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# The Impact of LRT Jabodebek in Enforcing Capability of the Intercity Transportation Network in the Greater Jakarta Area

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***Abstract*— Jakarta, Bogor, Depok, Tangerang, and Bekasi (Jabodetabek or Greater Jakarta) is the greater capital region in Indonesia. Unfortunately, the fast growth of the population in Jabodetabek was not supported by a good growth or improvement of public transportation. The transportation network was predicted and evaluated to suffer considerable congestion by 2020. The current presence of Bus Rapid Transit and Commuter Line were insufficient to accommodate the current demand for the total number of trips in urban and suburban areas. Additionally, land availability and cost budgeting condition extend this issue to be more challenging. Thus, civil engineers and the government's decision and collaboration contribute a significant role in solving and suggesting an optimal decision to strengthening transportation in Jabodetabek. Light Rail Transit (LRT) becomes a prominent answer to solve this problem, integrating the suburban to an urban area and reduce the traveling time. This paper evaluates the impact of LRT Jabodetabek in improving the capacity of traffic for the Greater Jakarta area and measure the effectiveness of LRT Jabodetabek. From this study, the analysis showed the positive contribution of LRT Jabodetabek in improving the longing dilemma by 2025. The paper also suggested future development of LRT Jabodetabek in optimizing the effectiveness through expanding its routes.**

***Keywords*— public transportation; Light Rail Transit (LRT); greater Jakarta; trip generation; transportation capacity.**

## I. Introduction

In 2014 the number of vehicles on the Jakarta roads was 17.523 million, with annual growth of 10.5% for cars, 10.9% for motorcycles, and about 1% for buses [1] while the road network length grew only 0.01%. The travel demand in the Greater Jakarta (Jakarta, Bogor, Depok, Tangerang, and Bekasi) is expected to increase by 40% in 2020 compared to 2002, and if there is no improvement made on the existing transportation system, total congestion will occur by 2020 [2].

Nowadays, there are Bus Rapid Transit (BRT), 375,000 passenger/day, and Commuter Line, 800,000-900,00 passengers/day, as public transportation in Jakarta. Considering the need for transport capacity of mass transportation reached 17.29 million trips per day, the existing public transportation operation is not able to cover all demand from the inner and the outer city and even vulnerable to be damaged and collapsed due to overload traffic demand.

Interestingly, traffic demands in the Greater Jakarta area are dominated by suburban users. There are 1.47 million vehicles per day initiated from sub-urban over the overall gross 2.464 billion trips each day in Greater Jakarta's highways and roads [3]. To support social and economic activities, Jakarta and its sub-urban need a new public transportation system to anticipate a big traffic jam in the future. Light Rail Transit (LRT) becomes a prominent answer to solve this problem, integrating the suburban to the urban area and reduce the traveling time.

Light Rail Transit (LRT) systems have become a popular decision to support transportation sustainability and urban quality. These systems have the potential to address congestion, environmental, and connectivity issues at the regional level [4], [5]. Additionally, LRT stimulates the growth of economic activity in stations and transit-oriented development (TOD) areas [5]. This paper evaluates the impact of LRT Jabodebek in improving the capacity of traffic for the Greater Jakarta area and measure the effectiveness of LRT Jabodebek. The analysis of network capability was performed to determine the effectiveness of LRT Jabodebek in reducing the volume-to-capacity ratio (VC Ratio) of roads and highways traffic in the Greater Jakarta area. This study only considered the improvement of traffic capability and neglected the possibility of significant changes in land uses and social-behavior near stations and TOD areas. Therefore, the paper is intended to evaluate and appreciate the direct benefit of LRT Jabodebek in reducing congestion in the Greater Jakarta area.

## II. Materials and Method

### A. *Study Area*

The research was conducted in the Greater Jakarta Area. The Jakarta Government's spatial planning RTRW (*Rencana Tata Ruang Wilayah*) 2030 in Local Regulation No 1, 2012 [6] and The West Java Government's spatial planning 2009-2029 in Local Regulation No 22, 2010 [7] has stated the development of railways transportation systems and networks in the form of rail-based mass transportation including the LRT network.

In the design and planning process, there are some highlighted aspects in choosing LRT as solutions to serve and support the urban and the suburban area of Greater Jakarta, i.e.,

- Relatively *does not require land acquisition*
- Large transport capacity
- Affordable investment value
- On-time/travel time is guaranteed
- No Crossing with other transport modes
- Safety
- Environmentally Friendly
- Service Quality
- Aesthetics
- Operating Cost and Effective Maintenance
- Construction time is rapid
- Ease of integration and expansion corridor

The benefits of LRT incite the urgency in implementing LRT to provide an elevated infrastructure concept that alters limited available problem in Jakarta compared to BRT and expanding the commuter line.

The total length of the LRT Jabodebek is 82.93km. There are six design service lines across the Greater Jakarta area:

- Cawang-Cibubur
- Cawang-Kuningan-Dukuh Atas
- Cawang- Bekasi Timur
- Dukuh Atas-Palmerah-Senayan
- Cibubur- Bogor
- Palmerah-Grogol

These service lines were built periodically into two stages. The first phase is about 44.43km, which consists of three service lines, i.e., Cibubur-Cawang, Cawang-Bekasi, Cawang-Dukuh Atas.


