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# ANALYSIS OF THE DETERMINATION OF RAIL-BASED URBAN TRANSPORTATION ROUTES IN THE CITY OF MANADO (CASE STUDY: ZERO POINT MANADO - SAM RATULANGI INTERNATIONAL AIRPORT)

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## ABSTRACT

*Consequently, the activities that develop as a result of the formation of activity/land use centers such as government administration centers, residential areas, schools, hospitals, entertainment facilities, shopping centers, tourism accommodation centers, causes huge movement generation which affects the existing transportation systems. It can be concluded that the resulting travel time will decrease with a large enough passenger carrying capacity. The recommended form is the type of LRT (Light Rail Transit) with rail-based technology. The method used in this research is literature study, primary data collection in the form of household interview surveys, and secondary data collected from several related institutions. The survey results were analyzed with the help of Microsoft Office Excel and modeling using a linear regression equation with the independent variables measured, namely family composition (X1), number of working members (X2), number of members attending school (X3), number of members working and attending school (X4), vehicle ownership (X5), family income (X6), and the dependent variable (Y) as the number of family movements per day. The modeling results obtained the best equation, namely Y=1.394+0.888X1 and the Determinant Coefficient ($R^2$) value obtained was 0.824 or 82.4%. LRT (Light Rail Transit) line concept with the starting point of the Station Zero Point Manado - Paal Dua Station 1 - Paal Dua Station 2 - Manado-Bitung Toll Gate Station - Manado-North Minahasa Station - Mapanget Station - Sam Ratulangi International Airport Station with a total of 7 stations and 6 segments and a total length of 15,400 meters.*

**KEYWORDS** *LRT (Light Rail Transit), Sustainable Transportation, Transportation Modeling, Network Concepts.*



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## INTRODUCTION

Manado City as the capital city of the province with considerable potential in both the tourism and industrial sectors provides more value to various business and investment opportunities. Thus the activities that occur due to the formation of centers of activity / land use such as government administration centers, settlements, schools, hospitals, entertainment facilities, shopping centers, tourism accommodation centers, cause a huge generation of movement which consequently affects the existing transportation system (Fatimah, 2019).

In Manado City more than 90% of trips are household-based, where the trip starts from home and ends back at home. To understand the pattern of movement that will occur from each household in Manado City, a study of the amount of generation that occurs in predicting the need for facilities and infrastructure in the coming years is needed. Reliable, safe and comfortable transportation are some of the reasons residents in urban areas choose modes of transportation that will make it easier to reach their destination. This is the root of the transportation problem in Manado City where people prefer to use private vehicles that use a lot of road space (ZULFIQAR, 2019).

Road infrastructure as *Supply*, based on existing data, the length of roads in the Manado city administration area based on the type of road handling by the city is 500 km, the type based on road handling by the Province is 30 km and the type based on road handling by the Ministry of Public Works is 40 km. The number of vehicles is 10,000 units of both two-wheeled and four-wheeled, the average two-wheeled vehicle increases by 40 units / day and four-wheeled vehicles or more on average increase by 12 units / day. Vehicles and traffic flow are identified as *demand* and road network (transportation infrastructure in the form of road network) is identified as *supply*. The current condition of Manado city population and the number of vehicles is increasing which results in additional movement needs (*demand*). On the other hand, the length of the road (*supply*) increases, and cannot keep up with the increase in the number of vehicles, if this condition continues, there will definitely be a condition of Demand> *Supply*.

To avoid more complex transportation problems in the future, good planning and handling are needed, especially to anticipate the increasing tendency to change the function of a zone or area in the long term (Tamin, 2014). Based on these conditions, it is time to look at sustainable transport *modes*. Transportation can cause negative effects on the environment such as: pollution generated by machinery, noise caused by the operation of machinery, traffic congestion, land devaluation, *urban sprawl* and injury to people and plants as a result of accidents.

Rail-based public transportation tends to be free from congestion so it can be concluded that the resulting travel time will be further reduced with a large enough passenger carrying capacity (Aminah, 2018). The recommended form is a *Light Rail* Transit (*LRT*) type mass transit system with rail-based technology. Then there must be a mode shift from private cars to rail-based transportation. Therefore it is necessary to conduct a study to determine the behavior of the perpetrators of the movement to and

from work in the selection of modes so that rail-based transportation can later compete with private cars and public transportation in the city (Mikrolet).

Thus the city of Manado will be equipped with various modes of transportation such as light rail, buses connecting Sam Ratulangi International Airport and important locations in the city of Manado. (Bongso et al., 2019) This light rail line or *LRT (Light Rail Transit)* requires a special line so that in its operation LRT *(Light Rail Transit)* can operate properly and become an added value for the LRT (Light Rail *Transit)* transportation mode in terms of saving time and passenger costs and accessibility (Basuki et al., 2022).

