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ASSESSMENT OF MRT FEEDER BUS ROUTES' CATCHMENT AREA USING GEOGRAPHICAL INFORMATION SYSTEM

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Abstract

Kajang Mass Rapid Transit (MRT) station is the last station for Sungai Buloh-Kajang line (SBK line). Assessing the current catchment area for its feeder bus route is important in ensuring the sustainability of feeder bus operation thus fulfilling its function to connect passenger with the MRT rail service. The objective of this study is to assess the composition of land use activities along the four routes of MRT feeder bus. In this study, the catchment area for all four routes of MRT feeder bus was assessed through on-site evaluation and applied Geographical Information System (GIS). The land use activities composition was calculated by using GIS tools. The catchment area used in this study was 400m buffer, considering the acceptable walking distance of passengers' willingness to travel to the bus stops, and the transit-oriented concept consideration. The key findings of this study were the percentage of land use composition and land use activities distribution that can contribute to the volume of passenger ingress at each bus stops location, and determines the issues generated from the overlapping feeder bus route. This study recommends a triangulation method in future research to identify the factors involved during route selection for a better feeder bus route optimisation.

Keywords: Feeder bus service, catchment area, Mass Rapid Transit, Geographical Information System, transit-oriented development.

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1. Introduction

This research study is to address an assessment of service catchment of Mass Rapid Transit (MRT) feeder bus. The evaluation of service catchment involves identifying the designated bus routes and its catchment areas. This study focuses on the service catchment of the feeder bus routes and stops by applying Geographical Information System (GIS) software and Global Positioning System (GPS) device for data analysis.

1.1. Background

Public transportations are deemed to be the backbone of people and goods transfer in near future. The urbanisation in Malaysian cities had resulted in increased demand for mobility and accessibility thus causing the escalating demand for transport infrastructures. This demand grows proportionally to the increased people and is mainly rely on land-based transportation including the rail-based transportation (Borhan, Ibrahim, Syamsunur, & Rahmat, 2017). In general, urban transportation is part of the component that keeps a city in its optimum functionality. Ensuring people accessibility through adequate mobility such as in term of monetary cost and time spent is part of effective transport functionalities (Jaramillo-álvarez, González-calderón, & González-calderón, 2013).

2. Problem Statement

The growing concern regarding the urban public transportation is its inability to convince users to shift their transportation mode from private vehicle to public transportation. Even though many metropolitan cities had invested in transit system, however, some of the transit system did not perform well because of insufficient number of commuters (Tangphaisankun, Okamura, & Nakamura, 2009). This study concerns about the feeder bus as part of the urban public transportation in moving people from one point to access railway service. The inability to shift people mode choice of transportation from private vehicle to feeder buses is due to many reasons why feeder bus service is less favourable.

As the function of feeder bus is to feed passenger to commute the MRT service, this seem not fully happened at MRT Kajang station even though this station had fully operated since 2017. The volume is not satisfying enough if compared to the MRT feeder bus maximum carrying capacity. Findings from recent study by Lim Jhin Lin and Ponrahono (2018) revealed that the highest volume of passenger riding an MRT feeder bus in route T461 is only 28 passengers, which is considered moderate, and some trips even do not have any passenger. Thus, both situations lead to few questions regarding the reliability of catchment area of feeder bus service, and the quality of service provided by MRT feeder bus and those perceived by passengers. In other hand, this lack of passenger volume reflects to the unfulfilling function of MRT feeder bus service and costly to the bus operator itself to run a trip without passenger riding on it.

Feeder bus is an alternative mode for user if they do not want to drive to rail transit or for those who has no private vehicles. According to Hu, Zhang, and Wang, (2012), the unnecessary distance between demand area and the bus stop or colleting point will reduce people willingness to ride a feeder bus. This is because of the level of accessibility and personal safety to bus stop influence the decision to use public bus. Chiu Chuen, Karim, and Yusoff, (2014), in their research within Klang Valley of Malaysia, had identified

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the rail- and-bus network is among the significant attraction factors that can attract mode shift toward using public transport as an alternative to make and complete their trip. Apart from that, unreliable frequency and routes, lack of provision of service, and inconsistence partnership between KTM commuter stations and service provider were among the refusal factors of passenger in feeder bus service (Bachok & Mohd Zin, 2017). This study includes identification of availability of the bus stops/signage as part of study to asses feeder bus facilities components, as we assume that these facilities contribute to users' convenience to access feeder bus service.

