

## AFFORDABILITY ASSESSMENT TO IMPLEMENT LIGHT RAIL TRANSIT (LRT) FOR GREATER YOGYAKARTA

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### ABSTRACT

The high population density and the increasing visitors in Yogyakarta aggravate the traffic congestion problem. BRT (Bus Rapid Transit) services, Trans Jogja has not managed to solve this problem yet. Introducing Light Rail Transit (LRT) has been considered as one of the solutions to restrain the congestion in Greater Yogyakarta. As the first indication that the LRT can be built in Greater Yogyakarta, the transportation affordability index was used to understand whether the LRT tariff was affordable. That tariff was calculated based on government policy in determining railway tariff. The forecasted potential passengers and LRT route have been analyzed as the previous steps to get LRT tariff. Potential passenger was forecasted from gravity mode, and the proposed LRT route was chosen using Multi Criteria Decision Analysis (MCDA). The existing transportation affordability index was calculated for comparison analysis using the percentage of the expenditures for transportation made by monthly income of each household. The result showed that the LRT for Greater Yogyakarta was the most affordable transport mode compared to the Trans Jogja Bus and motorcycle. The affordability index of Tram Jogja for people having average income was 10.66% while another people with bottom quartile income was 13.56%.

**Keywords:** Greater Yogyakarta, LRT, affordability.

### 1 INTRODUCTION

Yogyakarta plays roles as a city of education and tourism attracting people to come (Yogyakarta Government, 2002). The high population density and the increasing visitors could have effects not only on the traffic conditions in Yogyakarta but also on the development of Greater Yogyakarta. In fact, Greater Yogyakarta already has BRT (Bus Rapid Transit) services called Trans Jogja and commuter in the mainline railways to serve its residents movement. However, Trans Jogja has not operated optimally and the existing mainline leaves large portions of Greater Yogyakarta without guided transport services. This condition encourages people to use private vehicle. Koeswando (in Antara, 2012) discovered that some roads in Yogyakarta are close to the 0.75 of V/C ratio which means the number of vehicles in the road nearly closes to the road capacity. Munawar (in Grehenson, 2008) analyzed that there are 35 percent of major roads in Yogyakarta, which would be totally jammed by 2015 and the number of affected road would increase by 55 percent in 2025 if there is no improvement in transportation systems. Introducing tram and monorail could be one of the solutions in order to restrain the congestion in urban area. It should be noted that the advantages of tram are its

high reliability due to it has own track, high capacity and environmentally friendly.

In order to implement Light Rail Transit (LRT) system for Greater Yogyakarta, the affordability index of existing transports needs to be analyzed first to understand how much the transportation expenditure of a household and how big the demand of transport. The possible routes of LRT could be proposed to accommodate those potential passengers. In the end, the affordability index of LRT for Greater Yogyakarta could be determined. The LRT would be built to provide the new affordable transportation option by improving the quality, quantity and land use accessibility to reduce the travel distance. There were some limitations in this thesis:

- a) It discussed the affordability index of motorcycles, local bus and Trans Jogja as the existing transport mode.
- b) It did not consider the willingness to pay and detail construction.
- c) Some assumptions were used in calculations with a reasonable number.

## 2 AFFORDABILITY INDEX

Affordability can be defined as the ability of people to use their household income to obtain basic goods and services (VTPI, 2012). In transport case, it means that even people with lower income can purchase the access to basic goods and services without any worries. Carruthers *et al.* (2005) agreed that a family which has low income should be able to purchase the necessary trips like work, school, health and other social services or other urgent journeys without having to limit other important activities. In order to know the ability of people in purchasing the transportation, he uses the affordability index as a measurement.

Affordability index could be defined as a percentage of the expenditures for transportation made by a household over its income. The higher percentage of affordability index means that the affordability of transport is lower due to people find that it is difficult to buy a ticket. In other words, the decreasing income and the increasing travel cost make the transport unaffordable for some household.

