Analysing the effects of Land Use Characteristics on Passenger Ridership of Rail-based Transit Oriented Development – Lessons from Pandan Indah and Ampang LRT Station

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Abstract: Malaysia has been undergoing rapid industrialization and economic growth since the 1970s. Klang Valley and its conurbation is overwhelmed by traffic jams, where people tend to travel by their own cars. Consequently, government concedes public transportation, especially in Light Rail Transit (LRT) as the decisive approach to relieving traffic congestion in Klang Valley. However, after several years of this public transport being operated, LRT has not been able to persuade people to shift travel from the use of private to public transport. The result of a research study found that the public acceptance of the public transport service is very disappointing compared to the LRT ability to receive and carry passengers in large numbers (Malaysia Economic Monitor, 2015). It is believed to be due to lack of cooperation between land use planning and rail-based public transportation (Kuala Lumpur Structure Plan 2020). The purpose of this paper is to examine the effects of land use characteristics on passenger ridership of rail-based Transit Oriented Development (TOD) at Pandan Indah and Ampang LRT station.The observational survey method was conducted to collect data on land use density and diversity of mixed land use within 1000m radius around the selected LRT station. Whereas, the passenger volume count method was used to count the passenger ridership on weekday covering both during peak hour and off-peak hour for twelve hours duration at the two selected stations.The method of analysis such as graphical method, Simpson's diversity index, and relationship based on calculated diversity and density were applied. The findings revealed that the presence of compact developments with a mix of uses surrounding transit station contribute to the increase of passenger ridership.

Keywords: Transit Oriented Development (TOD), Light Rail Transit (LRT), Land use density, diversity of mixed land use

1. INTRODUCTION

Urbanization has been a key driver of Malaysia's success, but growing challenges in urban mobility threaten to dampen the benefits of cities. Malaysia's rapid urbanization has led to the expansion of cities and shifted the growth in residential development outside the urban area. But the employment and business centers are predominately concentrated within the urban area which eventually increases the travel distance of the commuters from residential areas to offices and business activities. The increase in travel distance coupled with affordability of owning

private vehicles has induces commuters to use private transportation especially motorcars to accomplish work and business activities. With trends of increasing car ownership, low population density and dispersed land use characteristic that promote automobile dependence, traffic congestion becomes a major problem in Klang Valley and its conurbation. It is estimated that commuters in Klang Valley travel 29km/h slower on average during morning peak hours compared to off-peak hours due to congestion, translating into income losses of RM10.8-19.6 billion annually for the city, or 1.0-1.8 percent of Malaysia's Gross Domestic Product (GDP) from delay costs alone. Including the costs of fuel wasted and the economic cost of CO2 and other emissions, the total cost of congestion in Klang Valley is estimated conservatively at 1.1 – 2.2 percent of GDP in 2014 (Malaysia Economic Monitor,2015).

Many new initiatives and multiple efforts have been taken by the government authorities to improve the public transportation system under the National Key Result areas (NKRA) especially in Kuala Lumpur in an attempt to reduce the traffic congestion by shift from the use of private to public transportation. The ongoing construction of Mass Rapid Transit (MRT), Bus Rapid Transit (BRT) and the extension of Light Rail Transit (LRT) in Klang Valley are some of the major public transportation projects which are undertaken to address the growing travel demand of the population and to relieving traffic congestion. Besides, the government has recognized and indicated its interest in the use of land use planning to solve the urban transport problem which is through appropriate Transit Oriented Development (TOD).To justify such large investments in public transportation and TOD, it is important to be able to understand the interaction between the station environment and the potential of transit usage. Thus, this paper attempts to examine the characteristics of the land use surrounding the LRT station to understand its possible effects on the passenger ridership of public transportation system.

The main goal of this research is to evaluate the relationship between land use characteristics and passenger ridership by analyzing the composition of land use and its impacts around the light rail stations. Generally, Ampang Line system network consists of two main service lines namely LRT Ampang Line and LRT Sri Petaling Line. At 34.4km in length, Ampang Line consists total of 29 stations. The data can be perfectly accurate and comprehensive if the data are collected at all 29 stations. However, due to the lack of human resources to carry out the survey at all 29 stations it is limited and focused on only two stations Pandan Indah and Ampang LRT station.

In addition, another limitation of this study is lacked some baseline data as certain data which should be obtained from public sector might be not available such as passenger ridership. The results of this study will be more accurate if the daily of passenger volume data can be obtained from the public sector. Therefore, only average hourly passenger volume was counted on the certain weekdays along two chosen stations.

2. LITERATURE REVIEW

Generally, the literature capture the same essence about the definition of transit oriented development (TOD). Transit-oriented development concepts advocate that land around transit stations should be used in such a way as to encourage transit system ridership by making transit and other non-automotive modes of travel more attractive and easier to use. In addition to transit facilities and services, important characteristics include being pedestrian-friendly, incorporating a mix of uses, and being compact, with carefully designed, located, and managed to park. The connection between land use and transportation is a fundamental concept in transportation. Land use planning and transport are inexorably connected. Everything that

happens to land use has transportation implications and every transportation action affects land use. A substantial number of studies have shown increase in transit ridership as a result of high development density and land use mix near the transit stations (Cervero, 1996) The high development density and mixed land use near KL Sentral and Terminal Gombak station (along Kelana Jaya LRT line) has substantially increases transit ridership (Muslihah Mustapha, 2011). Transit Planning Zones are also pursued in Johor Bahru and Nusajaya City Centre promoting the development of commercial and housing on the same site to support the strategy of encouraging city living and transit-oriented development (Ho C.S and Fong W. K., 2011). In addition, a study on TOD and transit ridership at a city level (such as New York and Hong Kong) shows that a combination of variables in different dimensions including land use, station characteristics, socio-economic and demographic characteristics, and inter-modal competition, are important in accounting for the variability of rail transit ridership (Becky, P.Y. Loo, Cynthia Chen, and Eric T.H. Chan, 2010). Nonetheless, land use initiatives remain an important tool for managing transportation demand (Cervero and Landis, 1995). In all factors of the built environment, the use of transit varies mainly according to the density of development and secondarily with the degree of land use mixing (Cervero, 1996; Ewing et al. 2010).

In Kuzmyak's study (Kuzmyak, Pratt, & Douglas, 2003), places with mixed land uses tend to have higher transit use. However, they noted that many of these environments tend to also be characterized by higher densities, so separating the mixed use effect from the density effect is hard. Messenger and Ewing (1996) suggested that more balanced areas with jobs and homes tend to have higher transit mode share. Tridib Banerjee and his colleagues used Simpson's diversity index in calculating land use diversity that captured both richness and evenness of diversity. They conduct the study in Vermont and Ventura Corridor in 2000 and found that transit ridership increases as land use diversity or land use mix increases. According to Tumlin and Millard-Ball (2003),density is paramount, The reason is that "all else being equal, the more housing and jobs within a short walk of the transit station, the greater the ridership." The Transit Cooperative Research Program (1996) reported that increments of ten percent in the population density around transit stations found to increase passenger ridership by five per cent, while double of density was shown a reduction in the vehicle traveling up to 20 percent.

