

Preliminary Insights into Feeder Bus Usage: A Case Study of Asia Jaya LRT Station in the Klang Valley

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Abstract

Addressing traffic congestion issues and promoting sustainable transportation in the Klang Valley is achievable by integrating feeder services with rail stations to extend connectivity beyond the existing rail coverage. This study examines the spatial patterns of feeder bus ridership in Petaling Jaya, which features one of the oldest LRT stations in the area. Two complementary feeder bus routes were analysed to visualise the current demand within urban transportation networks at each bus stop along the routes. Using big data, the feeder bus dataset from Asia Jaya LRT Station was obtained through smart card transactions that recorded passenger boarding and alighting. The research employed spatial analysis tools using Geographic Information Systems (GIS) and explored the temporal dimensions of feeder bus usage to provide insights into peak travel periods. Results revealed significant disparities in ridership among various geographic areas that could not be attributed to random chance. The study highlighted potential factors influencing ridership, including land use characteristics, accessibility to points of interest, and demographic considerations. These findings offer a foundation for further research in this domain. The study's outcomes, encompassing ridership trends, provide valuable insights for urban planners and transport authorities to enhance feeder bus services, improve connectivity, and ultimately increase the efficiency of public transportation networks.

1.0 INTRODUCTION

Governments worldwide, as well as urban transportation planners and policymakers, have recognized that the issues of traffic congestion, air pollution, and greenhouse gas emissions are inextricably linked and have therefore been giving increasing attention to the development of sustainable transportation (Chen et al., 2021; Yusoff et al., 2021). The Klang Valley, one of the most densely populated areas with a relatively high rate of urbanization and economic development, is the most suitable place for sustainable transportation. Kuala Lumpur experiences daily traffic congestion, with nearly 3 million vehicles navigating the city, resulting in increased travel times between destinations and negative impacts on the economy and the environment (Yusoff et al., 2021). As part of its National Transport Policy, the Malaysian Government aims to boost public transport usage to approximately 40% by 2030 (MOT Malaysia, 2019). The Government has adopted several measures, including promoting walkable areas and making public transportation more accessible (MOT Malaysia, 2019). In line with this target, a newer initiative, the EPU (2022), set a goal under its Low Carbon Nation Aspiration 2040 programme to achieve a modal share of public transport of 50% by 2040 (EPU, 2022). The Malaysian Government's objective is also consistent with the Sustainable Development Goals (SDGs) established by the United Nations. One of the proposed solutions to address these issues is to integrate feeder bus services into existing rail infrastructure, thereby providing access to more locations beyond those covered by the rail network (Bernama, 2023).

Feeder buses are certainly an integral part of any urban transportation network and play a vital role in providing first- and last-mile connectivity to major transit hubs, such as LRT stations, through multiple connection points. Feeder buses can make public transport more accessible, promote its use, and allow people to change to better modes of transportation smoothly (Gan et al., 2019). The spatial and temporal elements that determine passengers' demand and impact the ridership patterns optimization process should be understood thoroughly to optimize passenger demand (Abdul Halim et al., 2023; Chen et al., 2019; Li et al., 2020). The primary objectives of the study are to evaluate the spatial and temporal variables of passengers boarding and alighting the feeder bus, and to explore the preliminary factors that may influence demand at the Asia Jaya LRT station. With the advancement of technology and the utilization of user-generated smart card data for various transportation studies (Ma, 2024; Zhang et al., 2021) conducted in other countries, there are, however, very few local studies that have analyzed ridership based on smart card data. There are local studies (Abdullah et al., 2020; Nur Sunoto et al., 2021; Yu Li et al., 2022) that have examined ridership in relation to the surrounding catchment area and land use; however, the measurement of ridership data is limited to annual or monthly ridership summaries only. This study aims to address the gap in local studies that rely on conventional data collection methods. The use of big data sources in transportation planning has emerged worldwide, and there is a need to utilize them to better understand Malaysia's usage of public transportation based on user-generated data.

2.0 LITERATURE REVIEW

2.1 Sustainable Transportation and Feeder Bus Systems

In the context of its strategic plan, Malaysia will devise a smart approach to implementing a sustainable transport plan that aligns with national targets. Sustainable transportation refers to various approaches designed to minimise the negative effects of urban mobility on the environment, society, and economy. The key aspects of environmentally friendly transportation in Malaysia include promoting the use of public transit, reducing the dependence of drivers with only one occupant, and increasing the practice of walking and traveling as active mobility (Gomez et al., 2019). Feeder bus services are essential for the development of sustainable transport systems, as they provide connections between crucial transit stations, covering the first and last mile of the journey. In addition to these, links and connectivity are also significant elements. Improving connectivity will provide travellers with a broad spectrum of benefits, ranging from comfort and efficiency to the first and last-mile link, potentially eliminating the need for private cars (Ikeh & Yuen, 2022; Naharudin et al., 2020).

The significance of feeder bus services in improving transit accessibility and encouraging sustainable travel behaviour has been highlighted in prior studies (Bachok et al., 2021; Olabayonle et al., 2021). For

example, the feeder bus is part of the first and last mile connectivity that we must improve to increase overall public transportation usage (Kåresdotter et al., 2022). Feeder buses have the potential to attract more users, decrease reliance on automobiles, and alleviate traffic congestion on roadways by expanding the coverage of fixed-route transit systems and offering simple transfer options. Nevertheless, the efficacy of feeder bus networks depends upon various aspects, encompassing service frequency, route structure, fare convergence, and the quality of infrastructure and amenities at transit hubs. During reported past LRT breakdowns, several feeders were deployed to assist passengers during the disruption of the LRT line (Yee & Shah, 2022). Local news sources (Amir, 2022; Yeong, 2022) have, however, reported that the feeder buses were not operating according to their designated routes or stopping at the intended locations. By gaining a clearer understanding of the specific service area that needs to be targeted, the allocation of feeder service can be enhanced more efficiently.

2.2 Spatial Analysis of Transit Ridership

Geographic Information Systems (GIS) have been proven to be an excellent tool for analyzing the spatial distribution of transit ridership, detecting patterns or trends. Planners can utilise ridership mapping and spatial analysis to identify regions with high demand, evaluate the efficiency of current transit systems, and prioritise investments in infrastructure and service enhancements. GIS analysis facilitates the identification of trends and relationships between various transit variables and how individuals utilize public transportation. The integration of geographic information within big data has garnered significant attention from academics, industry, Government, and other organizations worldwide (Goodchild, 2016; Li et al., 2016). With that, many academics have incorporated big data into their spatial analyses to uncover patterns and relationships within spatial contexts (Chen et al., 2019; Mützel & Scheiner, 2022; Zhan et al., 2022).