2.1. Lack of transport-land use integration and implementation

Land use pattern, design and density had significantly affected the travel choice and total time spent for mobility and accessibility purpose. Sprawl development pattern had magnified the distance between the actual origin and destination points which resulted in more trips made by cars (Litman, 2008). Land use characteristics of the transport service catchment area did influence on the ridership as the activities generated will associate the demand (Jun, Choi, Jeong, Kwon, & Kim, 2015). The fragmented planning of land use and transportation will decrease the connectivity between people activities, road network and public transportation network. Therefore, an integrated transport-land use planning will reduce the need to travel and improve accessibility for people to commute by land public transportation and walking (Land Public Transport Commission, 2013).

Generally, catchment area concept is used to describe the geographical area where transit users are willing to walk comfortably at particular distance to access the transit station or stops (Flamm & Rivasplata, 2014). A catchment area is defined as the maximum or acceptable walking distance able to completed by passengers on foot rather than by driving (Pongprasert & Kubota, 2017). In regard to this, the half-mile circle concept in transit-oriented development had become widely accepted in gauging a transit station catchment area (Guerra, Cervero, & Tischler, 2012) and this concept is appropriate for population catchment area. However, willingness to walk differ among countries and cities due to various factors that influence the maximum walking distance (Johar, Jain, Garg, & Gundaliya, 2015). Azmi and Karim (2012) discover Shah Alam residents only willing to walk within a maximum distance of 200 meters to reach community facilities while Sukor and Fisal (2018) proved that the Penangites are willing to walk further to access bus services with an average of 600 meters.

The integration of transport service and land use pattern and activities did influence the propensity to walk (Chalermpong & Wibowo, 2007). The efficacy of public transit and high-density land use development are interdependent to each other (Chakraborty & Mishra, 2013). A study by Chakrabarti (2017) had identified neighbourhood density, proximity to transit stop, and availability of rail service are among the factors of preference to use public transport service. Apart from that, more people use transit in a higher volume jobs or residential area near to transit, mixed and dense neighbourhood types (Stojanovski, 2018), and pedestrian friendly environment, and better accessibility to reach transit. Thus, strategic integration of high density and mixed-used development and reliable transit access can promote the use of transit service.

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3. Research Questions

Based on our research focus, this study has one major research question:

- What is the land use activities composition along the four feeder bus routes served from Kajang MRT Station?

4. Purpose of the Study

This study aims to assess the feeder bus route catchment areas focused on the land use activities, thus, to evaluate the feeder bus route service catchment area for four Kajang MRT feeder bus routes.

5. Research Methods

This phase involves the collection of data in the form of primary data and secondary data. This phase involves analysing the data collected by using GIS software and GPS device, observation analysis and also using catchment area analysis to determine the catchment of the MRT feeder bus route.

5.1. Study Area

The Klang Valley mass rapid Transit (KVMRT) System is one of the massive public transportation projects recently undergo in Malaysia to improve the integration and efficiency of urban public transport especially within Klang Valley areas. This project involves three MRT lines: MRT Line 1 (Sungai Buloh – Kajang), MRT Line 2 (Sungai Buloh – Serdang – Putrajaya) and MRT Line 3 (still at planning stage). The Kajang MRT station (location shown as Figure 1.) is an elevated MRT station and acts as a complementary interchange station with Kajang KTM Station, and situated 1km away from Kajang town centre.