Transit-oriented development has a larger goal of reducing dependence on private vehicles. The use of high private vehicles in urban areas can cause problems in terms of reduced quality of urban life, incompetent economic management, pollution and uncontrolled urban development. But the effect produced, as expected, transit oriented development should cover all components of the city which includes elements of the social, economic and physical appearance of the city. It is important to ensure that transit-based planning to achieve its primary goal to reduce dependence on private vehicles and creating a more sustainable environment. A number of recent studies reveal the relationship between community design and health. Karen Petersmark and Risa Wilkerson, in their 2003 article *Land Use Affects Public Health* (p. 3), state, "Research has demonstrated that suburban residents drive twice as far, walk and cycle one-third as often, consume twice as much energy and produce twice as much air pollution as their urban counterparts who live where land use tends to be mixed". Parker and Arrington (2002) reveal that TOD can decrease infrastructure costs (such as roads, water, and sewer) through more compact and infill development. In addition to the benefits outlined above, The City of Calgary Department of Land Use, Planning, and Policy, in its 2004 Transit Oriented Development, Best Practice Handbook, notes that living and/or working in a TOD can provide other quality of life benefits such as better connections between jobs and housing, more walkable neighborhoods, more affordable housing, reduction in vehicle miles of travel, vibrant community, increased public safety, and improved road safety for travelers of all modes.

3. DESCRIPTION OF THE SELECTED LRT STATION

The Ampang Line is a light rail transit (LRT) system network in Klang Valley operated by RapidKL, a subsidiary of Prasarana Malaysia. The Ampang Line system network with a total length of 34.4 km consists of two main service lines namely LRT Ampang Line and LRT Sri Petaling Line, running between the suburb of Sentul in the north of Kuala Lumpur, and Ampang in the east, as well as Sri Petaling in the south (Figure 1) Trains branch off to either Ampang or Sri Petaling at Chan Sow Lin station about midway of both lines. The system is mostly at-grade outside the city and elevated with it runs through the city. The line was completely opened on 1998 ("Transport in Kuala Lumpur" n.d.).

The Ampang Line includes 29 stations which are eleven stations along the Sentul Timur as common stations, seven stations along the LRT Ampang Line and elevens stations the LRT Sri Petaling Line (Figure 2). Ridership on the Ampang Line has steadily increased with the passage of time. In 2013, the system carried 60.2 million passengers, with over 130,000 to 150,000 passengers per day on weekdays and an average of 120,000 per day on weekends ("Transport in Kuala Lumpur" n.d.). For this study, two from the total of 29 Ampang Line stations were selected. The Ampang and Pandan Indah LRT station were selected as a comparative case study (Figure 3). Pandan Indah and Ampang LRT station are located in the area of Pandan Indah and Ampang which has been identified by Ampang Jaya Local Plan 2020 as a major urban area which generally are the existing built-up area that makes up the combination area for the Kuala Lumpur city. The existing land use in these both major urban area is dominated by residential areas, business centers, community facilities, and recreation areas. Thus, the presence of different degree of land use diversity and density within this two catchment area will give a different result on the passenger ridership volume at both LRT station which indirectly give a better understanding of this study.