Spatial analysis involves various changes, manipulations, and techniques applied to geographical data to enhance its usefulness, facilitate decision-making, and identify hidden trends or outliers (Longley et al., 2015). Moran's I and Geary's C statistics can be used to measure spatial autocorrelation. These measures assess the extent of clustering or scattering of values within a dataset and provide a numerical estimate of how strongly linked neighbouring values are, which are close together in space. In other words, it is to understand whether similar values tend to occur near each other. Spatially positive autocorrelation implies that similar values are inclined to occur near one another, i.e., observations located at neighbouring sites tend to have more comparable values than would be expected by chance alone; on the other hand, negative spatial autocorrelation indicates that neighbouring values are relatively dissimilar (Anselin et al., 2010).

Previous research has explored various metropolitan areas using Geographic Information Systems (GIS) and other spatial analysis methods. Researchers have conducted numerous studies (Tu et al., 2022; Yang, 2023) to understand the factors that influence people's choices between modes of transit within different types of places they live. These factors include characteristics such as age or income level, as well as the location of a person's workplace and the number of people working nearby. To better understand travel behavior, Malaysian researchers (Abdullah et al., 2020; Yu Li et al., 2022) study the local context, coupled with demographic information and socio-economic data, while still considering location.

3.0 METHODS

3.1 Study Area

The study area of this research is the Asia Jaya LRT Station located in Petaling Jaya, an interesting urban centre within the Klang Valley region of Malaysia. This part of Petaling Jaya is one of the oldest and most mature areas, characterized by high population density and a diverse range of land uses, as shown in Figure 1. The land uses include residential areas, commercial zones, institutional buildings, and a high value of land use mix (Yu Li et al., 2022). Although mature, the study area is still undergoing redevelopment, with some new developments underway.

The Special Area Plan (RKK) for Seksyen 13, Petaling Jaya (2019) is a detailed planning document developed by the Petaling Jaya City Council (MBPJ) to guide the redevelopment and transformation of Section

13 into a vibrant, mixed-use urban district. The plan outlines land use zoning, development intensity, transportation infrastructure, and urban design guidelines for the area. The RKK highlights Asia Jaya LRT’s role as a key public transport hub in the redevelopment of Section 13. Studying feeder bus ridership as this study area aligns with the city’s goals for sustainable transport planning and offers valuable data to support the implementation of TOD strategies and to improve the last-mile solutions.

