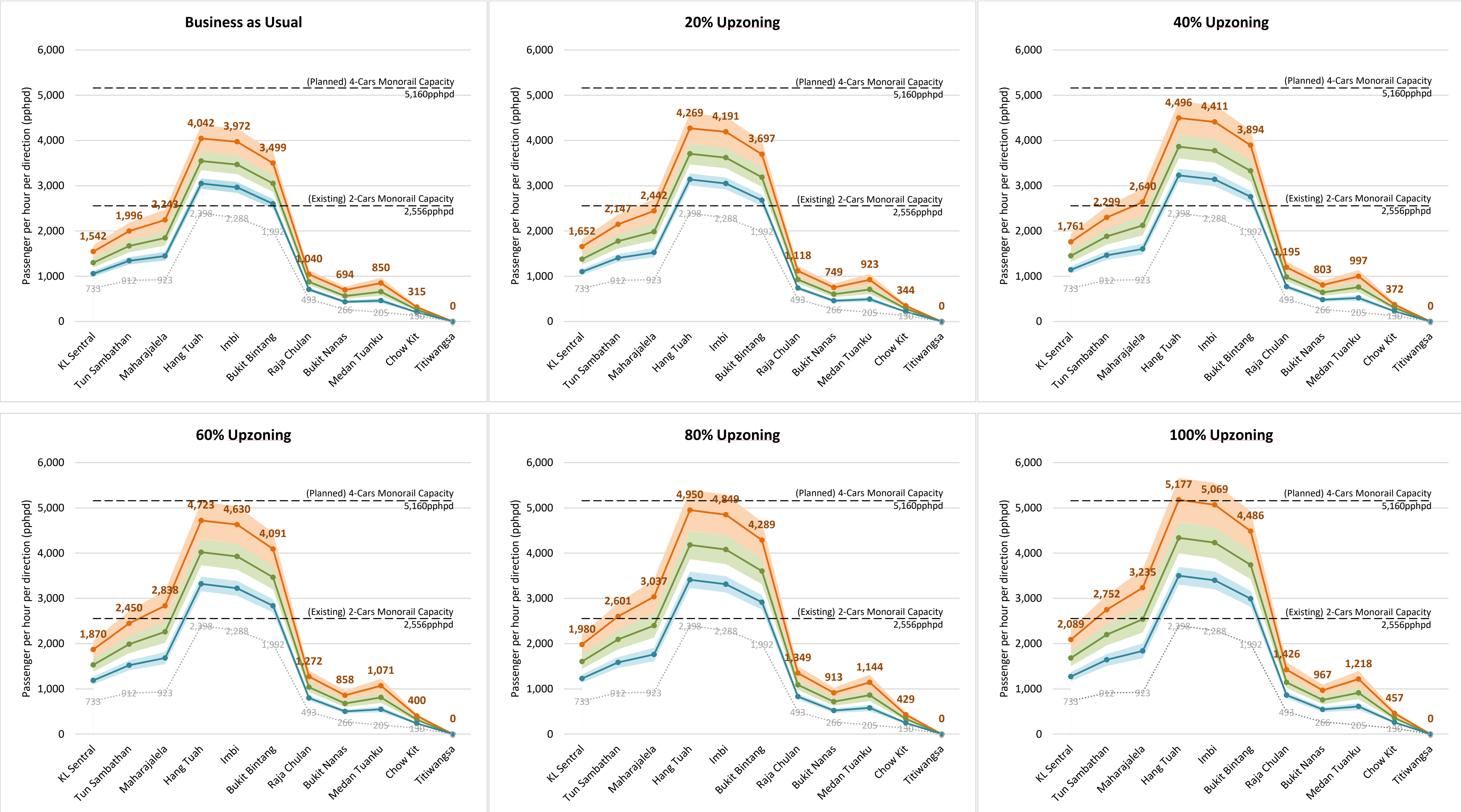


Figure 4.29: The density effect of Kuala Lumpur Zoning Intensification Scenarios with 20% expected future growth to use transit on the monorail inbound traffic potential monorail ridership inbound traffic movement (average weekday per peak hour). More detail ridership information is available in Appendix M (M1-M6).

Figure 4.30: The effect of Kuala Lumpur Zoning Intensification Scenarios with 40% target future growth to use transit on the monorail inbound traffic potential monorail ridership inbound traffic movement (average weekday per peak hour). More detail ridership information is available in Appendix O (O1-O6).

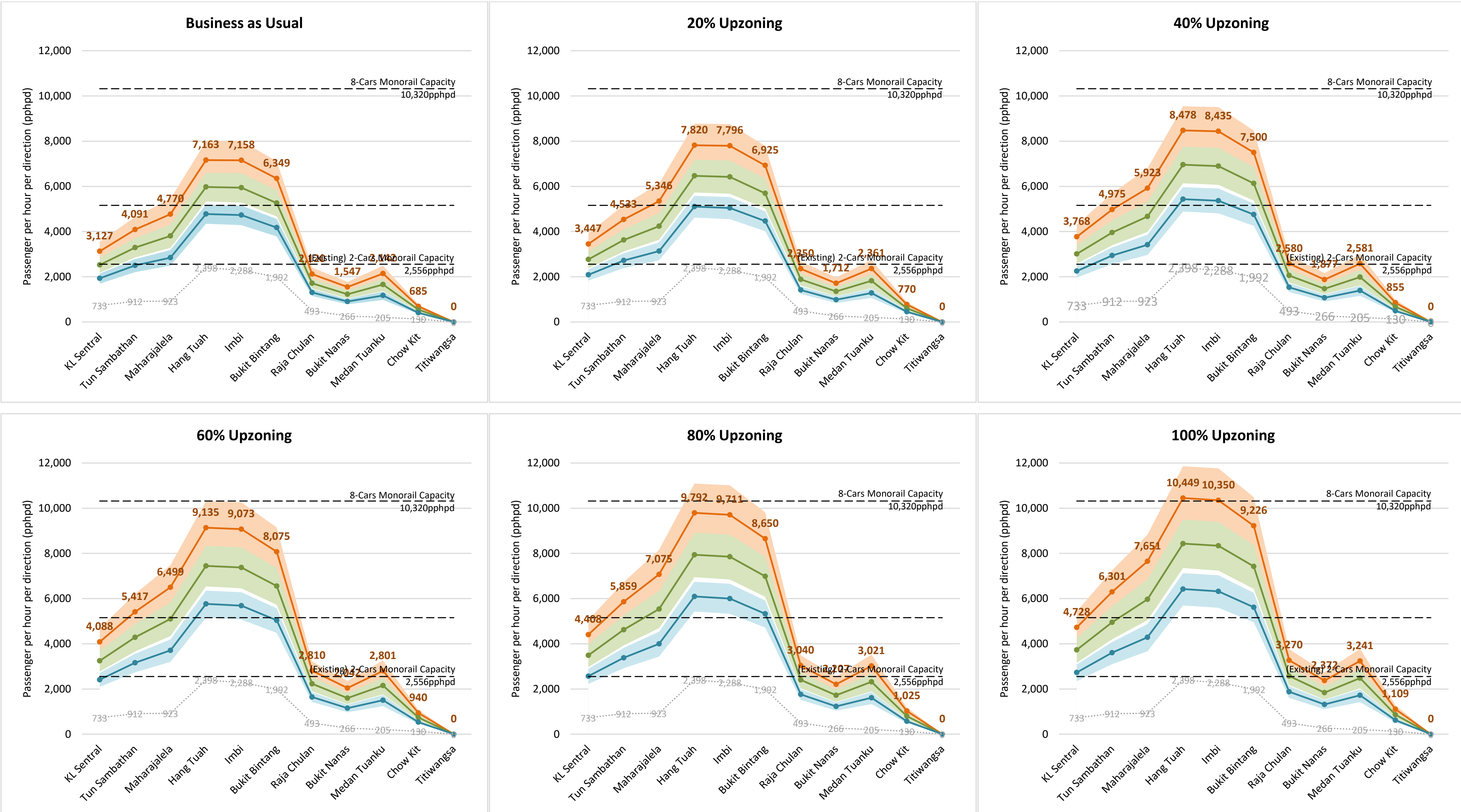


Figure 4.31: The effect of Kuala Lumpur Zoning Intensification Scenarios with 60% target future growth to use transit on the monorail inbound traffic potential monorail ridership inbound traffic movement (average weekday per peak hour). More detail ridership information is available in Appendix P (P1-P6).

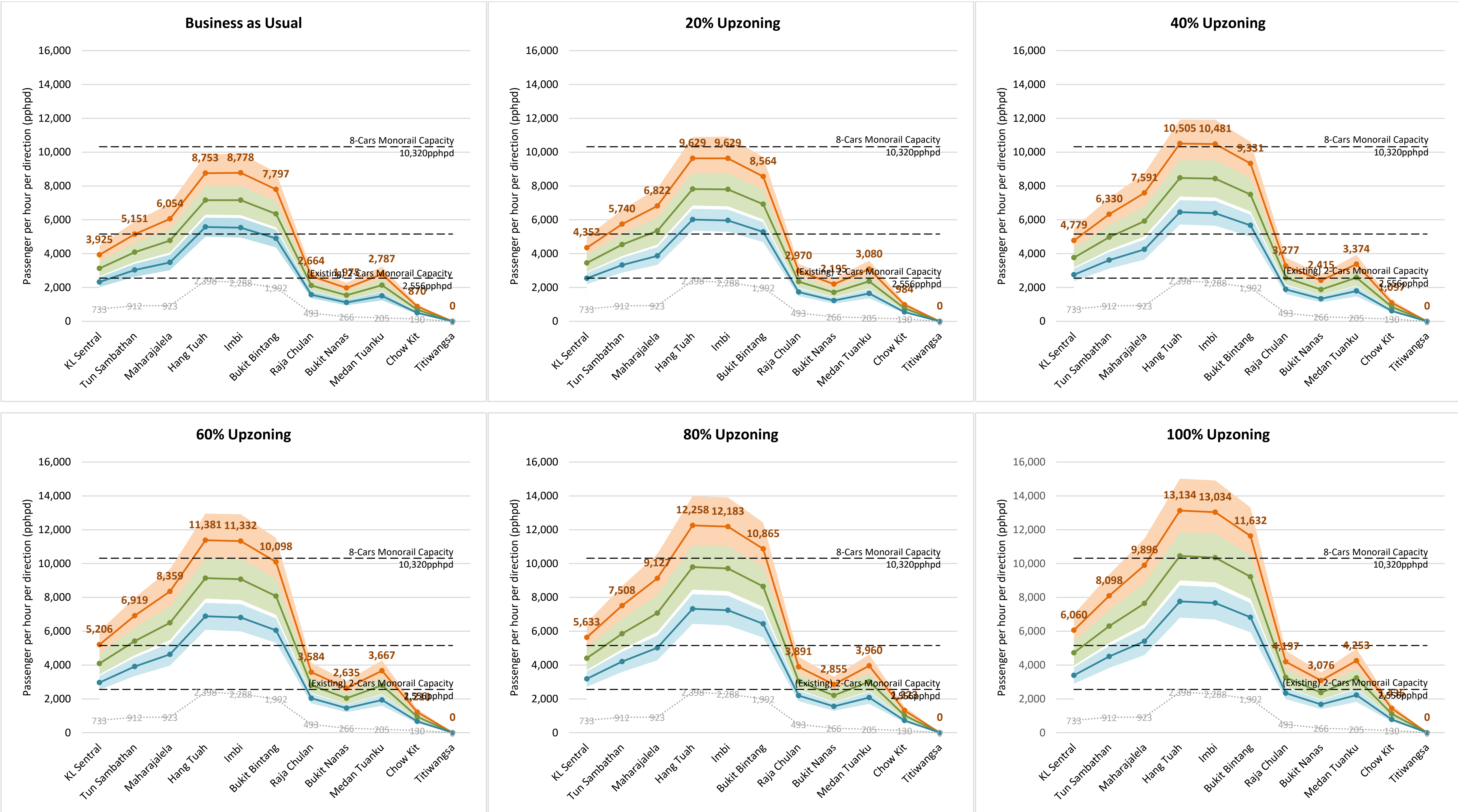


Figure 4.32: The effect of Kuala Lumpur Zoning Intensification Scenarios with 80% target future growth to use transit on the monorail inbound traffic potential monorail ridership inbound traffic movement (average weekday per peak hour). More detail ridership information is available in Appendix Q (Q1-Q6).

Table 4.7: The proportion of total growth to take transit implied from the zoning intensification scenarios and its target percentage of transit user.

Scenarios	Growth (Geographic space of 400m from transit station)	Target Percentage of Transit User (Geographic space of 400m from transit station)	Expected Number of People to Take Transit (Geographic space of 400m from transit station)	Total Growth	Proportion of Total Growth to Take Transit
Business as Usual (Early Zoning Plan)	477,671	Baseline 20%*	95,534	803,857	12%
		40%	191,068	803,857	24%
		60%	286,603	803,857	36%
		80%	382,137	803,857	48%
20% Upzoning	542,909	Baseline 20%*	108,582	803,857	14%
		40%	217,164	803,857	27%
		60%	325,745	803,857	41%
		80%	434,327	803,857	54%
40% Upzoning	608,147	Baseline 20%*	121,629	803,857	15%
		40%	243,259	803,857	30%
		60%	364,888	803,857	45%
		80%	486,518	803,857	61%
60% Upzoning	673,381	Baseline 20%*	134,676	803,857	17%
		40%	269,352	803,857	34%
		60%	404,029	803,857	50%
		80%	538,705	803,857	67%
80% Upzoning	738,619	Baseline 20%*	147,724	803,857	18%
		40%	295,448	803,857	37%
		60%	443,171	803,857	55%
		80%	590,895	803,857	74%
100% Upzoning	803,857	Baseline 20%*	160,771	803,857	20%
		40%	321,543	803,857	40%
		60%	482,314	803,857	60%
		80%	643,086	803,857	80%

* Note: Baseline 20% of the target percentage of transit user is mainly driven by the factor of density increase at the geographic space of 400m from transit station.

From the predicted potential monorail ridership results of Kuala Lumpur monorail zoning intensification scenarios for the 60% target future growth to take transit (Figure 4.31), the 60% upzoning zoning intensification scenario is again to be consider as the better zoning intensification in comparison with other scenarios (business as usual, 40% upzoning and 60% upzoning) for the similar reason that we have discussed earlier by captivating the maximal monorail transit capacity to allow higher number of community to use transit. Assuming that the 8-cars monorail transit capacity could accommodate 10,320 pphpd (2 times of the planned 4-cars monorail transit capacity documented at 5,160), the predicted peak of the error band of uppermost on-board passengers for the optimistic ridership trend (average weekday per peak hour) for Kuala Lumpur monorail inbound movement is anticipated at 10,317 pphpd. Given that the maximum monorail transit capacity is expected at 8-cars train with 10,320 pphd, the zoning intensification of beyond 60% upzoning does not provide a meaningful result for TOD promotion. At the target 60% of future growth to use transit, these zoning intensification scenarios would attract a number of transit users which higher than the maximum 8-cars monorail transit capacity could tolerate. This would lead to the monorail transit congestion and bring adverse effect in encouraging community to use transit. Limited by the transit technology, the largest monorail transit capacity is documented at 8-cars train at this moment. Even the city is wealthy enough, there is no more room for monorail transit capacity expansion and irrelevant to support the zoning intensification of beyond 60% upzoning. Taking this into account, 60% upzoning zoning intensification scenario is fit with the situation where 60% target future growth of transit users in TOD promotion.

At the expectation where 80% target future growth to use transit, most of the results from the zoning intensification scenarios for Kuala Lumpur monorail indicates that the predicted potential monorail ridership increase drastically and it would exceed the maximum 8-cars monorail transit capacity 10,320 pphpd could support. It is unexpected to note that the business as usual zoning intensification scenario with 80% target future growth of transit users can be supported by the 8-cars monorail transit capacity and as illustrated in Table 4.7 the proportion of its total growth to take transit (48%) is as good as to the 60% upzoning zoning intensification scenario with 60% target future growth to use transit (50%). However, it requires an enormous effort of improvement on the built environment and public transit quality as well as nurturing the community on transit use to achieve a high target of 80% future growth to take transit. It is remaining possible but rather challenging if comparing to the 60% future growth target to use transit to attain a similar outcome. Despite the fact that 60% upzoning zoning intensification scenario may not be suitable for the 80% target future growth to use transit (due to the difficulties to achieve as discussed earlier and the incompatibility of maximum 8-cars monorail transit capacity to cater the expected ridership for this moment) but then again at the 60% future growth target it could accomplish a substantial TOD promotion effect as akin to the challenging business as usual zoning intensification scenarios with 80% target future growth to use transit. Therefore, the 60% upzoning continuously to be a preferred option of zoning intensification scenario for TOD promotion.

The summary of the assessment results for the zoning intensification scenarios of Kuala Lumpur monorail is illustrated in Table 4.8. It indicates that the business as usual, 20 upzoning and 40% upzoning zoning intensification scenarios are good but

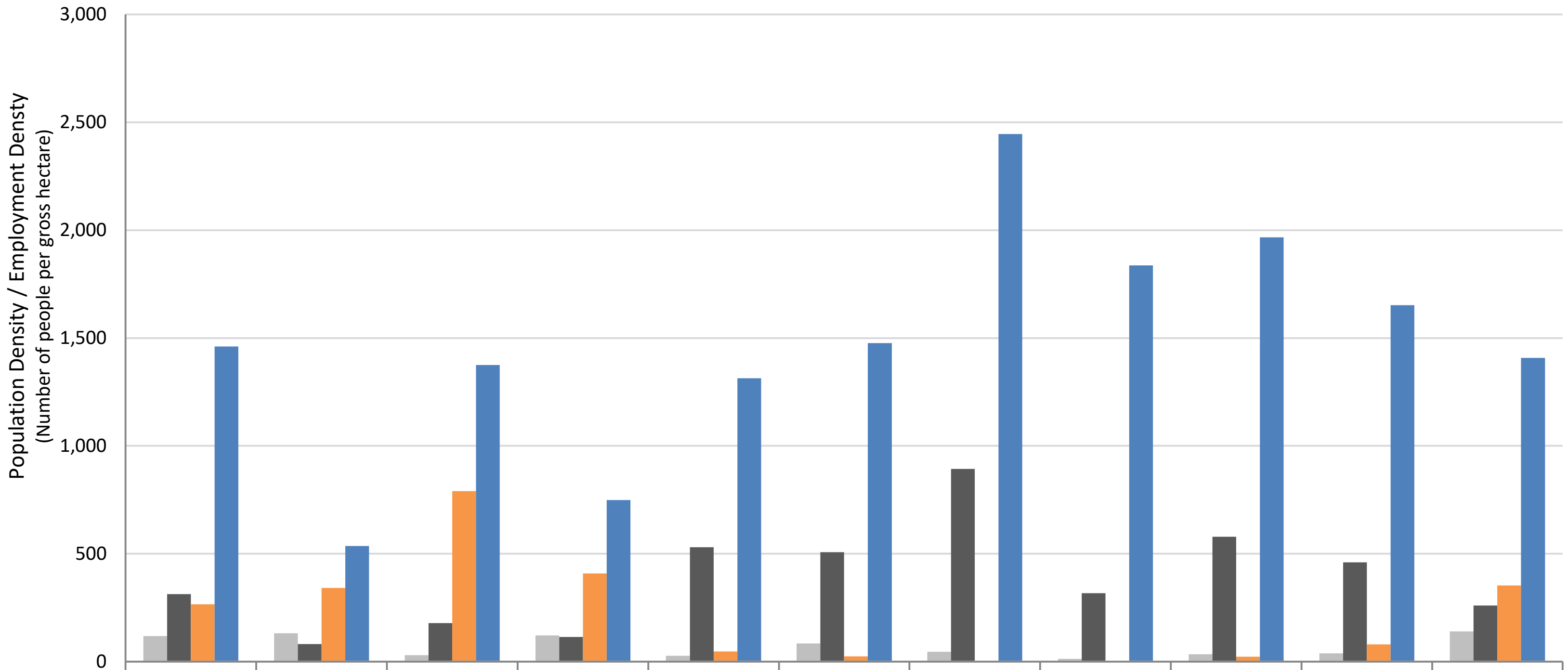
Table 4.8: A summary of the zoning intensification assessment results of the Kuala Lumpur monorail.