Figure 1. The Study Site Boundary

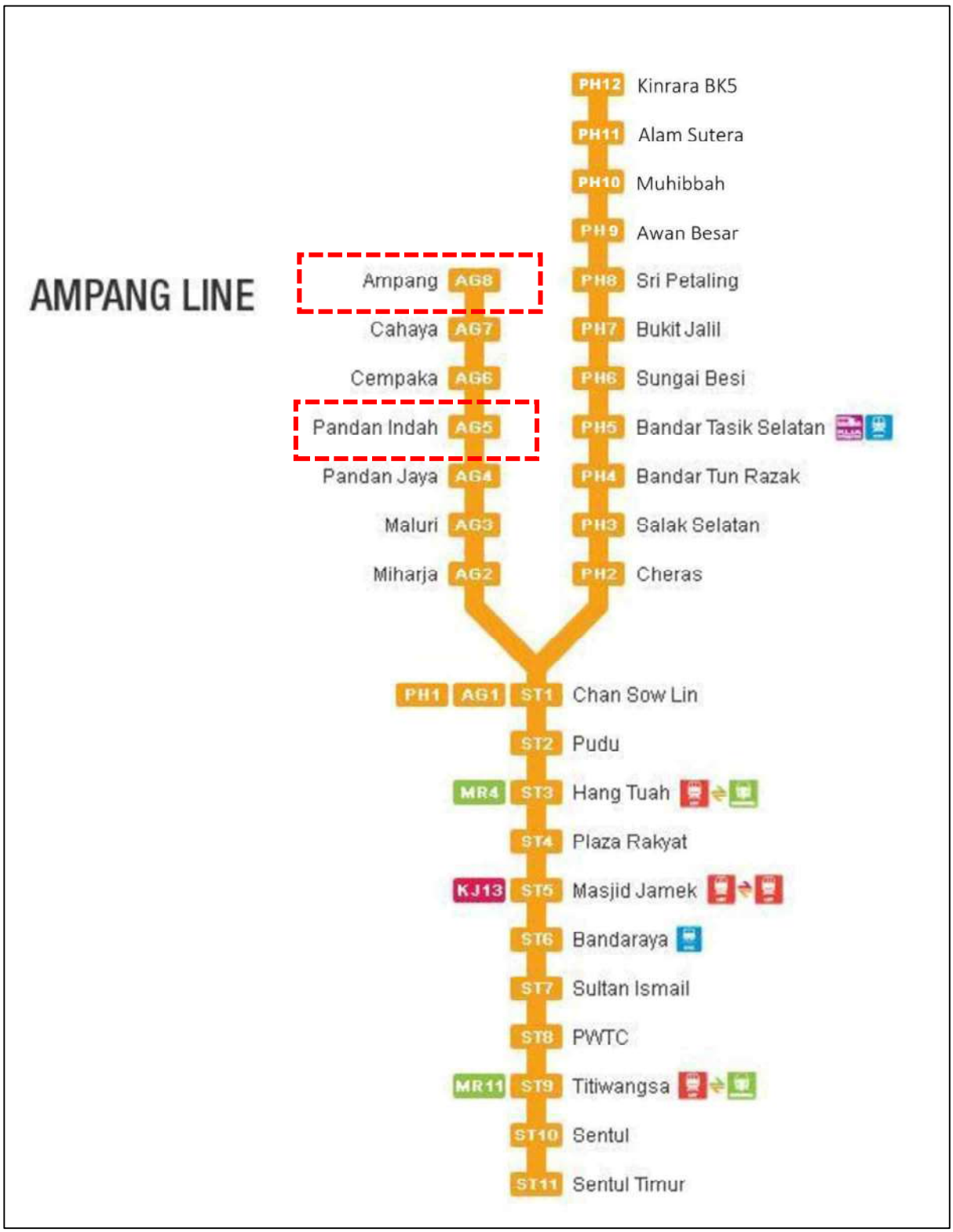


Figure 2. The location of Pandan Indah and Ampang LRT station in Ampang Line

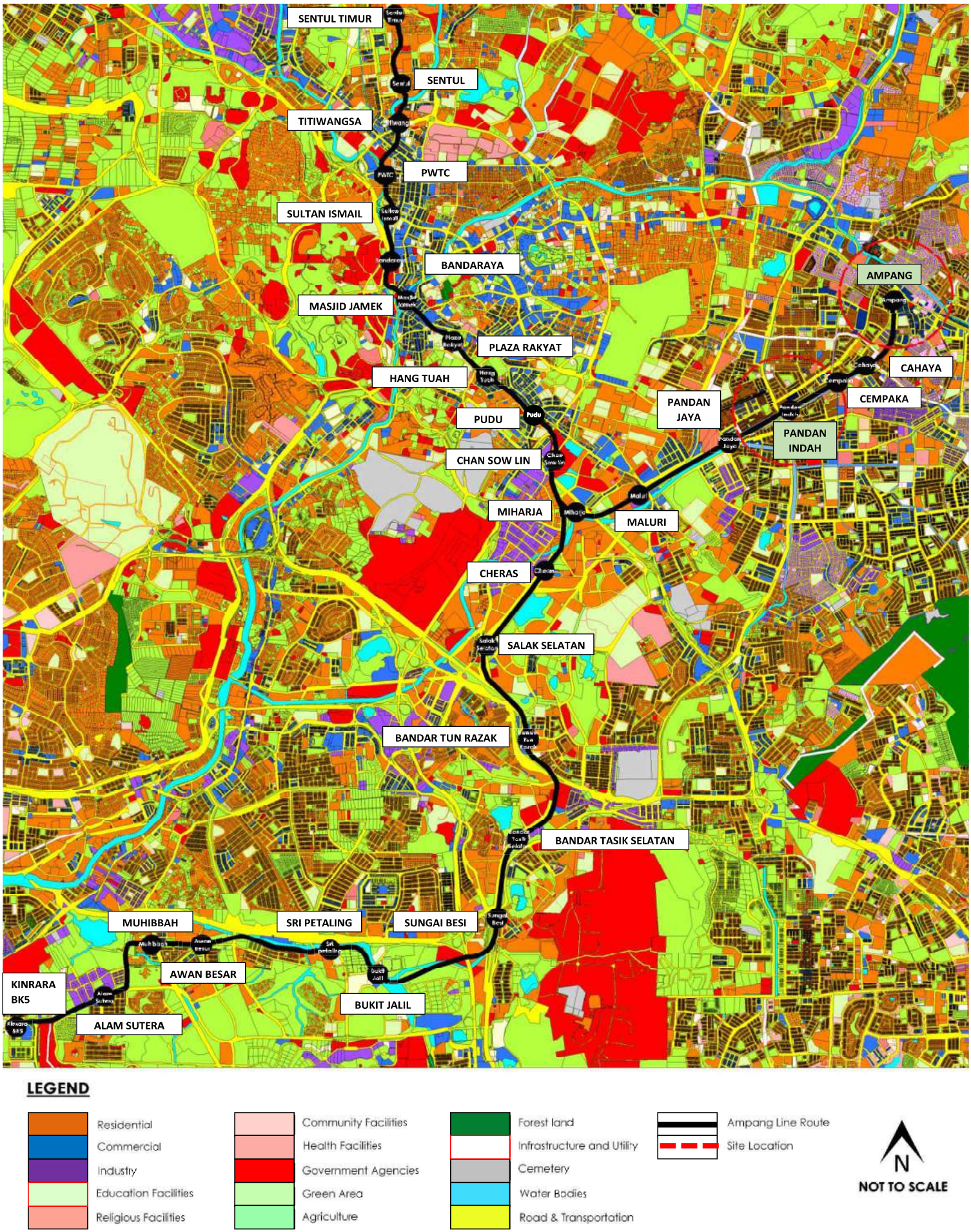


Figure 3. Ampang line route

4. RESEARCH METHODOLOGY

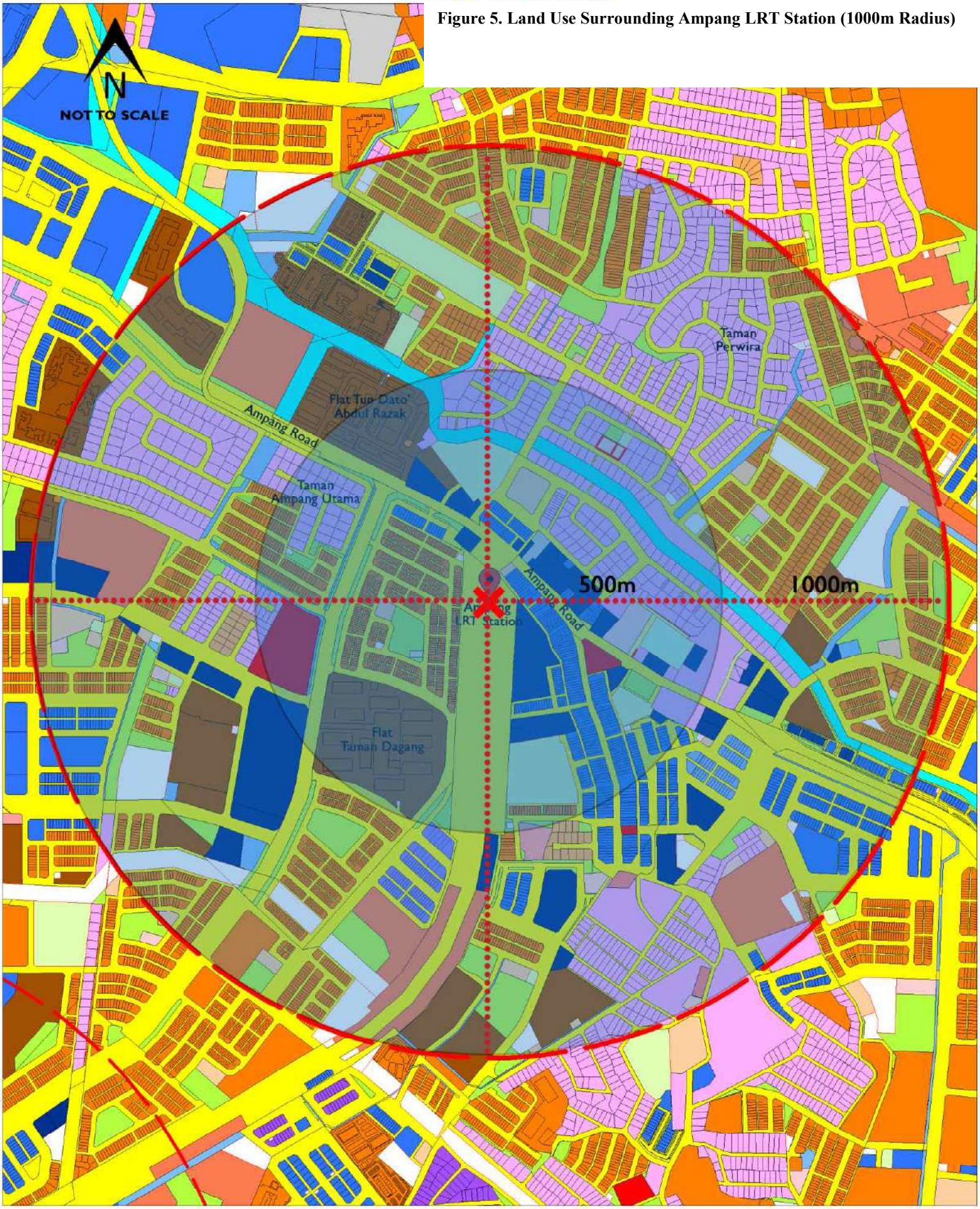
4.1 Methods of Data Collection

The data required in the research consist of two which are primary data and secondary data. The primary data for this research was collected by the observational survey and passenger volume count. The data collected from the observational survey was the land use details which include the type of land use and number of units of each land use surrounding the two chosen LRT stations. Besides that, passenger volume count was conducted in order to collect the passenger volume data at the two LRT stations. For the secondary data, the secondary data were collected from MPAJ and Rapid KL. The map of the study area (Ampang line) and land use map (Ampang,KL) are the secondary data needed in order to identify the location of the stations and existing land use surrounding the station.

The observational survey method was conducted to collect data on land use density and diversity of mixed land use within 1000m radius around Pandan Indah and Ampang LRT station (Figure 4 & 5). In this observational survey, the total of 8 enumerators are selected which are responsible for getting the land use details surrounding the transit station. By referring to the land use map, the land use details which include the type of land use (residential, commercial, institutional) and a number of units of each land use were recorded in land use survey form in order to measure the intensity of land use density. Photos also have been taken by using the digital camera to show the existing land use surrounding the transit station. Whereas, the passenger volume count method was used to count the passenger ridership on weekday (Tuesday, 22/3/2016 & Wednesday, 23/3/2016), both during peak hour and off-peak hour for twelve hours (7am-7pm) duration at the two selected stations. This method was administrated by positioning one enumerator each at the entrance and exit point of Side platform 1 and Side platform 2 of the Pandan Indah station and one enumerator at the entrance and exit point of the Ampang station (Figure 6 & 7). The manual traffic counter is the equipment used by the enumerators by pressing the keys according to the number of people who enter and exit the station regardless of sex and ages.