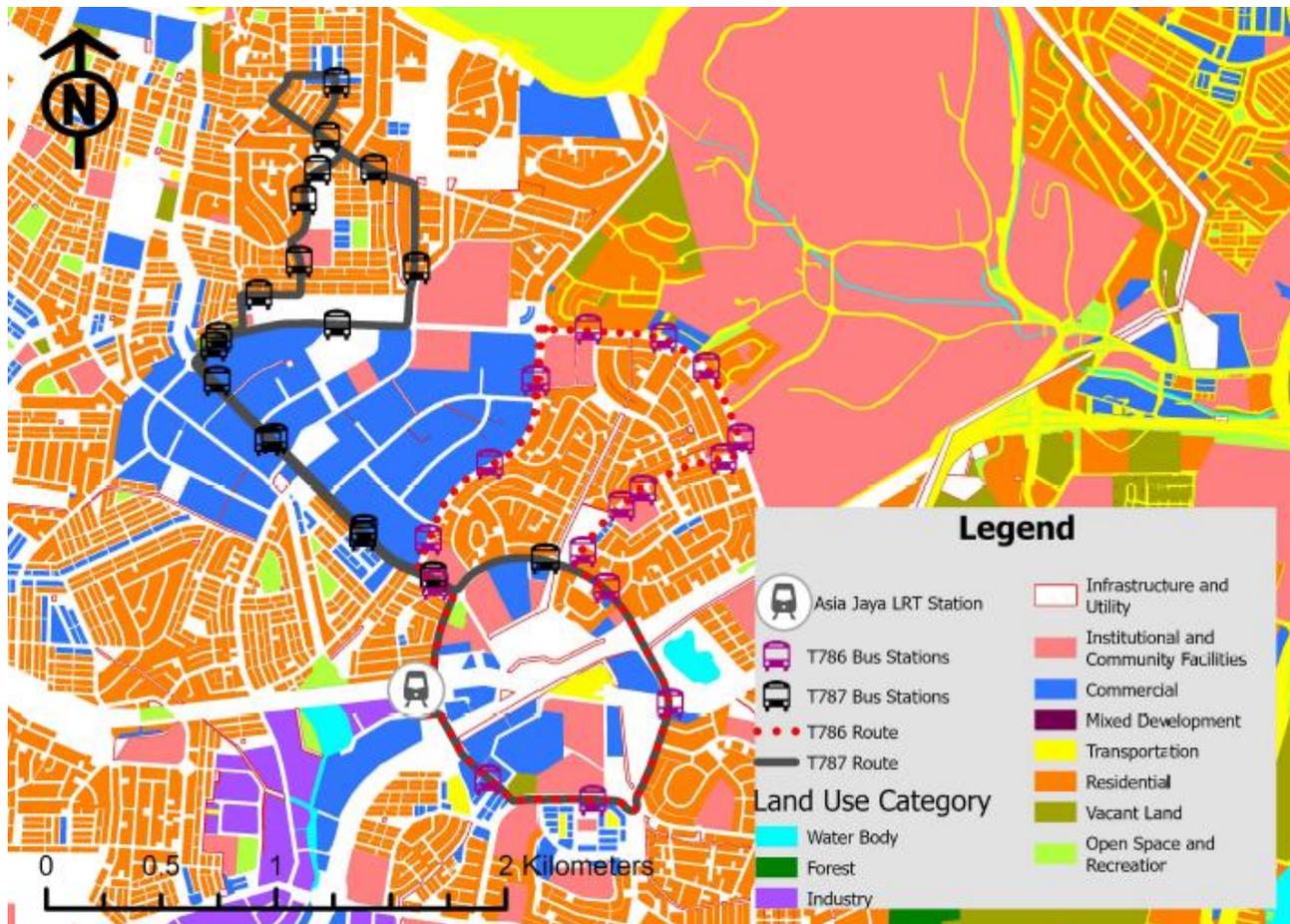


Figure 1. Land Use Map of the Study Area

Error! Reference source not found. shows a separate map without land use, indicating the two routes that serve the Asia Jaya LRT Station. Asia Jaya Station serves as a significant transit hub, providing connections to the Kelana Jaya Line’s stations. It is a prominent light rail transit (LRT) route catering to the Klang Valley region. The surrounding area is well known for its bustling commercial activity, hosting numerous types of businesses, stores, restaurants, service centers, healthcare facilities, and offices in close proximity. The station is also near the Federal Highway, one of the first highways in Klang Valley, providing easy connection via road networks and other public transportation. The feeder bus routes are marked with bus symbols, indicating the corresponding stops along the routes. The transport system plays a vital role in facilitating the movement of people to and from work, shopping, and other destinations in the bustling metropolitan environment of Petaling Jaya.

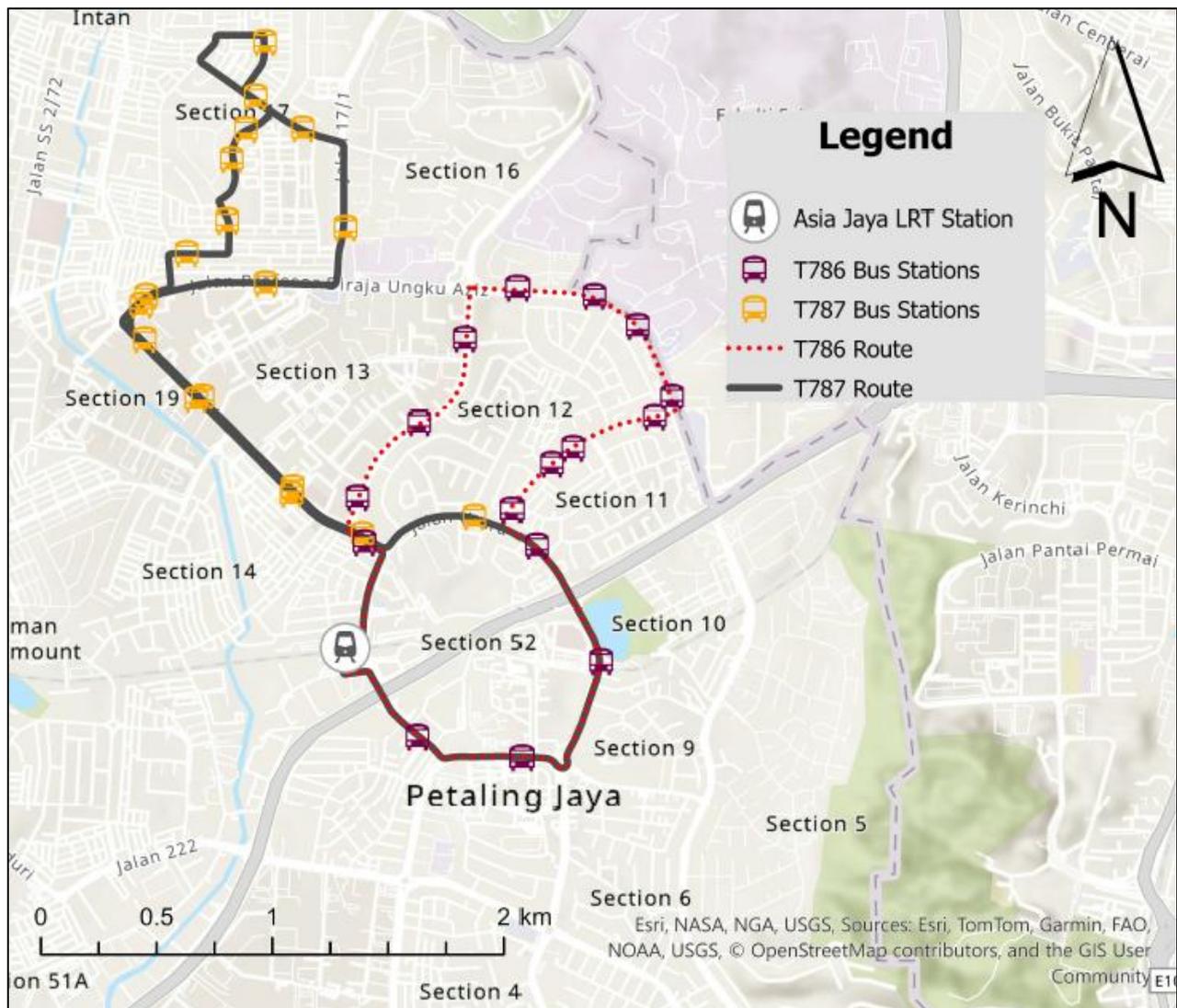


Figure 2. Study Area

3.2 Data Collection

Smart card transaction data were obtained from Prasarana's Rapid Bus, the transit agency that operates feeder bus services serving the Asia Jaya LRT Station. The total duration of the acquired dataset spans the first half of 2023, from January to June. The dataset includes anonymized logs of boarding and alighting activities of passengers on two feeder bus routes linked with the station, which are routes T786 and T787, as seen in **Error! Reference source not found.** Every transaction record includes details such as the boarding location, the alighting place, the date, and the time.

3.3 Usage Patterns of Ridership

The temporal structure of the study area was examined using graph plotting to examine the usage patterns of feeder bus ridership. Temporal analysis reveals variations in ridership on a daily, weekly, and monthly basis, providing insights into periods of high travel demand and periods of reduced activity.

3.4 Spatial Analysis

Geographic Information System (GIS) spatial analysis tools were utilised to visually represent and examine ridership patterns at bus stops along the two routes. Heat maps depicting the spatial distribution of transit intensity were generated using kernel density estimation. A Moran's I spatial autocorrelation analysis was performed to examine the spatial dependence of ridership data and find clustering patterns.