Zoning Intensification Scenarios	Expected 20% Transit User (Baseline) = *4-cars train* =	Expected 40% Transit User = *6-cars train* =	Expected 60% Transit User = *8-cars train* =	Expected 80% Transit User = *8-cars train* =
Business as Usual	↑ Overcapacity (excess) ↑ Satisfied Transit Service Quality	↑ Overcapacity (excess) ↑ Satisfied Transit Service Quality	↑ Overcapacity (excess) ↑ Satisfied Transit Service Quality	↑ Overcapacity (excess) ↑ Satisfied Transit Service Quality
20% Upzoning	↑ Overcapacity (excess) ↑ Satisfied Transit Service Quality	↑ Overcapacity (excess) ↑ Satisfied Transit Service Quality	↑ Overcapacity (excess) ↑ Satisfied Transit Service Quality	↓ Undercapacity (overcrowd) ↓ Unpleasant Transit Service Quality
40% Upzoning	↑ Overcapacity (excess) ↑ Satisfied Transit Service Quality	↑ Overcapacity (excess) ↑ Satisfied Transit Service Quality	↑ Overcapacity (excess) ↑ Satisfied Transit Service Quality	↓ Undercapacity (overcrowd) ↓ Unpleasant Transit Service Quality
60% Upzoning	↑ Capacity Balanced ↑ Satisfied Transit Service Quality	↑ Capacity Balanced ↑ Satisfied Transit Service Quality	↑ Capacity Balanced ↑ Satisfied Transit Service Quality	↓ Severe Undercapacity (overcrowd) ↓ Poorest Transit Service Quality
80% Upzoning	↓ Undercapacity (overcrowd) ↓ Unpleasant Transit Service Quality	↓ Undercapacity (overcrowd) ↓ Unpleasant Transit Service Quality	↓ Undercapacity (overcrowd) ↓ Unpleasant Transit Service Quality	↓ Severe Undercapacity (overcrowd) ↓ Poorest Transit Service Quality
100% Upzoning	↓ Undercapacity (overcrowd) ↓ Unpleasant Transit Service Quality	↓ Undercapacity (overcrowd) ↓ Unpleasant Transit Service Quality	↓ Undercapacity (overcrowd) ↓ Unpleasant Transit Service Quality	↓ Severe Undercapacity (overcrowd) ↓ Poorest Transit Service Quality

insufficient. These three zoning intensification scenarios generally could imply a satisfied transit service quality in most of the setting with the higher expected future growth of transit users. Nonetheless, they are expected in the situation of overcapacity where the transit capacity remains excess as the number of the predicted ridership below the maximum amount that monorail vehicle can occupy. In addition, these zoning intensification scenarios largely continue the idea of early zoning plan proposal by allowing the future growth to take place on the geographic space with poor accessibility to transit service (400-600m from transit station). On the other hand, the 80% upzoning and 100% upzoning zoning intensification scenarios indicated that the size of the monorail transit vehicle corresponding for the expected future growth in transit use would be under-capacity. Every single potential ridership suggested from these zoning intensification scenarios for each expected transit user settings are anticipated to be higher than the respective monorail transit capacity ability to accomodate. Therefore, we are expecting to foresee that this event would likely lead to passenger overcrowding issue and higher possibility of deteriorating the transit service quality. Considering the poor transit service quality, it is rational to imagine that most of the future growth would stay away from using monorail and reasonably for choosing private vehicle to travel. Consequently, these zoning intensification scenarios do not encourage greatest amount of future growth to use monorail transit service and in this way the TOD promotion is inefficient.

In the meantime, it is observed that the 60% upzoning is among the zoning intensification scenarios demonstrate the potential ridership implication for the future growth to fully capitalise the given size of monorail in the expected transit user settings while sustaining a balance between passenger and transit capacity accordingly along with satisfied transit service quality. Particularly, it fits in well with the higher transit travel pattern where 40% and 60% of the future growth is expected to use monorail transit service. The 40% transit modal share is equivalent to Taipei while 60% transit modal share is as good as to Singapore, both of these cities hold a relatively good record in TOD development. By comparing with the zoning intensification scenarios discussed earlier, the 60% upzoning is capable to effectively support most of the future growth to take the monorail and promote a meaningful TOD.

From the discussion above, it is clear that the preferable zoning intensification scenarios of Kuala Lumpur monorail for the significant TOD promotion recommended from this study are 60% upzoning. The suggested Kuala Lumpur monorail station area density under these zoning intensification scenarios are demonstrated in Figure 4.33. Based on this zoning intensification scenario, the highest recommended station area population density can be noticed at Maharajalela station where 791 residents per gross hectare. Meanwhile, the highest station area employment density proposed from the preferable zoning intensification scenarios can be observed at Raja Chulan station where 2,445 workers per gross hectare. Towards a better TOD promotion, Kuala Lumpur should allow the development to take place on this recommended station area density.



	KL Sentral	Tun Sambathan	Maharajalela	Hang Tuah	Imbi	Bukit Bintang	Raja Chulan	Bukit Nanas	Medan Tuanku	Chow Kit	Titiwangsa
Population (Existing 2012)	118	132	31	122	28	85	46	13	35	39	141
Employment (Existing 2012)	313	82	179	114	531	507	894	318	579	461	260
Population (60% Upzoning)	267	342	791	409	48	24	0	0	24	80	353
Employment (60% Upzoning)	1,461	536	1,375	750	1,314	1,476	2,445	1,836	1,966	1,653	1,408

Figure 4.33: The existing Kuala Lumpur monorail station area density in year 2012 and TOD promotion station area density suggested from the zoning intensification scenario of 60% upzoning.

4.6 Conclusion

This chapter examines the zoning intensification of Kuala Lumpur using Kuala Lumpur monorail as the case study. The zoning intensification scenarios include the present early zoning intensification plan proposed by the draft Kuala Lumpur City Plan 2020 as well as a series of upzonings where this study suggest for transfer of development rights to address the weakness of the existing early zoning plan to restraint the future growth on the geographic space of weak transit influence by channel the growth to further intensify the development within the walkable transit catchment area. Here, we evaluate the effect of these zoning intensification scenarios on Kuala Lumpur monorail station areas in terms of the expected amount of people to use transit with the transit capacity with the view to identify the level of zoning intensification that could promote TOD significantly. From the analysis, it is found that all the zoning intensification scenarios would promote more people to take transit and resulted in an increase of ridership that higher than the existing 2-cars monorail transit capacity could support. It is noticed that 60% upzoning is the preferable zoning intensification scenario for TOD promotion on Kuala Lumpur monorail. The assessment result shows that the 60% upzoning is among the zoning intensification scenarios that could fully capitalise the monorail capacity at various expected transit user growth by promoting most of the future growth to take transit. With the affordability for maximum 8-cars monorail capacity as well as its ancillary infrastructure upgrade in mind, it is worth for Kuala Lumpur to support 60% upzoning together with the 60% target future growth to use transit as this could greatly encourage a large amount of upcoming population and employment implied from zoning intensification to use transit thereby meaningfully promote TOD.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Summary of Findings

With the view of promoting TOD for Malaysian cities pursuing greater urban sustainability, this study aims to investigate the degree of an appropriate density increase for the transit station area. Taking this into account, we demonstrate it to evaluate the early zoning intensification effort by Kuala Lumpur for TOD promotion, specifically employing Kuala Lumpur monorail as our empirical case study for proposing an idea of TOD zoning intensification concept intended to provide meaningful lessons for benefiting Kuala Lumpur in TOD promotion.

First, to generalise the quantitative relation between station area density and ridership, this research systematically reviews the existing empirical studies that apply multiple regression model to examine the built environment, socioeconomic and transit service characteristics to the station level ridership. Despite of a large body of research identified from the recognised peer reviewed journal and reliable institution, we are surprised that a few research to date are qualified and well-suit to explain the effect station area density on ridership. From these eligible studies, we hold the other independent variables and specifically extract the coefficient of the station area density independent variable from the full regression empirical model respectively so that the relationship between ridership can be established. Collectively, the results from these studies provide us two separate sets of synthesis findings. The effects of station area population effect over ridership are noticed at the range of 9-23 average weekday passenger boarding is expected for every 100 population increment. On the other hand, the effects of station area employment effect over ridership are noticed at the range of 2-20 average weekday passenger boarding is expected for every 100 employment increment. Further, we observed consistent findings from the various literature reveals that 400m radial form is appropriate as the standard of transit catchment area where most people willing to walk for transit service is largely from this zone.

Second, in searching to verify the ability of building floor space in the estimation of urbanised station area population and employment, our empirical study from the five station areas in Tokyo indicated that building floor space together with the aggregate information of building morphology, density coefficient, and demographic attributes as well as real estate statistics, is able to generate reasonable estimation. With this in mind, we adopt this approach for our empirical case study of Kuala Lumpur monorail to provide the station area population and employment in both existing and zoning setting. Besides, the identified inaccuracy of building floor space model drawing from our empirical study from the five station areas in Tokyo where +16.99% and -11.20% for population estimation while +17.71% and -20.11% for employment estimation is also incorporated to the zoning intensification assessment results of Kuala Lumpur monorail as the error band so that we more ready to aware of the unexpected event.

Drawing from all the above findings, we apply them on our empirical case study of Kuala Lumpur monorail to evaluate a series of zoning intensification scenarios with monorail capacity. Our assessment result shows that the sign of ridership increase for the Kuala Lumpur monorail in zoning setting. This implies that the zoning intensification would give the effect to encourage more people to take transit. Nonetheless, most of the predicted potential ridership growth for Kuala Lumpur monorail expected from the zoning intensification scenarios can be observed at both extreme situations where it does not promote the future growth to sufficiently take full advantage of monorail capacity and it exceeds the given monorail capacity could handle. The zoning intensification scenarios for both of these circumstances are considered to be inefficient in TOD promotion. For the first situation, it does not allow most of the expected future growth which supposed transit users to take monorail. In the second situation, it generates a number of transit users where the given monorail capacity is unable to accommodate them and this would introduce traffic congestion issues and poor service quality (reliability and comfortability) to the monorail and ultimately discourage people to take monorail in the future, defeating the goal of TOD. According to the assessment results, this study noted that 60% upzoning is the greatest zoning intensification scenario in TOD promotion for Kaula Lumpur monorail as it strikes a balance in neither of these two extreme positions. The predicted monorail ridership from 60% upzoning at various transit user growth settings could fully capitalise the given monorail capacity by promoting most of the expected transit users from the future growth to take transit meanwhile compromise with the limitation of the monorail capacity.

It is important to noted that the 60% upzoning zoning intensification scenario in the preferred TOD settings where we are expecting a higher proportion of future growth to use transit (i.e. 40% or 60% of upcoming population and employment) would experience a greater amount of transit ridership demand than the present planned 4-cars train monorail could cater. It requires a larger size of monorail vehicle capacity and its' infrastructure as well as facility to sustain the passenger increment. To adopt the 60% upzoning zoning intensification scenario, Kuala Lumpur must further prepare ahead for monorail expansion to meet the new travel demand. Commonly, the monorail transit upgrade would involve with a huge amount of expenditure. Given the situation of limited financial budget, it is a challenge for Kuala Lumpur to expand the monorail transit system. It is recognised that through the upzoning from the transfer of development rights program, the developers of land parcels or zoning lots located within the prime transit walkable catchment area are granted for the reward to build extra floor space than the basic zoning regulation allowed on their properties. Further, developers also benefit in the development rights trading where the price of the unused development rights from the designated land parcels or zoning lots located at the greater distance over walkable catchment area of poor transit accessibility is expected to be at lower rate. Therefore, developers would enjoy much profit from the cheaper price of development rights purchase in return to maximise most of their high valued properties. To address the financial challenge of monorail expansion, alternatively Kuala Lumpur should frame the current upzoning approach of the transfer of development right program as the incentive-based agreement scheme, in which the Kuala Lumpur grants developer special privileges to purchase the additional air rights or development potential as density bonus, in exchange for a fee used to fund the monorail infrastructure expansion. By that means, this would benefit Kuala Lumpur to achieve the financial viability of monorail upgrades for supporting the 60% upzoning zoning intensification scenario in TOD promotion.

The zoning intensification assessment of Kuala Lumpur monorail case study presented from this study contains several drawbacks and the results are subject to error. The details of the current research limitation are further discussed in the next section. In this manner, the findings suggested from this study remain premature at this moment to provide a strong recommendation for Kuala Lumpur to formulate a meaningful zoning plan to intensify the monorail station areas in TOD promotion. Instead, it must be viewed as a first step toward the missing idea of an appropriate level of zoning intensification might be. More importantly, this research offers an insight into the zoning intensification formulation to the better promotion of TOD. To what extend the level of density is considered as appropriate for TOD promotion? Drawing from the case study of Kuala Lumpur monorail, this research learned that an appropriate TOD station area density must optimally match with the transit capacity. It is a level of density that strikes a balance to benefit most of the future population and employment to take transit while compromise with the given transit capacity to ensure a fine quality of transit service for the community. Despite the fact that the idea is derived from the research of using Kuala Lumpur monorail as a case study that mainly focused on the monorail transit with the geographic context at city centre of Kuala Lumpur; it does not restrict to serve monorail transit, city centre or Kuala Lumpur exclusively. Instead, the basic notion of this idea remains relevant to other Malaysian cities for TOD promotion in various context of the city that supported by diverse type of public transit services.

5.2 Limitation and Suggestion for Future Research

The present case study on the zoning intensification assessment of Kuala Lumpur monorail station areas has several limitations below.

First, the predicted potential monorail ridership from this study largely grounded on the population and employment growth within the primary walkable catchment area of 400m, where we are expecting a majority of people living and working around this area would take transit. The effect of zoning intensification on the potential ridership scenarios presented in this study is limited with the passengers who live and work within the geographic space of Kuala Lumpur monorail station areas. This would not be able to reflect the exact entire passengers in our reality. Rationally, we would expect a certain amount of passengers or transit users who do not originate from the geography context of walkable station area. For example, the kiss and ride passengers who are being dropped off at the transit station and catching their ride via transit. These transit users are generally originating from the geographic region where walking and cycling to transit service is unlikely. Therefore, these passengers are drive by their family member or significant others to the transit station. Without taking this into account, it introduces error into the potential monorail ridership prediction from this study. Besides, our study results do not contain the possible effects of zoning intensification in other urban rail transit station areas of Kuala Lumpur. As the urban rail transit network in Kuala Lumpur is connected with each other, the proposed zoning intensification for station areas of other urban rail transit system (e.g. light rail, mass rail and commuter rail) of Kuala Lumpur city would rationally give a certain degree of implication on the potential ridership scenarios of Kuala Lumpur monorail.

Furthermore, since the monorail serves for the station areas with the geographical context of bustling central district and often regarded as the center of gravity that attracts most people from other parts of Kuala Lumpur city. Hence, there is no reason for us to not anticipate that the zoning intensification on the other station areas of Kuala Lumpur would influence our current assessment result of potential ridership growth for monorail system in this study. In light of this, the present effect of zoning intensification for the potential ridership growth of Kuala Lumpur monorail contains errors that we are unable to address in this research at this moment.

Second, our assessment results on the effect of zoning intensification scenarios for the potential ridership growth of Kuala Lumpur monorail mainly concern with the population and employment increase from the future growth and the existing private vehicle commuters are insensitive to the traveler transport mode choice behavior (Figure 5.1). The existing number of private vehicle travelers who live and work in the walkable transit catchment areas from the zoning intensification scenarios for this study is assumed to follow the present trend and continually to choose automobile as the means of transport for their daily life. Given that we have improved the accessibility (ease of walking), public space quality and connectivity where strongly influences the people to use transit service, nevertheless, it does not mean that these attractive aspects of competitive advantage would turn private vehicle vulnerable to monorail transit alternative. As opposed to one that is imaginary, the competition among the various mode of transport [private vehicle, motorcycle, rail (monorail), bus, bicycle] consists of a wide range element (e.g. cost, time, quality, safety, and etc.). For instance, presuming that the monorail transit service quality and walking environment

Figure 5.1: The effect of the zoning intensification scenario on the ridership growth of our study on Kuala Lumpur monorail does not account on the behavioral change of existing private vehicle users over the monorail transit service.

offered by the TOD development to be more attractive than the private vehicle, in some way this would affect the preference of people to take monorail. This situation could be further complicated by the transportation mode choice where the decision of people is driven by a set of complex factors such as gender, age, income, education level, family size, trip purpose, and many more. Under this circumstance, there could be a possibility somewhat people who take private vehicle today would not repeat the similar travel behavior in the future. Therefore, our current assessment results of potential ridership growth for this study would tend to be biased.

Lastly, the station area density suggested from the preferable 60% upzoning in the zoning intensification assessment in this study is an aggregate uniform density.

This implies that every land parcels or zoning lots located within a similar station area are allowed to share an identical level of development intensity. Therefore, this would result in the undistinguishable station area built form short of centrality where the buildings of the land parcels or zoning lots at/immediate to transit station should apparently be more prominent in terms of elevation to serve as the symbol of transit centre. Furthermore, the uniform density is an inelastic response to the real estate market of the station area in reality. With the transit access improve, the land parcels or zoning lots at/immediate to transit station would receive higher land value increment. The transit induced land value increment gradually reduce as the distance to the transit station increase. Under the given situation, uniform density is very unlikely to drive and motivate the development in the station area. At the land parcels or zoning lots of higher land value increment, an additional density (on top of the uniform density) should be allowed for developers so that they would willing to pay higher price to acquire the land from landowner to deliver return on investment. While a reduced density (on the uniform density) for the land parcels or zoning lots further away to the transit station where land value increment is expected to be lower. The station area density without proper reaction to the market would definitely be facing difficulty in the TOD realization. Considering this fact, we would like to suggest for the future work to articulate the uniform station area density into an appropriate built form that responds to a good urban design and land value increment from the transit access.

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APPENDIX A

Underspecified Model (Omitted Variable Bias)

In the Chapter 2, this study claimed that the underspecified model with missing one or more relevant independent variable could generally causes the coefficient of the multiple regression model to be biased. This section illustrates the phenomenon intuitively by using the simple mathematical equation.

Here, we begin with the case where the true model has the following form:

$$y = a + bx + cz + u$$

with dependent variable y, independent variables x and z, coefficients b and c, constant a, and error term u. In this model, we wish to know the effect of x itself upon y (that is, we wish to obtain an estimate of b). However, due to our ignorance or data availability, we instead estimate the model by excluding independent variable z. In other words, we perform an underspecified model and suppose that the relation between x and z is given by:

$$z = d + fx + e$$

with coefficients f, constant d, and error term e. By substituting the second equation into the first, it gives:

$$y = (a + cd) + (b + cf)x + (u + ce)$$

From the above, it indicates that if a regression of y is conducted upon x only, this last equation is what is estimated, and the regression coefficient on x is actually an estimate of $(b + cf)$, giving not simply an estimate of the desired direct effect of x upon y (which is b), but rather of its sum with the indirect effect (the effect f of x on z times the effect c of z on y). Thus by omitting the variable z from the regression, we have estimated the total derivative of y with respect to x rather than its partial derivative with respect to x. The direction and extent of the bias are both contained in cf, since the effect sought is b but the regression estimates $b+cf$. The extent of the bias is the absolute value of cf, and the direction of bias is upward (toward a more positive or less negative value) if $cf > 0$ (if the direction of correlation between x and y is the same as that between x and z), and it is downward otherwise.

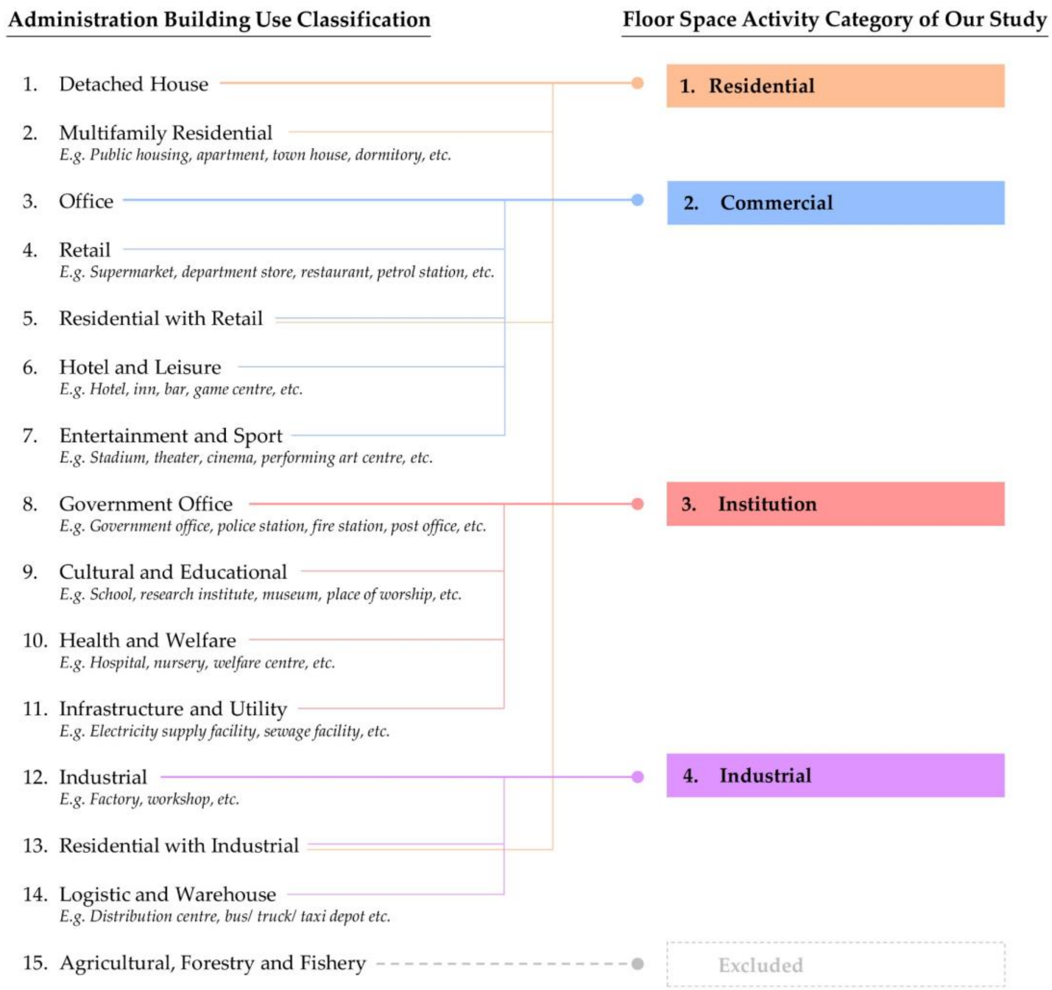
APPENDIX A (Continued)

Note: Two conditions must hold true for omitted-variable bias to exist in regression:

1. The omitted variable must be a determinant of the dependent variable (i.e. its true regression coefficient must not be zero); and
2. The omitted variable must be correlated with an independent variable specified in the regression (i.e. cov(z,x) must not equal zero).

