Development of Jakarta LRT System Along East-West Corridor: A Case Study of Jakarta LRT Pulo Gebang - Joglo

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Abstract: Transportation problems in Jakarta City are getting worsened in terms of quality and quantity. A well-planned and handling framework is essential to anticipate increasing demand in the future. An initiative made by the private sector is a light rail transit (LRT) line along Pulo Gebang - Joglo corridor. This paper aims to predict ridership by developing a demand forecasting model for the Jakarta Light Rail Transit (LRT) Pulo Gebang - Joglo line. A four-step model was developed by conducting a real demand survey and forming a base year transport model and scenario simulations. The results show a positive increase in ridership from 2024 to 2039, with an average increase per three years of being 10.98%. Potential shifting from train and bus users to LRT generates a significant portion, while possible shifting from private car and motorcycle generates a relatively small portion of 6.84% in 2024.

Keywords: Light Rail Transit, Demand Forecasting, Real Demand Survey

1 INTRODUCTION

For the last 20 years, Jakarta city has suffered from transportation and traffic problems with a very high level of complexity reflected in all-time traffic congestion on almost all main roads. Moreover, a weak public transport system and other supporting systems that do not operate optimally and are integrated have added much complexity (Hang Leung, 2016). In 2015, there were 47.5 million trips per day in the entire JABODETABEK (Jakarta, Bogor, Depok, Tangerang, and Bekasi) area, of which 73% were private vehicles, only 27% were served by public transport. The use of transportation modes indicates that the people of JABODETABEK tend to use private vehicles, which creates severe congestion resulting in a loss of IDR 100 trillion in 2018 (JICA, 2012, 2019).

Transportation problems that occur today are more complicated in terms of quality and quantity. Therefore, a well-planned and handling framework is essential to establish, particularly to anticipate increasing demand for transportation services in the future. In this paper, the proposed public transportation service is a light rail transit (LRT) corridor stretched along Pulo Gebang to Joglo.

Having reviewed the existing systems and problems and regional developments, urban and socio-economic activities in Jakarta, the public transport system should act as the backbone of the transportation system; thus, developing a comprehensive public transport system within a corridor is a must (Knupfer et al., 2018). On the other hand, given the context of environmental conservation issues and typical constraints in metropolitan areas such as limited land space, which is the main obstacle in the supply of transportation, the development of this system must

lead to the need for a clear statement of restrictions or demand regulation (Meyer D., Miller, 2001).

To create a problem solution, one of Jakarta's private sector business entities proposed developing a Light Rail Transit (LRT) system in the Pulo Gebang - Kebayoran Lama - Joglo corridor. The proposal has received a positive response from the DKI Jakarta Provincial Government for the proposed LRT initiative and the dynamics in the planning process for rail-based mass public transport in Jakarta.

A process of demand forecasting is carried out to predict the estimated demand based on existing constraints and becomes an essential part of policymaking (Nguyen et al., 2020). Planners and decision-makers must consider using multi-criteria decision-making tools to select suitable alternatives for mode choice and environmental impacts by involving various stakeholders (Meyer D., Miller, 2001). Understanding dynamic systems, user travel behavior patterns, physical factors, and other related factors are essential to formulate an accurate demand estimation (Polat, 2007;(Taylor, B.D., Camilla, 2003).

The purpose of this paper is to predict the ridership by developing a demand forecast for the Jakarta Light Rail Transit (LRT) along the Pulo Gebang - Joglo corridor. This paper is organized in the following order: Section 2 is a methodology that includes the proposed line, real demand survey, and transport modeling. Section 3 presents the results of mode choice probability, ability-to-pay (ATP), willingness-to-pay (WTP) results, potential shifting, existing and forecast ridership. Section 4 summarizes the research and identifies the directions for further research.

2 METHODOLOGY

The Pulo Gebang - Joglo LRT corridor is stretched along west-east in the southern part of Jakarta, connecting mixed-use areas, Transit Oriented Development (TOD), the city center and strategic areas such as Senayan, GBK, Palmerah, Karet (including Sudirman still within 500-meter radius), Bendungan Hilir, Kuningan (Ciputra World, Mega Kuningan, Kuningan City), Kota Casablanka, Tebet, Bassura City, Klender and Pulo Gebang. The Jakarta LRT route and station plan result from an initial study proposed by the private sector business entity and has received letter to proceed from the DKI Jakarta Government. The following is an overview of the proposed corridor for LRT Pulo Gebang – Joglo with 27 stations with a track length of 32.25 km.