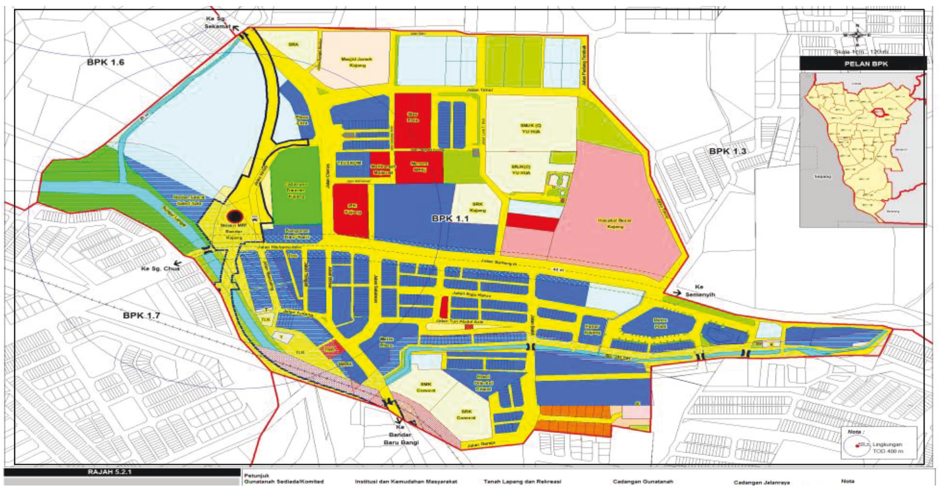

Figure 01. Location of Kajang MRT Station

Source: Draft Rancangan Tempatan Majlis Perbandaran Kajang (Pengubahan 4) 2020 (2018)

With the opening of the MRT SBK Line, feeder bus services have also been provided to enhance the convenience of taking the MRT. The feeder bus services provided in Kajang MRT Station covers four

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(4) routes: i) Route T461 – Taman Kajang Utama; ii) Route T462 – Seksyen 8 Bangi; iii) Route T463 – Seksyen 4 Bangi; and iv) Route T464 – Teras Jernang.

5.2. Data collection and analysis technique

5.2.1. On-board transit survey

To determine the service catchment of the feeder bus service, data collection involves routes tracking using Global Positioning System (GPS) device to analyse the service catchment areas of each bus stop through spatial analysis, which requires exact route taken by feeder bus.

5.2.2. GIS spatial and earth observation analysis

Spatial analysis is administered by utilizing software that utilizes GIS such as MapInfo Professional, Google Earth and Basecamp. The service catchment area, and the types of land use along the feeder bus route were identified through GIS spatial analysis. Figure 2. shows the flow of analysis technique used.

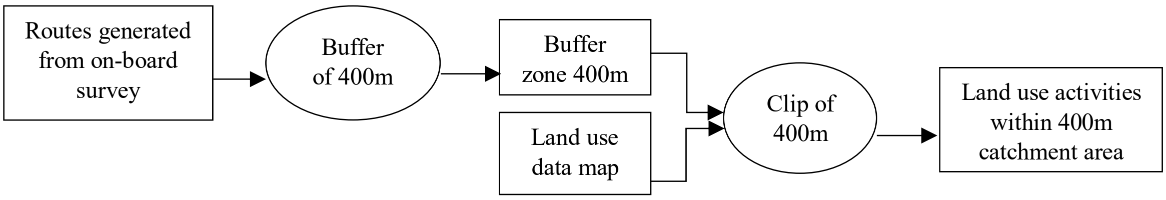

Figure 02. Flow of technique used in retrieving the land use composition

6. Findings

6.1. Feeder bus routes' trip characteristics

The feeder bus routes' trip characteristics are summarised as in Table 1.