Previous research shows a variety of analyses related to transportation infrastructure planning and development. (Justitia et al., 2017) analyzed the planning of the Gempol-Mojokerto toll road trajectory and found determining factors such as travel distance and spatial planning (Pemerintah & Perhubungan, 2012). (Astuti et al., 2019) used the Analytical Hierarchy Process method to select a railway route in Bangkalan, with the result that the new route was superior to the existing route (Hermawanto, 2018). modeled the selection of transportation modes at the State University of Malang and found that factors such as SIM ownership and convenience had a significant effect (Hartandi, 2010). (Rahma & Iswandari, 2017) studied traffic conditions in Banyuwangi and Rogojampi, finding different levels of saturation in the two directions. analyzed the location and layout of the Makassar-Parepare railway station, highlighting the importance of urban connectivity. studied the double track railway in Lampung, emphasizing the importance of Detail Engineering Design (DED) research for technical planning and development budget.

This research is needed to examine the planning of LRT in Manado City, especially the route from Zero Point Manado to Sam Ratulangi International Airport. The focus of the research includes analyzing the LRT generation model and determining the route and stopping station points (Supriadi et al., 2018). The research is limited to the LRT transportation mode, movement generation, trip distribution, and the condition of the Manado City area. The main objective is to analyze the movement generation model, travel distribution pattern, LRT line, and stopping station point (Wulansari & Astari, 2018). The results of this research are expected to be useful for the development of transportation courses, provide input for the government in planning regional and infrastructure development, and become a reference for similar research and students.

## RESEARCH METHOD

The operational definition in this study aims to avoid multiple interpretations of the variables used. Trip production (Y) is defined as the number of trips generated by each household, with associated variables such as family composition, number of family members working and studying, vehicle ownership, and family income. Data were collected through surveys and secondary sources, taking into account the

schedule, team organization, cost, and data collection mechanism. The research process included literature study, sample determination, data organization, household interviews, and data analysis using multiple linear regression with Microsoft Excel. The research population was households in Manado City, with samples taken using the Stratified Random Sampling technique. The research model used multiple linear regression analysis to measure the effect of independent variables on the dependent variable. Primary data was collected directly from respondents, while secondary data was obtained from relevant agencies.

## RESULT AND DISCUSSION

### Factors Affecting Movement Generation

In this study, 6 factors were used as considerations for determining the generation of movement in Manado City. These factors include family composition, number of working family members, number of family members attending school, vehicle ownership, and family income.

- **Family Composition:** The survey data shows that most families in Manado City consist of 4 members (35.78%), followed by families with 3 members (31.42%), 5 members (14.68%), and 2 members (8.26%).
- **Number of Working Family Members:** The majority of families have 2 working members (53.21%), while families with 1 working member have a percentage of 34.17%.
- **Number of Family Members Studying:** Most families have 1 member attending school (52.52%), followed by families with 2 members attending school (27.29%). There are also families with no members attending school (13.30%).
- **Family Members Who Work and Study:** 22.48% of families have 1 member who works while studying, while 75.46% of families do not have a member who works while studying.
- **Vehicle ownership:** Most Manado residents own a private vehicle (90.14%), while 9.86% do not own a private vehicle.
- **Family Income:** Most families have a monthly income between Rp.3,500,000 to Rp.4,000,000 (32.80%). Income in the interval of Rp.4,000,000 to Rp.4,500,000 is at 22.71%, indicating a middle income level in Manado City.

### Single Linear Regression Model Analysis

The single linear regression model analysis shows the relationship between certain parameters and the number of family movements per day in Manado City. Based on the analysis, family composition (X1) has a significant influence on the number of family movements with the equation $Y=1.394+0.888X1$ and $R^2=0.8244$. The number of working family members (X2) also influences with equation $Y=3.75+0.567X2$ and $R^2=0.1332$, and the number of studying family members (X3) with equation $Y=3.804+0.755X3$ and $R^2=0.2894$. However, the variables of the

number of family members working and studying (X4), vehicle ownership (X5), and family income (X6) have a smaller influence with $R^2$ of 0.0028, 0.0056, and 0.0013 respectively. This analysis shows that the variables of family composition, number of family members working, and number of family members studying can be used in the analysis of movement generation in Manado City.