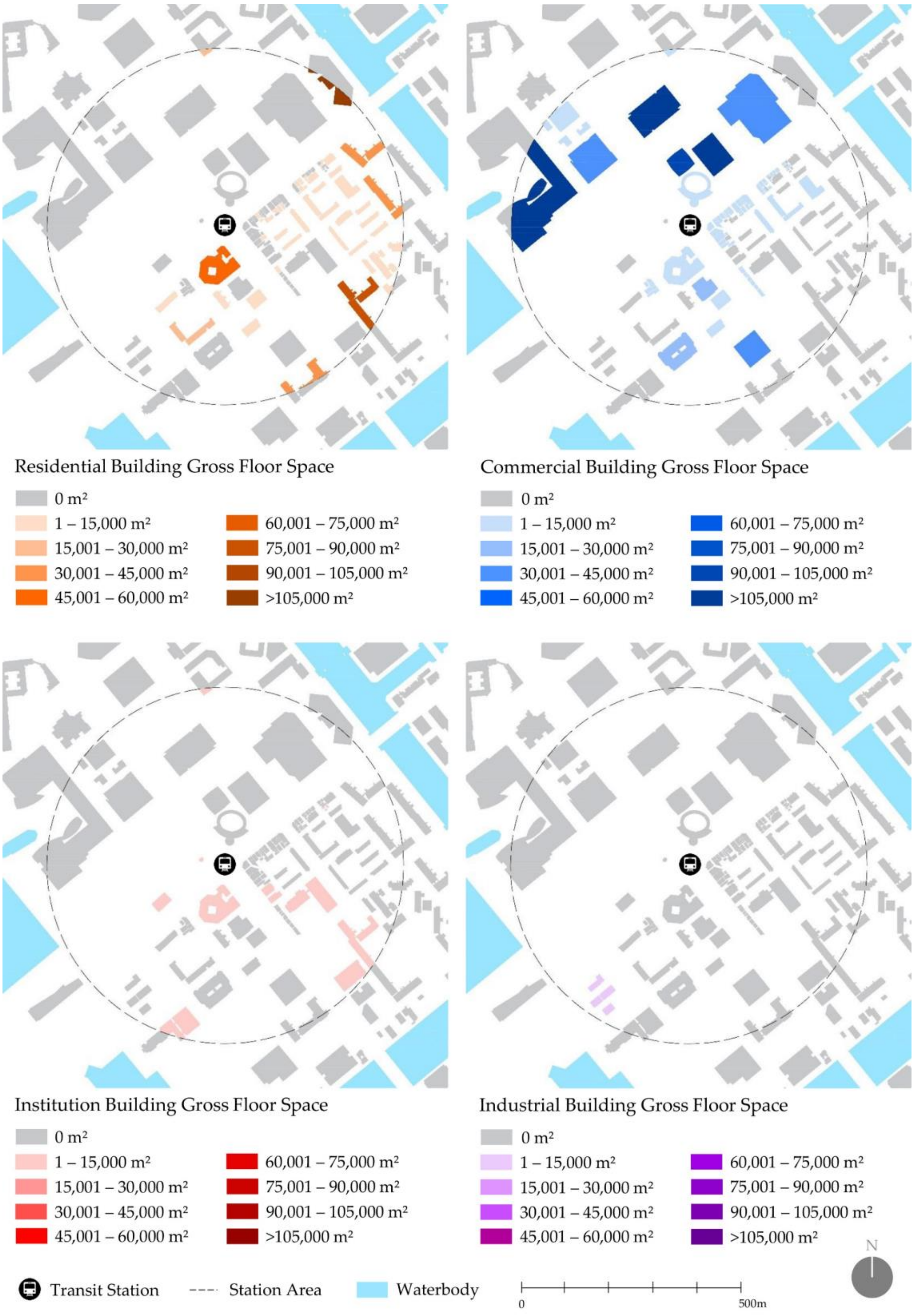
APPENDIX B

The revised floor space activity category from the administrative building use classification.



APPENDIX C

A series of visual maps illustrate the detailed gross floor space distribution (residential, commercial, institution, and industrial) among the buildings of the Toyosu station area in 2015.



APPENDIX D

Land Use Zoning Description (Source: Kuala Lumpur City Hall, 2013)

Land Use Zone	**Description**
City Centre Commercial	Refers to areas located within part of City Centre of Kuala Lumpur and the KL Sentral area. This zone is the highest hierarchy of commercial zones in Kula Lumpur reflecting its functions as the main and prime commercial location, which provide environment attractive to international business community.
Major Commercial	Refers to areas located within (i) part of City Centre of Kuala Lumpur, (ii) district centres and (iii) major commercial areas; which serve larger population thresholds and function as key employment centres. Land and building designated under this zone are to be used primarily for commercial development and activities.
Commercial	Refers to commercial areas principally linear in nature that located along major roads and commercial areas located outside district centres and major commercial zone. Land and building designated under this zone are to be used primarily for commercial development and activities.
Local Commercial	Refers to commercial areas located within or in close proximity to residential neighbourhoods and serve the local communities in providing the commonly required daily products and services. Land and building designated under this zone are to be used primarily for commercial development and activities.
Mixed Use	Refers to land and building intended for the development of a mix of varied but compatible land use and activities, primarily commercial such as retail and offices with residential or residing activities. Development refined to contain residing elements includes condominium, apartments, serviced residence and hotels. These residing

Land Use Zone	Description
	activities must not be less than 60% of the total gross floor space of the mixed use development.
Residential 1	Refers to designated low density residential areas where residential developments of 4 persons per acre up to maximum of 40 persons per acre. Residential units shall vary from the 1 unit per acre in the hillside areas of the city to conventional housing that is compatible with single-family neighbourhoods.
Residential 2	Refers to designated medium density residential areas where residential developments of 41 persons per acre up to maximum of 120 persons per acre. Residential units here vary from landed conventional link homes to low-rise multi-dwellings units or landed strata homes.
Residential 3	Refers to designated medium density residential areas where residential developments of 121 persons per acre up to maximum of 400 persons per acre. Residential units of this zone normally made up of low rise to high rise apartments or condominiums.
Traditional Village	Refers to designated existing villages whereby the village character and setting will be protected. While the area is predominantly residential, others uses that area compatible to the area may be permitted.
Established Housing	Refers to designated existing housing areas that are (i) housing of good quality and character, (ii) well-planned with relatively good infrastructure and amenities, (iii) relatively new or (iv) where developments are committed.
Public Housing	Refers to housing areas that provide decent safe housing for eligible low-income families, the elderly and persons with disabilities by Kuala Lumpur City Hall.
Industrial	Refers to land and building designated for light industry including manufacturing, packaging, servicing and warehousing. Other activities or uses that are ancillary to

Land Use Zone	Description
	the main industrial uses or activities that are deemed to be suitable within this zone may be permitted.
Technology Park	Refers to area in Bukit Jalil Technology Park which is designated for clean, high-technology and research and development industry in support of Kuala Lumpur's vision towards knowledge economy. Other activities or uses that are ancillary to the main high-technology or research and development may be permitted.
Mixed Use Industry	Refers to land and building allowed for a mix of light, non-polluting industrial and commercial development. The predominant activity is industry, where commercial component shall not exceed 30% of total gross floor area. This zone is intended to (i) revitalise some part of existing industrial areas in Kuala Lumpur and to promote creation of better and more modern industrial park environment, (ii) encourage the up-scaling of existing industries to higher end industrial activities that is less labour intense, (iii) accommodate industry-associated retailing, services and other commercial uses and (iv) meet the need for a mix of lower rent bulky goods retailing, specialised industrial, commercial and service activities alongside general industry.
Public Open Space	Refers to land which is under or will be under the ownership of Kuala Lumpur City Hall or other public authority, with or without access control, and which is set aside by private or public development for the public as open space for recreation, games, sport or cultural activity; including parks, playground, pocket parks, public gardens, outdoor or indoor sport facilities and associated buildings. It includes urban plazas, squares and buffer or linear green strips, normally linking parks and open spaces.

Land Use Zone	Description
Private Open Space	Refers to privately owned space use as open space, park, garden, playground, recreation ground, sports ground and golf course and other associated uses to which the general public has no right or limited access except with consent.
Forest Reserve	Refers to the primary gazetted forest area reserved for their natural environmental and urban biodiversity values and provides some limited opportunities for passive recreational activities with other activities necessary or expedient for the purposes of such passive recreation.
Institutional	Refers to land and building designated for cultural, civic, government and quasi-government facilities. Such facilities and uses include, amongst others; museums, cultural centres and library. It also includes specialised uses such as palace reserve, military camps, universities and police headquarters. The facilities can be owned and run by the government or quasi-governmental organisation, corporation or agency and/or managed by public or private entity.
Public Facilities	Refer to land and building designated to provide educational, religious, health, communities or safety and security for the public or local community and other activities that ancillary or expedient for the purposes of such facilities.
Cemetery	Refers to land designated for burial of the dead and building or facility for the cremation of human remains and the storage of ashes of human remains that have cremated.
Transportation	Refer to land and building designated or to be designated for provision of transport facilities including transport terminal, public transport stations, park and ride facilities, parking facilities, road reserves and other associated facilities whose primary functions are to support transport infrastructure and services.

Land Use Zone	**Description**
Infrastructure and Utility	Refers to land and buildings designated or to be designated for provision of infrastructure and utilities namely water supply, power supply (electricity, gas, chilled water, etc.), sewerage, telecommunication, drainage, solid waste disposal and other infrastructure provisions.

APPENDIX E

Kuala Lumpur monorail station level average weekday boarding per peak hour (2012) (Source: SPAD, 2012)

Monorail Station	Inbound (Average weekday per peak hour)			Outbound (Average weekday per peak hour)		
	Boarding	Alighting	On-board	Boarding	Alighting	On-board
KL Sentral	733	0	733	0	355	0
Tun Sambathan	184	5	912	84	135	355
Maharajarela	27	16	923	88	139	406
Hang Tuah	1596	121	2,398	416	141	457
Imbi	117	227	2,288	264	159	182
Bukit Bintang	78	374	1,992	420	369	77
Raja Chulan	26	1,525	493	76	1,205	26
Bukit Nanas	53	280	266	201	288	1,155
Medan Tuanku	68	129	205	78	25	1,242
Chow Kit	101	176	130	610	119	1,189
Titiwangsa	0	130	0	698	0	698

APPENDIX F

The formation of 400-600m geographic space from urban rail transit stations (includes monorail) as the sending area for transfer of development rights proposal has largely address the geographic space of weak transit access in Kuala Lumpur city centre.

APPENDIX G

The basis of potential ridership forecasting approach of this study is founded on the sketch planning model where it often used by urban planners and transit operators as an alternative travel demand models for forecasting future ridership in both short and long term of city region development (National Academies of Sciences, Engineering, and Medicine, 2018). It assumes that ridership is a function of population and employment variables. The potential ridership forecasting for this study involves several phases to attain the ultimate ridership prediction results (average weekday on-board passenger per peak hour per direction). The average weekday on-board passenger per peak hour measures a typical number of passenger who resides with the transit vehicle during the busiest time of working day. It is considered as critical aspect in the tranvel demand model, as most of the community rely on transit to commute to workplace, school and home at this particular moment. Thereby, the average weekday on-board passenger per peak hour is an important form of ridership prediction dimension where the transit capacity needed to fulfil in avoiding passenger congestion and maintaining good service quality. This is vital for TOD promotion as it attracts the community to use transit. By measuring the prediction of average weekday on-board passenger per peak hour implied with the transit capacity would help us to understand the performance of zoning intensification scenarios.

In the beginning, the study obtains the preliminary form of potential new ridership growth (average weekday boarding passenger). The average weekday boarding passenger prediction of Kuala Lumpur monorail by station is derived from the station area population and employment increment and the expected transit user proportion in future growth via the following equation (1):

$$\mathrm{P}ixy = \sum_{x=1}^{n} \mathrm{R}ix \sum_{y=1}^{n} \triangle\ \mathrm{R}y + \sum_{x=1}^{n} \mathrm{E}ix \sum_{y=1}^{n} \triangle\ \mathrm{E}y \qquad (1)$$

where P_{ixy} is the average weekday boarding passenger of station i suggested from the zoning intensification scenario x and expected travel pattern y, R_{ix} is the population growth around the walkable catchment area of station i implied from the zoning

APPENDIX G (Continued)

intensification scenario x, $\triangle R_y$ is the population elasticity on ridership in the expected travel pattern y, E_{ix} is the employment growth around the walkable catchment area of station i implied from the zoning intensification scenario x, $\triangle E_y$ is the employment elasticity on ridership in the expected travel pattern y.

Second, the preliminary form of potential new ridership growth is transforming into an initial intermediate form of potential new ridership growth (average weekday boarding passenger per peak hour) by means of the equation (2) below:

$$\mathrm{I}ixy = \frac{\mathrm{P}ixy \cdot \mathrm{T}}{\mathrm{B}} \qquad (2)$$

where I_{ixy} denotes for the average weekday boarding passenger per peak hour of station i suggested from the zoning intensification scenario x and expected travel pattern y, P_{ixy} is the average weekday boarding passenger of station i suggested from the zoning intensification scenario x and expected travel pattern y, T is the peak hour factor for average weekday boarding passenger, B is the average number of weekday peak hour.

Third, the initial intermediate form of potential new ridership growth (average weekday boarding passenger per peak hour) is computed to the subsequent intermediate form of potential new ridership growth (average weekday boarding passenger per peak hour per direction). At this phase, the potential new ridership growth (average weekday boarding passenger per peak hour) of the station will be distributed to the inbound and outbound direction. The new passenger's movement is assigned according to the existing inbound and outbound pattern. In this way, it yields the subsequent intermediate form of potential new ridership growth (average weekday boarding passenger per peak hour per direction) in two different directions. The equations below refer to the assignment formula for inbound (3a) and outbound (3b).

$$\mathrm{M}ixy, z = \mathrm{I}ixy \cdot \mathrm{G}i, z \qquad (3a)$$

APPENDIX G (Continued)

where $M_{ixy,z}$ signifies for the average weekday boarding passenger per peak hour of station *i* for inbound direction suggested from the zoning intensification scenario *x* and expected travel pattern *y*, I_{ixy} is the for average weekday boarding passenger per peak hour of station *i* suggested from the zoning intensification scenario *x* and expected travel pattern *y*, Gi,z is the passenger boarding ratio of station *i* for inbound direction.

$$\mathrm{M}ixy, a = \mathrm{I}ixy \cdot \mathrm{G}i, a \qquad (3b)$$

where $M_{ixy,a}$ signifies for the average weekday boarding passenger per peak hour of station *i* for outbound direction suggested from the zoning intensification scenario *x* and expected travel pattern *y*, I_{ixy} is the for average weekday boarding passenger per peak hour of station *i* suggested from the zoning intensification scenario *x* and expected travel pattern *y*, $G_{i,a}$ is the passenger boarding ratio of station *i* for outbound direction.

Forth, the former intermediate form of the potential new ridership growth (average weekday boarding passenger per peak hour per direction) will be turned into the final intermediate form of the potential new ridership growth (average weekday on-board passenger per peak hour per direction). Here, the potential new ridership growth (average weekday boarding passenger per peak hour per direction) of the station for two different directions is further refined into the on-board passengers who mainly occupy the transit vehicle. To obtain the on-board passengers, the boarding passengers (entering) of the current station and the cumulative on-board passenger from the earlier station (one station before the current station) will be summed while those alighting passengers (leaving) at the current station will be deducted. The number of alighting passengers is derived from the application of alighting ratio acquire from the existing trend of passenger trips. It is important to note that for the case of the first station where there is no other earlier station proceeded on this initial station, the cumulative on-board passengers of the former station in this circumstance are considered as zero. The equations of the potential new ridership growth (average weekday on-board passenger per peak hour per direction) for inbound (4a) and outbound (4b) are:

APPENDIX G (Continued)

$$\mathrm{U}ixy,z = \mathrm{M}ixy,z + [\mathrm{W}hxy,z - (\mathrm{W}hxy,z \cdot \mathrm{A}h)] \qquad (4a)$$

where $U_{ixy,z}$ represents the average weekday on-board passenger per peak hour of station *i* for inbound direction suggested from the zoning intensification scenario *x* and expected travel pattern *y*, $M_{ixy,z}$ is the average weekday boarding passenger per peak hour of station *i* for inbound direction suggested from the zoning intensification scenario *x* and expected travel pattern *y*, $W_{hxy,z}$ is the cumulative average weekday on-board passenger per peak hour of station *h* (the former station *i*) for inbound direction suggested from the zoning intensification scenario *x* and expected travel pattern *y*, A*h* is the alighting ratio of the existing cumulative average weekday on-board passenger per peak hour from station *h* leaving at station *i*.

$$\mathrm{U}ixy,a = \mathrm{M}ixy,a + [\mathrm{W}jxy,a - (\mathrm{W}jxy,a \cdot \mathrm{A}j)] \qquad (4b)$$

where $U_{ixy,a}$ represents the average weekday on-board passenger per peak hour of station *i* for outbound direction suggested from the zoning intensification scenario *x* and expected travel pattern *y*, $M_{ixy,a}$ is the average weekday boarding passenger per peak hour of station *i* for outbound direction suggested from the zoning intensification scenario *x* and expected travel pattern *y*, $W_{jxy,a}$ is the cumulative average weekday on-board passenger per peak hour of station *j* (the former station *i*) for outbound direction suggested from the zoning intensification scenario *x* and expected travel pattern *y*, A*j* is the alighting ratio of the existing cumulative average weekday on-board passenger per peak hour from station *j* leaving at station *i*.

Lastly, the final intermediate form of the potential new ridership growth (average weekday on-board passenger per peak hour per direction) will be merged with the existing ridership profile (average weekday on-board passenger per peak hour per direction) to attain the ultimate ridership prediction results (average weekday on-board passenger per peak hour per direction). The calculation for the ridership prediction of the station for inbound (5a) and outbound (5b) direction follows the equation below:

$$\mathrm{R}i,z = \mathrm{U}ixy,z + \mathrm{C}i,z \qquad (5a)$$

APPENDIX G (Continued)

where $R_{i,z}$ is the predicted potential ridership (average weekday on-board passenger per peak hour per direction) of station *i* for inbound direction, $U_{ixy,z}$ is the new potential ridership (average weekday on-board passenger per peak hour) of station *i* for inbound direction suggested from the zoning intensification scenario *x* and expected travel pattern *y*, $C_{i,z}$ is the current level of ridership (average weekday on-board passenger per peak hour per direction) of station *i* for inbound direction.

$$\mathrm{R}i,a = \mathrm{U}ixy,a + \mathrm{C}i,a \qquad (5b)$$

where $R_{i,a}$ is the predicted potential ridership (average weekday on-board passenger per peak hour per direction) of station *i* for outbound direction, $U_{ixy,a}$ is the new potential ridership (average weekday on-board passenger per peak hour) of station *i* for outbound direction suggested from the zoning intensification scenario *x* and expected travel pattern *y*, $C_{i,a}$ is the current level of ridership (average weekday on-board passenger per peak hour per direction) of station *i* for outbound direction.

APPENDIX H1

Kuala Lumpur monorail station level ridership growth (average weekday boarding) implied from the business as usual zoning intensification scenario

Possible Trend	Kuala Lumpur Station Area										
	KL Sentral	Tun Sambanthan	Maharajalela	Hang Tuah	Imbi	Bukit Bintang	Raja Chulan	Bukit Nanas	Medan Tuanku	Chow Kit	Titiwangsa
Optimistic	9,444	4,823	13,182	7,299	6,663	6,169	9,782	10,767	10,448	7,932	10,645
Modest	6,606	3,368	9,202	5,099	4,661	4,322	6,850	7,538	7,315	5,551	7,442
Pessimistic	3,769	1,912	5,222	2,898	2,658	2,476	3,918	4,308	4,183	3,171	4,240

APPENDIX H2

Kuala Lumpur monorail station level ridership growth (average weekday boarding) implied from the +20% upzoning zoning intensification scenario

Possible Trend	Kuala Lumpur Station Area										
	KL Sentral	Tun Sambanthan	Maharajalela	Hang Tuah	Imbi	Bukit Bintang	Raja Chulan	Bukit Nanas	Medan Tuanku	Chow Kit	Titiwangsa
Optimistic	10,719	5,549	15,729	8,103	7,142	7,127	11,267	11,958	11,569	9,443	11,764
Modest	7,498	3,875	10,980	5,660	4,997	4,993	7,890	8,372	8,100	6,609	8,225
Pessimistic	4,277	2,201	6,232	3,217	2,851	2,858	4,514	4,787	4,630	3,775	4,686

APPENDIX H3

Kuala Lumpur monorail station level ridership growth (average weekday boarding) implied from the +40% upzoning zoning intensification scenario

Possible Trend	Kuala Lumpur Station Area										
	KL Sentral	Tun Sambanthan	Maharajalela	Hang Tuah	Imbi	Bukit Bintang	Raja Chulan	Bukit Nanas	Medan Tuanku	Chow Kit	Titiwangsa
Optimistic	11,995	6,274	18,275	8,907	7,621	8,085	12,751	13,149	12,691	10,955	12,882
Modest	8,390	4,382	12,758	6,222	5,333	5,663	8,930	9,207	8,884	7,667	9,008
Pessimistic	4,785	2,490	7,242	3,536	3,045	3,241	5,110	5,265	5,078	4,379	5,133

APPENDIX H4

Kuala Lumpur monorail station level ridership growth (average weekday boarding) implied from the +60% upzoning zoning intensification scenario

Possible Trend	Kuala Lumpur Station Area									
	KL Sentral	Tun Sambanthan	Maharajalela	Hang Tuah	Imbi	Bukit Bintang	Raja Chulan	Bukit Nanas	Medan Tuanku	Chow Kit	Titiwangsa
Optimistic	13,271	7,000	20,821	9,711	8,100	9,043	14,235	14,339	13,812	12,467	14,001
Modest	9,282	4,889	14,536	6,783	5,669	6,333	9,970	10,042	9,669	8,725	9,790
Pessimistic	5,293	2,779	8,252	3,856	3,238	3,623	5,706	5,744	5,526	4,983	5,579

APPENDIX H5

Kuala Lumpur monorail station level ridership growth (average weekday boarding) implied from the +80% upzoning zoning intensification scenario

Possible Trend	Kuala Lumpur Station Area										
	KL Sentral	Tun Sambanthan	Maharajalela	Hang Tuah	Imbi	Bukit Bintang	Raja Chulan	Bukit Nanas	Medan Tuanku	Chow Kit	Titiwangsa
Optimistic	14,546	7,726	23,367	10,515	8,578	10,001	15,719	15,530	14,933	13,979	15,120
Modest	10,174	5,397	16,314	7,345	6,005	7,003	11,010	10,876	10,454	9,783	10,573
Pessimistic	5,802	3,068	9,262	4,175	3,431	4,006	6,302	6,222	5,974	5,587	6,026

APPENDIX H6

Kuala Lumpur monorail station level ridership growth (average weekday boarding) implied from the +100% upzoning zoning intensification scenario

Possible Trend	Kuala Lumpur Station Area										
	KL Sentral	Tun Sambanthan	Maharajalela	Hang Tuah	Imbi	Bukit Bintang	Raja Chulan	Bukit Nanas	Medan Tuanku	Chow Kit	Titiwangsa
Optimistic	15,822	8,452	25,913	11,319	9,057	10,959	17,203	16,721	16,055	15,491	16,239
Modest	11,066	5,904	18,092	7,906	6,341	7,673	12,050	11,711	11,238	10,841	11,355
Pessimistic	6,310	3,357	10,272	4,494	3,625	4,388	6,898	6,701	6,422	6,191	6,472

APPENDIX I

Kuala Lumpur monorail station boarding ratio for inbound and outbound in 2012.