4.0 RESULTS AND DISCUSSIONS

4.1 Usage Patterns of Ridership

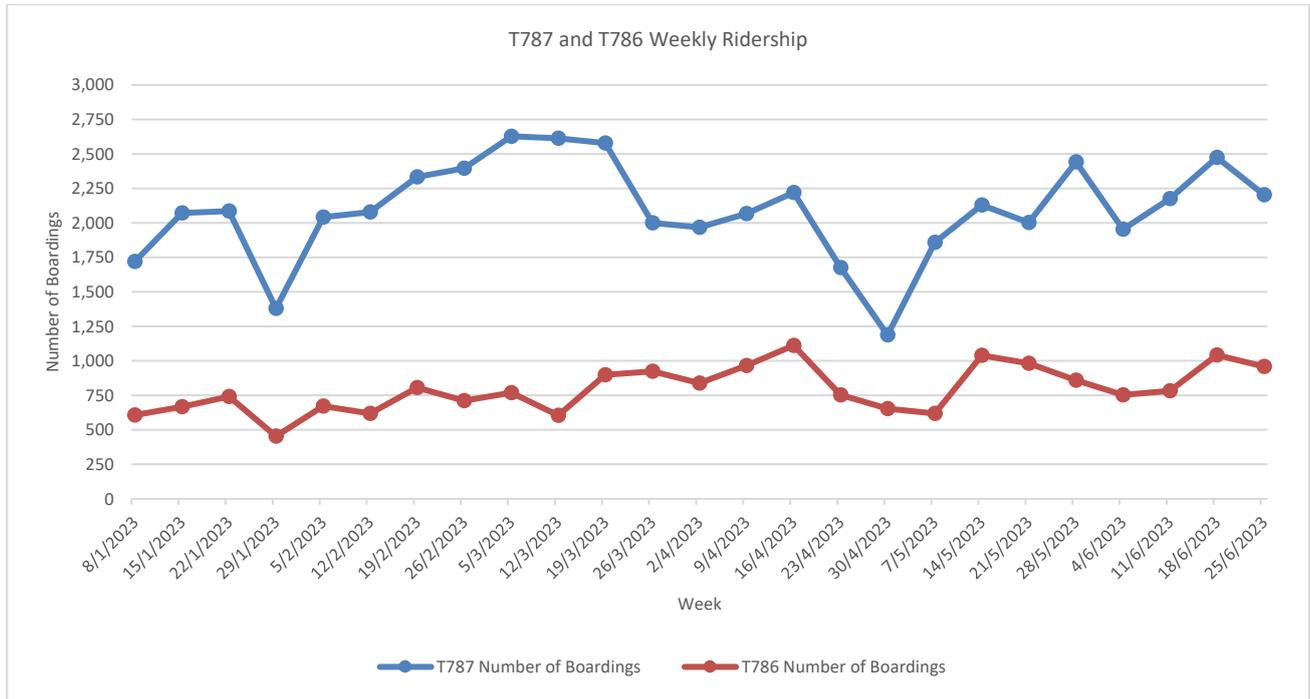


Figure 3. T786 Weekly Ridership.

Error! Reference source not found. shows a line graph displaying ridership for the number of boardings each week from the total data period for the T787 and T786 feeder bus routes. Over a half-year period, the lines show how the number of boardings fluctuated during different months. T787’s weekly ridership shows a higher overall ridership compared to T786. The number of T787 boardings fluctuated significantly, ranging from a low of 1187 to a high of 2628. The T787 route’s lowest monthly ridership still exceeds that of the T786, highlighting its popularity. The number of boardings for T786 is shown on the graph’s vertical axis, which is marked with numbers ranging from 250 to 1100 in increments of 50. Notably, there are peaks in ridership of 1,112, 1,041, and 1,043 boardings, which indicate some weeks of very high demand between April and July. In contrast, the line indicates a drop to as low as 454, with some reaching over 600, indicating that fewer people were riding for several weeks. Both routes experienced the lowest ridership in April and May 2023, primarily due to the Hari Raya festive season, followed by a recovery in June.

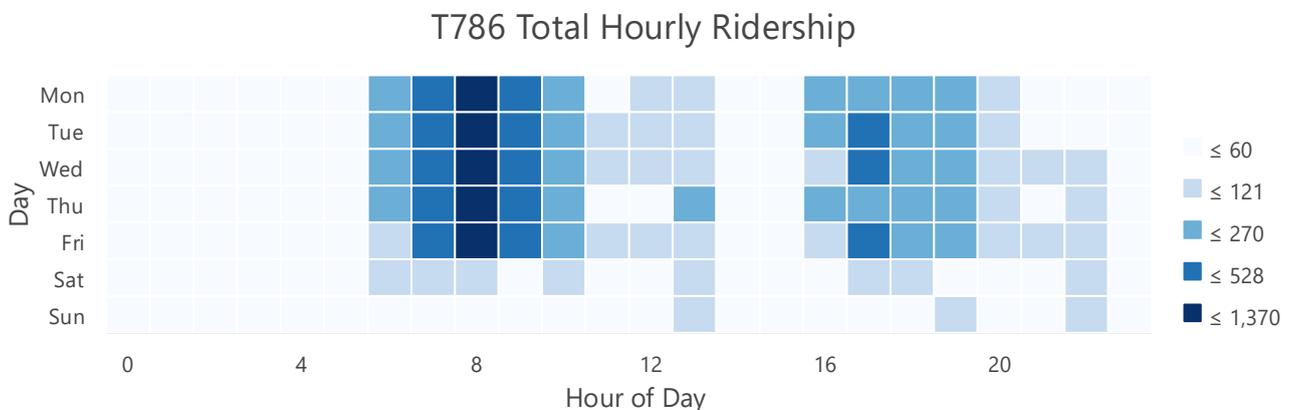


Figure 2. T786 Hourly Ridership.