Figure 4. Land Use Surrounding Pandan Indah LRT Station (1000m Radius)

Figure 5. Land Use Surrounding Ampang LRT Station (1000m Radius)



LEGEND

- Terrace Houses
- Bungalow
- Low-cost Highrise
- High-cost Highrise
- Safety Facilities
- Shop Houses
- Shop Offices
- Other Commercial
- Education Facilities
- Health Facilities
- Religious Facilities
- Community Facilities
- Green Area
- Road & Transportation
- Committed Residential
- 1000 meter Radius

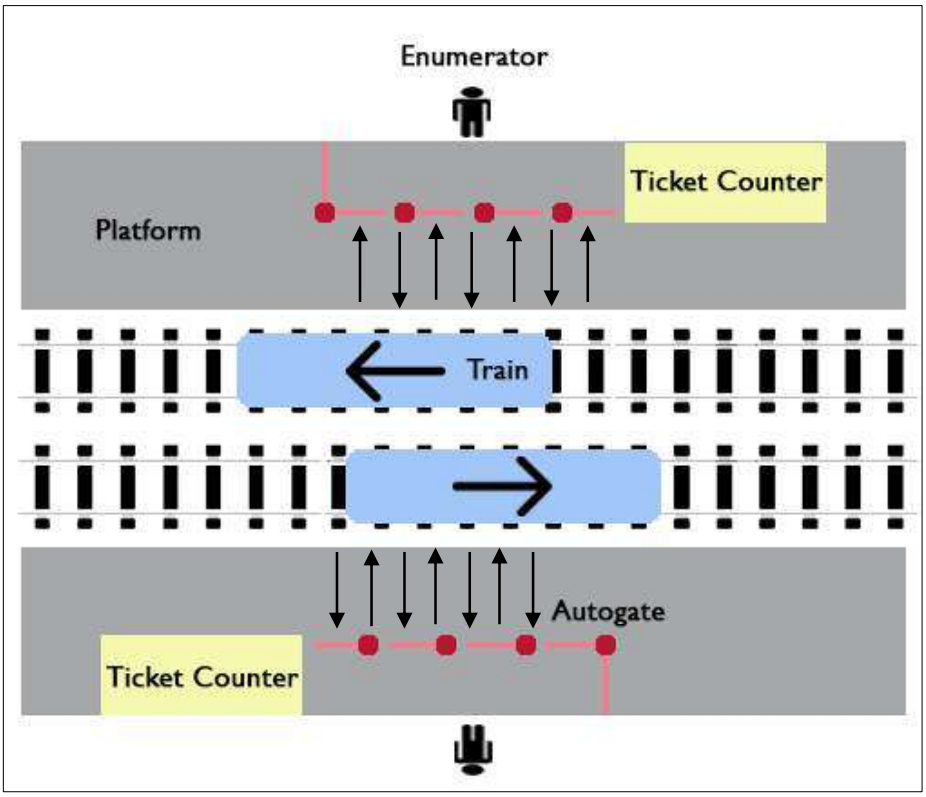


Figure 6. The location of the enumerators at Pandan Indah LRT Station

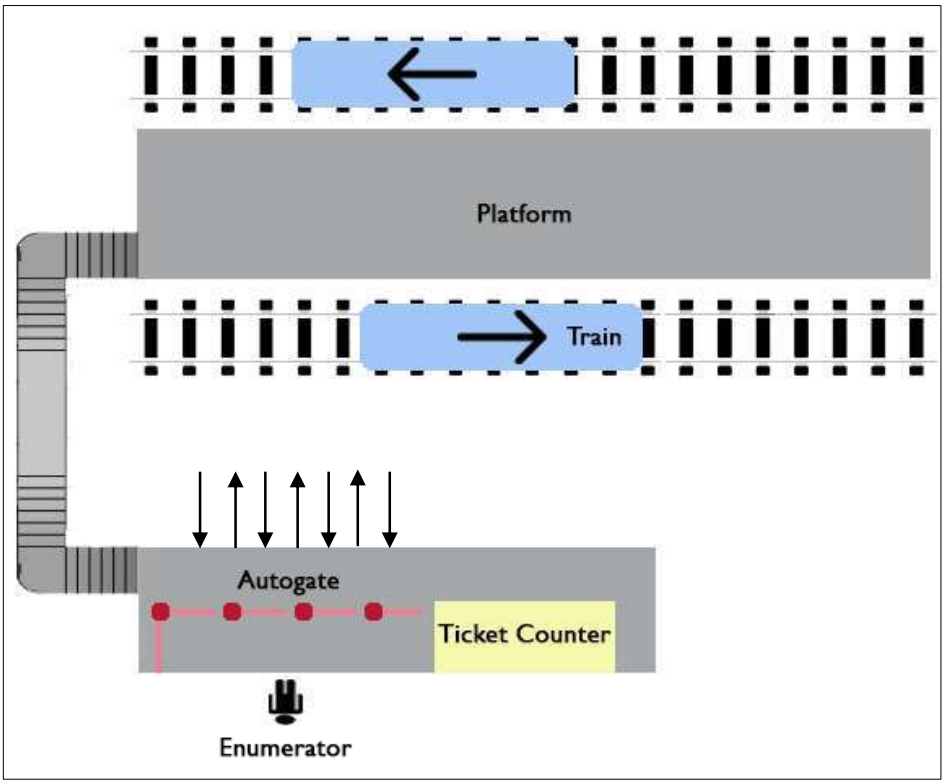


Figure 7. The location of the enumerator at Ampang LRT station

4.2 Methods of Data Analysis

For the method of analysis, the data that have been collected were analyzed through three methods, which are graphical method, Simpson's diversity index, and relationship based on calculated diversity and density.

The graphical method was applied in analyzing the land use details such as the type of land use (residential, commercial, and institutional) and a number of units of each land use which obtained through the observational survey. The analysis of land use development within catchment area is best explained in a map to show the location for each type of land use at Pandan Indah and Ampang LRT station. To determine the land use distribution surrounding two selected stations, the percentages for each type of land uses were measured by dividing the acreage of land use development with the total area within the catchment area. As for the land use density, the residential density was obtained by dividing the total residential unit with the total land area occupied. Meanwhile, the commercial density were calculated through building density where the number of commercial unit divided by the total land area occupied. Then, the final data of land use distribution and density were then presented through the tables, and bar graphs. While for the current passenger ridership, the passenger volume data which obtained through passenger volume count. The passenger volume count was conducted at the Pandan Indah and Ampang LRT station on the weekday for duration of twelve hours (7.00am to 7.00pm) due to cover both peak hours and off-peak hours. The result was documented in the tables, then the line graph was created to have an absolute understand on the passenger ridership trends during the specific period of time.

Three major land uses such as residential, commercial and institutional land uses were used to calculate land use Diversity Index (LUDI) of a mixed land use surrounding Pandan Indah and Ampang LRT station.The land use Diversity Index (LUDI) was calculated by using Simpson's diversity index. It measures both the distribution and the evenness of the individual land uses within the mix of land uses. The formula used to calculate this index is explained as follows: the square of the individual land use areas (a) divided by the square of the total area (A) is the measure of the individual (Ia) land use to the whole; the sum of these individual measures is the inverse of the diversity measure. Subtracting the inverse measure from 1 gives the land use diversity index of the total area [radius of 1000m from the station]. The greater the value of Land Use Diversity greater the mix of land use in the area. The values range from 0 to 1, where 1 denotes maximum possible diversity.