Table 01. Routes characteristics

Route	Duration	Distance (km)	Number of bus stops	
			With signage /shelter	Without signage/shelter
T461	~29minutes	9.48km	17	1
T462	~38minutes	18.2km	25	12
T463	~35minutes	13.4km	15	15
T464	~1hour 24minutes	50.5km	20	18

6.2. Service catchment area

30 types of land use activities were identified distributed along the routes. However, only eleven types of land use activities were selected as the relevant land use activities that act as trip/passenger generator and attraction areas, as the shown in Table 2. Whereas, Figure 2 to Figure 5 show the 400m catchment area along the route. From this finding, the first highest land use cover for all four routes is the designated housing area. Theoretically, housing area is one of the trip/passenger generator area in land use and ridership study especially during morning trips as they are going out for working and doing other activities. Whereas, the second and third highest land use covers for all routes are educational

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area, designated commercial area, non-designated commercial area, and sport and recreational infrastructure which are considered as the attraction area. High density residential area and high density of commercial area are said to be significant to propensity to walk as these areas have convenient environment.

Table 02. Land use area (m^2) along each feeder bus route

Land use activities	Route T461	Route T462	Route T463	Route T464
Designated industrial area	65780.27	212686.88	47829.20	346927.24
Non-designated industrial area	16773.41	15865.20	16008.46	312751.77
Religious area/building	42497.53	77728.25	48489.80	117681.51
Governmental buildings	-	142812.63	-	526247.99
Sport and recreational infrastructure	-	280381.86	(2)	346925.82
Health	-	112177.33	2126.08	132862.24
Education	(2)173607.66	199012.61	(3)204622.99	(2)2838582.78
Designated commercial area	(3)165628.42	(3)374005.24	103694.41	(3)849488.03
Non-designated commercial area	122680.34	(2)	121731.17	122794.68
Designated housing area	(1)1167045.30	(1)2173055.59	(1)1569315.90	(1)3769841.60
Non-designated housing area	3180.73	9000.71	3180.73	13029.53
Total area 11 land use (m^2)	**1757193.66**	**4814793.06**	**2554230.74**	**9377133.19**
Total area 30 land use (m^2)	**3,884,130.17**	**8,989,208.81**	**5,508,733.88**	**18,398,352.67**

Note: The superscript numbers in bracket indicate the three highest areas of relevant land use activities

Figure 03. Route T461's 400m catchment areas

Figure 04. Route T462's 400m catchment areas

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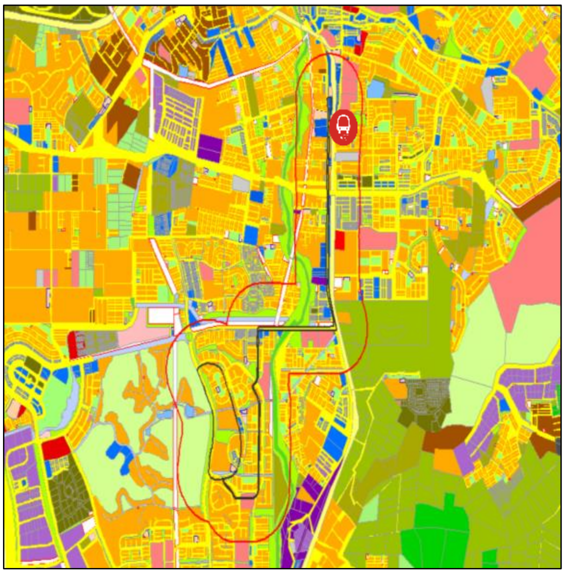