Fig. 1 Total Length of LRT Jabodebek

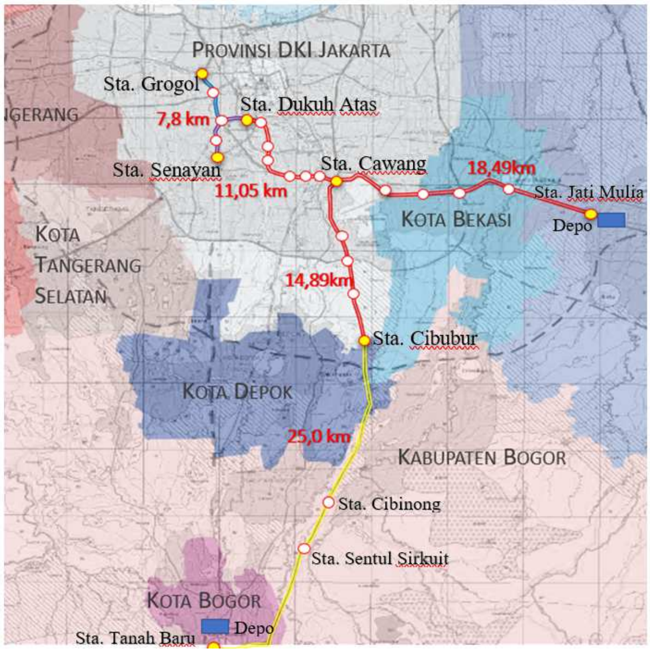


Fig. 2 Layout of LRT Jabodebek

Cawang area becomes the intersection of all lines in the first phase. The second phase is Dukuh Atas-Palmerah-Senayan-Bogor, with 38.5km total length. (See Fig. 1)

In general, there are at grade and elevated structures on this LRT Jabodebek. The elevated structure consists of bored/spun pile, pile cap, column, pier head, and U-Girder, as shown in Fig. 2. The selection of the type of structure depends on the existing land condition and government regulation. The maximum operational velocity is 80km/hour. The capacity of the train is 740 passengers under operational load and 1308 passengers under crush load. The train consists of two sets of trains, and each train set has six cars.

Fig. 3 Typical structure of LRT Jabodebek

Recently in 2019, LRT Jabodebek is still under construction by PT Adhi Karya (Persero) Tbk as design and build contractor. PT Kereta Api Indonesia will operate this Light Rail Transit in the future.

*B. Method*

The Four-Stage Model (FSM) is the most popular method in assessing the travel demand model for transportation and urban planning in macroscale evaluation.

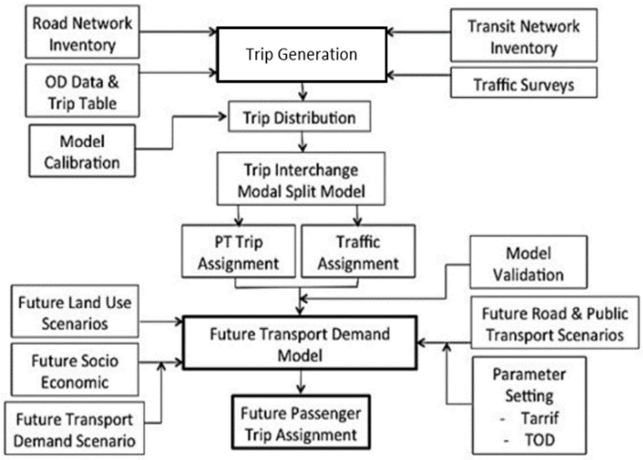


Fig. 4 Flowchart of the four-stage method (FSM)

In transportation planning, decision-making is essential to be evaluated as a holistic model considering socioeconomics, land use policy, and travel behavior of the studied transportation modes and urban areas [8]. This method provides four consecutive steps to account for those aspects, i.e., trip generation, trip distribution, modal choice, and trip assignment, as shown in Fig. 4.

The application of FSM is still a credible method for assessing the new plan and changes in mass public transportation in a specific region and social behavior. Several extensive studies showed that conventional FSM has sufficient and accepted accuracy in forecasting the traffic volume of the new plan transportation network at the regional level [9]–[11].

*1) Trip Generation*: The first step of the Four-Stage Model simulates the number of trip production and trip attractions for each zone. The analysis considers the number of trips generated according to socioeconomic, population, household income level, private car ownership, connectivity, and land use policy in each zone [12]–[14]. In this paper, the calculation of the total generated trip was assessed using direct dataset traffic volume and survey traffic counting in selected zones. These methods implicitly capture the variation of all socioeconomic aspects in developing the trip generation model of the Greater Jakarta area.

*2) Trip Distribution:* This step matches the trip makers' origins and destinations to develop a trip table (origin-destination matrix). The analysis is using the Gravity Model with balancing factors [8], [17] corresponding to the total generated trips from data collecting and TC survey. Gravity Model allows the splitting flow in desired zones and distributes the flow in the network links connecting all the zones in gravity interaction analogy.