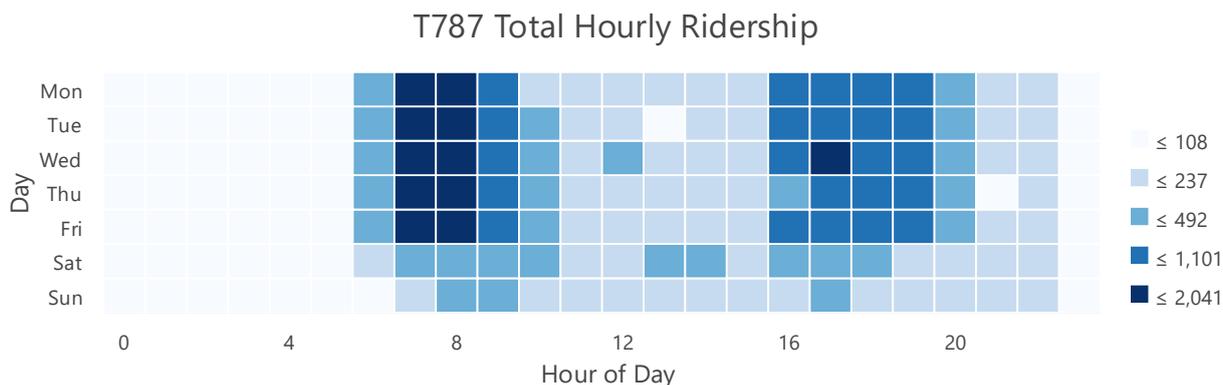


Figure 3. T787 Hourly Ridership.

Figure 2 and Figure 3 display the total number of hourly rides for the two routes, T786 and T787, covering different days of the week, from Monday to Sunday, in one-hour increments. Each row in the grid links to a day of the week, whereas the column links to the hour of the day. Bus routes in these figures show that the buses operate as early as 6 in the morning to 11 at night, with different shaded tones. The shaded tones represent the different amounts of ridership. It can be seen from the darker coloured shades that the peak hours consist of two, which are the morning peak and the afternoon peak. The morning peak can be observed from 7 am to 9 am and 5 pm to 7 pm, as highlighted in dark colours in the graphs. There is considerably less ridership on weekends, as seen in the figures, indicating that commuters might take the feeders to commute during the weekdays for school or to work. These figures are useful for the transportation planning authority to provide more buses during peak hours. There is considerably less ridership during the weekends, as seen in the figures for both routes. The T787 route, however, shows some ridership on weekends, possibly indicating leisure commuters.

4.2 Spatial Patterns of Ridership

The study revealed geographic variations in feeder bus ridership, with some stations experiencing greater demand than others. Clusters of high ridership intensity, particularly near major destinations such as the Asia Jaya LRT station itself, commercial centres, educational institutions, and residential complexes, were identified using heat maps created by kernel density estimation, as shown in the following figures.

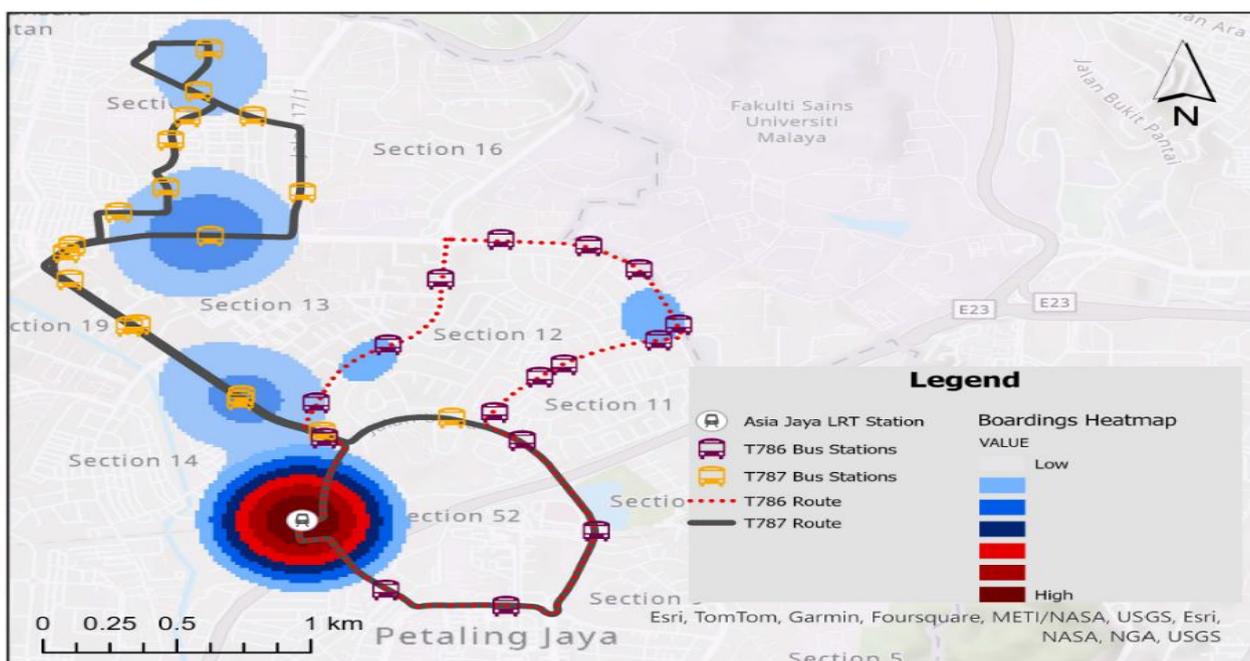


Figure 4. Kernel Density Heat Map of T786 and T787 Boardings

Error! Reference source not found. shows the heat map created by kernel density for boardings of both the T786 and T787 routes. It is seen that people board from the Asia Jaya Station the most. Referring to the pie charts in Figure 5 and Figure 6. The top individual boarding stations comprise a residential area, a commercial area, and educational institutions.