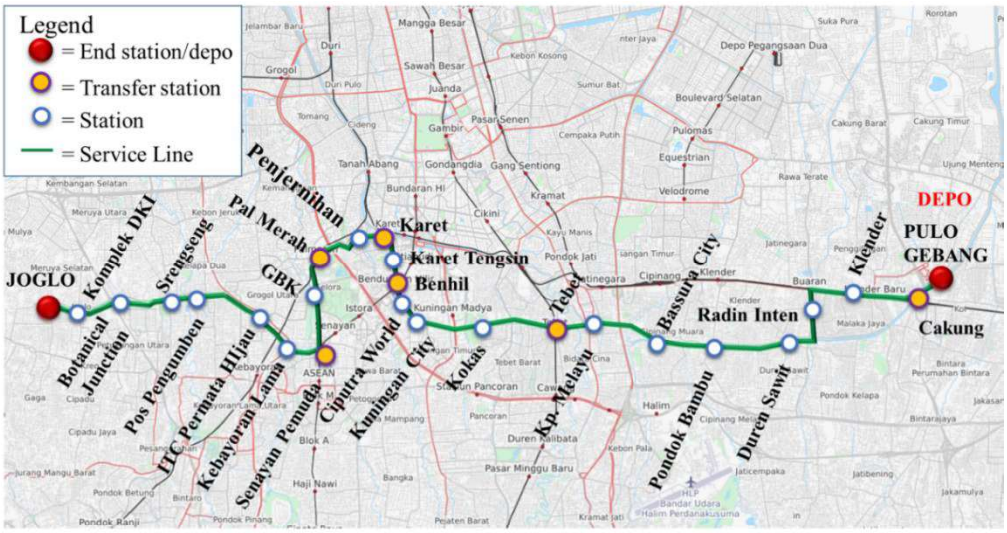

Figure 1. Proposed Corridor of LRT Pulo Gebang-Joglo

The proposed Jakarta LRT of the Pulo Gebang-Joglo line has already been submitted to the Indicative Jakarta Railway Masterplan of 2039. To optimize its role to achieve 60% trips using public transport in Jakarta in 2030, the Government emphasizes integrating mass transit systems, both road-based and rail-based systems. The integration will cover the Jakarta network comprising the North-South MRT, East-West MRT, Jabodebek LRT, Jakarta LRT, Loopline, and the Transjakarta BRT system. The positioning of the proposed line of Pulo Gebang- Joglo Corridor is indicated in the figure below.

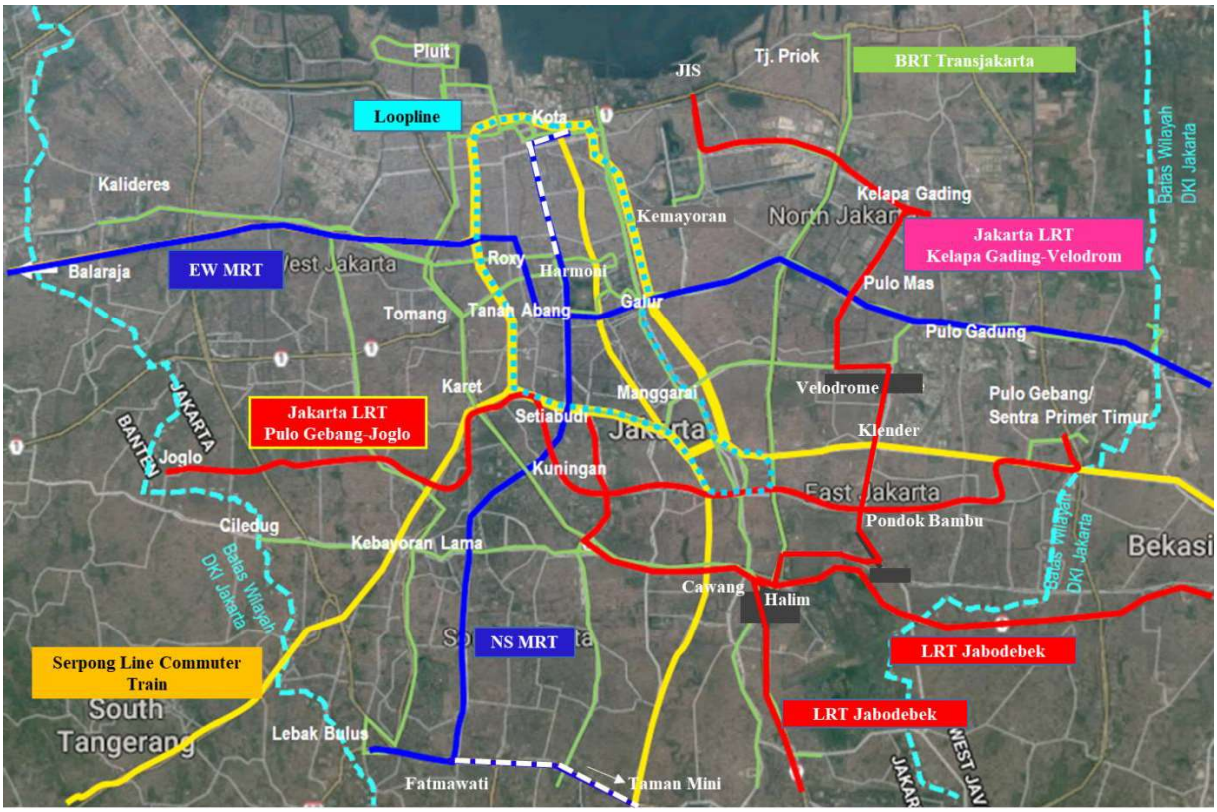

Figure 2. Indicative Jakarta Railway Masterplan 2039

The first stage of the study is to collect data by conducting a real demand survey (RDS). RDS includes surveys of traffic counting, public transport occupancy, ability-to-pay, and willingness-to-pay and also stated preference to determine tariff sensitivity based on an interview survey of 1,600 respondents who are potential LRT users. The stated preference survey is then used to analyze the possibility of mode shifting from private vehicles to public transportation by conducting a tariff sensitivity analysis (Ben-Akiva & Bierlaire, 1999). The ability-to-pay and willingness-to-pay surveys are considered important input parameters for the demand forecasting process.