	Kuala Lumpur Station Area										
	KL Sentral	Tun Sambanthan	Maharajalela	Hang Tuah	Imbi	Bukit Bintang	Raja Chulan	Bukit Nanas	Medan Tuanku	Chow Kit	Titiwangsa
Inbound Boarding	733	184	27	1,596	117	78	26	53	68	101	0
Outbound Boarding	0	84	88	416	264	420	76	201	78	610	698
Total Boarding	733	268	115	2,012	381	498	102	254	146	711	698
Inbound Boarding Ratio	1.00	0.69	0.23	0.79	0.31	0.16	0.25	0.21	0.47	0.14	0.00
Outbound Boarding Ratio	0.00	0.31	0.77	0.21	0.69	0.84	0.75	0.79	0.53	0.86	1.00

APPENDIX J1

Kuala Lumpur monorail station level potential ridership (average weekday per peak hour boarding) implied from the business as usual zoning intensification scenario.

Possible Trend	Traffic Direction	Kuala Lumpur Station Area										
		KL Sentral	Tun Sambanthan	Maharajalela	Hang Tuah	Imbi	Bukit Bintang	Raja Chulan	Bukit Nanas	Medan Tuanku	Chow Kit	Titiwangsa
Optimistic	Inbound	1,542	1,996	2,243	4,042	3,972	3,499	1,040	694	850	315	0
	Outbound	0	2,145	2,328	1,631	1,426	1,146	1,129	3,266	3,033	2,531	1,610
Modest	Inbound	1,299	1,669	1,844	3,546	3,468	3,050	874	565	656	259	0
	Outbound	0	1,726	1,871	1,400	1,173	946	859	2,633	2,496	2,128	1,336
Pessimistic	Inbound	1,056	1,343	1,446	3,050	2,963	2,601	708	435	463	204	0
	Outbound	0	1,308	1,414	1,168	921	745	588	2,001	1,958	1,725	1,061

APPENDIX J2

Kuala Lumpur monorail station level potential ridership (average weekday per peak hour boarding) implied from the +20% upzoning zoning intensification scenario.

Possible Trend	Traffic Direction	Kuala Lumpur Station Area										
		KL Sentral	Tun Sambanthan	Maharajalela	Hang Tuah	Imbi	Bukit Bintang	Raja Chulan	Bukit Nanas	Medan Tuanku	Chow Kit	Titiwangsa
Optimistic	Inbound	1,652	2,147	2,442	4,269	4,191	3,697	1,118	749	923	344	0
	Outbound	0	2,365	2,570	1,719	1,522	1,248	1,259	3,530	3,271	2,722	1,706
Modest	Inbound	1,376	1,775	1,983	3,705	3,621	3,188	928	603	708	279	0
	Outbound	0	1,880	2,040	1,461	1,241	1,017	950	2,818	2,662	2,262	1,403
Pessimistic	Inbound	1,100	1,403	1,525	3,140	3,050	2,680	739	457	492	215	0
	Outbound	0	1,396	1,510	1,203	959	786	640	2,106	2,053	1,801	1,100

APPENDIX J3

Kuala Lumpur monorail station level potential ridership (average weekday per peak hour boarding) implied from the +40% upzoning zoning intensification scenario.

Possible Trend	Traffic Direction	Kuala Lumpur Station Area										
		KL Sentral	Tun Sambanthan	Maharajalela	Hang Tuah	Imbi	Bukit Bintang	Raja Chulan	Bukit Nanas	Medan Tuanku	Chow Kit	Titiwangsa
Optimistic	Inbound	1,761	2,299	2,640	4,496	4,411	3,894	1,195	803	997	372	0
	Outbound	0	2,584	2,812	1,807	1,619	1,349	1,389	3,794	3,510	2,913	1,802
Modest	Inbound	1,452	1,881	2,122	3,863	3,774	3,326	982	641	759	299	0
	Outbound	0	2,034	2,209	1,522	1,308	1,088	1,040	3,003	2,829	2,395	1,470
Pessimistic	Inbound	1,143	1,463	1,603	3,231	3,138	2,758	770	479	522	227	0
	Outbound	0	1,483	1,606	1,238	998	826	692	2,212	2,148	1,877	1,138

APPENDIX J4

Kuala Lumpur monorail station level potential ridership (average weekday per peak hour boarding) implied from the +60% upzoning zoning intensification scenario.

Possible Trend	Traffic Direction	Kuala Lumpur Station Area										
		KL Sentral	Tun Sambanthan	Maharajalela	Hang Tuah	Imbi	Bukit Bintang	Raja Chulan	Bukit Nanas	Medan Tuanku	Chow Kit	Titiwangsa
Optimistic	Inbound	1,870	2,450	2,838	4,723	4,630	4,091	1,272	858	1,071	400	0
	Outbound	0	2,804	3,053	1,894	1,715	1,451	1,519	4,058	3,748	3,104	1,898
Modest	Inbound	1,529	1,986	2,260	4,022	3,927	3,464	1,036	679	811	319	0
	Outbound	0	2,187	2,378	1,584	1,376	1,159	1,131	3,188	2,996	2,529	1,537
Pessimistic	Inbound	1,187	1,523	1,682	3,321	3,225	2,837	801	501	551	238	0
	Outbound	0	1,570	1,702	1,273	1,036	867	744	2,317	2,244	1,954	1,176

APPENDIX J5

Kuala Lumpur monorail station level potential ridership (average weekday per peak hour boarding) implied from the +80% upzoning zoning intensification scenario.

Possible Trend	Traffic Direction	Kuala Lumpur Station Area										
		KL Sentral	Tun Sambanthan	Maharajalela	Hang Tuah	Imbi	Bukit Bintang	Raja Chulan	Bukit Nanas	Medan Tuanku	Chow Kit	Titiwangsa
Optimistic	Inbound	1,980	2,601	3,037	4,950	4,849	4,289	1,349	913	1,144	429	0
	Outbound	0	3,024	3,295	1,982	1,811	1,552	1,648	4,322	3,986	3,295	1,994
Modest	Inbound	1,605	2,092	2,399	4,180	4,081	3,602	1,090	718	862	339	0
	Outbound	0	2,341	2,547	1,645	1,443	1,230	1,222	3,372	3,162	2,663	1,604
Pessimistic	Inbound	1,230	1,583	1,761	3,411	3,312	2,915	832	523	580	249	0
	Outbound	0	1,658	1,798	1,308	1,075	907	796	2,423	2,339	2,030	1,214

APPENDIX J6

Kuala Lumpur monorail station level potential ridership (average weekday per peak hour boarding) implied from the +100% upzoning zoning intensification scenario.

Possible Trend	Traffic Direction	Kuala Lumpur Station Area										
		KL Sentral	Tun Sambanthan	Maharajalela	Hang Tuah	Imbi	Bukit Bintang	Raja Chulan	Bukit Nanas	Medan Tuanku	Chow Kit	Titiwangsa
Optimistic	Inbound	2,089	2,752	3,235	5,177	5,069	4,486	1,426	967	1,218	457	0
	Outbound	0	3,244	3,537	2,069	1,908	1,654	1,778	4,586	4,224	3,487	2,090
Modest	Inbound	1,681	2,198	2,538	4,339	4,234	3,740	1,144	756	914	359	0
	Outbound	0	2,495	2,715	1,706	1,511	1,301	1,313	3,557	3,329	2,796	1,671
Pessimistic	Inbound	1,274	1,644	1,840	3,501	3,400	2,994	862	544	610	261	0
	Outbound	0	1,745	1,894	1,343	1,114	948	848	2,529	2,434	2,106	1,253

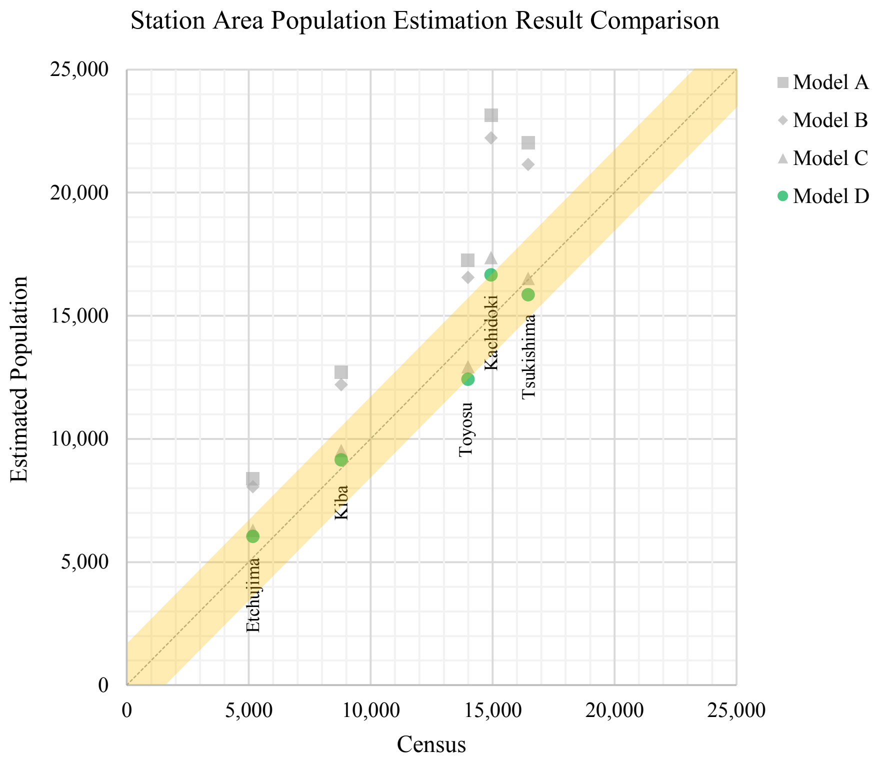
APPENDIX K

Alighting proportion of Kuala Lumpur monorail inbound and outbound in 2012.

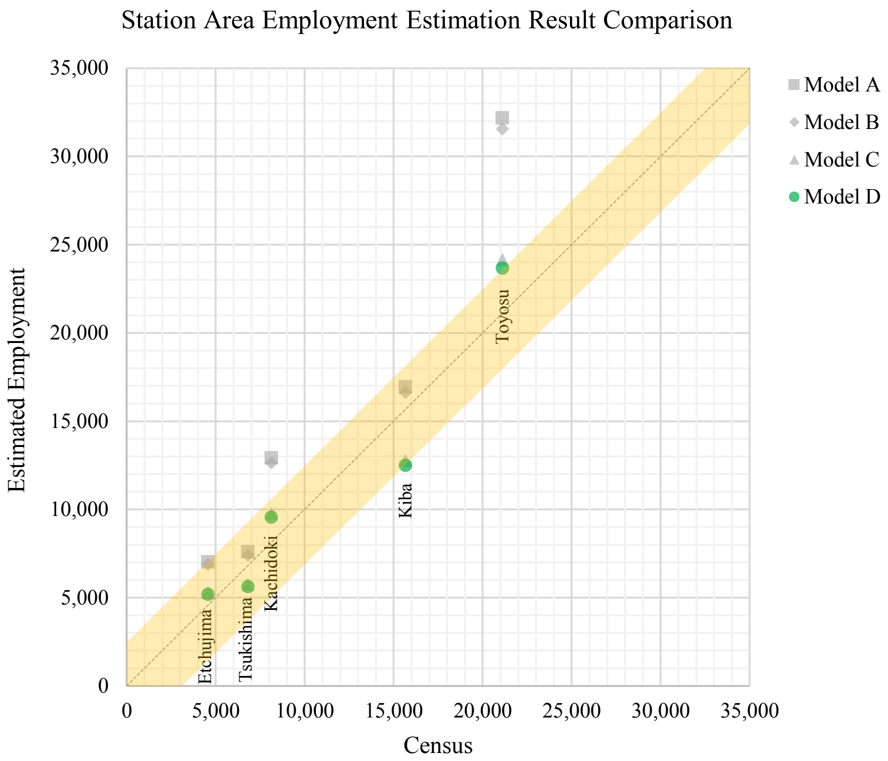
		Kuala Lumpur Station Areas										
		KL Sentral	Tun Sambanthan	Maharajalela	Hang Tuah	Imbi	Bukit Bintang	Raja Chulan	Bukit Nanas	Medan Tuanku	Chow Kit	Titiwangsa
Inbound	Boarding	733	184	27	1,596	117	78	26	53	68	101	0
	Alighting	0	5	16	121	227	374	1,525	280	129	176	130
	On-board	733	912	923	2,398	2,288	1,992	493	266	205	130	0
	Alighting Ratio	0.00	0.01	0.02	0.13	0.09	0.16	0.77	0.57	0.48	0.86	1.00
Outbound	Boarding	0	84	88	416	264	420	76	201	78	610	698
	Alighting	755	135	139	141	159	169	1,005	288	25	119	0
	On-board	0	755	806	857	582	477	226	1,155	1,242	1,189	698
	Alighting Ratio	1.00	0.17	0.16	0.24	0.33	0.75	0.87	0.23	0.02	0.17	0.00

APPENDIX L

The expected upper bound and lower bound error of building floor space (Model D) for station area population estimation is +16.99% and -11.20%, while station area employment estimation is +17.71% and -20.11%. These errors are indicated as yellow highlights on the figures below.



APPENDIX L (Continued)



APPENDIX M1

The predicted on-board ridership (average weekday per peak hour) of Kuala Lumpur monorail inbound traffic movement for business as usual zoning intensification scenario.

Possible Trend		Ridership	KL Sentral	Tun Sambanthan	Maharajalela	Hang Tuah	Imbi	Bukit Bintang	Raja Chulan	Bukit Nanas	Medan Tuanku	Chow Kit	Titiwangsa
Optimistic	Error Band (Upper Bound)	Boarding	1,685	519	332	2,177	325	178	273	281	564	213	0
		Alighting	0	17	44	322	390	683	2,896	649	370	829	348
		On-board	1,685	2,187	2,476	4,330	4,266	3,761	1,138	770	964	348	0
	Baseline	Boarding	1,542	469	287	2,090	294	163	236	247	489	196	0
		Alighting	0	15	40	292	364	636	2,694	593	333	731	315
		On-board	1,542	1,996	2,243	4,042	3,972	3,499	1,040	694	850	315	0
	Error band (Lower Bound)	Boarding	1,388	422	245	2,006	261	144	192	208	403	177	0
		Alighting	0	14	36	261	337	588	2,487	533	293	619	278
		On-board	1,388	1,796	2,005	3,750	3,673	3,230	935	610	720	278	0
Modest	Error Band (Upper Bound)	Boarding	1,399	418	240	2,002	263	148	199	213	415	179	0
		Alighting	0	14	36	261	337	588	2,489	537	297	633	282
		On-board	1,399	1,803	2,007	3,748	3,673	3,233	942	618	736	282	0
	Baseline	Boarding	1,299	383	208	1,941	241	137	173	189	363	168	0
		Alighting	0	13	33	240	319	555	2,349	498	271	564	259
		On-board	1,299	1,669	1,844	3,546	3,468	3,050	874	565	656	259	0
	Error band (Lower Bound)	Boarding	1,191	350	179	1,882	217	125	143	161	302	154	0
		Alighting	0	12	31	218	301	521	2,203	456	243	486	234
		On-board	1,191	1,529	1,678	3,342	3,258	2,862	801	506	565	234	0
Pessimistic	Error Band (Upper Bound)	Boarding	1,113	317	148	1,827	200	118	125	144	266	146	0
		Alighting	0	11	28	200	285	493	2,083	426	223	437	217
		On-board	1,113	1,419	1,538	3,165	3,080	2,705	747	466	508	217	0
	Baseline	Boarding	1,056	297	130	1,792	188	112	110	131	237	139	0
		Alighting	0	11	27	188	274	474	2,003	404	209	398	204
		On-board	1,056	1,343	1,446	3,050	2,963	2,601	708	435	463	204	0
	Error band (Lower Bound)	Boarding	994	278	113	1,759	174	105	93	115	202	131	0
		Alighting	0	10	25	176	264	455	1,920	380	193	353	189
		On-board	994	1,263	1,351	2,934	2,844	2,493	666	401	411	189	0

APPENDIX M2

The predicted on-board ridership (average weekday per peak hour) of Kuala Lumpur monorail inbound traffic movement for 20% upzoning zoning intensification scenario.

Possible Trend		Ridership	KL Sentral	Tun Sambanthan	Maharajalela	Hang Tuah	Imbi	Bukit Bintang	Raja Chulan	Bukit Nanas	Medan Tuanku	Chow Kit	Titiwangsa
Optimistic	Error Band (Upper Bound)	Boarding	1,814	569	391	2,241	340	193	310	306	617	234	0
		Alighting	0	18	47	352	414	724	3,075	700	401	904	381
		On-board	1,814	2,365	2,709	4,597	4,524	3,993	1,229	835	1,051	381	0
	Baseline	Boarding	1,652	512	337	2,145	307	176	267	268	534	214	0
		Alighting	0	17	43	317	384	671	2,846	637	359	794	344
		On-board	1,652	2,147	2,442	4,269	4,191	3,697	1,118	749	923	344	0
	Error band (Lower Bound)	Boarding	1,477	457	287	2,051	270	155	217	224	439	192	0
		Alighting	0	15	38	282	354	616	2,611	568	314	670	301
		On-board	1,477	1,919	2,167	3,937	3,853	3,391	997	653	779	301	0
Modest	Error Band (Upper Bound)	Boarding	1,489	453	281	2,046	273	159	225	230	452	194	0
		Alighting	0	15	39	282	354	616	2,614	573	318	685	306
		On-board	1,489	1,927	2,170	3,934	3,853	3,395	1,006	663	797	306	0
	Baseline	Boarding	1,376	413	243	1,979	250	146	195	204	394	180	0
		Alighting	0	14	36	258	333	579	2,455	529	289	609	279
		On-board	1,376	1,775	1,983	3,705	3,621	3,188	928	603	708	279	0
	Error band (Lower Bound)	Boarding	1,253	375	208	1,914	224	132	160	173	328	165	0
		Alighting	0	13	32	233	313	541	2,290	481	257	522	250
		On-board	1,253	1,615	1,791	3,472	3,384	2,974	844	536	607	250	0
Pessimistic	Error Band (Upper Bound)	Boarding	1,164	337	171	1,852	206	124	140	154	288	154	0
		Alighting	0	12	30	212	294	509	2,154	446	236	467	230
		On-board	1,164	1,489	1,631	3,271	3,183	2,798	783	491	543	230	0
	Baseline	Boarding	1,100	314	150	1,814	193	117	123	139	255	146	0
		Alighting	0	11	28	198	283	488	2,063	421	219	423	215
		On-board	1,100	1,403	1,525	3,140	3,050	2,680	739	457	492	215	0
	Error band (Lower Bound)	Boarding	1,030	292	130	1,777	178	109	103	122	217	137	0
		Alighting	0	10	26	184	271	466	1,969	394	201	373	198
		On-board	1,030	1,312	1,415	3,008	2,915	2,558	691	419	434	198	0

APPENDIX M3

The predicted on-board ridership (average weekday per peak hour) of Kuala Lumpur monorail inbound traffic movement for 40% upzoning zoning intensification scenario.