*3) Modal Choice:* The Mode Choice aims to get the type of transportation mode used for the trip that has been defined in the previous step. In this paper, the used mode choice model is a trip end model. The survey stated preference for this analysis is a binary answer (yes or no question/ 1 or 0). Thus, the binomial logit model is the appropriate model for this analysis. This model showed two alternative choices, i and j.

$$P(i) = \frac{e^{(U_i - U_j)}}{1 + e^{(U_i - U_j)}} \quad (1)$$

$$P(j) = 1 - P(i) = \frac{1}{1 + e^{U_i - U_j}} \quad (2)$$

The probability choosing mode i is a utility function from the deviation of the two alternatives. Assume that the utility function is linear, then

$$U_i - U_j = a_0 + a_1\left(X_{1U_i} - X_{1U_j}\right) + a_2\left(X_{2U_i} - X_{2U_j}\right) + \dots + a_n\left(X_{nU_i} - X_{nU_j}\right) \quad (3)$$

*4) Trip Assignment:* The trip assignment is the fourth step on FSM. This stage determines the traffic volume assigned on the roads of the transportation network. In this stage, this paper used the result of the TC survey as the validation of the assigned trip with a volume-based approach. There are two standard methods for trip assignment analysis, as foll*ows:*

- Trip assignment on the Principle All-or-Nothing: The All-or-Nothing method allows the flow assignments to all possible links using designed impedance attributes without considering the capacity restraint. This model allows the flow to prioritize the shortest path in every iteration of scenarios. This method does not consider congestion effects, and road capacity does not affect their routes [18]. This method is suitable for applying to low-density areas.
- Trip assignment on Capacity Restraint Method: The capacity restraint method is also known as user equilibrium. In contrast to the All-or-Nothing model, this method considers the capacity restraint on each link in the network. This model is appropriate to illustrate the congestion condition. In the assignment process, the flow will not move at the same time, but incrementally and stop until the capacity has reached.

Based on the characteristics in each method, this paper performed the trip assignment stage using the Capacity Restraint Method. Hence, the study performed FSM to evaluate the improvement of traffic demand in the Greater Jakarta area due to the operation of LRT Jabodebek using TRANPLAN Software.

In addition, the traffic capacity model was performed on this paper. It is commonly constructed through the geometric attributes of the road sections. These attributes, then, would be converted into the maximum vehicle density on the roads. The model considers several geometric attributes, e.g., the width of lane, design speed, the total width of the road section, the junction position, the road alignment, the space between vehicles, and the land use policy. In Indonesia, the traffic capacity model practically follows MKJI 1997 [20]. This paper constructed the traffic capacity model using MKJI 1997 and enhancing the model with Highway Capacity Manual (HCM) 2010 [21]. Based on these two model references, the geometry data collection and traffic counting surveys were performed in supporting the model.

This paper constructed one traffic capacity model based on the road condition in the pre-construction stage of LRT Jabodebek. According to the design plan of LRT Jabodebek in expanding traffic capacity without reducing the existing road's geometry, this paper assumes that there would not be significant changes in the traffic capacity model representing the fully operated LRT Jabodebek in 2020. Therefore, the evaluation of transportation network capability in the next five years considers the same capacity as the pre-construction stage of the traffic capacity model.

## III. Result and Discussion

### A. Trip Generation

The data collection considers three types of traffic's infrastructure, i.e., freeway (intercity toll road and intraurban toll road), urban streets, and commuter lines' railways. These types of infrastructures are selected to represent all possible instruments in generating movement in the Greater Jakarta area.

The trip generated in freeway used an open-source dataset from Traffic Volume, JasaMarga, in 2016 [15]. This dataset provides the monthly traffic volume in toll road segments. In capturing the worst scenario of traffic volume, this paper considered the maximum monthly traffic volume in the whole of 2016. Then, the data collected from six considered toll road sections that serve the Greater Jakarta area, as shown in Table I.

The generated trip in the urban street was approached using traffic counting (TC) in selected zones near serving lines of LRT Jabodebek. There are 12 street segments and 16 stations of the local minibus and share taxis. For the street segments survey, the traffic was counted allocating all possible direction of movements in two window times, i.e., morning and evening times. For the station survey, the TC considered in and out local minibus and share taxi in three window times, i.e., morning, noon, and evening times. See Table II and Table III.

TABLE I
TRAFFIC VOLUMES IN TOLL ROAD SECTIONS

| Toll Road Sections | Vehicle/month | Vehicle/day $\times 10^6$ | Trip/day $\times 10^6$ |
|---|---|---|---|
| **Intraurban Toll Road** | | | |
| Cawang-Tomang-Cengkareng | 18,694,487.00 | 0.603 | 0.900 |
| **Intercity Toll Road** | | | |
| Jagorawi | 18,142,160.00 | 0.585 | 0.778 |
| Sedyatmo | 7,024,496.00 | 0.227 | 0.306 |
| Cikampek | 19,437,800.00 | 0.627 | 0.807 |
| Ulujami | 3,905,175.00 | 0.126 | 0.125 |
| Tangerang | 11,490,200.00 | 0.371 | 0.448 |
| **Total Toll Road Flow** | **78,694,318.00** | **2.539** | **3.364** |
| **Total Toll Road Flow Passing DKI Jakarta (in/out)** | **59,999,831.00** | **1.935** | **2.464** |