Several socio-economic variables must be determined based on the survey result to assess the ability-to-pay and willingness-to-pay. The travel costs, the respondent's income level, the percentage of costs incurred for transportation, the intensity of the trip, and the distance traveled are the most frequently considered when analyzing the ability-to-pay (Ansusanto & Christianto, 2019). Other factors like the user's perception of the prevailing public transport rates are important variables to set the willingness-to-pay analysis (Gomez et al., 2017; Yusuf et al., 2014). Both parameters can be used as a reference to determine the applied fare of Jakarta LRT. It is derived from the responses of questionnaire surveys conducted in the surroundings of the

Jakarta LRT corridor plan. In particular, two values of willingness-to-pay will be generated, namely conventional (with direct questions) and by the mode choice method (with stated preference).

On the demand side, the characteristics of the travel pattern are derived from the socio-economic characteristics of the population represented by the travel characteristics and desire lines from the origin and destination matrix (Cole, 2005b; Ortúzar & Willumsen, 2011). The assumptions and reference data used in developing a network-based transportation model are as follows:

Table 1. Database and References

Database	SITRAM Phase 1 and Phase 2, JICA 2000 - 2001
	JUTPI, JICA 2008 - 2011
	JapTraPis, JICA 2009 - 2011
	JUTPI-2, JICA 2018 - 2019
Transportation and Traffic Studies	Feasibility Study of LRT Jakarta Network
	Pre-Feasibility Study of LRT Jakarta Corridor 1: Kebayoran Lama – Pulo Gadung Feasibility Study of LRT Jakarta Corridor Pulo Gebang - Joglo
Land Use Planning and Spatial Structure Plan	Master Plan of JABODETABEK
	RTRW DKI Jakarta Year 2030
	Perda No 1 Year 2014 about RDTR and Zoning Regulation

The next stage is to develop a transportation model to meet the network analysis needs. Simulations were carried out using generalized costs obtained from the results of surveys that have been carried out in previous studies and stated preference surveys (McNally, 2000; Cole, 2005). The survey data were reprocessed to obtain various variables that affect the choice of LRT modes, such as cost and time.

Demand forecasting or prediction is carried out using the four-step model method (Ceder, 2007). Overall simulations are carried out by EMME software for the entire mass public transport system network. The final result is ridership for the proposed LRT system and the entire mass public transport system network according to the implementation scenario that has been prepared: the methodology and the four-step model stages are schematically shown in Figure 2 and Figure 3.

After updating the database and tabulating all the necessary data, validation and model calibration are carried out against the base year model of 2020, which produces a travel origin-destination matrix (O-D Matrix) for the base year of 2020. The travel demand forecasting stage aims to project the base year O-D Matrix to the targeted year by adopting various vital parameters such as population, gross regional domestic product, income per capita, motorization rate, etc. All of these parameters correlate with the travel growth of the study area. The network scenario includes plans for the mass transport network development determined by the Government and based on the private sector's initiative, which is compiled in development and operation stages.

The final stage is a traffic simulation on the mass transit network to generate passenger loads or ridership on the entire mass transport network, including the LRT Pulo Gebang - Joglo line. The process of validation, calibration and forecasting is carried out using the EMME software version 4.3.2.