**Multiple Linear Regression Analysis**

Multiple linear regression analysis examines the relationship between the number of family movements per day (Y) and several independent variables (X1 to X6). Based on the results of the analysis using Microsoft Excel, several significant regression models were found. The first model involves family composition (X1) and the number of working family members (X2), resulting in the equation Y = 1.394 + 0.888X1 + 0.001X2 with $R^2$ = 0.824. The second model included X1 and the number of family members studying (X3), resulting in Y = 1.393 + 0.89X1 - 0.005X3 with $R^2$ = 0.824. The third model combined X1, X2, and X3, resulting in Y = 1.394 + 0.89X1 - 0.001X2 - 0.005X3 with $R^2$ = 0.824. The fourth model included variables X4, X5, and X6, resulting in Y = 1.416 + 0.887X1 + 0.001X2 + 0.009X4 + 0.009X5 - 0.007X6 with $R^2$ = 0.824. The final model combines all independent variables, resulting in Y = 1.418 + 0.89X1 - 0.002X2 - 0.007X3 + 0.01X4 + 0.008X5 - 0.008X6 with $R^2$ = 0.824. The analysis shows that family composition (X1) consistently has a significant influence on the number of family movements per day.

**Analysis of Movement Demand Calculation Model**

***Bivariate Analysis***

Bivariate correlation analysis aims to find the degree of closeness and direction of the relationship between variables. The higher the correlation value $r$ , the closer the relationship between variables. Correlation coefficient intervals are interpreted as follows: very strong (0.80-1.000), strong (0.60-0.799), moderately strong (0.40-0.599), low (0.20-0.399), and very low (0.00-0.199). In this analysis, the independent variables used in the regression model must have a high correlation with the dependent variable and must not be correlated among independent variables. If there is a correlation between independent variables, the one with the largest correlation to the dependent variable is selected. The correlation test results show that family composition (X1) has a very strong correlation with the number of movements of family members per day (Y) of 0.908. Meanwhile, the number of family members working (X2) and the number of family members studying (X3) have a moderately strong correlation of 0.365 and 0.538 respectively. Other variables such as the number of family members working and studying (X4), vehicle ownership (X5), and family income (X6) show a very low correlation. Therefore, only three independent variables are used in the model, namely family composition (X1), number of family members working (X2), and number of family members studying (X3).

***Multivariate Analysis***

Multivariate analysis used multiple linear regression analysis to predict the dependent variable (Y) based on several independent variables (X1, X2, ..., Xn) in a linear equation. The analysis results were obtained through Microsoft Excel and organized based on the coefficient of determination (R2) and constant values. The regression equation with the largest R2 value and the smallest constant was prioritized, as seen in Table 23. The best result for the number of movements of family members per day is Y = 1.394 + 0.888X1, with an R2 of 0.824392425, indicating that family composition affects daily movements by 82.4%, while the remaining 17.6% is influenced by other factors. Table 26 shows the regression model between the number of family movements per day (Y) and the independent variables such as family composition (X1), number of family members working (X2), studying (X3), working and studying (X4), vehicle ownership (X5), and family income (X6). The model shows a strong relationship between the independent and dependent variables, with a high coefficient of determination.

**Travel Distribution**

The results of the 2024 analysis show that the frequency of family trips in Manado City is mostly five times a day, with a percentage of 36.01%. In terms of transportation mode, the survey shows that the majority of people use private motorcycles (48.17%), followed by private cars (28.67%). Online transportation motorcycles are used by 7.80% of people, online transportation cars by 6.19%, public transportation in the city by 4.59%, and walking by 2.98%.

There were 249 male respondents (57.11%) and 187 female respondents (42.89%). In terms of age group, the male gender who traveled the most was for the age group 25-29 years as many as 51 respondents (11.70%). While for the female gender who are in the age group of 25-29 years as many as 54 respondents (12.39%). This result shows that people in Manado City who travel are mostly at productive age.

***Desire* Line**

Based on the questionnaire survey in 11 sub-districts in Manado City, the travel distribution pattern caused by the movement is obtained in the form of a desire line.

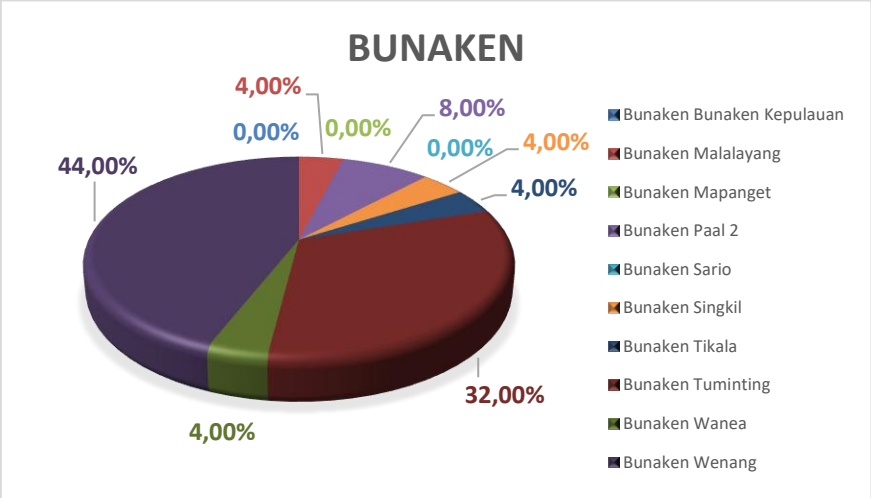


**Figure 1.** Percentage of Trip Purpose from Bunaken Sub-district to Other Sub-districts *(Source: 2024 Analysis Results)*