Figure 05. Route T463's 400m catchment areas

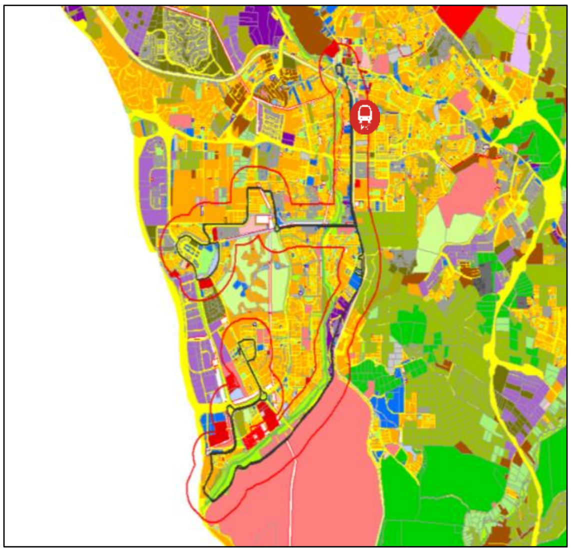

Figure 06. Route T464's 400m catchment areas

Figure 6 shows the catchment area for all four feeder bus routes served by Kajang MRT station which approximately covers an area of 21.88 km^2. However, only about 50% of total land use was identified as the trip/passenger generator and attraction areas. It should be noted that, in real situation, this percentage is not fully reflecting the bus stops catchment area as the distance between one stop to another is vary and could be longer than acceptable walking distance, thus introducing gaps in the route's catchment area and reduce the willingness to walk to access the feeder bus service (bus stops).

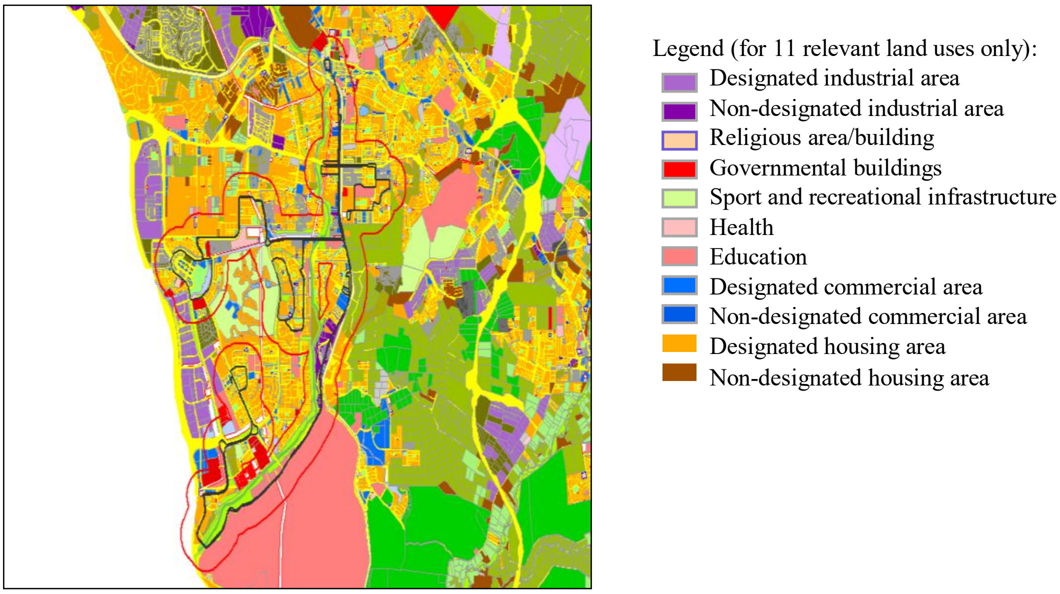

Figure 07. Combination of all four routes (400m catchment)

Due to high frequency of unidentified bus stops (without signage), full analysis of type and density of housing area is not applied in this paper. Further data collection is needed which involve the feeder bus operators to obtain the exact location of stops' areas and the passengers' origin and destination data to match with the land use attributes.

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7. Conclusion

Through findings from previous studies, a higher level of residential density within walking distance of transit stations is considered desirable for a feeder bus ridership. The route development must consider the neighbourhood pattern (origin) and the activities area (destination) so thus linking the demand and supply of feeder bus and the MRT service itself. Findings show that the land use density surrounding the feeder bus routes and Kajang MRT Station itself is not as high and concentrated as a typical central business district (CBD) or the transit-oriented development concept. Nevertheless, since the completion of the Kajang MRT Station, ensuring the accessibility to MRT station is crucial as to encourage residents to use public transportation as part of foundation for urban transport sustainability. This study recommends a triangulation method used in future research to identify the factors involved during route selection for a better feeder bus route optimisation.

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