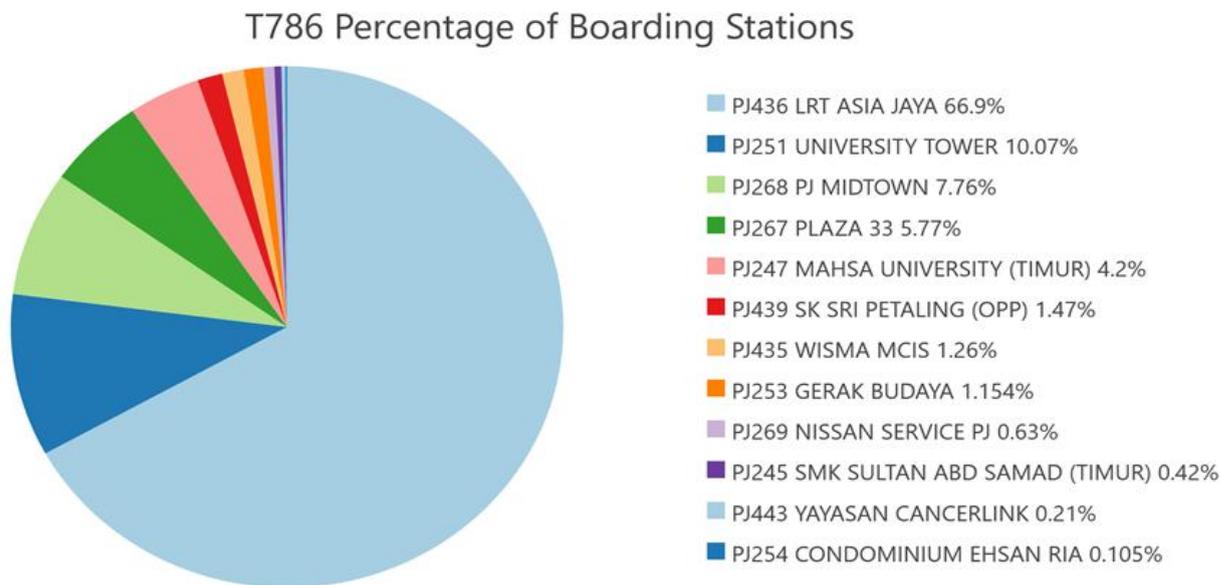


Figure 5. Percentage of Boarding Stations for T786

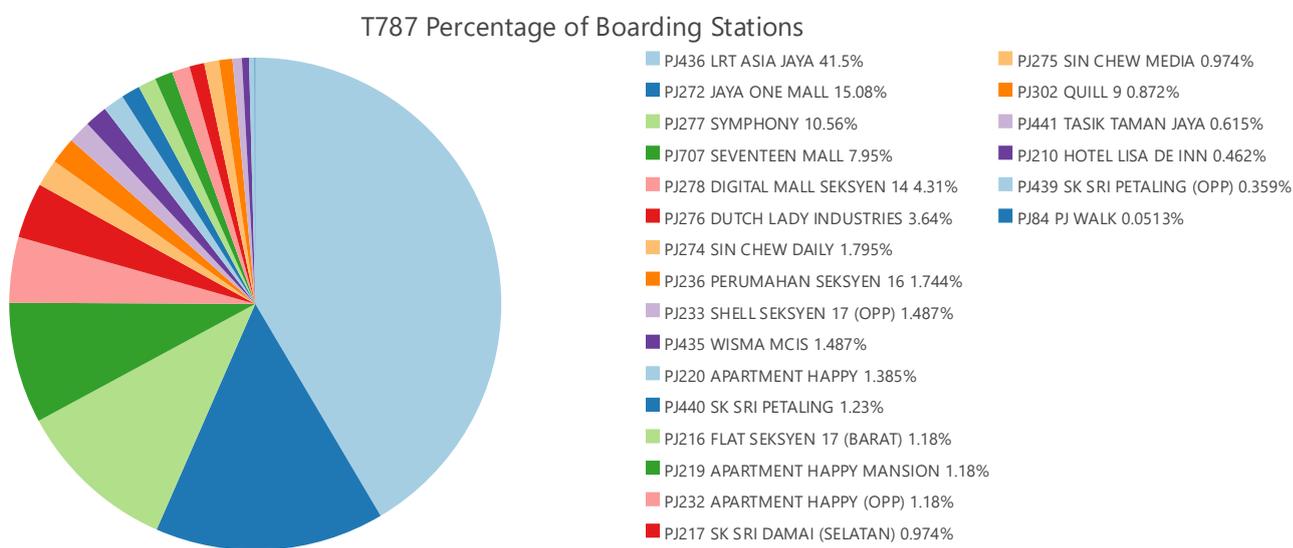


Figure 6. Percentage of Boarding Stations for T787

Alighting Stations for T786 and T787 vary slightly compared to boarding stations, as shown in Figures 9 and. For alighting stations, commercial centres, educational institutions, healthcare services, and residential complexes are some of the top alighting stations most frequently alighted during the study period.