Possible Trend		Ridership	KL Sentral	Tun Sambanthan	Maharajalela	Hang Tuah	Imbi	Bukit Bintang	Raja Chulan	Bukit Nanas	Medan Tuanku	Chow Kit	Titiwangsa
Optimistic	Error Band (Upper Bound)	Boarding	1,942	620	450	2,304	355	209	348	332	670	256	0
		Alighting	0	19	51	382	438	765	3,253	752	432	978	415
		On-board	1,942	2,543	2,942	4,864	4,781	4,225	1,320	899	1,137	415	0
	Baseline	Boarding	1,761	555	387	2,199	319	189	299	290	579	232	0
		Alighting	0	18	46	343	405	706	2,998	681	386	857	372
		On-board	1,761	2,299	2,640	4,496	4,411	3,894	1,195	803	997	372	0
	Error band (Lower Bound)	Boarding	1,566	492	329	2,096	280	166	242	241	476	206	0
		Alighting	0	16	41	303	371	645	2,736	604	334	721	324
		On-board	1,566	2,042	2,330	4,123	4,032	3,553	1,059	696	838	324	0
Modest	Error Band (Upper Bound)	Boarding	1,579	488	322	2,091	284	169	251	248	489	209	0
		Alighting	0	16	41	303	371	645	2,739	610	340	737	329
		On-board	1,579	2,051	2,333	4,120	4,033	3,557	1,070	708	858	329	0
	Baseline	Boarding	1,452	443	279	2,017	259	156	217	219	426	193	0
		Alighting	0	15	38	276	348	604	2,561	560	308	653	299
		On-board	1,452	1,881	2,122	3,863	3,774	3,326	982	641	759	299	0
	Error band (Lower Bound)	Boarding	1,315	399	237	1,945	231	139	177	185	353	175	0
		Alighting	0	13	34	248	324	562	2,377	506	272	557	265
		On-board	1,315	1,702	1,905	3,603	3,509	3,087	888	566	648	265	0
Pessimistic	Error Band (Upper Bound)	Boarding	1,215	357	195	1,877	212	130	155	165	309	163	0
		Alighting	0	12	31	224	304	526	2,225	467	248	497	244
		On-board	1,215	1,560	1,724	3,377	3,285	2,890	820	517	578	244	0
	Baseline	Boarding	1,143	331	170	1,835	198	122	135	148	273	154	0
		Alighting	0	11	29	208	291	502	2,124	439	230	449	227
		On-board	1,143	1,463	1,603	3,231	3,138	2,758	770	479	522	227	0
	Error band (Lower Bound)	Boarding	1,065	306	146	1,794	182	113	113	128	231	143	0
		Alighting	0	11	27	192	277	478	2,019	408	209	394	207
		On-board	1,065	1,361	1,480	3,082	2,987	2,622	716	436	458	207	0

APPENDIX M4

The predicted on-board ridership (average weekday per peak hour) of Kuala Lumpur monorail inbound traffic movement for 60% upzoning zoning intensification scenario.

Possible Trend		Ridership	KL Sentral	Tun Sambanthan	Maharajalela	Hang Tuah	Imbi	Bukit Bintang	Raja Chulan	Bukit Nanas	Medan Tuanku	Chow Kit	Titiwangsa
Optimistic	Error Band (Upper Bound)	Boarding	2,071	670	509	2,368	370	224	385	357	723	277	0
		Alighting	0	21	54	413	462	806	3,432	804	462	1,053	448
		On-board	2,071	2,720	3,175	5,131	5,039	4,457	1,410	963	1,224	448	0
	Baseline	Boarding	1,870	598	437	2,254	332	202	331	311	624	251	0
		Alighting	0	19	49	369	425	741	3,150	725	412	921	400
		On-board	1,870	2,450	2,838	4,723	4,630	4,091	1,272	858	1,071	400	0
	Error band (Lower Bound)	Boarding	1,655	528	370	2,141	289	176	267	258	512	221	0
		Alighting	0	17	43	324	388	674	2,860	639	355	771	347
		On-board	1,655	2,166	2,493	4,310	4,212	3,714	1,121	740	897	347	0
Modest	Error Band (Upper Bound)	Boarding	1,669	524	363	2,136	294	180	278	266	527	224	0
		Alighting	0	17	44	324	388	674	2,864	646	361	790	353
		On-board	1,669	2,176	2,496	4,307	4,213	3,720	1,133	753	918	353	0
	Baseline	Boarding	1,529	473	314	2,055	268	165	240	234	458	206	0
		Alighting	0	15	40	294	362	628	2,667	591	326	697	319
		On-board	1,529	1,986	2,260	4,022	3,927	3,464	1,036	679	811	319	0
	Error band (Lower Bound)	Boarding	1,378	424	267	1,977	238	147	195	196	379	185	0
		Alighting	0	14	36	262	336	582	2,464	531	286	593	281
		On-board	1,378	1,788	2,019	3,733	3,635	3,200	931	597	689	281	0
Pessimistic	Error Band (Upper Bound)	Boarding	1,267	377	218	1,903	218	137	170	175	330	171	0
		Alighting	0	13	33	236	313	542	2,296	488	261	527	257
		On-board	1,267	1,631	1,816	3,483	3,388	2,982	856	543	612	257	0
	Baseline	Boarding	1,187	348	190	1,857	203	128	148	156	291	161	0
		Alighting	0	12	30	219	299	516	2,184	456	240	474	238
		On-board	1,187	1,523	1,682	3,321	3,225	2,837	801	501	551	238	0
	Error band (Lower Bound)	Boarding	1,101	320	163	1,812	186	117	123	135	246	149	0
		Alighting	0	11	28	201	284	489	2,068	422	218	414	216
		On-board	1,101	1,410	1,545	3,156	3,058	2,686	740	453	481	216	0

APPENDIX M5

The predicted on-board ridership (average weekday per peak hour) of Kuala Lumpur monorail inbound traffic movement for 80% upzoning zoning intensification scenario.

Possible Trend		Ridership	KL Sentral	Tun Sambanthan	Maharajalela	Hang Tuah	Imbi	Bukit Bintang	Raja Chulan	Bukit Nanas	Medan Tuanku	Chow Kit	Titiwangsa
Optimistic	Error Band (Upper Bound)	Boarding	2,199	721	568	2,432	385	240	423	382	776	298	0
		Alighting	0	22	58	443	486	848	3,610	856	493	1,127	482
		On-board	2,199	2,898	3,408	5,397	5,297	4,689	1,501	1,028	1,311	482	0
	Baseline	Boarding	1,980	641	488	2,308	345	215	363	333	670	269	0
		Alighting	0	20	52	395	445	776	3,302	769	438	984	429
		On-board	1,980	2,601	3,037	4,950	4,849	4,289	1,349	913	1,144	429	0
	Error band (Lower Bound)	Boarding	1,744	563	412	2,187	299	187	292	274	548	236	0
		Alighting	0	17	46	345	405	703	2,984	674	376	822	369
		On-board	1,744	2,289	2,656	4,497	4,391	3,876	1,183	783	956	369	0
Modest	Error Band (Upper Bound)	Boarding	1,759	559	405	2,180	305	191	304	284	564	239	0
		Alighting	0	18	46	346	404	703	2,989	682	383	842	376
		On-board	1,759	2,300	2,659	4,493	4,394	3,882	1,197	798	979	376	0
	Baseline	Boarding	1,605	503	349	2,093	277	174	262	249	489	218	0
		Alighting	0	16	42	312	376	653	2,773	622	344	742	339
		On-board	1,605	2,092	2,399	4,180	4,081	3,602	1,090	718	862	339	0
	Error band (Lower Bound)	Boarding	1,440	449	296	2,008	244	154	212	208	404	195	0
		Alighting	0	14	37	277	348	602	2,551	555	301	628	297
		On-board	1,440	1,874	2,133	3,864	3,761	3,313	974	627	730	297	0
Pessimistic	Error Band (Upper Bound)	Boarding	1,318	397	241	1,928	224	143	185	185	351	180	0
		Alighting	0	13	34	248	323	558	2,367	509	273	556	270
		On-board	1,318	1,702	1,909	3,589	3,490	3,075	892	569	647	270	0
	Baseline	Boarding	1,230	365	210	1,879	208	133	161	165	309	168	0
		Alighting	0	12	32	229	307	530	2,245	474	251	499	249
		On-board	1,230	1,583	1,761	3,411	3,312	2,915	832	523	580	249	0
	Error band (Lower Bound)	Boarding	1,136	334	180	1,830	190	122	133	142	260	155	0
		Alighting	0	11	29	209	291	501	2,118	436	226	434	225
		On-board	1,136	1,459	1,609	3,231	3,130	2,750	765	471	505	225	0

APPENDIX M6

The predicted on-board ridership (average weekday per peak hour) of Kuala Lumpur monorail inbound traffic movement for 100% upzoning zoning intensification scenario.

Possible Trend		Ridership	KL Sentral	Tun Sambanthan	Maharajalela	Hang Tuah	Imbi	Bukit Bintang	Raja Chulan	Bukit Nanas	Medan Tuanku	Chow Kit	Titiwangsa
Optimistic	Error Band (Upper Bound)	Boarding	2,328	771	627	2,496	400	255	460	407	829	320	0
		Alighting	0	23	62	473	510	889	3,789	907	524	1,202	515
		On-board	2,328	3,076	3,641	5,664	5,555	4,921	1,592	1,092	1,397	515	0
	Baseline	Boarding	2,089	684	538	2,362	358	228	395	354	715	287	0
		Alighting	0	21	55	421	466	811	3,454	813	464	1,047	457
		On-board	2,089	2,752	3,235	5,177	5,069	4,486	1,426	967	1,218	457	0
	Error band (Lower Bound)	Boarding	1,833	598	454	2,232	309	197	317	291	585	250	0
		Alighting	0	18	48	366	422	731	3,109	710	397	873	392
		On-board	1,833	2,413	2,818	4,684	4,571	4,037	1,245	827	1,015	392	0
Modest	Error Band (Upper Bound)	Boarding	1,849	594	446	2,225	315	202	330	301	601	254	0
		Alighting	0	18	48	367	421	732	3,114	718	405	894	400
		On-board	1,849	2,424	2,822	4,680	4,574	4,044	1,260	843	1,039	400	0
	Baseline	Boarding	1,681	533	384	2,131	285	183	284	264	521	231	0
		Alighting	0	17	44	330	391	677	2,880	652	363	786	359
		On-board	1,681	2,198	2,538	4,339	4,234	3,740	1,144	756	914	359	0
	Error band (Lower Bound)	Boarding	1,502	473	325	2,040	251	162	230	220	430	205	0
		Alighting	0	15	39	292	359	622	2,638	580	316	664	313
		On-board	1,502	1,960	2,246	3,994	3,886	3,426	1,018	657	772	313	0
Pessimistic	Error Band (Upper Bound)	Boarding	1,369	417	265	1,953	230	149	200	195	373	188	0
		Alighting	0	14	35	260	333	575	2,439	529	285	586	284
		On-board	1,369	1,773	2,002	3,695	3,593	3,167	929	594	682	284	0
	Baseline	Boarding	1,274	383	230	1,900	213	138	174	174	327	175	0
		Alighting	0	13	33	239	315	544	2,305	492	261	524	261
		On-board	1,274	1,644	1,840	3,501	3,400	2,994	862	544	610	261	0
	Error band (Lower Bound)	Boarding	1,172	348	196	1,848	194	126	143	148	275	161	0
		Alighting	0	12	30	218	297	512	2,167	450	234	455	235
		On-board	1,172	1,508	1,674	3,305	3,201	2,815	790	488	529	235	0

APPENDIX N1

The predicted on-board ridership (average weekday per peak hour) of Kuala Lumpur monorail outbound traffic movement for business as usual zoning intensification scenario.

Possible Trend		Ridership	KL Sentral	Tun Sambanthan	Maharajalela	Hang Tuah	Imbi	Bukit Bintang	Raja Chulan	Bukit Nanas	Medan Tuanku	Chow Kit	Titiwangsa
Optimistic	Error Band (Upper Bound)	Boarding	0	234	1,109	570	728	943	816	1,059	637	1,298	1,771
		Alighting	2,388	441	283	378	418	967	3,165	770	55	301	0
		On-board	0	2,388	2,594	1,768	1,576	1,266	1,289	3,638	3,349	2,768	1,771
	Baseline	Boarding	0	212	958	547	658	864	705	930	553	1,195	1,610
		Alighting	2,145	396	261	342	378	847	2,841	698	51	274	0
		On-board	0	2,145	2,328	1,631	1,426	1,146	1,129	3,266	3,033	2,531	1,610
	Error band (Lower Bound)	Boarding	0	191	818	525	583	768	575	783	456	1,079	1,443
		Alighting	1,902	350	237	302	332	709	2,480	618	46	245	0
		On-board	0	1,902	2,061	1,480	1,257	1,005	946	2,851	2,686	2,276	1,443
Modest	Error Band (Upper Bound)	Boarding	0	189	801	524	588	787	595	802	469	1,092	1,448
		Alighting	1,896	350	239	307	340	728	2,518	625	46	246	0
		On-board	0	1,896	2,057	1,495	1,278	1,029	971	2,894	2,717	2,293	1,448
	Baseline	Boarding	0	173	695	508	540	731	516	711	410	1,019	1,336
		Alighting	1,726	318	224	282	312	644	2,291	574	43	227	0
		On-board	0	1,726	1,871	1,400	1,173	946	859	2,633	2,496	2,128	1,336
	Error band (Lower Bound)	Boarding	0	159	597	492	487	664	426	608	342	938	1,219
		Alighting	1,556	286	207	253	279	548	2,038	518	39	207	0
		On-board	0	1,556	1,684	1,294	1,055	847	730	2,343	2,253	1,949	1,219
Pessimistic	Error Band (Upper Bound)	Boarding	0	144	493	477	449	630	373	544	302	885	1,125
		Alighting	1,405	258	196	235	262	489	1,870	479	36	191	0
		On-board	0	1,405	1,519	1,222	980	793	652	2,149	2,084	1,819	1,125
	Baseline	Boarding	0	135	433	468	421	598	328	493	268	844	1,061
		Alighting	1,308	240	187	221	246	441	1,740	450	34	180	0
		On-board	0	1,308	1,414	1,168	921	745	588	2,001	1,958	1,725	1,061
	Error band (Lower Bound)	Boarding	0	126	377	459	391	560	276	434	229	797	995
		Alighting	1,211	222	177	205	227	386	1,596	418	32	169	0
		On-board	0	1,211	1,307	1,107	853	689	515	1,835	1,819	1,623	995

APPENDIX N2

The predicted on-board ridership (average weekday per peak hour) of Kuala Lumpur monorail outbound traffic movement for 20% upzoning zoning intensification scenario.

Possible Trend		Ridership	KL Sentral	Tun Sambanthan	Maharajalela	Hang Tuah	Imbi	Bukit Bintang	Raja Chulan	Bukit Nanas	Medan Tuanku	Chow Kit	Titiwangsa
Optimistic	Error Band (Upper Bound)	Boarding	0	257	1,307	587	761	1,024	929	1,154	697	1,429	1,884
		Alighting	2,646	489	299	405	457	1,082	3,436	835	60	320	0
		On-board	0	2,646	2,878	1,871	1,689	1,385	1,442	3,949	3,629	2,993	1,884
	Baseline	Boarding	0	231	1,126	562	686	933	800	1,011	604	1,306	1,706
		Alighting	2,365	437	275	365	412	944	3,071	752	54	290	0
		On-board	0	2,365	2,570	1,719	1,522	1,248	1,259	3,530	3,271	2,722	1,706
	Error band (Lower Bound)	Boarding	0	207	958	537	605	824	650	845	497	1,168	1,520
		Alighting	2,082	384	248	320	358	786	2,664	662	49	258	0
		On-board	0	2,082	2,259	1,550	1,333	1,086	1,048	3,061	2,878	2,430	1,520
Modest	Error Band (Upper Bound)	Boarding	0	205	939	536	612	843	673	868	511	1,183	1,527
		Alighting	2,077	383	251	326	367	808	2,707	670	49	260	0
		On-board	0	2,077	2,255	1,567	1,357	1,113	1,078	3,111	2,913	2,451	1,527
	Baseline	Boarding	0	187	813	518	560	779	583	768	446	1,097	1,403
		Alighting	1,880	347	234	298	336	712	2,452	612	45	239	0
		On-board	0	1,880	2,040	1,461	1,241	1,017	950	2,818	2,662	2,262	1,403
	Error band (Lower Bound)	Boarding	0	170	695	500	503	703	478	652	371	1,001	1,273
		Alighting	1,683	310	215	266	298	601	2,167	549	41	216	0
		On-board	0	1,683	1,823	1,342	1,108	904	802	2,490	2,387	2,057	1,273
Pessimistic	Error Band (Upper Bound)	Boarding	0	153	571	484	462	662	418	583	326	937	1,170
		Alighting	1,507	277	202	246	277	535	1,978	505	38	199	0
		On-board	0	1,507	1,632	1,264	1,026	841	713	2,274	2,196	1,909	1,170
	Baseline	Boarding	0	142	499	474	433	626	366	525	288	888	1,100
		Alighting	1,396	257	192	230	259	480	1,832	472	36	187	0
		On-board	0	1,396	1,510	1,203	959	786	640	2,106	2,053	1,801	1,100
	Error band (Lower Bound)	Boarding	0	133	432	464	400	582	306	459	246	833	1,025
		Alighting	1,283	236	182	212	238	417	1,670	436	34	174	0
		On-board	0	1,283	1,386	1,135	883	721	555	1,919	1,896	1,684	1,025

APPENDIX N3

The predicted on-board ridership (average weekday per peak hour) of Kuala Lumpur monorail outbound traffic movement for 40% upzoning zoning intensification scenario.

Possible Trend		Ridership	KL Sentral	Tun Sambanthan	Maharajalela	Hang Tuah	Imbi	Bukit Bintang	Raja Chulan	Bukit Nanas	Medan Tuanku	Chow Kit	Titiwangsa
Optimistic	Error Band (Upper Bound)	Boarding	0	280	1,504	604	794	1,106	1,041	1,249	757	1,560	1,996
		Alighting	2,904	538	316	433	496	1,196	3,706	899	64	339	0
		On-board	0	2,904	3,162	1,974	1,802	1,504	1,595	4,260	3,910	3,217	1,996
	Baseline	Boarding	0	251	1,294	576	715	1,002	896	1,091	655	1,418	1,802
		Alighting	2,584	478	289	389	445	1,042	3,301	807	58	306	0
		On-board	0	2,584	2,812	1,807	1,619	1,349	1,389	3,794	3,510	2,913	1,802
	Error band (Lower Bound)	Boarding	0	223	1,098	549	626	880	725	908	538	1,258	1,598
		Alighting	2,263	418	259	338	385	862	2,847	706	52	272	0
		On-board	0	2,263	2,458	1,619	1,409	1,167	1,150	3,272	3,070	2,584	1,598
Modest	Error Band (Upper Bound)	Boarding	0	221	1,077	548	635	900	752	935	553	1,275	1,606
		Alighting	2,257	417	262	345	395	889	2,896	715	52	273	0
		On-board	0	2,257	2,454	1,639	1,437	1,196	1,185	3,329	3,109	2,608	1,606
	Baseline	Boarding	0	200	930	528	579	828	650	824	482	1,175	1,470
		Alighting	2,034	375	244	314	359	780	2,612	651	48	250	0
		On-board	0	2,034	2,209	1,522	1,308	1,088	1,040	3,003	2,829	2,395	1,470
	Error band (Lower Bound)	Boarding	0	181	793	509	518	742	530	696	400	1,063	1,327
		Alighting	1,809	333	223	279	317	655	2,295	580	43	226	0
		On-board	0	1,809	1,961	1,391	1,161	960	873	2,638	2,521	2,165	1,327
Pessimistic	Error Band (Upper Bound)	Boarding	0	162	649	491	476	695	463	621	350	990	1,215
		Alighting	1,610	297	209	257	293	581	2,086	531	40	207	0
		On-board	0	1,610	1,745	1,305	1,071	888	775	2,398	2,308	1,999	1,215
	Baseline	Boarding	0	150	566	480	444	653	404	558	309	933	1,138
		Alighting	1,483	273	198	239	273	519	1,924	494	38	193	0
		On-board	0	1,483	1,606	1,238	998	826	692	2,212	2,148	1,877	1,138
	Error band (Lower Bound)	Boarding	0	139	488	469	409	604	336	484	262	869	1,056
		Alighting	1,355	249	186	219	249	447	1,743	454	35	180	0
		On-board	0	1,355	1,465	1,163	914	754	596	2,003	1,973	1,746	1,056

APPENDIX N4

The predicted on-board ridership (average weekday per peak hour) of Kuala Lumpur monorail outbound traffic movement for 60% upzoning zoning intensification scenario.

Possible Trend		Ridership	KL Sentral	Tun Sambanthan	Maharajalela	Hang Tuah	Imbi	Bukit Bintang	Raja Chulan	Bukit Nanas	Medan Tuanku	Chow Kit	Titiwangsa
Optimistic	Error Band (Upper Bound)	Boarding	0	302	1,701	621	828	1,187	1,154	1,344	817	1,692	2,109
		Alighting	3,163	586	332	460	536	1,311	3,976	964	69	359	0
		On-board	0	3,163	3,446	2,077	1,916	1,624	1,748	4,571	4,190	3,442	2,109
	Baseline	Boarding	0	270	1,462	591	743	1,071	991	1,172	705	1,529	1,898
		Alighting	2,804	519	303	412	479	1,139	3,530	862	62	323	0
		On-board	0	2,804	3,053	1,894	1,715	1,451	1,519	4,058	3,748	3,104	1,898
	Error band (Lower Bound)	Boarding	0	238	1,238	561	648	936	799	971	579	1,347	1,676
		Alighting	2,443	452	270	356	412	939	3,030	750	55	285	0
		On-board	0	2,443	2,656	1,689	1,484	1,249	1,252	3,483	3,262	2,738	1,676
Modest	Error Band (Upper Bound)	Boarding	0	237	1,214	559	659	957	831	1,002	595	1,367	1,685
		Alighting	2,438	451	274	364	422	969	3,085	760	55	286	0
		On-board	0	2,438	2,652	1,712	1,516	1,280	1,292	3,547	3,305	2,765	1,685
	Baseline	Boarding	0	214	1,047	538	599	876	717	881	517	1,253	1,537
		Alighting	2,187	404	253	330	382	849	2,773	689	51	261	0
		On-board	0	2,187	2,378	1,584	1,376	1,159	1,131	3,188	2,996	2,529	1,537
	Error band (Lower Bound)	Boarding	0	192	890	517	533	781	583	740	429	1,126	1,381
		Alighting	1,935	357	230	291	336	708	2,423	611	45	235	0
		On-board	0	1,935	2,100	1,440	1,214	1,017	945	2,785	2,656	2,273	1,381
Pessimistic	Error Band (Upper Bound)	Boarding	0	171	727	498	489	727	508	659	374	1,042	1,260
		Alighting	1,713	316	215	268	309	627	2,195	557	42	214	0
		On-board	0	1,713	1,858	1,346	1,117	936	836	2,522	2,420	2,088	1,260
	Baseline	Boarding	0	158	633	485	455	681	443	590	329	977	1,176
		Alighting	1,570	289	204	249	286	558	2,016	516	39	200	0
		On-board	0	1,570	1,702	1,273	1,036	867	744	2,317	2,244	1,954	1,176
	Error band (Lower Bound)	Boarding	0	145	543	474	417	627	366	510	278	905	1,087
		Alighting	1,427	262	191	227	259	478	1,816	471	36	185	0
		On-board	0	1,427	1,544	1,191	944	786	637	2,088	2,049	1,807	1,087

APPENDIX N5

The predicted on-board ridership (average weekday per peak hour) of Kuala Lumpur monorail outbound traffic movement for 80% upzoning zoning intensification scenario.