Land Use Diversity Index (LUDI) = 1- [Sum (Ia1, Ia2, Ia3, …….Ian)]

Individual areas = Ia1….. Ian = $(a1)^2$ /A2, /$(a2)^2$/A2, /$(a3)^2$ /A2,…..... /$(an)^2$/A2

The analysis between the relationship of land use characteristics and passenger ridership was made by comparing the calculated diversity of mixed land use and density with the average passenger ridership to identify whether the land use diversity and density are significant to the number of passenger ridership at the selected stations.The land use diversity index (LUDI) and passenger ridership at each station were compared to each other as the value of land use diversity and the number of passenger ridership is different at the both station. The analysis between the relationship of land use diversity and passenger ridership is presented in a comparison table diagram to show the different effect of land use diversity to the number of passenger ridership at each selected station.The residential, population and commercial density at each station were compared between each other as both of the selected station falls under different categories of density. In addition, the

comparison also was made with passenger ridership as the number of passenger ridership is different at the both stations. The analysis between the relationship of land use density and passenger ridership is best explained in a combination of bar and line chart to show the connection of land use density to the number of passenger ridership at each selected station. Finally, the relationship between land use characteristics and passenger ridership were analyzed by combining the effect of land use diversity and density on transit ridership. The effect of land use diversity and density at each selected station was examined to see the inter-correlated between these factors to support the transit ridership.

5. DATA ANALYSIS AND FINDINGS

Based on the analysis, it was recognized that both stations had a different land use characteristics in terms of land use diversity and density.There is more land identified under residential in Ampang as compared to Pandan Indah. Land under institutional is slightly higher in Ampang compared to Pandan Indah. Furthermore, land under commercial in Ampang also is significantly higher compared to Pandan Indah (Figure 8)

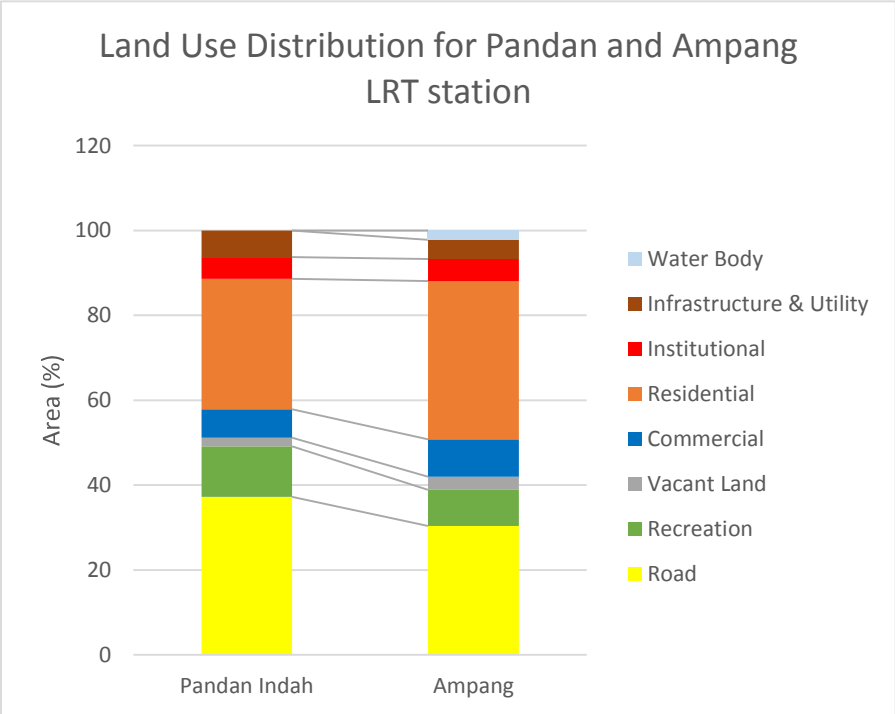


Figure 8. Land Use Distribution for Pandan Indah and Ampang LRT station (%)

5.1 Land use diversity

Pandan Indah LRT station are mostly surrounded by residential areas, commercial, and institutional with the total area of 96.1 hectares, 21.11 hectares, and 15.99 hectares respectively (Figure 9). Subsequently, these 3 types of development covers of 133.2 ha from the total area of 313.3 ha.

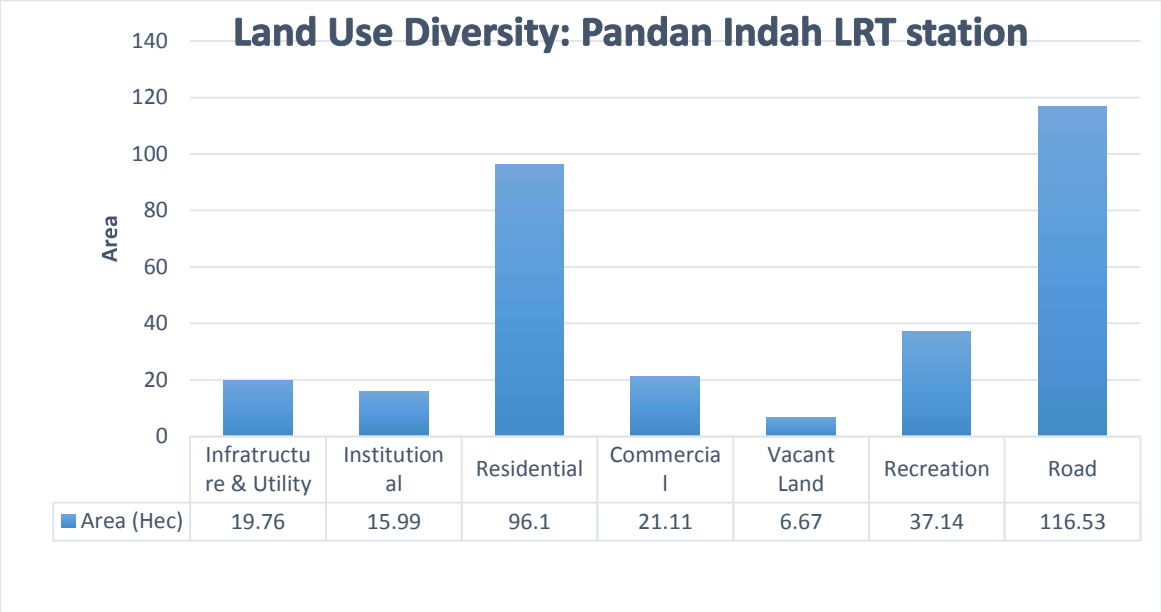


Figure 9. Land use Diversity at Pandan Indah LRT station

There are various type of housing identified in the catchment of Ampang LRT station with the acreage of 116.95 hectares and has covered up to 37.3 % of the total area. Meanwhile, the acreage for commercial area is 27.42 hectares and has covered about 8.7% of the total area. The institutional such as schools, community, health, and religious center covered about 16.44 hectares from the whole catchment area (Figure 10).