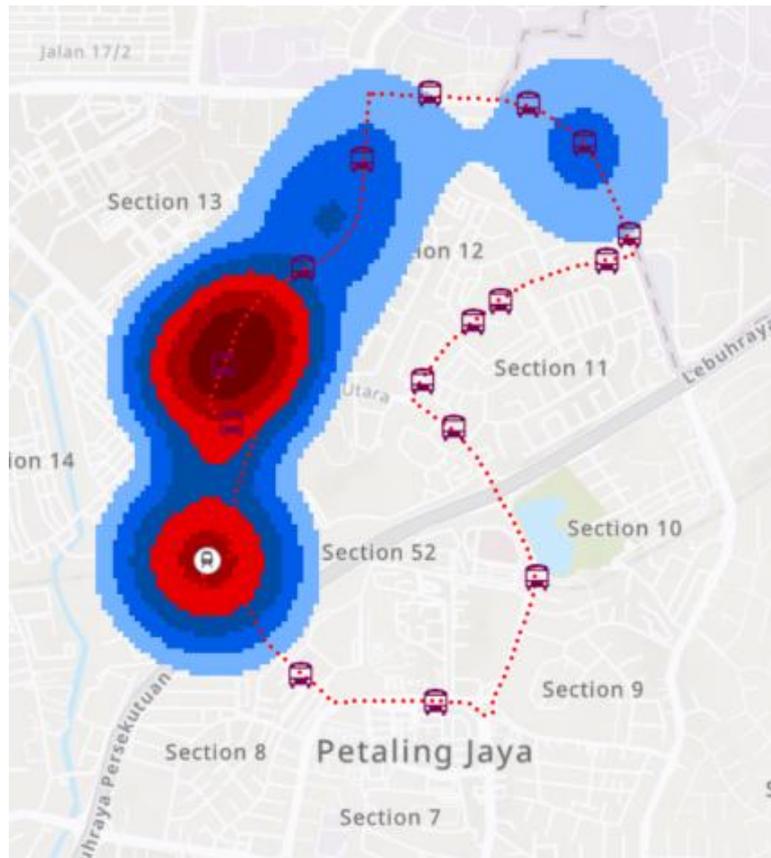


Figure 7. T786 Alighting Heat Map



Figure 8. T787 Alighting Heat Map

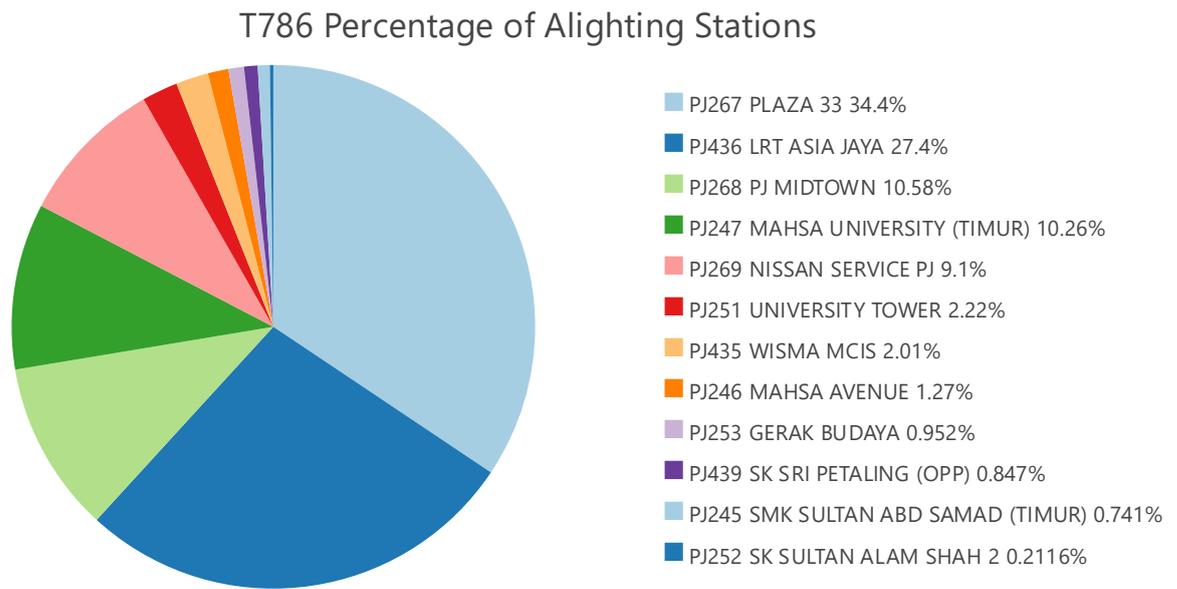


Figure 9

and Figure 10. The pie charts show the percentages of each alighting station for both T786 and T787, indicating the various bus route stops. The pie charts indicate that some bus stops have a very small number of people using them.

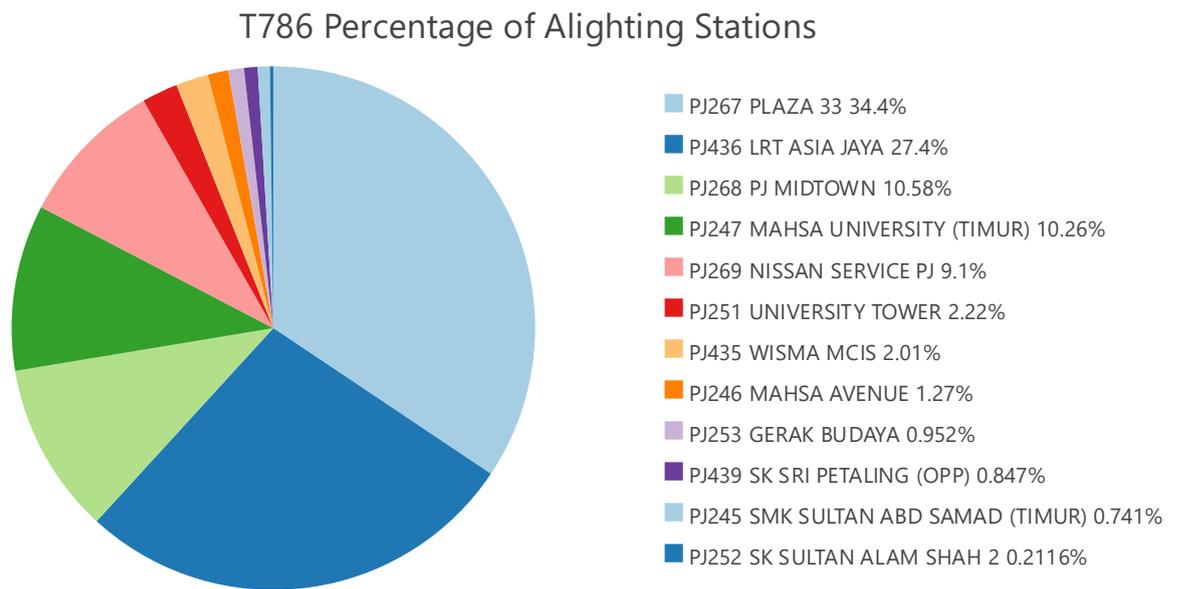


Figure 9. T786 Percentage of Alighting Stations

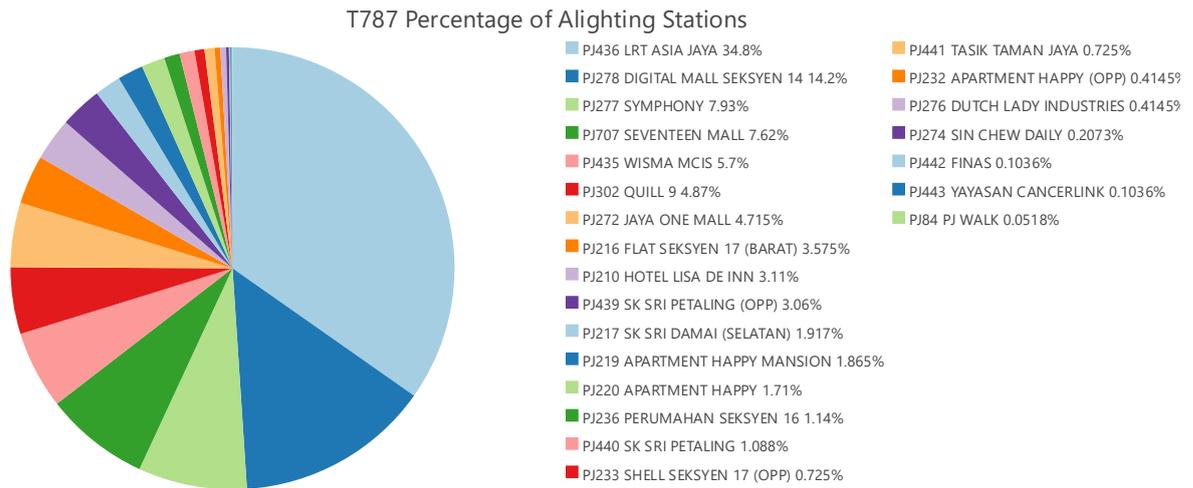


Figure 10. T787 Percentage of Alighting Stations.