Possible Trend		Ridership	KL Sentral	Tun Sambanthan	Maharajalela	Hang Tuah	Imbi	Bukit Bintang	Raja Chulan	Bukit Nanas	Medan Tuanku	Chow Kit	Titiwangsa
Optimistic	Error Band (Upper Bound)	Boarding	0	325	1,899	638	861	1,268	1,266	1,439	877	1,823	2,222
		Alighting	3,421	634	349	487	575	1,426	4,247	1,028	73	378	0
		On-board	0	3,421	3,730	2,180	2,029	1,743	1,901	4,881	4,470	3,667	2,222
	Baseline	Boarding	0	289	1,630	605	771	1,140	1,086	1,253	756	1,640	1,994
		Alighting	3,024	560	317	435	512	1,236	3,760	917	66	339	0
		On-board	0	3,024	3,295	1,982	1,811	1,552	1,648	4,322	3,986	3,295	1,994
	Error band (Lower Bound)	Boarding	0	254	1,377	573	669	991	874	1,034	620	1,437	1,753
		Alighting	2,624	485	281	374	439	1,015	3,213	794	58	298	0
		On-board	0	2,624	2,855	1,759	1,560	1,330	1,354	3,693	3,454	2,892	1,753
Modest	Error Band (Upper Bound)	Boarding	0	252	1,352	571	682	1,014	910	1,068	637	1,459	1,764
		Alighting	2,619	485	285	383	450	1,049	3,275	805	58	300	0
		On-board	0	2,619	2,851	1,784	1,596	1,363	1,399	3,764	3,501	2,922	1,764
	Baseline	Boarding	0	227	1,165	548	619	924	784	937	553	1,331	1,604
		Alighting	2,341	433	263	346	406	917	2,934	727	53	273	0
		On-board	0	2,341	2,547	1,645	1,443	1,230	1,222	3,372	3,162	2,663	1,604
	Error band (Lower Bound)	Boarding	0	203	988	526	548	820	635	784	457	1,189	1,436
		Alighting	2,061	381	238	304	354	762	2,551	642	48	244	0
		On-board	0	2,061	2,239	1,489	1,267	1,074	1,016	2,933	2,790	2,380	1,436
Pessimistic	Error Band (Upper Bound)	Boarding	0	180	806	504	503	760	553	697	397	1,095	1,305
		Alighting	1,816	335	222	279	325	673	2,303	582	44	222	0
		On-board	0	1,816	1,971	1,387	1,162	984	897	2,647	2,532	2,178	1,305
	Baseline	Boarding	0	166	699	491	467	708	481	622	349	1,022	1,214
		Alighting	1,658	306	209	258	299	597	2,108	538	41	206	0
		On-board	0	1,658	1,798	1,308	1,075	907	796	2,423	2,339	2,030	1,214
	Error band (Lower Bound)	Boarding	0	152	599	478	426	649	396	535	295	940	1,118
		Alighting	1,498	276	195	234	270	509	1,889	489	37	190	0
		On-board	0	1,498	1,623	1,219	974	818	678	2,172	2,126	1,869	1,118

APPENDIX N6

The predicted on-board ridership (average weekday per peak hour) of Kuala Lumpur monorail outbound traffic movement for 100% upzoning zoning intensification scenario.

Possible Trend		Ridership	KL Sentral	Tun Sambanthan	Maharajalela	Hang Tuah	Imbi	Bukit Bintang	Raja Chulan	Bukit Nanas	Medan Tuanku	Chow Kit	Titiwangsa
Optimistic	Error Band (Upper Bound)	Boarding	0	348	2,096	655	895	1,349	1,379	1,534	937	1,954	2,335
		Alighting	3,680	682	365	514	615	1,540	4,517	1,093	78	397	0
		On-board	0	3,680	4,014	2,284	2,142	1,862	2,054	5,192	4,750	3,892	2,335
	Baseline	Boarding	0	309	1,798	620	800	1,209	1,182	1,333	807	1,752	2,090
		Alighting	3,244	601	331	458	546	1,334	3,990	972	70	355	0
		On-board	0	3,244	3,537	2,069	1,908	1,654	1,778	4,586	4,224	3,487	2,090
	Error band (Lower Bound)	Boarding	0	270	1,517	585	691	1,047	948	1,097	661	1,526	1,831
		Alighting	2,804	519	293	393	466	1,092	3,397	839	61	311	0
		On-board	0	2,804	3,053	1,829	1,636	1,411	1,456	3,904	3,646	3,046	1,831
Modest	Error Band (Upper Bound)	Boarding	0	268	1,490	583	706	1,071	988	1,135	679	1,550	1,843
		Alighting	2,799	518	297	402	478	1,130	3,464	850	62	313	0
		On-board	0	2,799	3,049	1,856	1,675	1,447	1,506	3,982	3,697	3,080	1,843
	Baseline	Boarding	0	241	1,282	558	639	972	851	994	589	1,409	1,671
		Alighting	2,495	462	273	363	429	985	3,095	766	56	284	0
		On-board	0	2,495	2,715	1,706	1,511	1,301	1,313	3,557	3,329	2,796	1,671
	Error band (Lower Bound)	Boarding	0	214	1,086	534	563	859	687	828	486	1,251	1,490
		Alighting	2,187	404	246	317	373	816	2,680	673	50	253	0
		On-board	0	2,187	2,378	1,538	1,321	1,131	1,088	3,080	2,924	2,488	1,490
Pessimistic	Error Band (Upper Bound)	Boarding	0	189	884	511	516	792	598	735	421	1,147	1,350
		Alighting	1,919	354	229	290	340	719	2,411	608	45	230	0
		On-board	0	1,919	2,084	1,429	1,208	1,032	959	2,771	2,644	2,268	1,350
	Baseline	Boarding	0	173	766	497	478	736	519	655	370	1,066	1,253
		Alighting	1,745	322	215	267	313	636	2,200	560	42	213	0
		On-board	0	1,745	1,894	1,343	1,114	948	848	2,529	2,434	2,106	1,253
	Error band (Lower Bound)	Boarding	0	158	654	483	435	671	426	560	311	976	1,149
		Alighting	1,570	289	199	241	281	539	1,963	507	39	195	0
		On-board	0	1,570	1,702	1,247	1,005	851	719	2,256	2,203	1,930	1,149

APPENDIX O1

The predicted on-board ridership (average weekday per peak hour) of Kuala Lumpur monorail inbound traffic movement for business as usual zoning intensification scenario with 40% expected future growth to use monorail.

Possible Trend		Ridership	KL Sentral	Tun Sambanthan	Maharajalela	Hang Tuah	Imbi	Bukit Bintang	Raja Chulan	Bukit Nanas	Medan Tuanku	Chow Kit	Titiwangsa
Optimistic	Error Band (Upper Bound)	Boarding	2,611	819	602	2,706	526	281	523	510	1,064	324	0
		Alighting	0	26	68	512	552	977	4,166	1,007	610	1,483	566
		On-board	2,611	3,403	3,937	6,131	6,106	5,410	1,768	1,270	1,725	566	0
	Baseline	Boarding	2,329	725	517	2,541	465	251	448	441	914	291	0
		Alighting	0	23	61	453	502	886	3,775	898	537	1,286	500
		On-board	2,329	3,030	3,486	5,574	5,537	4,902	1,576	1,119	1,496	500	0
	Error band (Lower Bound)	Boarding	2,022	634	436	2,377	399	214	362	363	741	253	0
		Alighting	0	20	53	392	450	792	3,367	779	456	1,063	426
		On-board	2,022	2,635	3,018	5,003	4,951	4,373	1,367	951	1,236	426	0
Modest	Error Band (Upper Bound)	Boarding	2,141	660	458	2,429	424	231	399	396	815	268	0
		Alighting	0	21	56	414	468	825	3,511	825	489	1,156	457
		On-board	2,141	2,780	3,182	5,197	5,154	4,560	1,448	1,018	1,345	457	0
	Baseline	Boarding	1,930	589	394	2,305	378	208	343	344	703	243	0
		Alighting	0	19	50	370	430	756	3,217	743	434	1,009	407
		On-board	1,930	2,500	2,844	4,779	4,727	4,178	1,304	905	1,173	407	0
	Error band (Lower Bound)	Boarding	1,699	521	334	2,182	328	180	278	285	573	215	0
		Alighting	0	17	44	324	392	686	2,912	654	374	841	352
		On-board	1,699	2,204	2,493	4,351	4,288	3,781	1,147	779	978	352	0
Pessimistic	Error Band (Upper Bound)	Boarding	1,672	501	314	2,151	322	180	275	282	566	213	0
		Alighting	0	17	43	316	384	672	2,856	643	368	830	348
		On-board	1,672	2,156	2,428	4,263	4,201	3,709	1,128	766	965	348	0
	Baseline	Boarding	1,531	454	272	2,068	291	164	237	247	491	196	0
		Alighting	0	15	39	286	359	627	2,660	588	332	731	315
		On-board	1,531	1,970	2,202	3,984	3,917	3,455	1,032	691	850	315	0
	Error band (Lower Bound)	Boarding	1,377	409	232	1,986	258	146	194	208	405	177	0
		Alighting	0	14	35	256	333	580	2,456	529	291	619	278
		On-board	1,377	1,772	1,968	3,699	3,624	3,190	927	607	720	278	0

APPENDIX O2

The predicted on-board ridership (average weekday per peak hour) of Kuala Lumpur monorail inbound traffic movement for 20% upzoning zoning intensification scenario with 40% expected future growth to use monorail.

Possible Trend		Ridership	KL Sentral	Tun Sambanthan	Maharajalela	Hang Tuah	Imbi	Bukit Bintang	Raja Chulan	Bukit Nanas	Medan Tuanku	Chow Kit	Titiwangsa
Optimistic	Error Band (Upper Bound)	Boarding	2,862	917	714	2,828	558	312	600	562	1,169	367	0
		Alighting	0	29	75	571	598	1,057	4,513	1,110	672	1,632	632
		On-board	2,862	3,750	4,389	6,646	6,606	5,861	1,948	1,400	1,897	632	0
	Baseline	Boarding	2,542	808	612	2,645	492	277	513	485	1,003	327	0
		Alighting	0	25	66	503	541	954	4,070	986	590	1,413	557
		On-board	2,542	3,325	3,870	6,012	5,963	5,285	1,729	1,229	1,643	557	0
	Error band (Lower Bound)	Boarding	2,195	702	515	2,463	419	235	413	397	813	282	0
		Alighting	0	22	58	433	483	848	3,608	850	498	1,164	471
		On-board	2,195	2,875	3,333	5,362	5,299	4,686	1,490	1,038	1,353	471	0
Modest	Error Band (Upper Bound)	Boarding	2,329	734	542	2,520	448	254	456	435	894	300	0
		Alighting	0	23	61	458	503	885	3,771	902	535	1,268	507
		On-board	2,329	3,040	3,521	5,583	5,529	4,898	1,583	1,115	1,474	507	0
	Baseline	Boarding	2,090	652	466	2,383	398	227	392	377	770	270	0
		Alighting	0	21	54	407	460	807	3,439	809	474	1,103	450
		On-board	2,090	2,721	3,132	5,108	5,046	4,466	1,419	987	1,283	450	0
	Error band (Lower Bound)	Boarding	1,830	572	393	2,246	344	196	316	311	627	237	0
		Alighting	0	18	48	355	416	728	3,092	707	405	917	386
		On-board	1,830	2,384	2,729	4,620	4,548	4,016	1,240	844	1,066	386	0
Pessimistic	Error Band (Upper Bound)	Boarding	1,797	550	370	2,212	338	195	313	308	619	234	0
		Alighting	0	18	47	345	407	712	3,029	694	399	904	381
		On-board	1,797	2,330	2,654	4,521	4,451	3,934	1,218	831	1,051	381	0
	Baseline	Boarding	1,638	496	319	2,120	304	177	270	269	536	214	0
		Alighting	0	16	42	311	378	661	2,808	632	358	794	343
		On-board	1,638	2,117	2,394	4,204	4,130	3,646	1,108	746	924	343	0
	Error band (Lower Bound)	Boarding	1,464	443	271	2,029	268	156	219	225	441	191	0
		Alighting	0	15	38	276	349	608	2,577	564	312	670	300
		On-board	1,464	1,892	2,126	3,879	3,798	3,346	989	650	779	300	0

APPENDIX O3

The predicted on-board ridership (average weekday per peak hour) of Kuala Lumpur monorail inbound traffic movement for 40% upzoning zoning intensification scenario with 40% expected future growth to use monorail.

Possible Trend		Ridership	KL Sentral	Tun Sambanthan	Maharajalela	Hang Tuah	Imbi	Bukit Bintang	Raja Chulan	Bukit Nanas	Medan Tuanku	Chow Kit	Titiwangsa
Optimistic	Error Band (Upper Bound)	Boarding	3,113	1,015	826	2,950	590	343	677	614	1,275	409	0
		Alighting	0	31	82	629	645	1,137	4,860	1,213	734	1,780	699
		On-board	3,113	4,096	4,840	7,161	7,107	6,312	2,129	1,529	2,070	699	0
	Baseline	Boarding	2,756	891	707	2,749	519	303	579	530	1,093	363	0
		Alighting	0	28	72	553	581	1,022	4,365	1,073	643	1,539	613
		On-board	2,756	3,620	4,255	6,450	6,389	5,669	1,882	1,339	1,789	613	0
	Error band (Lower Bound)	Boarding	2,369	770	594	2,549	440	256	464	432	885	311	0
		Alighting	0	24	62	474	515	903	3,849	920	540	1,265	517
		On-board	2,369	3,115	3,647	5,722	5,647	4,999	1,614	1,126	1,471	517	0
Modest	Error Band (Upper Bound)	Boarding	2,518	807	626	2,612	472	276	514	474	973	332	0
		Alighting	0	25	66	502	537	945	4,032	979	582	1,379	556
		On-board	2,518	3,300	3,860	5,970	5,904	5,236	1,718	1,213	1,603	556	0
	Baseline	Boarding	2,250	714	537	2,460	418	246	440	410	837	297	0
		Alighting	0	23	59	445	489	858	3,660	874	514	1,198	492
		On-board	2,250	2,942	3,421	5,436	5,366	4,754	1,534	1,070	1,393	492	0
	Error band (Lower Bound)	Boarding	1,960	623	453	2,311	359	211	354	337	681	258	0
		Alighting	0	20	51	385	440	769	3,273	759	437	993	420
		On-board	1,960	2,564	2,965	4,890	4,809	4,251	1,332	910	1,154	420	0
Pessimistic	Error Band (Upper Bound)	Boarding	1,923	599	426	2,273	353	210	351	334	671	255	0
		Alighting	0	19	50	374	430	752	3,203	746	430	978	414
		On-board	1,923	2,503	2,879	4,778	4,702	4,160	1,308	896	1,137	414	0
	Baseline	Boarding	1,745	538	367	2,172	318	190	302	291	580	232	0
		Alighting	0	17	45	336	398	695	2,955	675	384	857	371
		On-board	1,745	2,265	2,587	4,423	4,343	3,838	1,185	801	997	371	0
	Error band (Lower Bound)	Boarding	1,551	477	311	2,072	278	167	245	242	477	206	0
		Alighting	0	16	40	297	365	635	2,697	599	333	720	323
		On-board	1,551	2,012	2,283	4,058	3,972	3,503	1,051	694	838	323	0

APPENDIX O4

The predicted on-board ridership (average weekday per peak hour) of Kuala Lumpur monorail inbound traffic movement for 60% upzoning zoning intensification scenario with 40% expected future growth to use monorail.

Possible Trend		Ridership	KL Sentral	Tun Sambanthan	Maharajalela	Hang Tuah	Imbi	Bukit Bintang	Raja Chulan	Bukit Nanas	Medan Tuanku	Chow Kit	Titiwangsa
Optimistic	Error Band (Upper Bound)	Boarding	3,364	1,113	938	3,072	622	373	754	666	1,380	451	0
		Alighting	0	34	89	688	691	1,217	5,208	1,316	796	1,928	765
		On-board	3,364	4,443	5,292	7,676	7,607	6,763	2,309	1,659	2,242	765	0
	Baseline	Boarding	2,970	974	803	2,853	546	329	644	574	1,182	399	0
		Alighting	0	30	78	603	620	1,090	4,660	1,160	696	1,665	670
		On-board	2,970	3,914	4,639	6,888	6,814	6,052	2,036	1,449	1,936	670	0
	Error band (Lower Bound)	Boarding	2,543	838	674	2,635	461	277	515	466	957	340	0
		Alighting	0	25	67	515	547	959	4,090	990	582	1,366	562
		On-board	2,543	3,355	3,961	6,081	5,994	5,312	1,737	1,213	1,588	562	0
Modest	Error Band (Upper Bound)	Boarding	2,706	880	710	2,703	496	299	572	513	1,052	364	0
		Alighting	0	27	71	546	572	1,005	4,292	1,057	629	1,490	606
		On-board	2,706	3,560	4,199	6,356	6,279	5,574	1,854	1,310	1,733	606	0
	Baseline	Boarding	2,410	777	609	2,538	439	266	489	443	904	324	0
		Alighting	0	24	63	482	519	910	3,882	940	553	1,293	535
		On-board	2,410	3,163	3,709	5,765	5,685	5,041	1,649	1,152	1,503	535	0
	Error band (Lower Bound)	Boarding	2,090	674	512	2,375	375	227	393	363	735	280	0
		Alighting	0	21	55	416	464	811	3,454	812	468	1,068	454
		On-board	2,090	2,744	3,201	5,160	5,070	4,486	1,424	975	1,242	454	0
Pessimistic	Error Band (Upper Bound)	Boarding	2,048	648	482	2,334	369	226	390	360	724	276	0
		Alighting	0	20	54	404	453	792	3,376	797	461	1,052	447
		On-board	2,048	2,676	3,105	5,036	4,952	4,385	1,398	961	1,223	447	0
	Baseline	Boarding	1,851	579	415	2,224	331	203	335	313	625	250	0
		Alighting	0	19	48	361	418	729	3,103	719	411	920	400
		On-board	1,851	2,412	2,779	4,642	4,555	4,030	1,262	856	1,070	400	0
	Error band (Lower Bound)	Boarding	1,638	511	350	2,115	289	177	270	260	513	220	0
		Alighting	0	16	43	317	381	663	2,818	634	354	771	346
		On-board	1,638	2,132	2,440	4,238	4,145	3,660	1,112	738	896	346	0

APPENDIX O5

The predicted on-board ridership (average weekday per peak hour) of Kuala Lumpur monorail inbound traffic movement for 80% upzoning zoning intensification scenario with 40% expected future growth to use monorail.

Possible Trend		Ridership	KL Sentral	Tun Sambanthan	Maharajalela	Hang Tuah	Imbi	Bukit Bintang	Raja Chulan	Bukit Nanas	Medan Tuanku	Chow Kit	Titiwangsa
Optimistic	Error Band (Upper Bound)	Boarding	3,615	1,211	1,050	3,194	654	404	830	718	1,485	494	0
		Alighting	0	36	96	747	737	1,297	5,555	1,419	858	2,077	832
		On-board	3,615	4,789	5,743	8,191	8,107	7,214	2,489	1,788	2,415	832	0
	Baseline	Boarding	3,183	1,058	898	2,956	573	354	709	618	1,272	435	0
		Alighting	0	32	84	653	659	1,158	4,956	1,248	748	1,791	726
		On-board	3,183	4,209	5,023	7,326	7,240	6,436	2,189	1,559	2,082	726	0
	Error band (Lower Bound)	Boarding	2,716	906	753	2,721	481	298	566	501	1,029	369	0
		Alighting	0	27	72	556	580	1,015	4,331	1,060	624	1,467	607
		On-board	2,716	3,595	4,276	6,441	6,342	5,625	1,860	1,301	1,706	607	0
Modest	Error Band (Upper Bound)	Boarding	2,894	954	794	2,795	519	322	629	552	1,131	396	0
		Alighting	0	29	76	590	607	1,065	4,552	1,134	675	1,602	656
		On-board	2,894	3,819	4,537	6,742	6,655	5,912	1,989	1,407	1,862	656	0
	Baseline	Boarding	2,571	839	680	2,616	459	285	538	477	971	351	0
		Alighting	0	26	68	520	548	961	4,103	1,005	593	1,387	577
		On-board	2,571	3,384	3,997	6,094	6,004	5,329	1,764	1,235	1,613	577	0
	Error band (Lower Bound)	Boarding	2,220	725	571	2,439	390	243	431	389	789	302	0
		Alighting	0	22	58	447	489	853	3,635	865	500	1,144	488
		On-board	2,220	2,924	3,436	5,429	5,331	4,720	1,517	1,041	1,330	488	0
Pessimistic	Error Band (Upper Bound)	Boarding	2,174	697	538	2,395	385	241	428	385	776	297	0
		Alighting	0	22	57	433	476	832	3,550	848	492	1,126	481
		On-board	2,174	2,849	3,331	5,293	5,202	4,610	1,489	1,026	1,310	481	0
	Baseline	Boarding	1,958	621	463	2,276	345	216	367	335	670	268	0
		Alighting	0	20	51	386	437	763	3,251	763	437	983	428
		On-board	1,958	2,559	2,971	4,861	4,768	4,222	1,338	911	1,143	428	0
	Error band (Lower Bound)	Boarding	1,725	545	390	2,158	299	188	296	277	549	235	0
		Alighting	0	17	45	338	398	691	2,938	669	375	821	369
		On-board	1,725	2,252	2,597	4,418	4,319	3,816	1,174	782	955	369	0

APPENDIX O6

The predicted on-board ridership (average weekday per peak hour) of Kuala Lumpur monorail inbound traffic movement for 100% upzoning zoning intensification scenario with 40% expected future growth to use monorail.