There is a critical percentage for transportation affordability so that the household income is not spent too much on access. Mostly, the affordability is not more than 20% of budgets on transport and less than 45% if transport and housing costs are combined. Evaluation of transportation affordability can be reviewed from the number of vehicles that a household must own, the costs of owning and driving each vehicle, indirect costs, such as parking and the quality and cost of alternative modes, such as walking, cycling, bus, taxi and ridesharing (Litman, 2011). A research proved that the 25 percent of income from household living in auto-dependent communities is spent on transportation whilst the household living in transit-rich communities needs to use nine percent of their income on transportation out of the toll fee. A higher income will give the passengers more opportunities to satisfy their need (Yusoff *et al.*, 2010).

## 3 NECESSARY PROCEDURES

The LRT was planned for Greater Yogyakarta which consists of Yogyakarta city, some regions of Bantul regency and Sleman regency. The reasons were because Yogyakarta is the municipality of Yogyakarta Special Region and regencies of Bantul and Sleman have population densities over 1,500 per square kilometer far higher than the other regencies and effectively are resident areas of people who have activities at Yogyakarta.

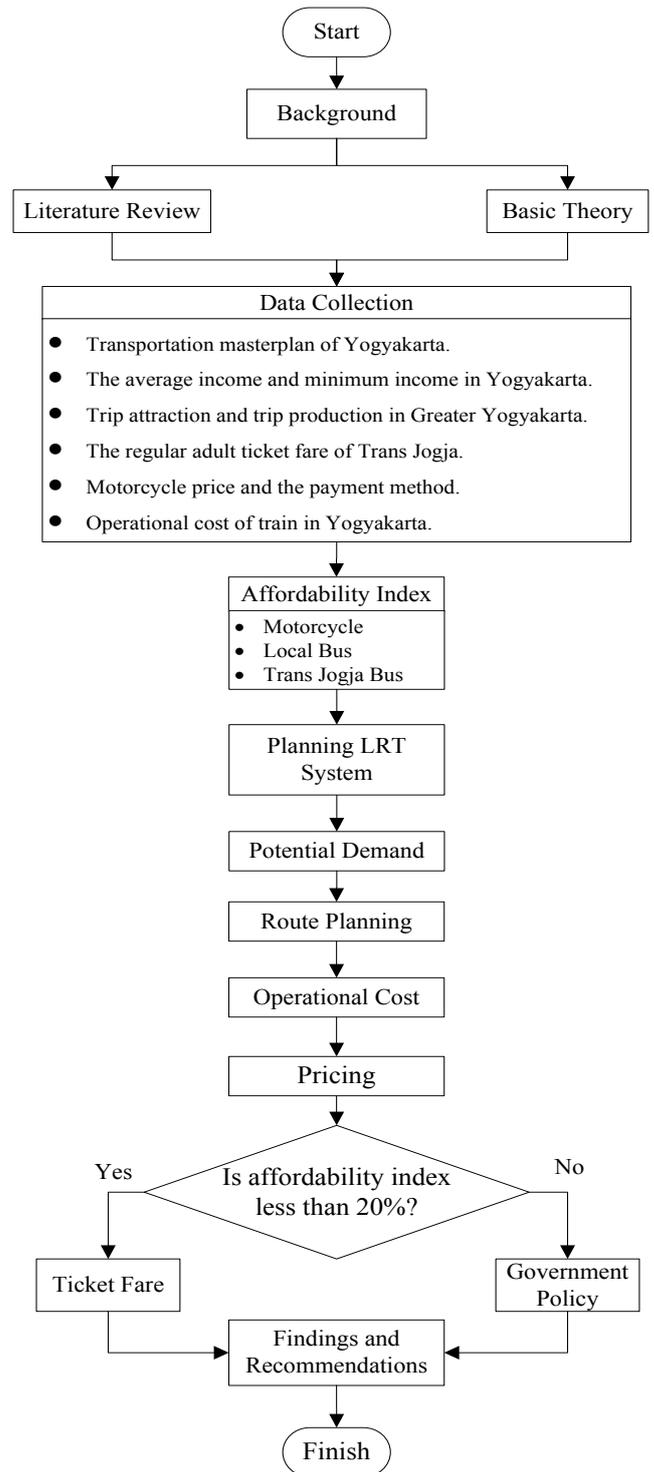


Figure 1. Research flowchart.