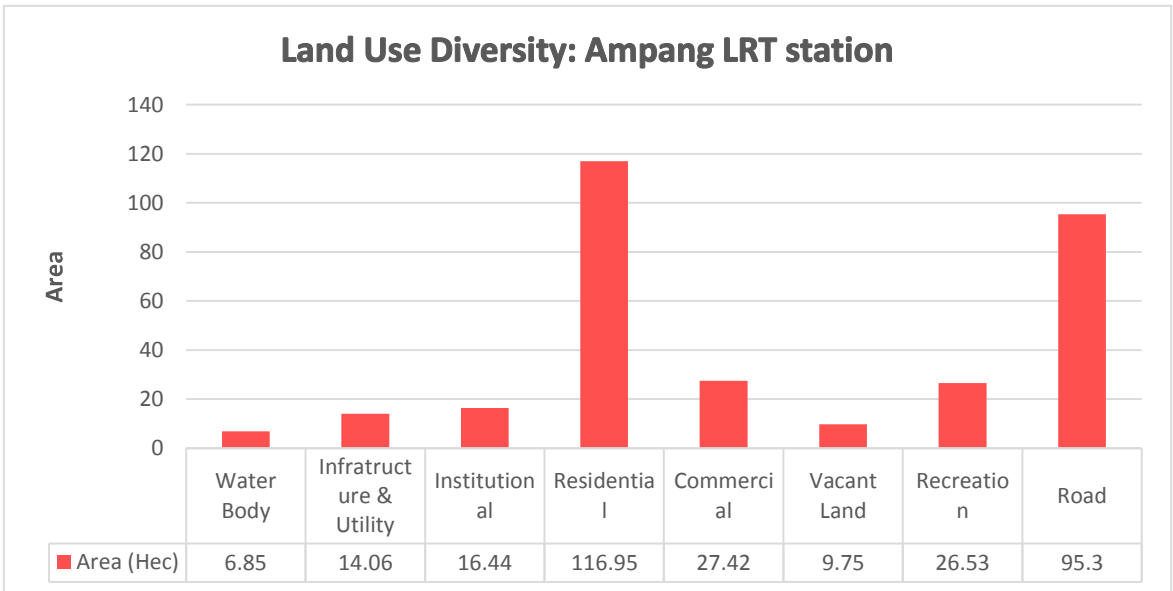


Figure 10. Land use Diversity at Ampang LRT station

The catchment area of Pandan Indah and Ampang LRT station have greater value of land use diversity with 0.8988 (Table 1) and 0.8502 (Table 2) respectively. According to the Simpson's diversity index, the values range is from 0 to 1, where 1 denotes maximum possible diversity. The greater the value of Land Use Diversity greater the mix of land use in the area. Therefore, Pandan Indah and Ampang LRT station catchment area are fall under higher diversity of mixed land use.

Table 1. Land use diversity index (Pandan Indah LRT station)

Ia1- Residential	**0.094086212**
Ia2 - Commercial	0.004539998
Ia3 - Institutional	0.002604810
Land Use Diversity Index (LUDI) **Land Use Diversity (LD) = 1- [Sum (Ia1 , Ia2 , Ia3)]**	**0.8988**

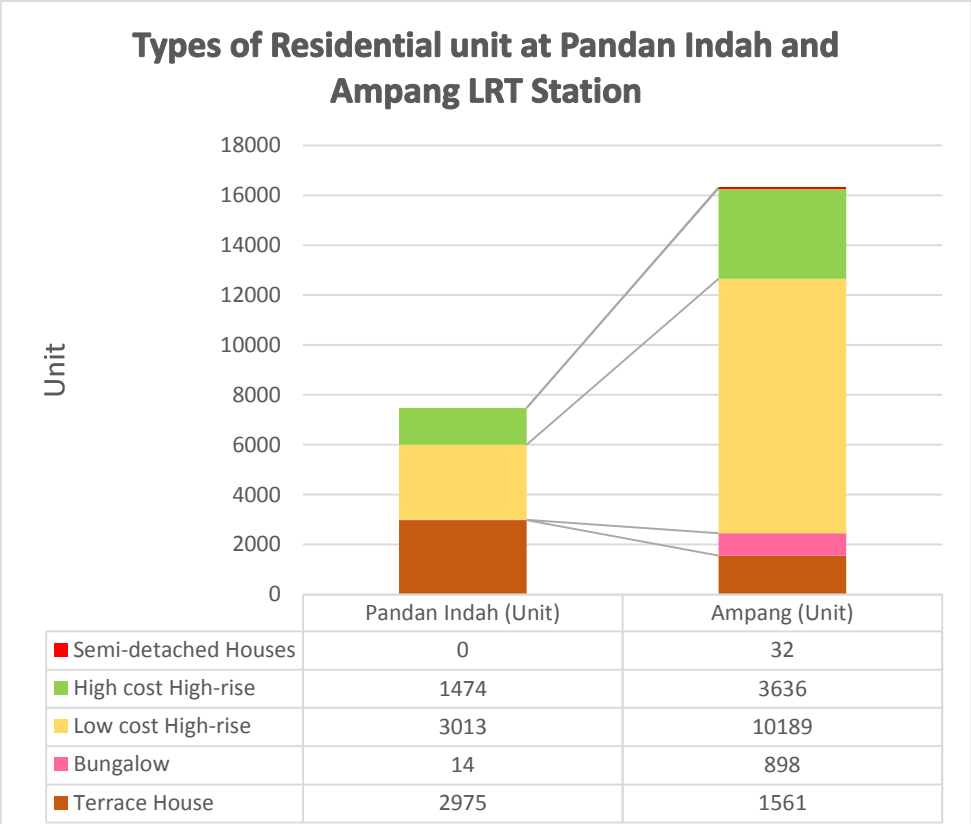
Table 2. Land use diversity index (Ampang LRT station)

Ia1- Residential	**0.139341237**
Ia2 - Commercial	0.007659741
Ia3 - Institutional	0.002753485
Land Use Diversity Index (LUDI) **Land Use Diversity (LD) = 1- [Sum (Ia1 , Ia2 , Ia3)]**	**0.8502**

5.2 Land use density

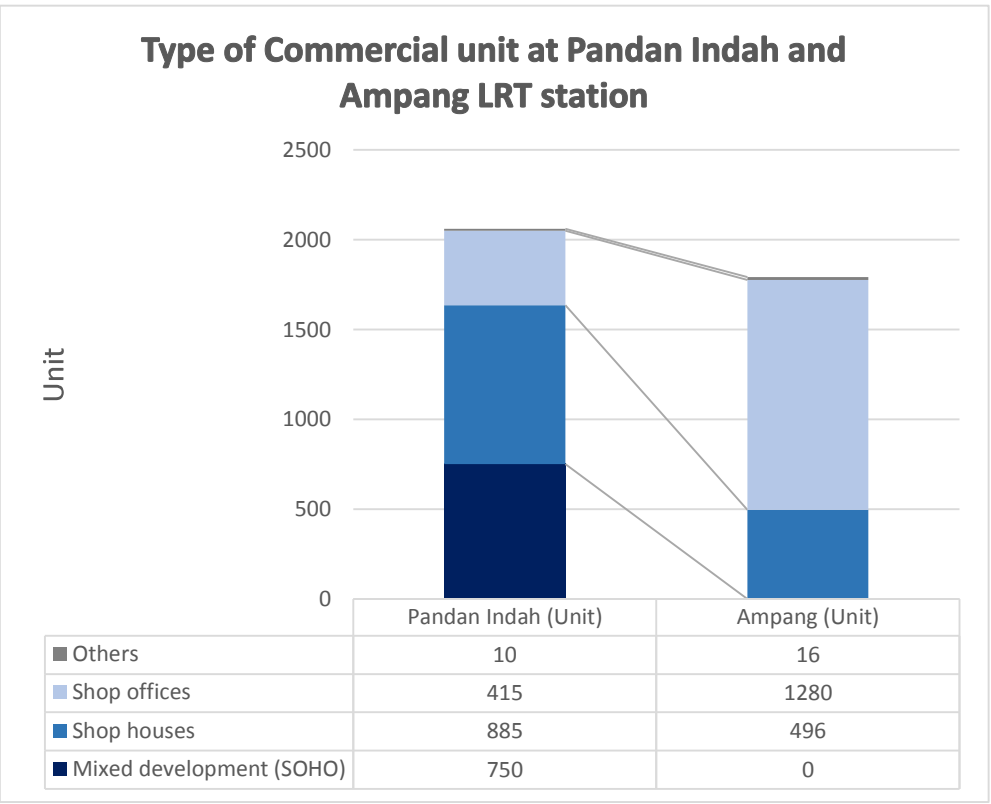
In terms of population density, the catchment area of Ampang LRT station has a medium-density residential neighborhood with the total of 697.56 people per hectare. Ampang LRT station also had the highest number of the residential unit specifically flat/apartment are located surrounding the Ampang LRT station with comfortable walking distance to the station (Figure 11). Therefore, Ampang LRT station has the highest population density as people focus on this area as their place to live compared to the Pandan Indah LRT station which categorized as low- density residential neighborhood with the total of 388.97 people per hectare. These highest number of population density are proficient to attract people to using the Ampang LRT station as their mode of transport.