Possible Trend		Ridership	KL Sentral	Tun Sambanthan	Maharajalela	Hang Tuah	Imbi	Bukit Bintang	Raja Chulan	Bukit Nanas	Medan Tuanku	Chow Kit	Titiwangsa
Optimistic	Error Band (Upper Bound)	Boarding	3,866	1,308	1,162	3,316	685	434	907	770	1,590	536	0
		Alighting	0	39	103	805	784	1,377	5,902	1,522	921	2,225	898
		On-board	3,866	5,136	6,195	8,706	8,608	7,665	2,670	1,918	2,587	898	0
	Baseline	Boarding	3,397	1,141	993	3,060	600	380	774	662	1,361	471	0
		Alighting	0	34	90	703	699	1,226	5,251	1,335	801	1,917	783
		On-board	3,397	4,504	5,407	7,764	7,665	6,819	2,343	1,669	2,229	783	0
	Error band (Lower Bound)	Boarding	2,890	974	832	2,807	502	319	617	535	1,101	398	0
		Alighting	0	29	77	597	612	1,070	4,572	1,130	666	1,568	653
		On-board	2,890	3,835	4,590	6,800	6,690	5,938	1,983	1,388	1,823	653	0
Modest	Error Band (Upper Bound)	Boarding	3,083	1,027	878	2,886	543	345	687	591	1,210	427	0
		Alighting	0	31	82	634	642	1,125	4,813	1,211	722	1,713	706
		On-board	3,083	4,079	4,876	7,128	7,030	6,250	2,124	1,504	1,992	706	0
	Baseline	Boarding	2,731	902	752	2,694	479	305	587	510	1,038	378	0
		Alighting	0	27	72	557	578	1,012	4,325	1,071	632	1,482	620
		On-board	2,731	3,605	4,285	6,422	6,323	5,616	1,879	1,317	1,723	620	0
	Error band (Lower Bound)	Boarding	2,351	776	631	2,504	406	258	469	415	843	323	0
		Alighting	0	24	62	477	513	895	3,816	917	531	1,220	522
		On-board	2,351	3,104	3,672	5,699	5,591	4,955	1,609	1,107	1,418	522	0
Pessimistic	Error Band (Upper Bound)	Boarding	2,299	746	595	2,456	401	256	467	411	829	319	0
		Alighting	0	23	60	462	500	872	3,724	900	523	1,201	514
		On-board	2,299	3,023	3,557	5,551	5,452	4,836	1,579	1,090	1,396	514	0
	Baseline	Boarding	2,065	663	510	2,328	358	229	400	357	715	286	0
		Alighting	0	21	54	411	457	797	3,398	807	464	1,046	456
		On-board	2,065	2,707	3,163	5,080	4,981	4,413	1,415	966	1,217	456	0
	Error band (Lower Bound)	Boarding	1,811	579	429	2,201	309	198	322	294	585	249	0
		Alighting	0	18	47	358	414	719	3,059	704	396	872	391
		On-board	1,811	2,372	2,754	4,598	4,493	3,973	1,235	825	1,014	391	0

APPENDIX P1

The predicted on-board ridership (average weekday per peak hour) of Kuala Lumpur monorail inbound traffic movement for business as usual zoning intensification scenario with 60% expected future growth to use monorail.

Possible Trend		Ridership	KL Sentral	Tun Sambanthan	Maharajalela	Hang Tuah	Imbi	Bukit Bintang	Raja Chulan	Bukit Nanas	Medan Tuanku	Chow Kit	Titiwangsa
Optimistic	Error Band (Upper Bound)	Boarding	3,549	1,136	889	3,261	731	383	772	739	1,562	436	0
		Alighting	0	35	93	708	720	1,282	5,476	1,372	851	2,137	784
		On-board	3,549	4,650	5,446	7,999	8,011	7,112	2,407	1,774	2,485	784	0
	Baseline	Boarding	3,127	995	761	3,013	639	337	659	635	1,337	385	0
		Alighting	0	31	82	620	645	1,145	4,889	1,208	743	1,842	685
		On-board	3,127	4,091	4,770	7,163	7,158	6,349	2,120	1,547	2,142	685	0
	Error band (Lower Bound)	Boarding	2,666	858	641	2,767	539	282	529	518	1,078	329	0
		Alighting	0	27	70	529	568	1,005	4,278	1,030	622	1,506	574
		On-board	2,666	3,498	4,068	6,307	6,279	5,556	1,807	1,295	1,751	574	0
Modest	Error Band (Upper Bound)	Boarding	2,845	898	674	2,845	578	307	585	567	1,189	352	0
		Alighting	0	28	74	561	594	1,053	4,494	1,099	670	1,647	620
		On-board	2,845	3,715	4,314	6,598	6,582	5,836	1,928	1,396	1,915	620	0
	Baseline	Boarding	2,528	792	578	2,659	509	272	501	490	1,020	314	0
		Alighting	0	25	66	495	537	951	4,053	976	588	1,425	546
		On-board	2,528	3,295	3,807	5,971	5,942	5,264	1,712	1,226	1,657	546	0
	Error band (Lower Bound)	Boarding	2,183	690	487	2,474	434	231	403	402	826	272	0
		Alighting	0	22	57	427	480	845	3,595	842	498	1,174	463
		On-board	2,183	2,851	3,281	5,329	5,283	4,669	1,477	1,037	1,365	463	0
Pessimistic	Error Band (Upper Bound)	Boarding	2,141	660	458	2,429	424	231	399	396	815	268	0
		Alighting	0	21	56	414	468	825	3,511	825	489	1,156	457
		On-board	2,141	2,780	3,182	5,197	5,154	4,560	1,448	1,018	1,345	457	0
	Baseline	Boarding	1,930	589	394	2,305	378	208	343	344	703	243	0
		Alighting	0	19	50	370	430	756	3,217	743	434	1,009	407
		On-board	1,930	2,500	2,844	4,779	4,727	4,178	1,304	905	1,173	407	0
	Error band (Lower Bound)	Boarding	1,699	521	334	2,182	328	180	278	285	573	215	0
		Alighting	0	17	44	324	392	686	2,912	654	374	841	352
		On-board	1,699	2,204	2,493	4,351	4,288	3,781	1,147	779	978	352	0

APPENDIX P2

The predicted on-board ridership (average weekday per peak hour) of Kuala Lumpur monorail inbound traffic movement for 20% upzoning zoning intensification scenario with 60% expected future growth to use monorail.

Possible Trend		Ridership	KL Sentral	Tun Sambanthan	Maharajalela	Hang Tuah	Imbi	Bukit Bintang	Raja Chulan	Bukit Nanas	Medan Tuanku	Chow Kit	Titiwangsa
Optimistic	Error Band (Upper Bound)	Boarding	3,926	1,283	1,057	3,444	779	429	887	817	1,720	499	0
		Alighting	0	39	103	796	789	1,402	5,997	1,527	945	2,359	883
		On-board	3,926	5,170	6,124	8,772	8,761	7,788	2,678	1,968	2,743	883	0
	Baseline	Boarding	3,447	1,120	904	3,169	679	376	757	702	1,471	439	0
		Alighting	0	34	91	695	704	1,247	5,332	1,339	822	2,031	770
		On-board	3,447	4,533	5,346	7,820	7,796	6,925	2,350	1,712	2,361	770	0
	Error band (Lower Bound)	Boarding	2,926	961	759	2,896	570	313	606	569	1,186	372	0
		Alighting	0	29	77	590	616	1,088	4,640	1,135	684	1,658	642
		On-board	2,926	3,858	4,540	6,846	6,800	6,025	1,992	1,426	1,928	642	0
Modest	Error Band (Upper Bound)	Boarding	3,128	1,008	800	2,982	613	341	672	626	1,307	400	0
		Alighting	0	31	82	627	646	1,143	4,884	1,214	740	1,814	695
		On-board	3,128	4,105	4,822	7,178	7,145	6,343	2,131	1,542	2,109	695	0
	Baseline	Boarding	2,769	886	685	2,776	539	302	574	539	1,120	355	0
		Alighting	0	28	73	551	582	1,027	4,385	1,074	648	1,567	610
		On-board	2,769	3,627	4,239	6,464	6,421	5,695	1,884	1,350	1,822	610	0
	Error band (Lower Bound)	Boarding	2,378	766	576	2,571	457	254	461	440	907	304	0
		Alighting	0	24	62	472	516	908	3,866	921	545	1,287	514
		On-board	2,378	3,121	3,635	5,733	5,674	5,021	1,616	1,135	1,497	514	0
Pessimistic	Error Band (Upper Bound)	Boarding	2,329	734	542	2,520	448	254	456	435	894	300	0
		Alighting	0	23	61	458	503	885	3,771	902	535	1,268	507
		On-board	2,329	3,040	3,521	5,583	5,529	4,898	1,583	1,115	1,474	507	0
	Baseline	Boarding	2,090	652	466	2,383	398	227	392	377	770	270	0
		Alighting	0	21	54	407	460	807	3,439	809	474	1,103	450
		On-board	2,090	2,721	3,132	5,108	5,046	4,466	1,419	987	1,283	450	0
	Error band (Lower Bound)	Boarding	1,830	572	393	2,246	344	196	316	311	627	237	0
		Alighting	0	18	48	355	416	728	3,092	707	405	917	386
		On-board	1,830	2,384	2,729	4,620	4,548	4,016	1,240	844	1,066	386	0

APPENDIX P3

The predicted on-board ridership (average weekday per peak hour) of Kuala Lumpur monorail inbound traffic movement for 40% upzoning zoning intensification scenario with 60% expected future growth to use monorail.

Possible Trend		Ridership	KL Sentral	Tun Sambanthan	Maharajalela	Hang Tuah	Imbi	Bukit Bintang	Raja Chulan	Bukit Nanas	Medan Tuanku	Chow Kit	Titiwangsa
Optimistic	Error Band (Upper Bound)	Boarding	4,303	1,430	1,225	3,627	826	475	1,002	895	1,878	563	0
		Alighting	0	43	114	884	859	1,522	6,518	1,681	1,038	2,582	983
		On-board	4,303	5,690	6,801	9,544	9,512	8,465	2,949	2,163	3,002	983	0
	Baseline	Boarding	3,768	1,245	1,047	3,325	720	415	855	768	1,605	494	0
		Alighting	0	38	99	770	763	1,350	5,775	1,471	901	2,220	855
		On-board	3,768	4,975	5,923	8,478	8,435	7,500	2,580	1,877	2,581	855	0
	Error band (Lower Bound)	Boarding	3,187	1,063	878	3,025	601	345	683	621	1,294	416	0
		Alighting	0	32	84	651	665	1,171	5,001	1,241	747	1,809	710
		On-board	3,187	4,218	5,011	7,385	7,322	6,495	2,177	1,557	2,104	710	0
Modest	Error Band (Upper Bound)	Boarding	3,410	1,119	926	3,119	649	376	758	684	1,425	447	0
		Alighting	0	34	90	693	698	1,233	5,275	1,330	810	1,980	770
		On-board	3,410	4,495	5,330	7,757	7,708	6,850	2,334	1,688	2,303	770	0
	Baseline	Boarding	3,009	980	792	2,893	569	331	648	589	1,221	395	0
		Alighting	0	30	79	607	626	1,104	4,718	1,172	707	1,709	674
		On-board	3,009	3,958	4,672	6,957	6,900	6,127	2,057	1,473	1,987	674	0
	Error band (Lower Bound)	Boarding	2,573	843	665	2,668	480	278	519	479	988	337	0
		Alighting	0	26	68	518	552	970	4,137	1,000	592	1,401	565
		On-board	2,573	3,391	3,988	6,138	6,065	5,373	1,754	1,234	1,629	565	0
Pessimistic	Error Band (Upper Bound)	Boarding	2,518	807	626	2,612	472	276	514	474	973	332	0
		Alighting	0	25	66	502	537	945	4,032	979	582	1,379	556
		On-board	2,518	3,300	3,860	5,970	5,904	5,236	1,718	1,213	1,603	556	0
	Baseline	Boarding	2,250	714	537	2,460	418	246	440	410	837	297	0
		Alighting	0	23	59	445	489	858	3,660	874	514	1,198	492
		On-board	2,250	2,942	3,421	5,436	5,366	4,754	1,534	1,070	1,393	492	0
	Error band (Lower Bound)	Boarding	1,960	623	453	2,311	359	211	354	337	681	258	0
		Alighting	0	20	51	385	440	769	3,273	759	437	993	420
		On-board	1,960	2,564	2,965	4,890	4,809	4,251	1,332	910	1,154	420	0

APPENDIX P4

The predicted on-board ridership (average weekday per peak hour) of Kuala Lumpur monorail inbound traffic movement for 60% upzoning zoning intensification scenario with 60% expected future growth to use monorail.

Possible Trend		Ridership	KL Sentral	Tun Sambanthan	Maharajalela	Hang Tuah	Imbi	Bukit Bintang	Raja Chulan	Bukit Nanas	Medan Tuanku	Chow Kit	Tititwangsa
Optimistic	Error Band (Upper Bound)	Boarding	4,679	1,577	1,393	3,810	874	521	1,117	973	2,036	627	0
		Alighting	0	47	124	972	929	1,642	7,039	1,835	1,131	2,805	1,083
		On-board	4,679	6,209	7,479	10,317	10,262	9,141	3,220	2,357	3,261	1,083	0
	Baseline	Boarding	4,088	1,370	1,191	3,481	760	454	953	834	1,739	548	0
		Alighting	0	41	108	845	822	1,452	6,218	1,602	980	2,409	940
		On-board	4,088	5,417	6,499	9,135	9,073	8,075	2,810	2,042	2,801	940	0
	Error band (Lower Bound)	Boarding	3,447	1,165	997	3,154	632	376	759	673	1,402	459	0
		Alighting	0	34	92	713	713	1,255	5,363	1,346	810	1,961	778
		On-board	3,447	4,578	5,483	7,924	7,843	6,964	2,361	1,688	2,280	778	0
Modest	Error Band (Upper Bound)	Boarding	3,693	1,229	1,052	3,257	685	410	844	743	1,544	495	0
		Alighting	0	37	98	759	750	1,323	5,665	1,446	880	2,147	845
		On-board	3,693	4,884	5,839	8,336	8,271	7,357	2,537	1,833	2,497	845	0
	Baseline	Boarding	3,249	1,073	900	3,010	599	360	721	639	1,322	436	0
		Alighting	0	32	86	663	670	1,181	5,050	1,271	767	1,851	737
		On-board	3,249	4,290	5,104	7,450	7,379	6,558	2,229	1,597	2,152	737	0
	Error band (Lower Bound)	Boarding	2,769	920	754	2,765	504	301	576	518	1,069	370	0
		Alighting	0	28	73	564	589	1,033	4,408	1,079	639	1,515	616
		On-board	2,769	3,661	4,342	6,542	6,457	5,725	1,893	1,332	1,761	616	0
Pessimistic	Error Band (Upper Bound)	Boarding	2,706	880	710	2,703	496	299	572	513	1,052	364	0
		Alighting	0	27	71	546	572	1,005	4,292	1,057	629	1,490	606
		On-board	2,706	3,560	4,199	6,356	6,279	5,574	1,854	1,310	1,733	606	0
	Baseline	Boarding	2,410	777	609	2,538	439	266	489	443	904	324	0
		Alighting	0	24	63	482	519	910	3,882	940	553	1,293	535
		On-board	2,410	3,163	3,709	5,765	5,685	5,041	1,649	1,152	1,503	535	0
	Error band (Lower Bound)	Boarding	2,090	674	512	2,375	375	227	393	363	735	280	0
		Alighting	0	21	55	416	464	811	3,454	812	468	1,068	454
		On-board	2,090	2,744	3,201	5,160	5,070	4,486	1,424	975	1,242	454	0

APPENDIX P5

The predicted on-board ridership (average weekday per peak hour) of Kuala Lumpur monorail inbound traffic movement for 80% upzoning zoning intensification scenario with 60% expected future growth to use monorail.

Possible Trend		Ridership	KL Sentral	Tun Sambanthan	Maharajalela	Hang Tuah	Imbi	Bukit Bintang	Raja Chulan	Bukit Nanas	Medan Tuanku	Chow Kit	Tititwangsa
Optimistic	Error Band (Upper Bound)	Boarding	5,056	1,724	1,561	3,993	922	566	1,232	1,050	2,193	690	0
		Alighting	0	51	135	1,060	998	1,762	7,559	1,990	1,225	3,027	1,183
		On-board	5,056	6,729	8,156	11,089	11,013	9,817	3,490	2,551	3,520	1,183	0
	Baseline	Boarding	4,408	1,495	1,334	3,637	801	493	1,050	900	1,874	602	0
		Alighting	0	44	117	920	881	1,554	6,661	1,733	1,059	2,598	1,025
		On-board	4,408	5,859	7,075	9,792	9,711	8,650	3,040	2,207	3,021	1,025	0
	Error band (Lower Bound)	Boarding	3,708	1,267	1,116	3,283	663	407	836	725	1,510	503	0
		Alighting	0	37	99	774	762	1,338	5,724	1,451	873	2,112	846
		On-board	3,708	4,938	5,954	8,463	8,365	7,434	2,546	1,819	2,456	846	0
Modest	Error Band (Upper Bound)	Boarding	3,975	1,339	1,178	3,394	721	444	931	801	1,662	543	0
		Alighting	0	40	105	825	802	1,413	6,056	1,562	950	2,314	920
		On-board	3,975	5,274	6,347	8,916	8,834	7,865	2,740	1,979	2,691	920	0
	Baseline	Boarding	3,489	1,167	1,007	3,126	630	389	794	688	1,422	476	0
		Alighting	0	35	92	720	715	1,257	5,382	1,369	826	1,993	801
		On-board	3,489	4,621	5,536	7,943	7,858	6,990	2,402	1,721	2,317	801	0
	Error band (Lower Bound)	Boarding	2,964	996	843	2,861	527	325	634	557	1,150	402	0
		Alighting	0	30	79	610	625	1,096	4,679	1,158	687	1,628	667
		On-board	2,964	3,931	4,695	6,946	6,848	6,077	2,031	1,430	1,893	667	0
Pessimistic	Error Band (Upper Bound)	Boarding	2,894	954	794	2,795	519	322	629	552	1,131	396	0
		Alighting	0	29	76	590	607	1,065	4,552	1,134	675	1,602	656
		On-board	2,894	3,819	4,537	6,742	6,655	5,912	1,989	1,407	1,862	656	0
	Baseline	Boarding	2,571	839	680	2,616	459	285	538	477	971	351	0
		Alighting	0	26	68	520	548	961	4,103	1,005	593	1,387	577
		On-board	2,571	3,384	3,997	6,094	6,004	5,329	1,764	1,235	1,613	577	0
	Error band (Lower Bound)	Boarding	2,220	725	571	2,439	390	243	431	389	789	302	0
		Alighting	0	22	58	447	489	853	3,635	865	500	1,144	488
		On-board	2,220	2,924	3,436	5,429	5,331	4,720	1,517	1,041	1,330	488	0

APPENDIX P6

The predicted on-board ridership (average weekday per peak hour) of Kuala Lumpur monorail inbound traffic movement for 100% upzoning zoning intensification scenario with 60% expected future growth to use monorail.