This research was started with collecting the data from various reliable sources including the transportation master plan of Yogyakarta and the income of people in Greater Yogyakarta. Then, the analysis were carried out using systematic steps in order to make the research were easy to be analyzed (see Figure 1). There were several steps in the analysis:

- a) The existing transportation affordability index was calculated using the percentage of the expenditures for transportation made by a household in a month over the monthly income of that household earns. The transport modes that were calculated are motorcycle (as private vehicle) and Trans Jogja bus (as public transport).
- b) In introducing LRT, the potential demand was forecasted using the matrix of origin destination so that the trip production and attraction were determined.
- c) The LRT routes were proposed to link some areas by considering the road width, possible locations of parking lots and disused tracks. A route that will be built firstly was determined using MCDA. The route planning was carried out in order to calculate the operational cost of LRT.
- d) The operational cost was calculated using the Permen no 28/2012 so that the ticket fare of LRT was able to be predicted. As a result, the transportation affordability of LRT was known whether it is affordable.

## 4 RESULTS AND DISCUSSIONS

### 4.1 Affordability of Existing Transport Mode

The cost for using bus services was calculated from the tariff for 60 trips while the motorcycle cost was calculated from the initial cost and operational cost reduced by the salvage value for 5 years use. Using the average salary of IDR 1406.991k per month and the bottom quartile salary of IDR 1106.465k (calculated using the lower quartile formula based on data from BPS Yogyakarta), the affordability of the existing transport modes were calculated in Table 1 and Table 2.

### 4.2 The Demand of Transport

The potential passengers were forecasted in 2019, when the LRT was planned to operate, using gravity model. In the matrix of origin destination, the total of trip production and the total of trip attraction were needed to be equal. Therefore, each trip attraction was multiplied by the modification factor (*f*).

The distance between two districts in Greater Yogyakarta measured with Google Earth was used for the  $C_{ij}$  parameter. Based on that, the average  $C_{ij}$  was 7.64 km. By using the *k* factor of two, the  $\beta$  value was obtained 0.262. The result of matrix of origin destination showed the trip distribution of 24 districts in Greater Yogyakarta which has 1,611,017 potential trips in 2019.

Table 1. Affordability index of bus service in Yogyakarta

Public Transport	Ticket Fare (in IDR)		Affordability Index	
	per trip	60 trips	average	bottom quartile
Tariff Local Bus	2,500	150,000	10.66%	13.56%
Tariff Trans Jogja	3,000	180,000	12.79%	16.27%

Table 2. The affordability index of motorcycle

Type	Cost	motorcycle cost per month	
Initial cost	21,892,000	Rp431,288.02	
Operational cost	9,350,000	affordability index	
Salvage value	5,005,312	average	bottom quartile
Total	26,236,688	30.65%	38.98%