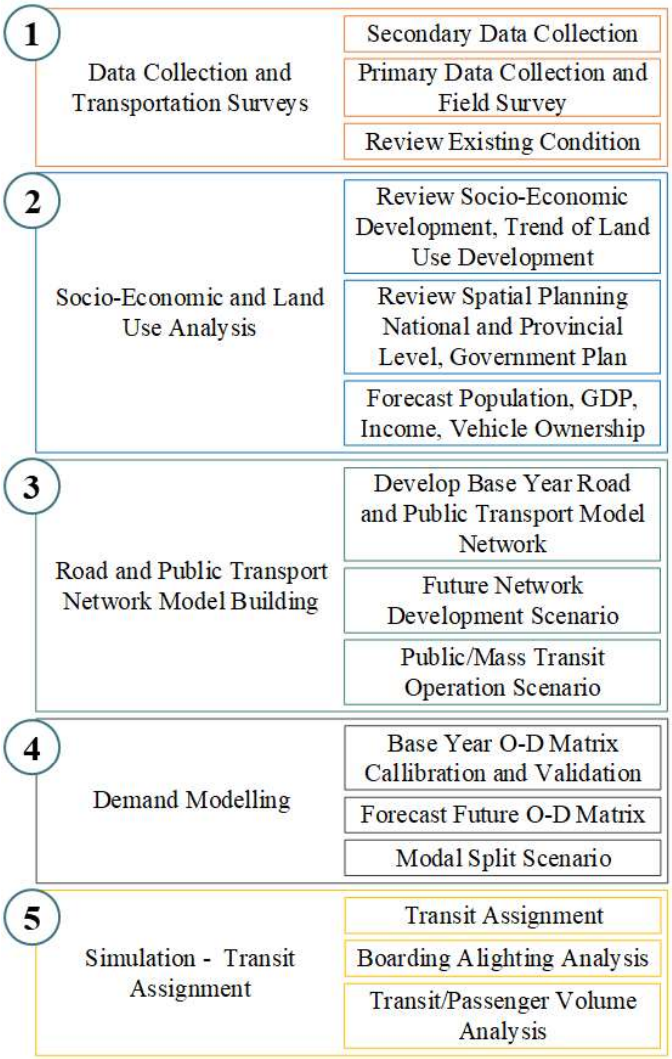

Figure 3. Methodology

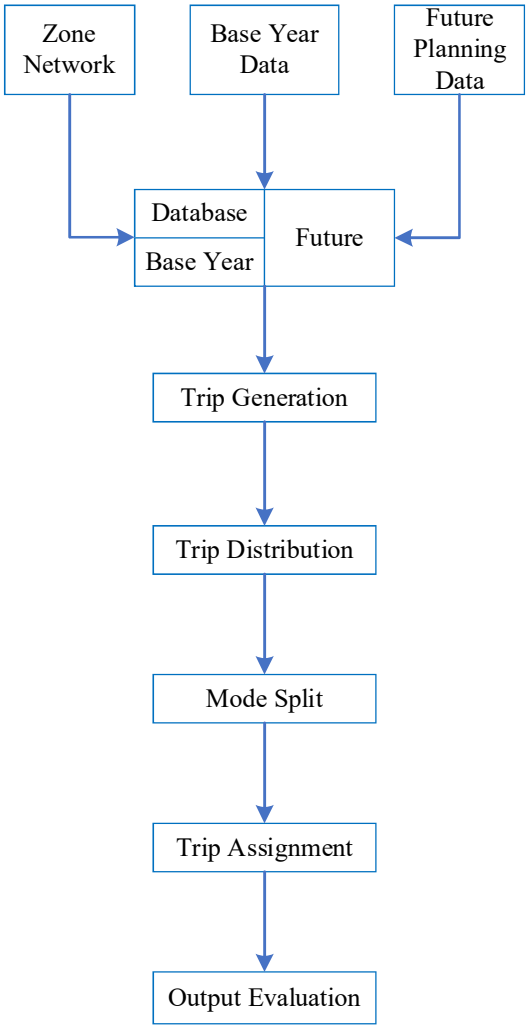

Figure 4. Four-Step Model

3 RESULT AND DISCUSSION

3.1 Mode Choice Probability Model

A sensitivity analysis using data obtained from the stated preference survey is performed to seek the probability of selecting the LRT compared to other modes, such as private cars, motorcycles, buses, and trains. The fare sensitivity of the Jakarta LRT with the four different modes can be seen in Figure 4 to Figure 7.

In Figure 4 and Figure 5, the probability of people choosing LRT compared to the private car and motorcycle modes for the LRT fare of IDR 1,000 is consecutively 30% and 15%. The figures indicate that the lines represent the private vehicle and motorcycle users do not cross the line represents the LRT users meaning that shifting between private cars and motorcycle users to LRT does not occur. It is because the coverage area of the proposed LRT line has not yet reached the trip origin. Moreover, lack of access to nearby stations has resulted in a small portion of mode shifting probability from private car and motorcycle users to the LRT.