Table 1 presents a summary of land use categories in the proximity of each bus stop, based on the top 5 bus boarding and alighting locations, as per the GIS main level 1 land use category guide from Plan Malaysia (2021). A good display of mixed land use can be seen in the top 5 boarding and alighting stations that contributed to the ridership.

Table 1. Summary of Land Use Category in the Top 5 of Boardings and Alighting

	Top 5 Stations	Land Use Category in Proximity
T787 Alighting	LRT Asia Jaya	Industrial, Residential, Commercial
	Digital Mall Seksyen 14	Industrial, Residential, Commercial,
	Symphony	Commercial, Industrial
	Seventeen Mall	Commercial, Residential
	Wisma MCIS	Commercial
T787 Boarding	LRT Asia Jaya	Industrial, Residential, Commercial
	Jaya One Mall	Industrial, Residential, Commercial
	Symphony	Commercial, industrial
	Seventeen Mall	Commercial, Residential
	Digital Mall Seksyen 14	Industrial, Residential, commercial,
T786 Alighting	Plaza 33	Industrial, Residential, Commercial, Institutional, and Community Facilities
	LRT Asia Jaya	Industrial, Residential, Commercial
	PJ Midtown	Industrial, Residential, Commercial
	MAHSA University (Timur)	Institutional and Community Facilities, Residential
	Nissan Service PJ	Industrial, Commercial

T786 Boarding	LRT Asia Jaya	Industrial, Residential, Commercial
	University Tower	Institutional and Community Facilities, Residential, Commercial
	PJ Midtown	Industrial, Residential, Commercial
	Plaza 33	Industrial, Residential, Commercial, Institutional, and Community Facilities
	Mahsa University (Timur)	Institutional and Community Facilities, Residential

Spatial autocorrelation analysis revealed significant clustering of ridership data, suggesting spatial dependence in feeder bus usage patterns. The results of Moran's I Statistics for Spatial Autocorrelation are in Table 2 for the boarding and alighting of passengers of both routes to measure the spatial autocorrelation of each dataset. Positive values indicated a positive spatial autocorrelation. The corresponding z-scores and p-values were calculated to assess the significance of Moran's I index. All four datasets were found to exhibit significant spatial autocorrelation, as evidenced by their low p-values ($p < 0.05$). This suggests that the spatial patterns within each dataset are unlikely to have occurred by random chance.

Table 2. Moran's I Statistics

	Moran's Index	Z-score	p-value
T787 Alighting	0.000919	7.972	0.000
T787 Boarding	0.000395	3.514	0.000441
T786 Alighting	0.002814	11.882	0.000
T786 Boarding	0.001157	5.632	0.000

Moran's I is a valuable diagnostic tool for identifying spatial patterns and guiding further modeling or policy analysis. The results indicate that there are spatial factors that affect travel, thereby influencing bus usage patterns. This, in turn, has implications for transport planning and service optimization. Further analysis of riders' clustering patterns will be conducted to identify areas of highest demand and take appropriate steps regarding route planning, timetabling, and resource allocation.

5.0 CONCLUSION

In conclusion, this research has found significant results on the spatial and temporal feeder bus ridership at Asia Jaya LRT Station in Petaling Jaya. This study has utilized smart card transaction data and GIS spatial analysis techniques to identify preliminary factors contributing to passenger demand, as well as suggest ways to improve the service through initial investigations. Furthermore, the feeder bus ridership analysis over time shows fluctuations in demand on a daily, weekly, and monthly basis, indicating peak travel times and periods of decreased activity. Understanding the temporal aspect can inform decisions on scheduling adjustments, frequency improvements, and resource allocation strategies. This enables a more efficient alignment of supply and demand, enhancing commuters' user experience. Spatial analysis of Moran's I also revealed spatial clustering of high ridership. By knowing when and where people are using these buses, those in charge can improve the service to make it more efficient, thereby helping to build transportation connectivity and supporting sustainable urban mobility. Maps produced helped to spatially inspect areas with high demand for further analysis and improved management of buses.

The primary objective of this investigation is to provide valuable insights for city planners and transport authorities in optimizing feeder bus systems and improving transit connections within the region, based on an analysis of smart-card transactions collected from all feeder buses serving the Asia Jaya station. Considering that feeder bus services operate around the Asia Jaya LRT station, such findings would greatly inform policymakers involved with regional public transportation planning, particularly those concerned with

designing effective feeder bus routes as part of their integrated urban development strategies for areas like Klang Valley, among others.

The results of this study hold significant implications for the design and formulation of urban transport policies in the Klang Valley and other comparable urban areas, particularly in the selection of feeder bus routes. Policymakers can enhance the efficiency of feeder bus services and transit connections by understanding the spatial and temporal dynamics of feeder bus ridership and recognising the factors influencing passenger demand. There are limitations, but there are some ways to improve the study in the future, such as increasing the study period. Currently, the smart card data used is historical data from the first six months of 2023. Additionally, another rail station can be used for comparison with the results of this study. Another limitation is that the smart card data retrieved by *Prasarana* on the basis of ridership may contain missing records or anomalies. However, it can be well understood that the received ridership count is sufficient as long as the overall pattern and trend can be seen from the bus routes.

In the future, there are numerous opportunities for further research to build upon the discoveries of this study and enhance sustainable transportation planning in the Klang Valley. More data can be integrated to better understand the readily available information. Potential areas for future research could involve comprehensive examinations of socio-economic variables that impact the use of feeder buses, assessments of strategies for integrating multiple modes of transportation, evaluations of fare regulations and subsidies, and long-term investigations into changes in travel behaviour. Points of interest can be used in conjunction with land use categories for a more detailed categorization of land use.

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