## 4.3 LRT Routes for Yogyakarta

### 4.3.1 Route Planning

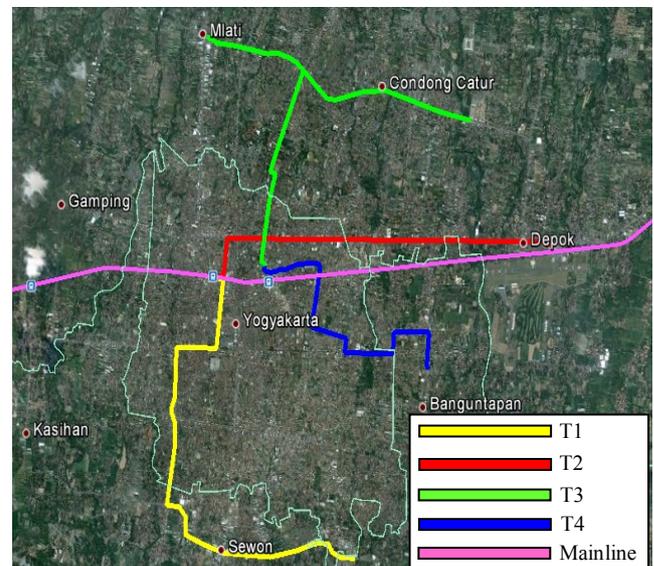


Figure 2. The proposed LRT routes of Greater Yogyakarta.

Using some main considerations such as road width, disused track and park & ride building, there were four proposed routes for Yogyakarta:

- a) Line *T1* – This route has 10.4 km long linking Tugu train station and Giwangan bus station via city center (kraton and CBD Malioboro).
- b) Line *T2* – This route has 8.96 km long linking Adi Sucipto airport and Tugu station via CBD Yogya Solo Street.
- c) Line *T3* – It started from Kridosono Stadium and branched at Kaliurang crossroad to Jombor Bus Station and to Casa Grande real estate area. This route has total length of 10.56 km

- d) Line *T4* – Line *T4* was the shortest route connecting Banguntapan (resident area) and Gondokusuman (school and working areas). It has 6.68 km length.

#### 4.3.2 Route Priority

In order to make an effective and efficient construction, the routes needed to be built step by step. Therefore, one route was chosen to be built first to understand the human behaviors and responses toward the LRT. Also, it could determine what the issues and benefits that could be learnt for the next route constructions. There were several criteria that were considered in choosing which route needed to be built first shown in Table 3. At this point, it was impossible to gain an overall evaluation of the best route from different score of criteria. In order to make it more comparable, the result was analyzed to construct the scale to represent the preference of each criterion. There are many ways in scaling however the most common way is by scaling from 0 as least preferred to 100 as most preferred.

The scores were assigned to the remaining options so that differences in the numbers represent differences in strength of preference were comparable. In making a decision, the importance of each criterion was taken into consideration. The weight on a criterion reflected both the range of difference of options and how much the difference matters. For example, safety is often seen as the very important criterion. The total weight was 100% and was used to assess the score of each criterion shown in Table 4. In conclusion, the route T1 was preferred to be built as the first tramway line since it got highest score.

#### 4.4 Affordability Index of LRT Ticket

In most cases, infrastructure is also owned by the light rail operator and track access charges (TAC) do not apply. However, it was assumed that government would build the infrastructures and the light rail operator needs to pay the TAC. In order to calculate the affordability index of the LRT, the tariff should be analyzed based on Permen no 28/2012 as government policy about determining railway tariff. Thus, the cost for using LRT can be known. The LRT was planned to serve Line *T1* of 10.4 km length. The travel time would be 15 minutes (including the waiting time in stations) because the use of Regio-Citadis tram as the rolling stock.

Since the rolling stock was not lease, the capital cost consisted of two calculations; depreciation of asset and capital interest. Using the straight line depreciation method and Bank Indonesia rate of 5.75%, the total capital cost was IDR 200,568 per trip.

The operational cost was divided to three categories; direct fixed cost, direct variable cost and general cost. Direct fixed costs consisted of the salary of LRT crew who run the tram and the costs for using infrastructures. The values was assumed and showed a result of IDR 55,824 per trip. The direct variable cost was the cost for using the electricity and the lubricant. It cost IDR 70,184 per trip. To summarize, the total direct operational cost was IDR 126,008 per trip.

General cost was considered as the officer salaries, marketing, advertising and tax. It could be defined as the indirect costs. It was assumed that the general cost was IDR 6.5k per km. Therefore, the total general cost per trip was IDR 67.6k.