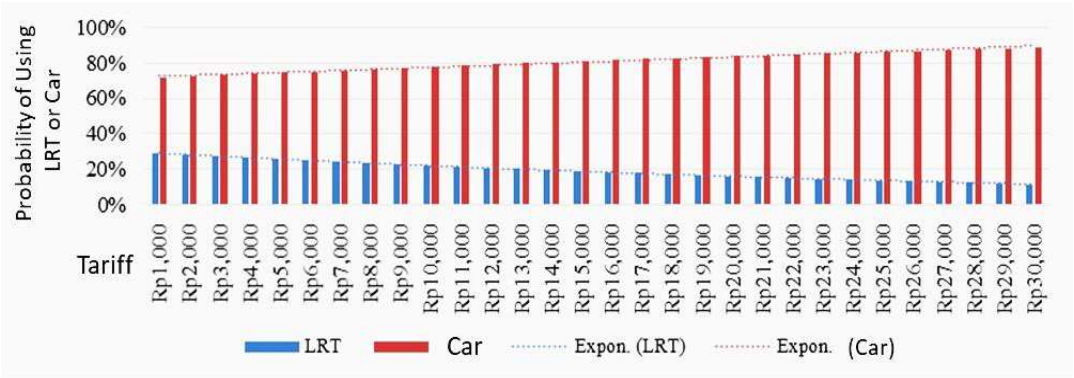

Figure 5. Tariff Sensitivity Analysis: LRT Jakarta vs Private Car

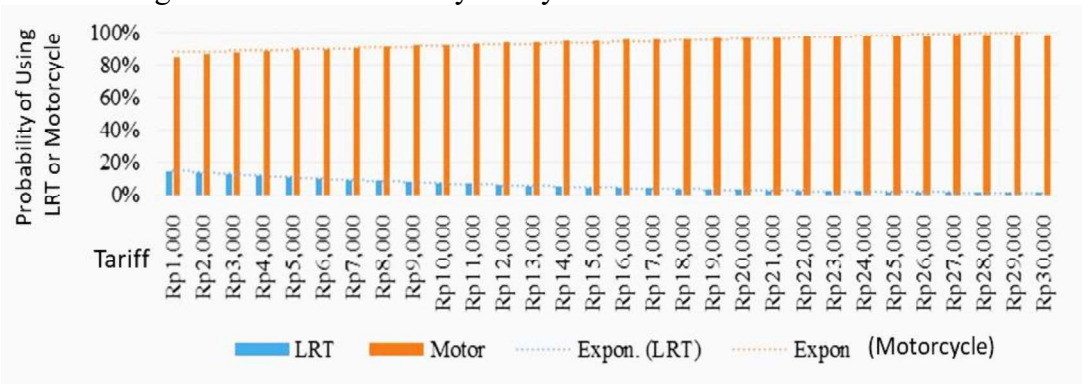

Figure 6. Tariff Sensitivity Analysis: LRT Jakarta vs Motorcycle

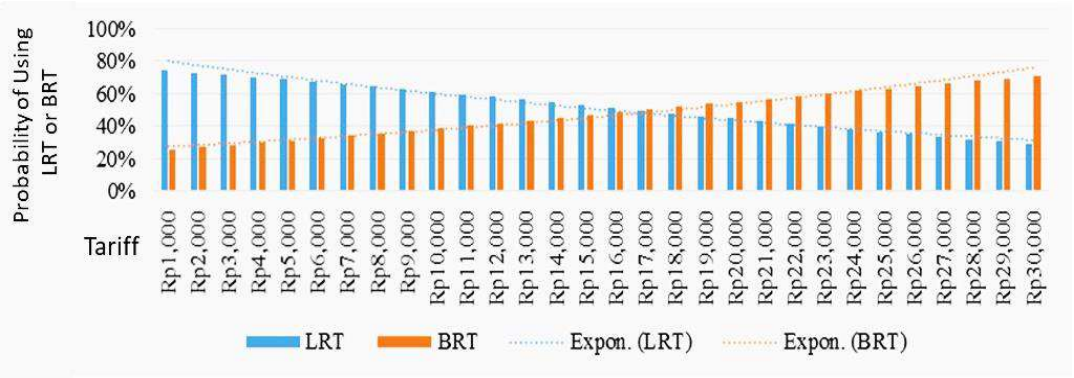

Figure 7. Tariff Sensitivity Analysis: LRT Jakarta vs Bus

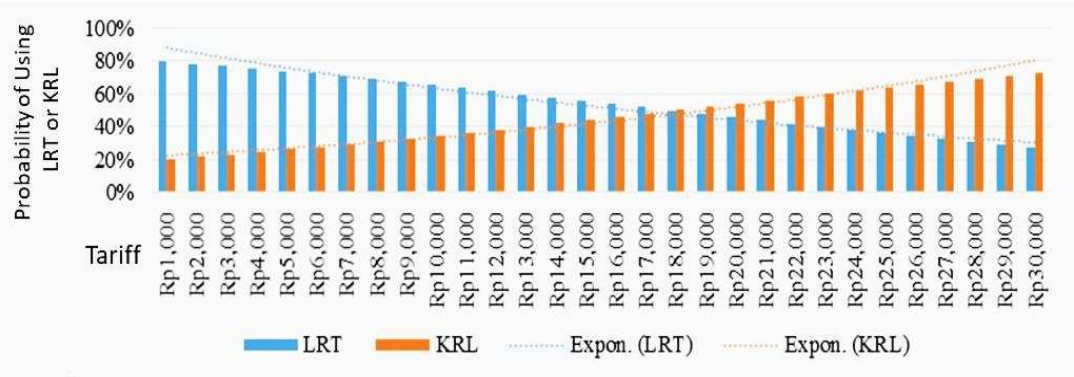

Figure 8. Tariff Sensitivity Analysis: LRT Jakarta vs KRL

In Figure 6 and Figure 7, the probability of people selecting LRT compared to the bus and train users for the LRT fare price of IDR 1,000 is consecutively 75% and 80%. A probability of 50% bus and train users shifts to the LRT is shown sequentially at the value of IDR 17,000 and IDR 18,000. The results show that bus and train users have significant flexibility to shift to the LRT.

Commuter train produces a significant shift compared to private vehicles since it is connected and integrated with the proposed LRT line in stations like Palmerah, Karet, Tebet, Klender, and Cakung. Trips coming from the Bekasi area heading to Kuningan Area may straightly transfer at Cakung station and using the Jakarta LRT heading to Kuningan. In addition, the Jakarta LRT also offers better service and comfort than the commuter train.

A similar trend with train users, a significant shifting also occurs on bus users, caused by its operating system over a mixed-traffic lane and suffers from traffic congestions, thus creating many delays. Another reason is that bus with a smaller capacity than the Jakarta LRT has caused an additional delay to wait for the bus to carry all waiting passengers.