TABLE II
TRAFFIC VOLUMES IN URBAN STREET SEGMENTS

| Street Name | Total Trip | |
|---|---|---|
| | **Morning** | **Evening** |
| MT Haryono | 3,196 | 2,282 |
| Gatot Subroto | 19,575 | 9,718 |
| Rasuna Said (fast lane) | 6,463 | 7,504 |
| Rasuna Said (slow lane) | 4,656 | 6,530 |
| Rasuna Said (North Junction) | 2,681 | 3,128 |
| Rasuna Said (South Junction) | 5,055 | 3,641 |
| Rasuna Said (East Junction) | 4,438 | 2,887 |
| Rasuna Said (West Junction) | 3,770 | 4,426 |
| Pancoran | 10,087 | 13,586 |
| Tendean | 1,081 | 696 |
| Cikoko Barat | 762 | 648 |
| Otista-Dewi Sartika | 2,739 | 3,914 |

[a] The total trips have to consider all possible directions of traffic, including the U-turn in junction segments.

TABLE III
TRAFFIC VOLUMES IN MINIBUS-SHARE TAXI STATIONS

| MiniBus-Share Taxi Stations | Total Vehicles | | | | | |
|---|---|---|---|---|---|---|
| | **Morning** | | **Noon** | | **Evening** | |
| | **In** | **Out** | **In** | **Out** | **In** | **Out** |
| Sta. Harjamukti | 12,471 | 4,687 | 6,240 | 6,241 | 7,491 | 9,669 |
| Sta. Ciracas | 5,132 | 1,935 | 2,571 | 2,572 | 3,088 | 3,981 |
| Sta. Kampung Rambutan | 26,160 | 19,979 | 39,240 | 36,493 | 33,860 | 28,917 |
| Sta. Cawang | 17,460 | 18,355 | 14,018 | 14,919 | 20,382 | 18,115 |
| Sta. Ciliwung | 15,752 | 22,332 | 15,232 | 16,485 | 23,231 | 18,584 |
| Sta. Cikoko | 14,509 | 24,095 | 15,609 | 17,032 | 24,355 | 18,486 |
| Sta. Pancoran | 86,653 | 60,326 | 180,654 | 106,517 | 5,945 | 3,462 |
| Sta. Rasuna Said | 3,176 | 8,111 | 5,298 | 5,453 | 7,715 | 5,131 |
| Sta. Setiabudi | 1,216 | 3,114 | 1,798 | 2,001 | 2,959 | 1,974 |
| Sta. Dukuh Atas | 3,210 | 6,614 | 4,028 | 4,441 | 6,465 | 4,588 |
| Sta. Jatimulya | 10,932 | 20,155 | 19,976 | 16,730 | 20,068 | 14,503 |
| Sta. Bekasi Barat | 9,608 | 14,431 | 13,282 | 12,576 | 25,508 | 21,446 |
| Sta. Cikunir 2 | 3,865 | 10,977 | 6,200 | 6,927 | 10,312 | 6,695 |
| Sta. Cikunir 1 | 3,225 | 9,244 | 5,221 | 5,833 | 8,684 | 5,638 |
| St. Jatibening Baru | 3,436 | 9,758 | 5,511 | 6,157 | 9,167 | 5,951 |

The trip generated in commuter lines were collected open-source dataset in 'Statistik Komuter Jabodebek 2014', Badan Pusat Statistik[16]. The report provides the total number of passengers monthly in a year and the operational schedule of the commuter lines. The direct relation of these variables could produce a direct generated trip/day from the Komuter Jabodebek railway. Then, the summary of total trips generated in the Greater Jakarta area is shown in Table IV.

TABLE IV
SUMMARY TRAFFIC VOLUMES OF THE GREATER JAKARTA AREA

| Toll Road Sections | Vehicle/day $\times 10^6$ | Trip/day $\times 10^6$ | % of Total Trips |
|---|---|---|---|
| ***Commuter Movement*** | | | |
| Toll Road | 1.94 | 2.46 | 14.25% |
| Non-Toll Road | 0.59 | 0.99 | 5.72% |
| Railway | 0.49 | 0.49 | |
| Total Trips on Road | 2.53 | 3.45 | |
| Total Trips incl. Rail | 3.02 | 3.94 | 22.81% |
| ***DKI Jakarta Movement*** | | | |
| Total Trips on Road | | 13.350 | 77.19% |
| ***Commuter and DKI Jakarta Movement*** | | | |
| **Total Trips on Road** | | **16.804** | |
| **Total Trips incl. Rail** | | **17.294** | **100.00%** |

*B. Trip Distribution*

In this paper, there were 415 selected zones around the Greater Jakarta area to distribute the generated traffic flow. Gravity Model allows the splitting flow in desired zones and distributes the flow in the network links connecting all the zones in gravity interaction analogy. The selected zones represent the nodes of the network, and the interactions represent the link. Figure 5 describes the Origin-Destination Desire Line Network as a result of balancing and splitting flow from the Gravity Model.