The catchment area of Ampang and Pandan Indah LRT station has a low-density of commercial development. The total existing commercial development within the catchment area of Ampang station is 1792 commercial units comprising 496 unit of shop houses, 1280 unit of shop offices, and 16 unit of others commercial. Hence, the commercial density within the catchment of Ampang station is 65.35 unit per hectare. Meanwhile, the total existing commercial development within the catchment area of Pandan Indah station is 2060 commercial units comprising 750 unit of mixed development (SOHO), 885 unit of shop houses, 415 unit of shop offices, and 10 unit of others commercial. Hence, the density for commercial within the catchment of Pandan Indah indicates that there are 97.58 unit per hectare (Figure 12).



	Pandan Indah (Unit)	Ampang (Unit)
Semi-detached Houses	0	32
High cost High-rise	1474	3636
Low cost High-rise	3013	10189
Bungalow	14	898
Terrace House	2975	1561

Figure 11. Type of Residential unit at Pandan Indah and Ampang LRT Station



	Pandan Indah (Unit)	Ampang (Unit)
Others	10	16
Shop offices	415	1280
Shop houses	885	496
Mixed development (SOHO)	750	0

Figure 12. Type of Commercial unit at Pandan Indah and Ampang LRT Station

5.3 Passenger ridership

Figure 13 and 14 indicate the number of passenger who enter and exit at Pandan Indah and Ampang LRT station on day 2 (Wednesday). The passenger volume analysis focused on the data that was collected on Wednesday because the passenger ridership on this day is normally higher than the other days. The number of passenger ridership at the Ampang LRT station was quite large compared to Pandan Indah LRT station. The highest number of passenger ridership recorded during evening peak hour (3-hour volume) in Ampang LRT station, which is 4067 passengers, while the lowest number of passenger ridership is during the off-peak hour (6-hour volume) in Pandan Indah which is about 1201 passengers. Same goes for the morning peak hour (3-hour volume), the number of passenger ridership in Ampang LRT station is higher than Pandan Indah LRT station which about 3696 passengers. However, Ampang LRT station is still busy with the passenger who enter to and exit from the station during the off-peak hour which were about 2339 passengers, whilst in Pandan Indah LRT station, the situation is different during the off-peak hour with only 1201 number of users.From the comparison, it can be found that the usage at the Ampang LRT station is higher compared to the usage at the Pandan Indah LRT station. Therefore, this result determines that residents living near Ampang LRT stations are more likely to commute by transit compared to Pandan Indah LRT station users.

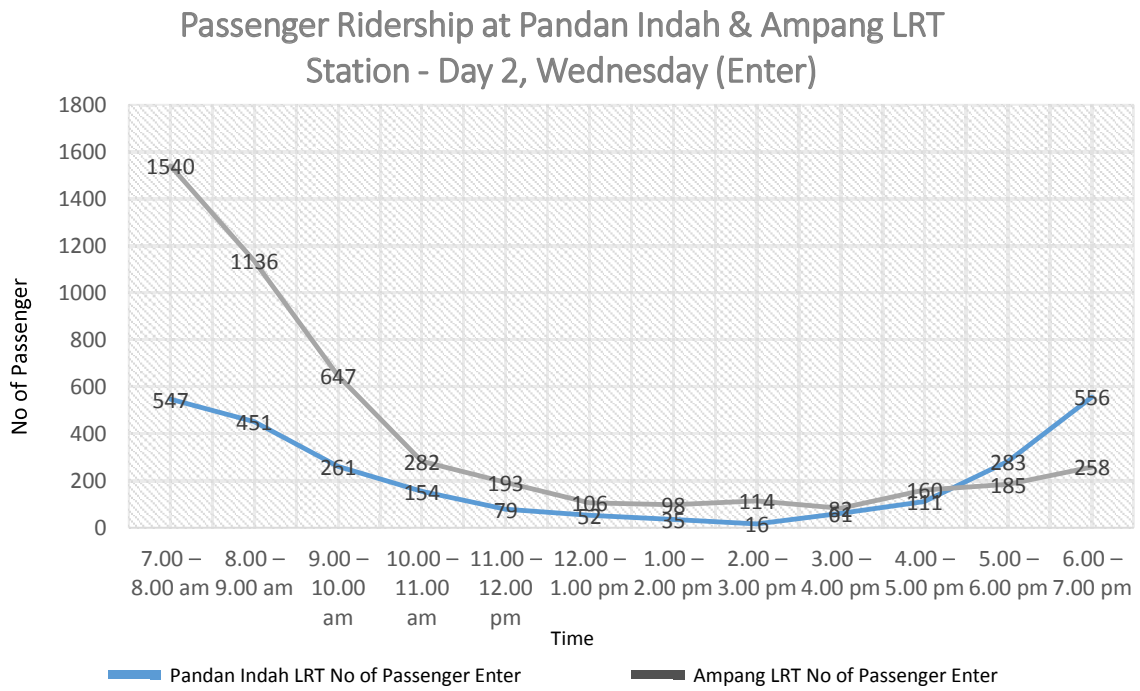


Figure 13. The number of passenger ridership at Pandan Indah and Ampang LRT station – Day 2, Wednesday (Enter)

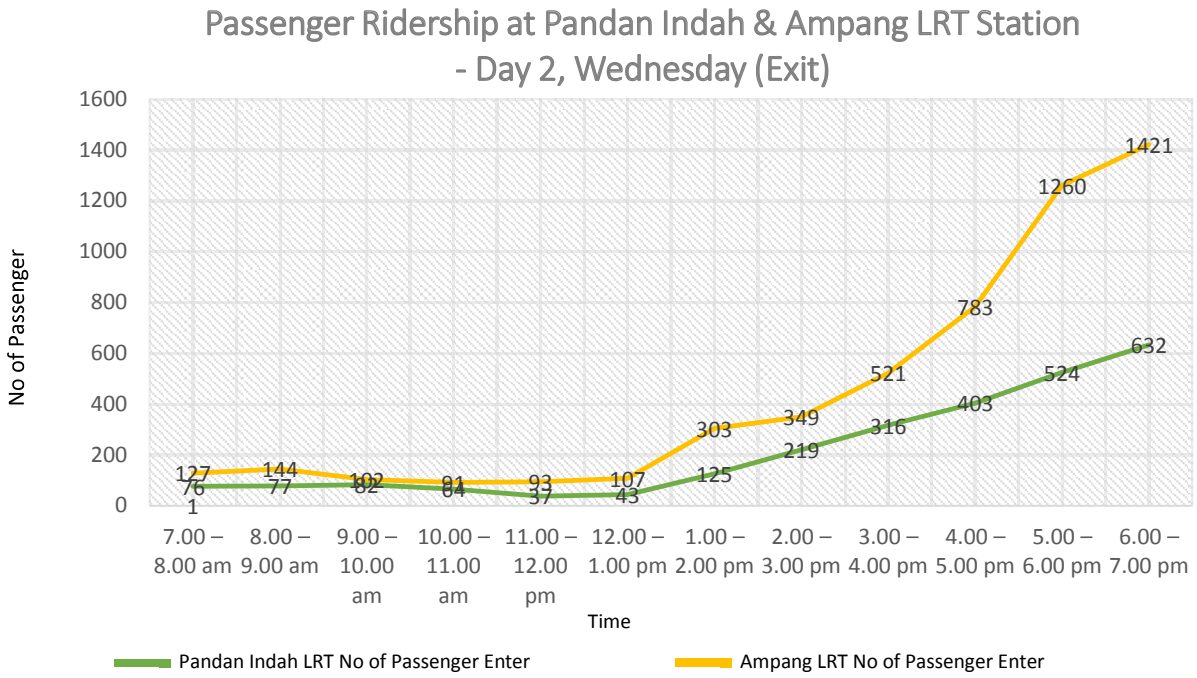


Figure 14. The number of passenger ridership at Pandan Indah and Ampang LRT station – Day 2, Wednesday (Exit)