3.2 Ability-to-Pay and Willingness-to-Pay Values

Table 2 indicated the value of ability-to-pay and willingness-to-pay for each transport mode. The ability-to-pay value is determined based on the availability of ability-to-pay per day. In terms of willingness-to-pay, the value is determined based on gap analysis between previous and target modes. Both willingness-to-pay values are presented below.

Table 2. Ability-to-Pay and Willingness-to-Pay Values (IDR/km)

Current Transport Users	Ability-to-Pay	Willingness-to-Pay	
		(Conventional)	(Time Value)
Overall	1,437	1,025	1,249
Public Transportation	1,139	975	1,051
Private Transportation	1,635	1,075	1,447

The value of ability-to-pay and willingness-to-pay for private transportation is the largest compared to others. The smallest value is conventional willingness-to-pay for public transport users. Further evaluation is carried out to formulate fare. The recommended fare is based on the willingness-to-pay analysis using the time value method, which does not exceed the ability-to-pay value for all transport modes.

3.3 Forecasted Ridership

The LRT line of Pulo Gebang-Joglo will serve 27 stations stretched along 32,25 km connecting the east part and west part of Jakarta. It will travel at an average speed of 30 km/hour with a headway of 5 minutes at peak hour and 10 minutes during the off-peak hour. The transit assignment indicated the potential ridership of 172,000 passengers per day at the beginning of its commercial operation in 2024. The results of the transit assignment of the Jakarta LRT are depicted in Figure 8.

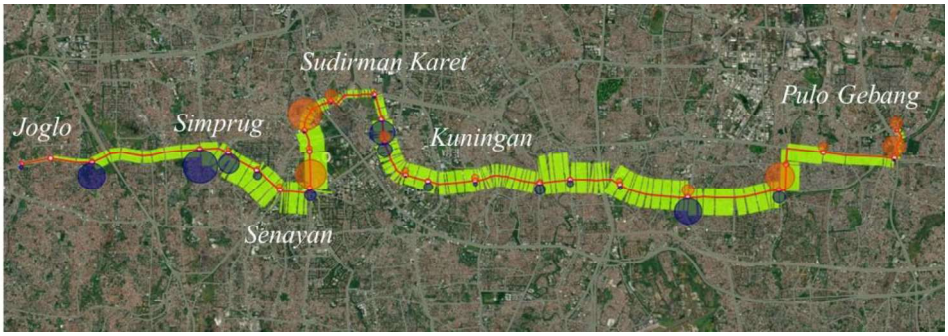

Figure 9. Total Passenger Volume and Boarding Alighting for the Pulo Gebang - Joglo LRT Corridor in 2024

Demand ridership is also analyzed based on each direction to identify the needs of facilities in each station. It is estimated that 84,000 passengers per day to the Joglo direction and 88,000 passengers per day to the Pulo Gebang direction. The Average Trip Length (ATL) for LRT Pulo Gebang - Joglo is 9.7 km. The boarding and alighting passengers profile in each station is shown in Table 3.

Table 3. Total Estimation of Boarding, Alighting, and Daily Flow of Passengers in Both Directions in 2024

Station	Weekday				Daily Pax Flow	
	Total boarding in both directions	Total Alighting in both directions	Gap	%	Pulo Gebang to Joglo	Joglo to Pulo Gebang
Pulogebang	4754	4730	24	1%	4754	0
Cakung	9665	9401	264	3%	11981	4730
Klender	3568	3916	348	10%	15549	11693
Raden Inten	1361	1282	79	6%	16831	15609
Duren Sawit	14665	14124	541	4%	21057	16812
Pondok Bambu	9674	10860	1186	12%	21761	20497
Basura City	3355	2526	829	25%	22597	22387
Kampung Melayu	4213	19033	4820	52%	20491	22394
Tebet	27384	13737	13647	50%	17308	35108
Kokas	2402	1933	469	20%	18172	18278
Kuningan City	1208	1875	667	55%	17471	18806
Ciputra World 1	3781	3386	395	10%	17717	18772
Benhil	9339	9180	159	2%	15190	18623
Karet Tengsin	7538	7741	203	3%	11228	15937
Karet	5059	4996	63	1%	8884	12178
Penjernihan	4518	4380	138	3%	9717	9771
Palmerah	12676	12436	240	2%	15077	10466
GBK	8381	8127	254	3%	10724	15586
Senayan Pemuda	13884	13687	197	1%	14224	10979
Kebayoran Lama	3043	3315	272	9%	13281	14282
ITC Permata Hijau	6606	5949	657	10%	9457	13611
Pos Pengumben	1920	1920	0	0%	9568	9130
Srengseng	4290	4498	208	5%	7393	9241
Botanical Junction	4841	4931	90	2%	4441	7274
Komplek DKI	2014	2049	35	2%	2392	4412
Joglo	2398	2392	6	0%	0	2398