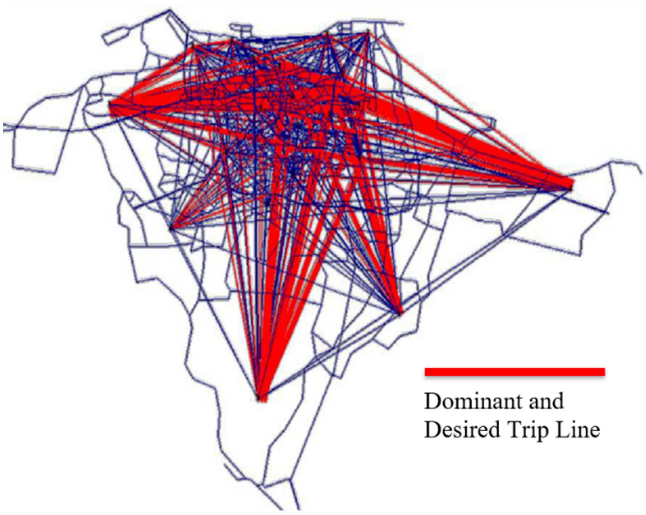


Fig. 5 The trip desired line (origin-destination) in the Greater Jakarta area

*C. Mode Choice*

Stated Preference Survey conducted at some different location to get the information from the society which use private vehicles and public transport. The total number of respondents is 200 respondents. The level of education is classified as Elementary School (0%), Junior High School (JHS) (4%), Senior High School (SHS) (48%), University (48%). Figure 6 and Figure describe the categorical cluster of respondents according to mode usage and the level of education.

The survey intentionally was designed to capture the preference of society to choose LRT Jabodebek as their mode with several ranges of tickets fare and scenario of time benefits. The survey brings results in several conditions, as shown in Figure 7-11.

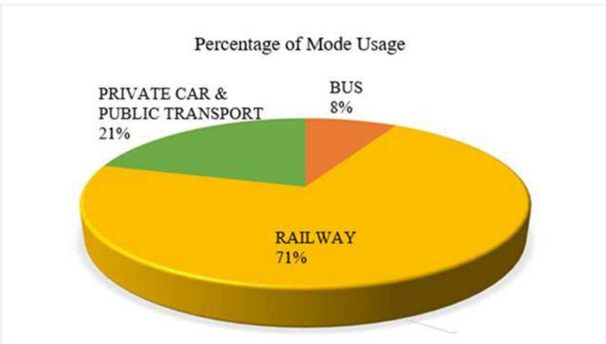


Fig. 6 Respondents transportation mode usage

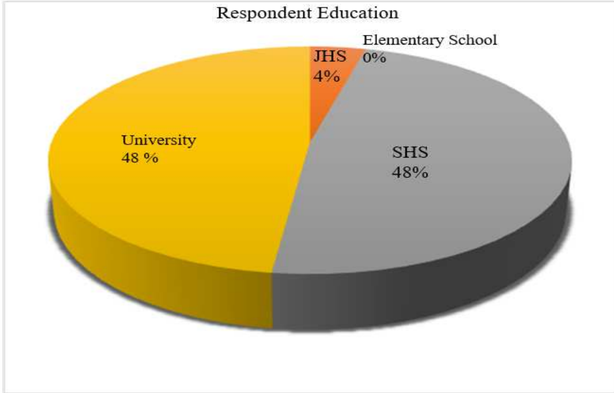


Fig. 7 Respondents level of education

Figure 8 presents the scenario of LRT being able to cut the travel time 5-10 minutes. Most of the respondent's desire to pay IDR 7,500. Figure 9 shows that by cutting travel time 11-15 minutes, 89 respondents desire to pay IDR 10,000, and 87 respondents desire to pay IDR 7,500.

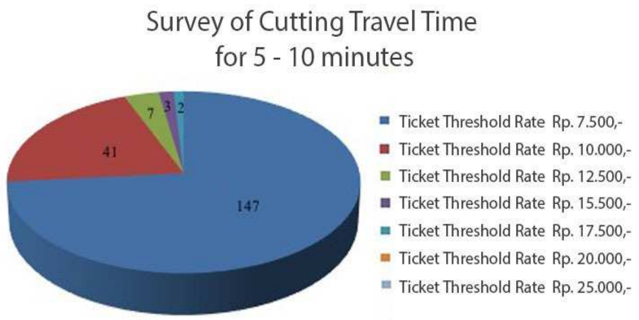


Fig. 8 Respondent ticket preference by cutting travel time 5-10 minutes


Fig. 9 Respondent ticket preference by cutting travel time 11-15 minutes

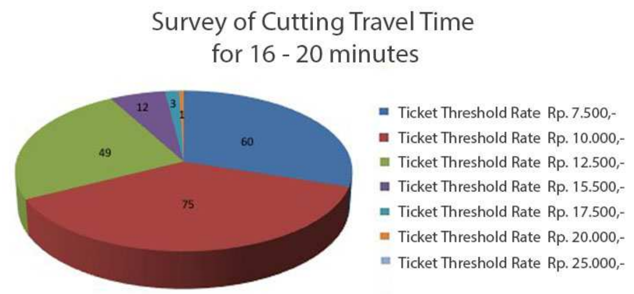


Fig. 10 Respondent ticket preference by cutting travel time 16-20 minutes

Figure 10 presents the scenario of LRT being able to cut the travel time 16-20 minutes. There were seventy-five or most respondents, desire to pay IDR 10,000, as shown in Figure 10. Figure 11 presents the scenario of LRT being able to able to cut the travel time 21-25 minutes. There were sixty-one or most respondents, desire to pay IDR 10,000, as shown in Figure 11. Figure 12 presents the scenario of LRT being able to able to cut the travel time 26-30 minutes—most of the respondents or about fifty respondents desire to pay IDR 10,000.