5.4 Relationship between land use diversity and passenger ridership

According to the analysis on the relationship between land use diversity and passenegr riership, the total land use within both catchment area of Pandan Indah and Ampang LRT station have high land use diversity. However, the diversity value of Pandan Indah does not give impact on the higher passenger ridership as Ampang LRT station (Table 3)

Table 3. Land use diversity and Passenger ridership

Pandan Indah LRT station				**Ampang LRT station**			
Land Use Diversity Index (LUDI)	**Day 1**	**Day 2**	**Average daily ridership**	**Land Use Diversity Index (LUDI)**	**Day 1**	**Day 2**	**Average daily ridership**
0.8988	5567	5204	5386	0.8502	9602	10102	9852

5.5 Relationship between land use density and passenger ridership

In understanding the relation between land use density and passenger ridership, Pandan Indah and Ampang LRT station have low density of commercial development. As a result, the commercial land use not too much contributing in ridership at the two selected station. However, the high number of passenger ridership at Ampang LRT station is compatible with residential density surrounding Ampang station where Ampang has a medium-density residential neighborhood as people focus on this area as their place to live. The residential density within the catchment area of Ampang station is 139.51 dwelling unit per hectare whilst for population density is 697.56 people per hectare. Nevertheless, Pandan Indah catchment area has a lower population and residential density which covers 388.97 people per hectare and 77.79 dwelling unit per hectare (Table 4). Thus, lower density residential

neighborhood at Pandan Indah catchment area has results on lower ridership at Pandan Indah LRT station.

Table 4. Land use density and Passenger ridership.

Station	**Residential Density (du/ha)**	**Population Density (people/ha)**	**Commercial Density (u/ha)**	**Day 1**	**Day 2**	**Average daily ridership**
Pandan Indah	77.79	388.97	97.58	5567	5204	5386
Ampang	139.51	697.56	65.35	9602	10102	9852

5.6 Land Use Diversity, Density, and Passenger Ridership

The effect of land use diversity and density on the ridership pattern for the Ampang LRT station is different with Pandan Indah LRT station. Pandan Indah is the areas of higher diversity and lower density with a lower level of ridership. Although the Pandan Indah catchment area has high diversity, the diversity of mixed land use at inner area is slightly lower compared to Ampang LRT station (Table 5). Besides, the possibility of a distance factor between LRT stations may contribute to lower ridership rates at Pandan Indah station. For instance, the nearest LRT station to the Pandan Indah LRT station is Cempaka and Cahaya LRT station. Therefore, because of the distance is near to each other, people will choose the station which provides more convenient and facilities as their main transportation hub. Besides, other influence such as no bus service available in this station which automatically discourage people to choose Pandan Indah LRT station as their main transportation hub. The use of LRT services will decrease if the LRT station is not provided with a supporting public transport such as bus and taxi services in order to encourage people to use the LRT services in this station.

Table 5. Determination of diversity, density and ridership in Pandan Indah and Ampang LRT station.

Station	Land Use Diveristy Index (LUDI)	Density		Day 1	Day 2	Average daily riderhsip
	Total Land use	**Residential (du/ha)**	**Commercial (u/ha)**			
Ampang	0.8502	139.51	97.58	9602	10102	9852
Pandan Indah	0.8988	77.79	65.35	5567	5204	5386

In contrast, Ampang station showed the opposite situation. Ampang shows the higher diversity, medium density, and higher ridership. The higher diversity of mixed land use within the inner area and medium density within Ampang catchment area has contributed to the higher ridership at Ampang LRT station. Besides, the presence of other transit amenities at Ampang LRT station also influences the transit ridership. At the Ampang LRT station, bus and taxi services are oriented to act as feeder services to the rail-based transport system (Figure 15&16). Moreover, there is a park and ride facilities and also bicycle parking

facilities close to the Ampang LRT station which make it easier, for the LRT user to bring their vehicles and park at the station (Figure 17&18). All these services are basically contributing to the increase of passenger ridership at Ampang LRT station.

Figure 15. Bus service

Figure 16. Taxi service

Figure 17. Park and Ride facilities

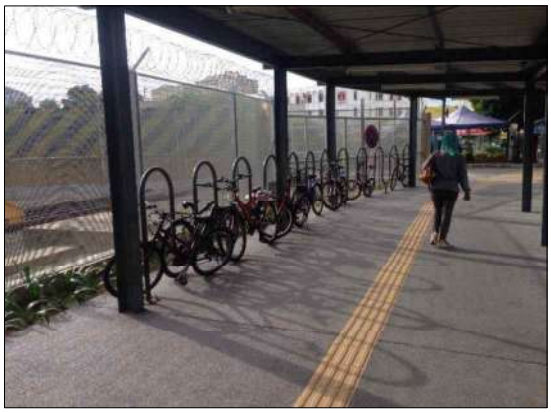


Figure 18. Bicycle parking facilities

6. CONCLUSION

This study has found about how various types of land use and levels of density impact transit user. The result shows that the high diversity and density of land use surrounding transit station have a positive effect in supporting high ridership. Thus, this study has concluded that the number of passenger ridership of the transit services was totally influenced by the land use diversity and density.

In order to increase the usage of LRT service at Pandan Indah and Ampang area, several strategies should be implemented to increase the density around the LRT station. The purpose of increasing the density is to provide transit opportunities for people as much as possible. High densities can be achieved by locating new office development in transit-supportive areas and encouraging new housing close to transit facilities and within existing activity centers. These proposals are to ensure the presence of high level of employment density and residential density surrounding the transit station. Furthermore, to increase the use of transit at Pandan Indah LRT station, bus services should be provided to play the role as the backbone of public transportation in Pandan Indah. Park and ride facilities can be provided near to the LRT

station. People that drive into town could be encouraged to use the car parking lots and switch to LRT to complete their travel. Besides, the convenient and secured bicycle storage location can be provided at Pandan Indah LRT station to encourage people to ride bicycle to the station. This facility offers a safe and secure place for riders to leave their bicycle and switch to LRT. The result of this study shows that the higher passenger ridership of the transit services is strongly rely on various types of land use and levels of density. Besides, the presence of transit facilities and amenities such as park and ride facilities, bicycle parking facilities, bus and taxi services at the station also play the important part in increasing the number of passenger ridership as took place by Ampang LRT station.

This study provide a better understanding on how the land use characteristics are integrated into the number of transit ridership which is significant in many ways. At first, it helps to increase the transit ridership as the findings of the research provide a clear picture to the town planners in designing development along the transit corridor. In addition, it helps the policy makers, administrators, politicians, etc. who are involved in the decision and policy-making to form policies and strategies to improve the development of a Transit-Oriented Development. It contributes to the field of transportation planning as transport planner could make use of the findings in their design to create more efficient transit system in the future. Last but not least, it adds to the existing knowledge about the subject and assists in further research on the subject.

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