Table 3. Performance matrix

Option	Demand	Land Acquisition			Accessibility	Integration
		Disused track	Houses	Others		
T1	49770	v	-	-	3	2
T2	25125	-	-	v	4	2
T3	32727	-	-	v	2	2
T4	78182	-	v	-	5	1

A tick indicates the presence of the feature

Table 4. Overall scores

Option	Demand	Land Acquisition			Accessibility	Integration	Score
		Disused track	Houses	Others			
T1	46.45	100	100	100	33.33	100	70
T2	0.00	0	100	0	66.67	100	47
T3	14.33	0	100	0	0.00	100	34
T4	100.00	0	0	100	100.00	0	55
Weight	25%	15%	10%	5%	25%	20%	100%

The maintenance was planned as the mainline train's maintenance. There were first month, third month, sixth month and the twelfth month maintenance. It was assumed that the maintenance cost was 5% of the tram price. Therefore, the maintenance cost was IDR 99,537 per trip.

Using the percentage profit for operator of 8%, the total cost was IDR 503,793 per trip. Therefore, the tariff for Line *T1* was IDR 2500 per trip per passenger. As a result, the affordability index of a person with average income was 10.66% while the affordability index of a person with bottom quartile income was 13.56%.

In conclusion, the ticket fare was affordable both for people with average income and for people with bottom quartile income. Moreover, comparing with the other transport modes (bus Trans Jogja and motorcycle) in Greater Yogyakarta, the expense of LRT was more affordable.

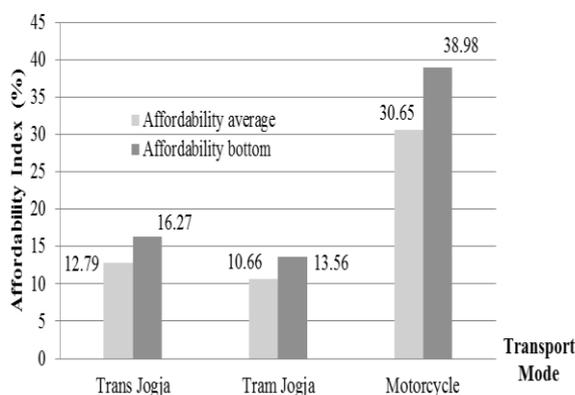


Figure 3. Affordability index comparison.

## 5 CONCLUSION

### 5.1 Findings

There are several findings in this thesis:

- The affordability index of Trans Jogja for people with average income was 12.79% while for people with bottom quartile income was 16.27% which both of them were affordable.
- The affordability index of motorcycle for people with average income was 30.65% while for people with bottom quartile income was 38.98% which both of them were not affordable.
- The potential passengers in Greater Yogyakarta in 2012 were 1,364,992 trips while the forecasted trip in 2019 was 1,611,017 trips.
- There have been proposed four LRT routes to serve Greater Yogyakarta; Line *T1*, Line *T2*, Line *T3*, Line *T4*. Using MCDA method, Line *T1* has

been chosen as the first LRT route to be built and it gave LRT tariff of IDR 2500 per trip.

- The affordability index of Tram Jogja for people with average income was 10.66% while for people with bottom quartile income was 13.56%.
- In conclusion, the Tram Jogja was the new affordable transportation option both for people with average income and for people with bottom quartile income.

### 5.2 Recommendations

There are recommendations, which have to be taken into consideration in building the routes and some areas for further research, which can be developed:

- The LRT routes could not cover all areas in Yogyakarta, the Trans Jogja system should be re-routed to support the LRT as a feeder and to serve the uncovered areas by LRT.
- There are many methods in conducting MCA, the AHP method would be good to be used because it requires some experts.
- In order to determine the best ticket fare, the willingness to pay needs to be analyzed alongside with the government policy.
- Since the routes have been proposed, the schedule and the number of the LRT vehicles used can be analyzed.
- The transport policy needs to be made to support the operational of LRT including the safety and the impact to the environment. There are several lay out to reduce issues about safety.

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