Fig. 11 Respondent ticket preference by cutting travel time 21-25 minutes


Fig. 12 Respondent ticket preference by cutting travel time 26-30 minutes

There are several types of transportation modes for Binomial Logit Model analysis, such as buses to LRT, the commuter line to LRT, public transport only (a combination of bus and commuter line) LRT, private vehicles to LRT and combination of all non-LRT to LRT. See Table V – IX.

TABLE V
UTILITY FUNCTION FOR BUS TO LRT

| **Regression Model** | **Regression Coeff.** | **Wald** | **df** | **Sig** |
|---|---|---|---|---|
| Constant | 6.061 | 98.613 | 1 | 0.001 |
| Time Difference with LRT (X1) | 0.061 | 10.791 | 1 | 0 |
| LRT's fare (X2) | -0.621 | 159.21 | 1 | 0 |
| *Nagelkerke R Square* | 0.713 | | | |
| **U = 6.061 + 0.061 X1 - 0.621 X2** | | | | |

TABLE VI
UTILITY FUNCTION FOR COMMUTER LINE TO LRT

| **Regression Model** | **Regression Coeff.** | **Wald** | **df** | **Sig** |
|---|---|---|---|---|
| Constant | 5.075 | 721.964 | 1 | 0 |
| Time Difference with LRT (X1) | 0.112 | 326.659 | 1 | 0 |
| LRT's fare (X2) | -0.634 | 1391.993 | 1 | 0 |
| *Nagelkerke R Square* | 0.722 | | | |
| **U = 5.075 + 0.112 X1 - 0.634 X2** | | | | |

TABLE VII
UTILITY FUNCTION FOR BUS AND COMMUTER LINE TO LRT

| **Regression Model** | **Regression Coeff.** | **Wald** | **df** | **Sig** |
|---|---|---|---|---|
| Constant | 5.241 | 629.8 | 1 | 0 |
| Time Difference with LRT (X1) | 0.116 | 251.168 | 1 | 0 |
| LRT's fare (X2) | -0.631 | 1170.835 | 1 | 0 |
| *Nagelkerke R Square* | 0.725 | | | |
| **U = 5.241 + 0.116 X1 - 0.631 X2** | | | | |

TABLE VIII
UTILITY FUNCTION FOR PRIVATE VEHICLE TO LRT

| **Regression Model** | **Regression Coeff.** | **Wald** | **df** | **Sig** |
|---|---|---|---|---|
| Constant | 5.048 | 193.38 | 1 | 0 |
| Time Difference with LRT (X1) | 0.115 | 83.496 | 1 | 0 |
| LRT's fare (X2) | -0.648 | 377.309 | 1 | 0 |
| *Nagelkerke R Square* | 0.712 | | | |
| U = 5.048 + 0.115 X1 - 0.648 X2 | | | | |

TABLE IX
UTILITY FUNCTION FOR BUS, COMMUTER LINE, AND PRIVATE VEHICLE TO LRT

| **Regression Model** | **Regression Coeff.** | **Wald** | **df** | **Sig** |
|---|---|---|---|---|
| Constant | 5.158 | 821.082 | 1 | 0 |
| Time Difference with LRT (X1) | 0.115 | 333.425 | 1 | 0 |
| LRT's fare (X2) | -0.631 | 1,553.834 | 1 | 0 |
| *Nagelkerke R Square* | 0.72 | | | |
| **U = 5.258 + 0.115 X1 - 0.631 X2** | | | | |

### *D. Trip Assignment*

In capturing the effectiveness of LRT Jabodebek, the paper tried to measure the improvement of transportation network capability in the Greater Jakarta area. The assessment was conducted by presenting the reduced volume-to-capacity ratio (VC Ratio) of roads and highways traffic in the Greater Jakarta area. Thus, this paper constructed three travel demand models to delineate the reductions on the network. The models consider the demand for the pre-construction phase, the demand for the post-construction phase, and the demand in the next five years of operation.

This paper assumes that the demand in different time windows increases with the compound growth rate. According to the theory of trip generation, socioeconomic features represents the characteristic of the growth of travel demand in the studied area [12]. The gross domestic product is appropriate in illustrating the socioeconomic condition [8]. Thus, this paper constructed the travel demand model for several time windows using the growth rate of Indonesia ON 2017 GDP, 5.1% annually [19].

Figure 13 shows the travel volume demand of the Great Jakarta area in 2017. In general, the total traffic volume in the intraurban area is around 70,000-90,000 vehicles/day. However, there are significant travel demand (>90,000 vehicles/day) around Tangerang, Bekasi, Taman Mini, and Kampung Rambutan. This condition indicates the high demand for passing in/out to DKI Jakarta. This condition confirms the necessity of LRT Jabodebek in serving the Greater Jakarta area.