Possible Trend		Ridership	KL Sentral	Tun Sambanthan	Maharajalela	Hang Tuah	Imbi	Bukit Bintang	Raja Chulan	Bukit Nanas	Medan Tuanku	Chow Kit	Titiwangsa
Optimistic	Error Band (Upper Bound)	Boarding	5,432	1,871	1,730	4,177	970	612	1,348	1,128	2,351	754	0
		Alighting	0	54	145	1,148	1,068	1,882	8,080	2,144	1,318	3,250	1,283
		On-board	5,432	7,249	8,833	11,862	11,764	10,494	3,761	2,746	3,779	1,283	0
	Baseline	Boarding	4,728	1,620	1,477	3,792	841	532	1,148	966	2,008	656	0
		Alighting	0	47	126	995	940	1,656	7,104	1,864	1,139	2,787	1,109
		On-board	4,728	6,301	7,651	10,449	10,350	9,226	3,270	2,372	3,241	1,109	0
	Error band (Lower Bound)	Boarding	3,968	1,369	1,234	3,412	694	439	913	776	1,618	546	0
		Alighting	0	40	106	835	810	1,422	6,086	1,556	936	2,264	914
		On-board	3,968	5,298	6,426	9,002	8,886	7,903	2,731	1,951	2,632	914	0
Modest	Error Band (Upper Bound)	Boarding	4,258	1,449	1,304	3,531	756	479	1,017	860	1,780	591	0
		Alighting	0	43	113	891	855	1,503	6,446	1,677	1,020	2,481	995
		On-board	4,258	5,664	6,855	9,495	9,397	8,372	2,943	2,125	2,885	995	0
	Baseline	Boarding	3,730	1,261	1,114	3,243	660	418	868	738	1,523	517	0
		Alighting	0	37	99	776	759	1,334	5,714	1,467	886	2,135	864
		On-board	3,730	4,953	5,968	8,436	8,337	7,421	2,574	1,845	2,482	864	0
	Error band (Lower Bound)	Boarding	3,159	1,073	933	2,958	550	349	691	596	1,230	435	0
		Alighting	0	32	84	656	662	1,158	4,951	1,237	734	1,742	718
		On-board	3,159	4,201	5,049	7,351	7,239	6,429	2,170	1,529	2,025	718	0
Pessimistic	Error Band (Upper Bound)	Boarding	3,083	1,027	878	2,886	543	345	687	591	1,210	427	0
		Alighting	0	31	82	634	642	1,125	4,813	1,211	722	1,713	706
		On-board	3,083	4,079	4,876	7,128	7,030	6,250	2,124	1,504	1,992	706	0
	Baseline	Boarding	2,731	902	752	2,694	479	305	587	510	1,038	378	0
		Alighting	0	27	72	557	578	1,012	4,325	1,071	632	1,482	620
		On-board	2,731	3,605	4,285	6,422	6,323	5,616	1,879	1,317	1,723	620	0
	Error band (Lower Bound)	Boarding	2,351	776	631	2,504	406	258	469	415	843	323	0
		Alighting	0	24	62	477	513	895	3,816	917	531	1,220	522
		On-board	2,351	3,104	3,672	5,699	5,591	4,955	1,609	1,107	1,418	522	0

APPENDIX Q1

The predicted on-board ridership (average weekday per peak hour) of Kuala Lumpur monorail inbound traffic movement for business as usual zoning intensification scenario with 80% expected future growth to use monorail.

Possible Trend		Ridership	KL Sentral	Tun Sambanthan	Maharajalela	Hang Tuah	Imbi	Bukit Bintang	Raja Chulan	Bukit Nanas	Medan Tuanku	Chow Kit	Tititwangsa
Optimistic	Error Band (Upper Bound)	Boarding	4,488	1,454	1,177	3,816	936	485	1,020	967	2,060	547	0
		Alighting	0	45	118	904	888	1,586	6,787	1,737	1,093	2,790	1,002
		On-board	4,488	5,897	6,956	9,868	9,915	8,814	3,047	2,278	3,245	1,002	0
	Baseline	Boarding	3,925	1,265	1,006	3,486	813	423	870	830	1,760	480	0
		Alighting	0	39	103	787	788	1,404	6,004	1,518	948	2,397	870
		On-board	3,925	5,151	6,054	8,753	8,778	7,797	2,664	1,975	2,787	870	0
	Error band (Lower Bound)	Boarding	3,310	1,083	845	3,158	680	350	697	673	1,415	405	0
		Alighting	0	33	87	665	685	1,217	5,189	1,281	787	1,950	722
		On-board	3,310	4,360	5,118	7,611	7,606	6,739	2,247	1,639	2,267	722	0
Modest	Error Band (Upper Bound)	Boarding	3,549	1,136	889	3,261	731	383	772	739	1,562	436	0
		Alighting	0	35	93	708	720	1,282	5,476	1,372	851	2,137	784
		On-board	3,549	4,650	5,446	7,999	8,011	7,112	2,407	1,774	2,485	784	0
	Baseline	Boarding	3,127	995	761	3,013	639	337	659	635	1,337	385	0
		Alighting	0	31	82	620	645	1,145	4,889	1,208	743	1,842	685
		On-board	3,127	4,091	4,770	7,163	7,158	6,349	2,120	1,547	2,142	685	0
	Error band (Lower Bound)	Boarding	2,666	858	641	2,767	539	282	529	518	1,078	329	0
		Alighting	0	27	70	529	568	1,005	4,278	1,030	622	1,506	574
		On-board	2,666	3,498	4,068	6,307	6,279	5,556	1,807	1,295	1,751	574	0
Pessimistic	Error Band (Upper Bound)	Boarding	2,611	819	602	2,706	526	281	523	510	1,064	324	0
		Alighting	0	26	68	512	552	977	4,166	1,007	610	1,483	566
		On-board	2,611	3,403	3,937	6,131	6,106	5,410	1,768	1,270	1,725	566	0
	Baseline	Boarding	2,329	725	517	2,541	465	251	448	441	914	291	0
		Alighting	0	23	61	453	502	886	3,775	898	537	1,286	500
		On-board	2,329	3,030	3,486	5,574	5,537	4,902	1,576	1,119	1,496	500	0
	Error band (Lower Bound)	Boarding	2,022	634	436	2,377	399	214	362	363	741	253	0
		Alighting	0	20	53	392	450	792	3,367	779	456	1,063	426
		On-board	2,022	2,635	3,018	5,003	4,951	4,373	1,367	951	1,236	426	0

APPENDIX Q2

The predicted on-board ridership (average weekday per peak hour) of Kuala Lumpur monorail inbound traffic movement for 20% upzoning zoning intensification scenario with 80% expected future growth to use monorail.

Possible Trend		Ridership	KL Sentral	Tun Sambanthan	Maharajalela	Hang Tuah	Imbi	Bukit Bintang	Raja Chulan	Bukit Nanas	Medan Tuanku	Chow Kit	Titiwangsa
Optimistic	Error Band (Upper Bound)	Boarding	4,990	1,650	1,401	4,060	999	546	1,174	1,071	2,271	632	0
		Alighting	0	50	132	1,022	981	1,747	7,481	1,943	1,218	3,087	1,135
		On-board	4,990	6,590	7,859	10,897	10,916	9,715	3,408	2,537	3,590	1,135	0
	Baseline	Boarding	4,352	1,432	1,197	3,694	867	475	1,001	918	1,939	552	0
		Alighting	0	44	115	887	867	1,541	6,594	1,693	1,054	2,649	984
		On-board	4,352	5,740	6,822	9,629	9,629	8,564	2,970	2,195	3,080	984	0
	Error band (Lower Bound)	Boarding	3,658	1,219	1,003	3,330	722	392	799	742	1,559	463	0
		Alighting	0	37	97	747	750	1,328	5,671	1,421	871	2,152	813
		On-board	3,658	4,840	5,747	8,329	8,301	7,365	2,493	1,814	2,502	813	0
Modest	Error Band (Upper Bound)	Boarding	3,926	1,283	1,057	3,444	779	429	887	817	1,720	499	0
		Alighting	0	39	103	796	789	1,402	5,997	1,527	945	2,359	883
		On-board	3,926	5,170	6,124	8,772	8,761	7,788	2,678	1,968	2,743	883	0
	Baseline	Boarding	3,447	1,120	904	3,169	679	376	757	702	1,471	439	0
		Alighting	0	34	91	695	704	1,247	5,332	1,339	822	2,031	770
		On-board	3,447	4,533	5,346	7,820	7,796	6,925	2,350	1,712	2,361	770	0
	Error band (Lower Bound)	Boarding	2,926	961	759	2,896	570	313	606	569	1,186	372	0
		Alighting	0	29	77	590	616	1,088	4,640	1,135	684	1,658	642
		On-board	2,926	3,858	4,540	6,846	6,800	6,025	1,992	1,426	1,928	642	0
Pessimistic	Error Band (Upper Bound)	Boarding	2,862	917	714	2,828	558	312	600	562	1,169	367	0
		Alighting	0	29	75	571	598	1,057	4,513	1,110	672	1,632	632
		On-board	2,862	3,750	4,389	6,646	6,606	5,861	1,948	1,400	1,897	632	0
	Baseline	Boarding	2,542	808	612	2,645	492	277	513	485	1,003	327	0
		Alighting	0	25	66	503	541	954	4,070	986	590	1,413	557
		On-board	2,542	3,325	3,870	6,012	5,963	5,285	1,729	1,229	1,643	557	0
	Error band (Lower Bound)	Boarding	2,195	702	515	2,463	419	235	413	397	813	282	0
		Alighting	0	22	58	433	483	848	3,608	850	498	1,164	471
		On-board	2,195	2,875	3,333	5,362	5,299	4,686	1,490	1,038	1,353	471	0

APPENDIX Q3

The predicted on-board ridership (average weekday per peak hour) of Kuala Lumpur monorail inbound traffic movement for 40% upzoning zoning intensification scenario with 80% expected future growth to use monorail.

Possible Trend		Ridership	KL Sentral	Tun Sambanthan	Maharajalela	Hang Tuah	Imbi	Bukit Bintang	Raja Chulan	Bukit Nanas	Medan Tuanku	Chow Kit	Tititwangsa
Optimistic	Error Band (Upper Bound)	Boarding	5,492	1,846	1,625	4,304	1,063	607	1,327	1,175	2,481	717	0
		Alighting	0	55	146	1,139	1,073	1,907	8,175	2,149	1,342	3,384	1,268
		On-board	5,492	7,283	8,762	11,927	11,917	10,617	3,769	2,796	3,935	1,268	0
	Baseline	Boarding	4,779	1,598	1,388	3,901	921	527	1,131	1,006	2,118	624	0
		Alighting	0	48	127	987	945	1,677	7,185	1,868	1,159	2,901	1,097
		On-board	4,779	6,330	7,591	10,505	10,481	9,331	3,277	2,415	3,374	1,097	0
	Error band (Lower Bound)	Boarding	4,005	1,355	1,162	3,501	763	433	902	811	1,703	521	0
		Alighting	0	40	106	829	814	1,439	6,153	1,562	955	2,354	904
		On-board	4,005	5,320	6,376	9,048	8,997	7,991	2,740	1,989	2,737	904	0
Modest	Error Band (Upper Bound)	Boarding	4,303	1,430	1,225	3,627	826	475	1,002	895	1,878	563	0
		Alighting	0	43	114	884	859	1,522	6,518	1,681	1,038	2,582	983
		On-board	4,303	5,690	6,801	9,544	9,512	8,465	2,949	2,163	3,002	983	0
	Baseline	Boarding	3,768	1,245	1,047	3,325	720	415	855	768	1,605	494	0
		Alighting	0	38	99	770	763	1,350	5,775	1,471	901	2,220	855
		On-board	3,768	4,975	5,923	8,478	8,435	7,500	2,580	1,877	2,581	855	0
	Error band (Lower Bound)	Boarding	3,187	1,063	878	3,025	601	345	683	621	1,294	416	0
		Alighting	0	32	84	651	665	1,171	5,001	1,241	747	1,809	710
		On-board	3,187	4,218	5,011	7,385	7,322	6,495	2,177	1,557	2,104	710	0
Pessimistic	Error Band (Upper Bound)	Boarding	3,113	1,015	826	2,950	590	343	677	614	1,275	409	0
		Alighting	0	31	82	629	645	1,137	4,860	1,213	734	1,780	699
		On-board	3,113	4,096	4,840	7,161	7,107	6,312	2,129	1,529	2,070	699	0
	Baseline	Boarding	2,756	891	707	2,749	519	303	579	530	1,093	363	0
		Alighting	0	28	72	553	581	1,022	4,365	1,073	643	1,539	613
		On-board	2,756	3,620	4,255	6,450	6,389	5,669	1,882	1,339	1,789	613	0
	Error band (Lower Bound)	Boarding	2,369	770	594	2,549	440	256	464	432	885	311	0
		Alighting	0	24	62	474	515	903	3,849	920	540	1,265	517
		On-board	2,369	3,115	3,647	5,722	5,647	4,999	1,614	1,126	1,471	517	0

APPENDIX Q4

The predicted on-board ridership (average weekday per peak hour) of Kuala Lumpur monorail inbound traffic movement for 60% upzoning zoning intensification scenario with 80% expected future growth to use monorail.

Possible Trend		Ridership	KL Sentral	Tun Sambanthan	Maharajalela	Hang Tuah	Imbi	Bukit Bintang	Raja Chulan	Bukit Nanas	Medan Tuanku	Chow Kit	Titiwangsa
Optimistic	Error Band (Upper Bound)	Boarding	5,995	2,041	1,849	4,549	1,126	668	1,481	1,279	2,691	802	0
		Alighting	0	60	160	1,256	1,166	2,067	8,870	2,354	1,466	3,681	1,401
		On-board	5,995	7,976	9,665	12,957	12,918	11,519	4,130	3,055	4,280	1,401	0
	Baseline	Boarding	5,206	1,765	1,578	4,109	975	579	1,261	1,094	2,297	696	0
		Alighting	0	52	138	1,087	1,024	1,813	7,775	2,043	1,265	3,154	1,210
		On-board	5,206	6,919	8,359	11,381	11,332	10,098	3,584	2,635	3,667	1,210	0
	Error band (Lower Bound)	Boarding	4,352	1,492	1,320	3,673	804	475	1,004	880	1,847	578	0
		Alighting	0	44	116	911	879	1,551	6,635	1,702	1,038	2,556	995
		On-board	4,352	5,800	7,004	9,767	9,692	8,617	2,986	2,163	2,972	995	0
Modest	Error Band (Upper Bound)	Boarding	4,679	1,577	1,393	3,810	874	521	1,117	973	2,036	627	0
		Alighting	0	47	124	972	929	1,642	7,039	1,835	1,131	2,805	1,083
		On-board	4,679	6,209	7,479	10,317	10,262	9,141	3,220	2,357	3,261	1,083	0
	Baseline	Boarding	4,088	1,370	1,191	3,481	760	454	953	834	1,739	548	0
		Alighting	0	41	108	845	822	1,452	6,218	1,602	980	2,409	940
		On-board	4,088	5,417	6,499	9,135	9,073	8,075	2,810	2,042	2,801	940	0
	Error band (Lower Bound)	Boarding	3,447	1,165	997	3,154	632	376	759	673	1,402	459	0
		Alighting	0	34	92	713	713	1,255	5,363	1,346	810	1,961	778
		On-board	3,447	4,578	5,483	7,924	7,843	6,964	2,361	1,688	2,280	778	0
Pessimistic	Error Band (Upper Bound)	Boarding	3,364	1,113	938	3,072	622	373	754	666	1,380	451	0
		Alighting	0	34	89	688	691	1,217	5,208	1,316	796	1,928	765
		On-board	3,364	4,443	5,292	7,676	7,607	6,763	2,309	1,659	2,242	765	0
	Baseline	Boarding	2,970	974	803	2,853	546	329	644	574	1,182	399	0
		Alighting	0	30	78	603	620	1,090	4,660	1,160	696	1,665	670
		On-board	2,970	3,914	4,639	6,888	6,814	6,052	2,036	1,449	1,936	670	0
	Error band (Lower Bound)	Boarding	2,543	838	674	2,635	461	277	515	466	957	340	0
		Alighting	0	25	67	515	547	959	4,090	990	582	1,366	562
		On-board	2,543	3,355	3,961	6,081	5,994	5,312	1,737	1,213	1,588	562	0

APPENDIX Q5

The predicted on-board ridership (average weekday per peak hour) of Kuala Lumpur monorail inbound traffic movement for 80% upzoning zoning intensification scenario with 80% expected future growth to use monorail.

Possible Trend		Ridership	KL Sentral	Tun Sambanthan	Maharajalela	Hang Tuah	Imbi	Bukit Bintang	Raja Chulan	Bukit Nanas	Medan Tuanku	Chow Kit	Titiwangsa
Optimistic	Error Band (Upper Bound)	Boarding	6,497	2,237	2,073	4,793	1,190	729	1,635	1,383	2,902	887	0
		Alighting	0	65	173	1,374	1,259	2,227	9,564	2,560	1,591	3,978	1,534
		On-board	6,497	8,669	10,568	13,987	13,918	12,421	4,491	3,314	4,625	1,534	0
	Baseline	Boarding	5,633	1,932	1,769	4,317	1,029	631	1,392	1,182	2,475	768	0
		Alighting	0	56	150	1,187	1,103	1,949	8,366	2,218	1,371	3,406	1,323
		On-board	5,633	7,508	9,127	12,258	12,183	10,865	3,891	2,855	3,960	1,323	0
	Error band (Lower Bound)	Boarding	4,699	1,628	1,479	3,845	845	517	1,106	949	1,991	636	0
		Alighting	0	47	126	992	944	1,662	7,117	1,842	1,122	2,758	1,085
		On-board	4,699	6,280	7,633	10,486	10,388	9,243	3,232	2,338	3,207	1,085	0
Modest	Error Band (Upper Bound)	Boarding	5,056	1,724	1,561	3,993	922	566	1,232	1,050	2,193	690	0
		Alighting	0	51	135	1,060	998	1,762	7,559	1,990	1,225	3,027	1,183
		On-board	5,056	6,729	8,156	11,089	11,013	9,817	3,490	2,551	3,520	1,183	0
	Baseline	Boarding	4,408	1,495	1,334	3,637	801	493	1,050	900	1,874	602	0
		Alighting	0	44	117	920	881	1,554	6,661	1,733	1,059	2,598	1,025
		On-board	4,408	5,859	7,075	9,792	9,711	8,650	3,040	2,207	3,021	1,025	0
	Error band (Lower Bound)	Boarding	3,708	1,267	1,116	3,283	663	407	836	725	1,510	503	0
		Alighting	0	37	99	774	762	1,338	5,724	1,451	873	2,112	846
		On-board	3,708	4,938	5,954	8,463	8,365	7,434	2,546	1,819	2,456	846	0
Pessimistic	Error Band (Upper Bound)	Boarding	3,615	1,211	1,050	3,194	654	404	830	718	1,485	494	0
		Alighting	0	36	96	747	737	1,297	5,555	1,419	858	2,077	832
		On-board	3,615	4,789	5,743	8,191	8,107	7,214	2,489	1,788	2,415	832	0
	Baseline	Boarding	3,183	1,058	898	2,956	573	354	709	618	1,272	435	0
		Alighting	0	32	84	653	659	1,158	4,956	1,248	748	1,791	726
		On-board	3,183	4,209	5,023	7,326	7,240	6,436	2,189	1,559	2,082	726	0
	Error band (Lower Bound)	Boarding	2,716	906	753	2,721	481	298	566	501	1,029	369	0
		Alighting	0	27	72	556	580	1,015	4,331	1,060	624	1,467	607
		On-board	2,716	3,595	4,276	6,441	6,342	5,625	1,860	1,301	1,706	607	0

APPENDIX Q6

The predicted on-board ridership (average weekday per peak hour) of Kuala Lumpur monorail inbound traffic movement for 100% upzoning zoning intensification scenario with 80% expected future growth to use monorail.

Possible Trend		Ridership	KL Sentral	Tun Sambanthan	Maharajalela	Hang Tuah	Imbi	Bukit Bintang	Raja Chulan	Bukit Nanas	Medan Tuanku	Chow Kit	Titiwangsa
Optimistic	Error Band (Upper Bound)	Boarding	6,999	2,433	2,297	5,037	1,254	790	1,788	1,487	3,112	971	0
		Alighting	0	70	187	1,491	1,352	2,387	10,258	2,766	1,715	4,274	1,667
		On-board	6,999	9,362	11,472	15,017	14,919	13,322	4,852	3,573	4,970	1,667	0
	Baseline	Boarding	6,060	2,098	1,960	4,525	1,083	683	1,522	1,271	2,654	841	0
		Alighting	0	61	162	1,286	1,182	2,085	8,956	2,393	1,476	3,658	1,436
		On-board	6,060	8,098	9,896	13,134	13,034	11,632	4,197	3,076	4,253	1,436	0
	Error band (Lower Bound)	Boarding	5,047	1,764	1,637	4,017	887	559	1,208	1,018	2,135	694	0
		Alighting	0	50	135	1,074	1,008	1,773	7,599	1,983	1,206	2,960	1,176
		On-board	5,047	6,760	8,262	11,205	11,083	9,869	3,478	2,513	3,442	1,176	0
Modest	Error Band (Upper Bound)	Boarding	5,432	1,871	1,730	4,177	970	612	1,348	1,128	2,351	754	0
		Alighting	0	54	145	1,148	1,068	1,882	8,080	2,144	1,318	3,250	1,283
		On-board	5,432	7,249	8,833	11,862	11,764	10,494	3,761	2,746	3,779	1,283	0
	Baseline	Boarding	4,728	1,620	1,477	3,792	841	532	1,148	966	2,008	656	0
		Alighting	0	47	126	995	940	1,656	7,104	1,864	1,139	2,787	1,109
		On-board	4,728	6,301	7,651	10,449	10,350	9,226	3,270	2,372	3,241	1,109	0
	Error band (Lower Bound)	Boarding	3,968	1,369	1,234	3,412	694	439	913	776	1,618	546	0
		Alighting	0	40	106	835	810	1,422	6,086	1,556	936	2,264	914
		On-board	3,968	5,298	6,426	9,002	8,886	7,903	2,731	1,951	2,632	914	0
Pessimistic	Error Band (Upper Bound)	Boarding	3,866	1,308	1,162	3,316	685	434	907	770	1,590	536	0
		Alighting	0	39	103	805	784	1,377	5,902	1,522	921	2,225	898
		On-board	3,866	5,136	6,195	8,706	8,608	7,665	2,670	1,918	2,587	898	0
	Baseline	Boarding	3,397	1,141	993	3,060	600	380	774	662	1,361	471	0
		Alighting	0	34	90	703	699	1,226	5,251	1,335	801	1,917	783
		On-board	3,397	4,504	5,407	7,764	7,665	6,819	2,343	1,669	2,229	783	0
	Error band (Lower Bound)	Boarding	2,890	974	832	2,807	502	319	617	535	1,101	398	0
		Alighting	0	29	77	597	612	1,070	4,572	1,130	666	1,568	653
		On-board	2,890	3,835	4,590	6,800	6,690	5,938	1,983	1,388	1,823	653	0