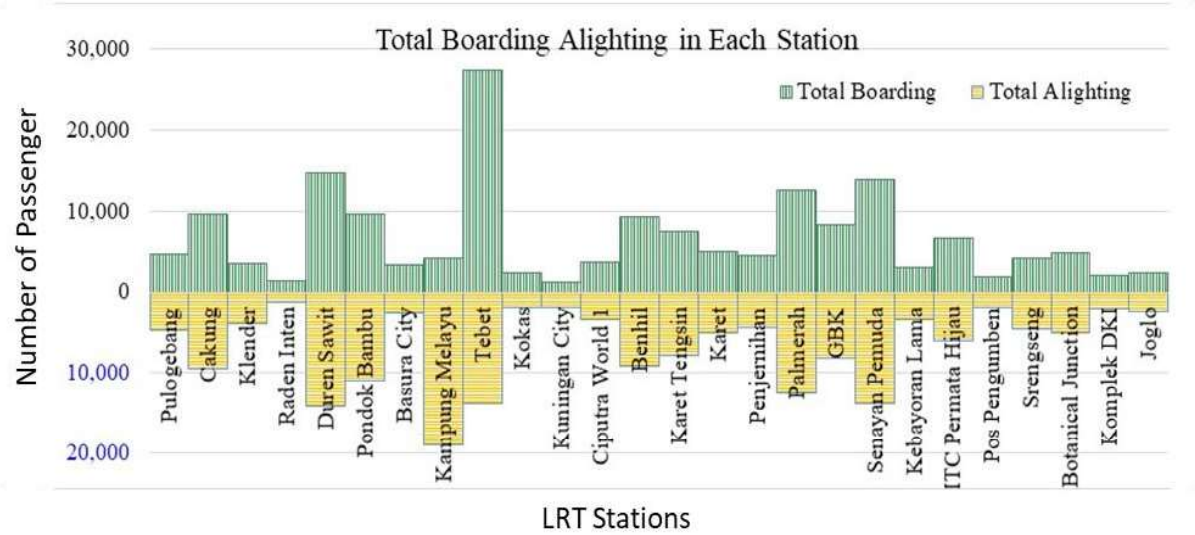

Figure 10. Total Boarding Alighting in Both Directions in 2024

As indicated in Table 3 and Figure 9, a significant boarding happens in Tebet station reflects transferred passengers from the commuter train of Jakarta-Bogor Line to the Jakarta LRT Line. The integration between those two networks resulted in the highest passenger loads on the Tebet station.

Daily passenger flows, as indicated in Figure 10, describes the passenger loads between stations. The passenger intensity in the western part of the corridor tends higher than in the eastern region. The station located in the east part is closed to the activity center. Its strategic location with the nearby station has created a more developed transit network, and integration with MRT and commuter train has affected the passenger loads significantly.

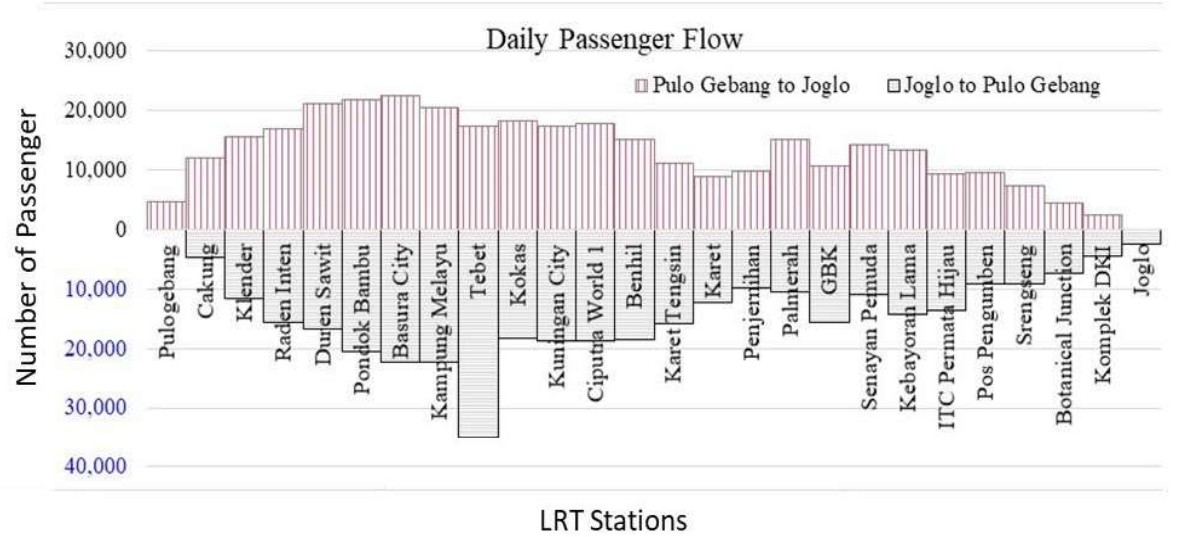

Figure 11. Daily Passenger Flows in Both Directions in 2024

The mode shifting from private transportation to mass public transit is considered to increase the use of public transportation. The potential shifting from private transport mode to The Jakarta LRT is shown in the following table.