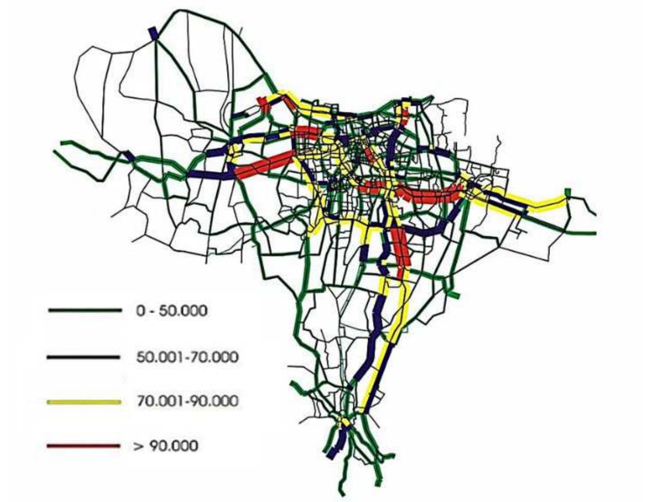


Fig. 13 The travel demand model for the Greater Jakarta area in the pre-construction stage (2017)

Figure 14 shows the forecasted volume demand of the Great Jakarta area in 2020 at the post-construction phase of LRT Jabodebek (not fully operated). On average, the model indicates a reduction of the total traffic volume in the intraurban area to around 50,000-70,000 vehicles/day. However, the predicted model shows several significant travel demands (>90,000 vehicles/day) around the intraurban roads, Tangerang, Bekasi, Taman Mini, and Kampung Rambutan. The increasing demand on the intraurban roads illustrates the effect of the growth rates. However, the model consistently indicates the high demand for passing in/out to DKI Jakarta. In this stage, there is no significant improvement shown by the operation of LRT Jabodebek.

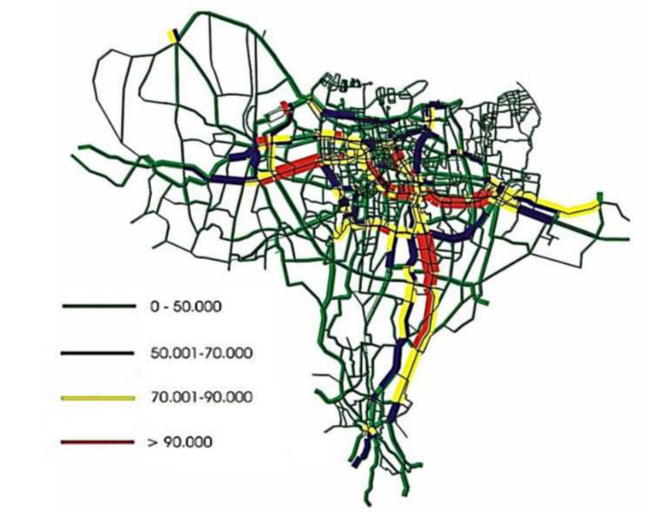


Fig. 14 The forecasted travel demand model for the Greater Jakarta area in post-construction stage (2020)

Figure 15 shows the forecasted volume demand of the Great Jakarta area in 2025 at the full performance of LRT Jabodebek. After being operated for five years, the model indicates the significant reduction of the volume of vehicles/day. The total traffic volume in the intraurban area is reduced to <50,000 vehicles/day. The travel demand in overall connection to pass in/out DKI Jakarta is reduced to 50,000-70,000 vehicles/day. Interestingly, the model consistently indicates the high demand for passing in/out to DKI Jakarta. The presence of LRT Jabodebek proves a valuable improvement by reducing the total demand for vehicles/day on road-based trips.

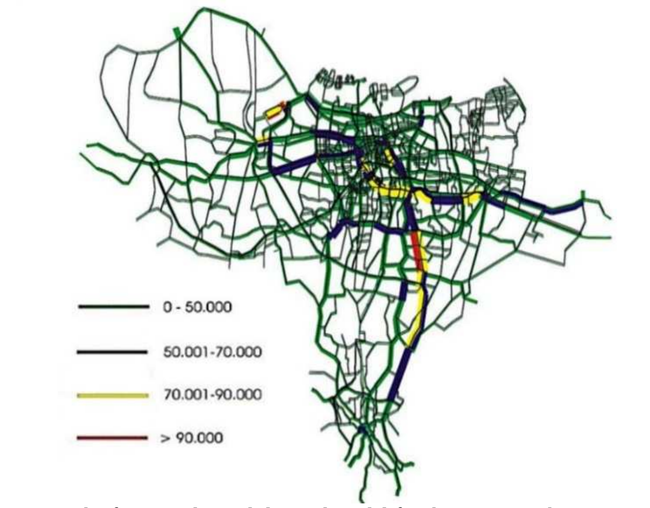


Fig. 15 The forecasted travel demand model for the Greater Jakarta area in full operation for five years (2025)

### *E. Transportation Network Capability*

Furthermore, the analysis of network capability was performed to determine the effectiveness of LRT in reducing the volume-to-capacity ratio (VC Ratio) of roads and highways traffic in the Greater Jakarta area. Accordingly, the primary purpose of LRT is integrating accessibility and mobility of Greater Jakarta into Jakarta. For connecting the suburban area, intercity public buses and personal cars become the dominant transportation options to serve suburban residents into the urban area. These types of transportation interestingly are accommodated by roads and highways, which have a fixed traffic capacity. This paper strategically implements this characteristic of predicted daily traffic and fixed capacity of roads and highways to determine the LRT Jabodebek's effectiveness. Instead of simulating the network generation of LRT Jabodebek, this paper evaluated the efficacy of LRT Jabodebek by measuring a reduction of VC ratio of roads and highways traffic in Jakarta when LRT Jabodebek entirely operated.