Table 4. Potential Shifting from Private Vehicles to The Jakarta LRT

Year	% shifting only at LRT Line	% Shifting Whole Network
2020	3.22%	0.88%
2024	6.84%	1.89%
2030	9.40%	3.11%
2040	11.33%	4.04%
2050	12.41%	5.23%

Based on Table 4, it is indicated that when the commercial operation of LRT begins in 2024, only 6.84% of private vehicle users shift to the proposed LRT line and 1.89% for the overall network. A significant increase in shifting from private vehicles to the Jakarta LRT will happen from 2030 to 2050 due to the push and pull policy implementation of 60% trips using public transport in Jakarta.

The indicative ridership in the planning year is obtained after the transit assignment is conducted based on its time horizon and simulation scenarios. The decision to determine the concession period is by discussions with relevant stakeholders. This indicative demand is considered conservative since it has not yet included potential passengers derived from the accessibility improvement. Table 5 and Figure 11 shows the result of the demand forecast for the Jakarta LRT line.

Table 5. Demand Forecasting Indicative for LRT Line Pulo Gebang – Joglo

Year	Passenger bound to Joglo	Passenger bound to Pulo Gadung	Total
2024	84,504	88,032	172,536
2027	88,231	96,459	184,690
2030	100,364	114,935	215,299
2033	112,141	131,698	243,839
2036	119,422	141,763	261,185
2039	130,837	158,841	289,678

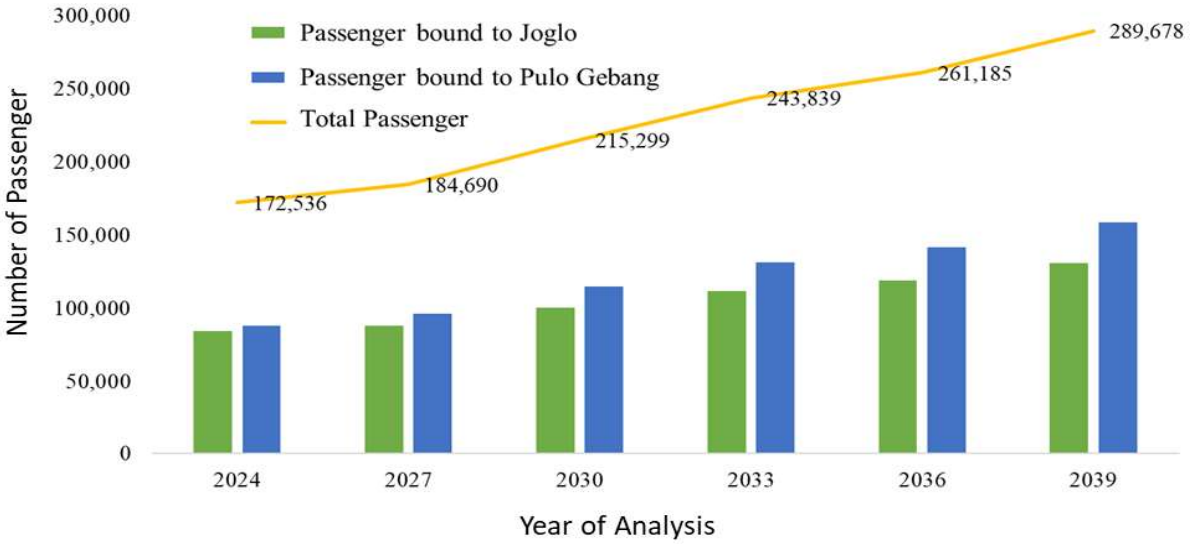

Figure 12. Demand Forecasting Indicative for LRT Pulo Gebang – Joglo

Based on Figure 11, it is indicated that from 2024 to 2039, there will be a positive increase in ridership, with an average increase per three years is 10.98%. The highest growth happens from 2027 to 2030, with a rise of 16.57%. The lowest is from 2024 to 2027, with a portion of 7.04%. The demand forecast may still increase significantly by improving the integration with other mass public transportation such as the Jakarta LRT of Kelapa Gading-Velodrome, Jabodebek LRT, Elevated Loopline, East-West MRT, North-South MRT, and Railway (KRL) development.

4 CONCLUSION AND FURTHER RESEARCH

The total ridership for the Jakarta LRT case study along the Pulo Gebang-Joglo corridor is 172,536 passengers in the first year of commercial operation in 2024. The total ridership in 2027 is 184,690, and for 2030, 2033, 2036, and 2039, the estimated ridership can be seen in Figure 11. The proposed LRT line shows a significant increase in ridership from 2024 to with an average rise per three years is 10.98%. Potential shifting from other public transportation modes (bus and train) to Jakarta LRT generates a major portion while shifting from transportation mode (private car and motorcycle) generates a relatively small portion of 6.84% in 2024.

It can be concluded that ridership can be optimized by extending the service line closer to the residential area and the accessibility improvement to the nearby station. Another method is mode integration in a particular station that increases ridership's possibility as mutual relationships within the transport networks. Therefore, it is essential to consider the integration concept when developing a new public transport service with existing networks to attract more passengers and ease of transfer.

Limitations on this paper can be developed for future research. Further investigation on detailed demand forecasting of the Jakarta LRT Pulo Gebang-Joglo line can be conducted by considering the improvement on the first and last mile conditions and the shifting behavior of public transport passengers. This further study is expected to capture potential additional ridership to optimize the Jakarta LRT service system shortly.

5 ACKNOWLEDGMENT

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