This paper constructed three transportation network capability models to delineate the reductions on the network. The models consider the demand for the pre-construction phase, the demand for the post-construction phase, and the demand in the next five years of operation. These models are constructed using three travel demand models and one traffic capacity model.

Figure 16 shows the VC ratio across the Greater Jakarta area in 2017 with the pre-construction phase. The model shows that the transportation capability inside DKI Jakarta is almost reaching its limit. On average, the overall network in DKI Jakarta has a VC ratio of around 0.76-0.98. From this condition, the model proves the necessity of expanding the traffic capacity inside DKI Jakarta. For the outer side of DKI Jakarta and the Greater Jakarta area, the transportation network is insufficient to serve the traffic demand. This area is dominated by the VC ratio >0.98. Interestingly, Figure 13 only arguably indicates that the enormous demand occurred only in several locations in the Greater Jakarta area. This condition conveys that the existing traffic capacity in the outer side of DKI Jakarta and Greater Jakarta area is lower than the inside of DKI Jakarta and insufficient to serve the movement of commuter passing in/out DKI Jakarta. This model precisely depicts the dilemma in the current condition in the Greater Jakarta area.

Figure 16 shows the estimated VC ratio across the Greater Jakarta area in the post-construction phase, the year of 2020, and Figure 17 shows the estimated VC ratio across the Greater Jakarta area with LRT entirely operated for five years operation. The result pointed out a significant reduction in the number of existing cars in roads and highways when LRT is operated in 2025. However, there is no substantial reduction in traffic volume in 2020. This condition indicated that the effectiveness of LRT would not be significant in the first year

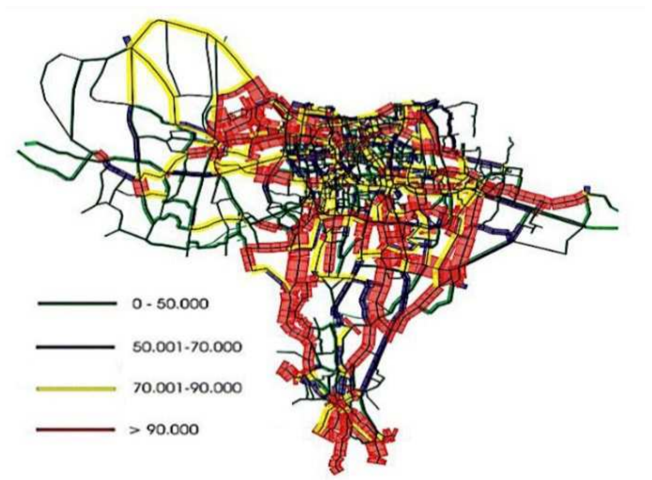


Fig.16 The VC Ratio Model for the Greater Jakarta area in the pre-construction stage (2017)

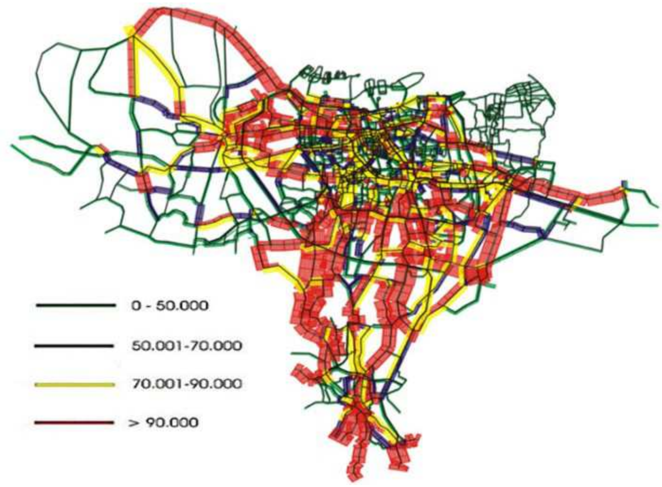


Fig. 17 The VC Ratio Model for the Greater Jakarta area in post-construction stage (2020).

## IV. Conclusion

Based on the analyses above, it can be concluded that: LRT Jabodebek is planned and designed for integrating the traffic that is linked and generated from suburban into an urban area. The three service routes of LRT are strategically arranged to answer the dominant traffic desire from sub urban.Due to the limited available space in Jakarta and to optimize the budget, LRT Jabodebek provides an elevated infrastructure that intensifies the existing land use for expanded transportation needs. The traffic capability analysis shows that LRT Jabodebek is improving the VC ratio of overall traffic in Jakarta and the Greater Jakarta area. The optimal significance of improvement is estimated to be achieved in 2025. Based on the current proposed LRT Jabodebek routes, Tangerang and Depok remain vulnerable to congestion in the year 2025 because there is no direct route that serves these areas. Inspired by the currently estimated effectiveness, future development to expand the routes becomes a suggestion.

## Nomenclature

| | |
|---|---|
| $P(i)$ | probability using mode i |
| $U_i$ | utility in choosing mode i |
| $U_i - U_j$ | difference of utility of mode i and mode j |
| $a_0$ | constant utility difference |
| $a_1, a_2, \ldots, a_n$ | coefficient of each attribute from the least-squares multiple linear regression vs. the probability maximum |

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