In this research study area, namely Wenang, Tikala, Paal Dua, and Mapanget sub-districts, an origin-destination matrix was created using the with-constraint-pull method. This method is used if the available information is an estimate of future movement pulls, while estimates of generation are not available or may be available but the accuracy is low.

Mathematically, this method can be expressed with the following equation:

$$T_{id} = t_{id} \times E_d$$

Using this equation, future movements can be calculated and are shown in Table 29. It can be seen that the attraction-constrained method ensures that the total future movement attraction of each zone is the same as expected (as shown by the value of $E_d$ = 1 for all zones). Likewise, the total future movement for the entire study area is the same as expected.

**Table 1.** MAT using the with-constraint-pull Method

| District | Wenang | Tikala | Paal Dua | Mapanget | *oi* | *Oi* | *Ei* |
|---|---|---|---|---|---|---|---|
| Wenang | 0 | 1 | 2 | 2 | 5 | 0 | 0.09 |
| Tikala | 16 | 0 | 0 | 1 | 17 | 1 | 0.08 |
| Paal Dua | 11 | 8 | 0 | 4 | 23 | 6 | 0.25 |
| Mapanget | 14 | 4 | 2 | 0 | 20 | 21 | 1.03 |
| *dd* | 41 | 13 | 4 | 7 | 65 | | |
| *Dd* | 41 | 13 | 4 | 7 | | 65 | |
| *Ed* | 1 | 1 | 1 | 1 | | | 1.00 |

*(Source: Analysis Result 2024)*

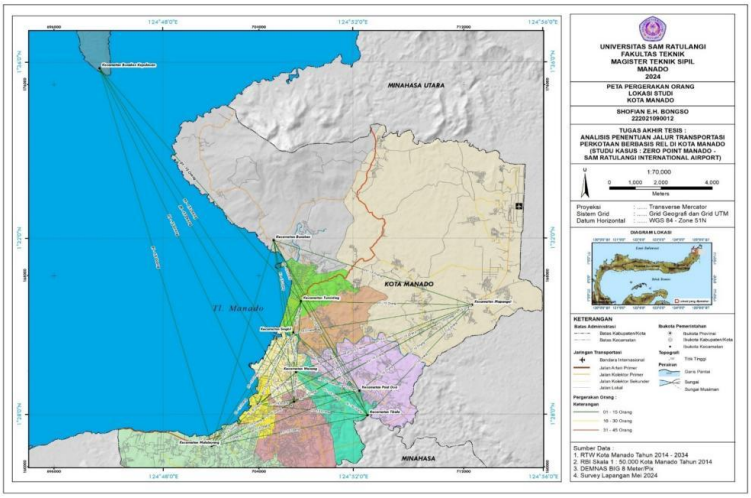


**Figure 2.** Desire Line / Travel Distribution of Manado City People
*(Source: Analysis Result 2024)*

**Service Potential in the Form of Demand *Light Rail Transit* in Manado City.**

Road infrastructure as Supply, based on existing data obtained the length of the road in the administrative area of Manado city based on the type of road handling by the city is 500 km long, the type based on road handling by the Province is 30 km long and the type based on road handling by the Ministry of Public Works is 40 km long. The number of vehicles is 10,000 units of both two-wheelers and four-wheelers, the average two-wheeled vehicle increases by 40 units / day and four-wheeled vehicles or more on average increase by 12 units / day. Vehicles and traffic flow are identified as demand and road network (transportation infrastructure in the form of road network) is identified as supply. The current condition of Manado city population and the number of vehicles is increasing which results in additional movement needs (demand). On the other hand, the length of the road (supply) increases, and cannot keep up with the increase in the number of vehicles, if this condition continues, there will definitely be a condition of Demand> Supply.

As a solution, alternative modes of public transportation are developed that can accommodate many passengers, thereby reducing the use of private vehicles. Based on this condition, it is time to look at the Sustainable Transport Modes program. The definition of Sustainable Transport Modes is Sustainable Transport Modes are transportation vehicles which are designed in some ways to reduce the enviromental damage. This also means that we are using minimum energy resources. Transportation can cause negative effects on the environment such as: pollution generated by machinery, noise caused by the operation of machinery, traffic congestion, land devaluation, urban sprawl and injury to people and plants as a result of accidents. As one of the efforts towards reducing pollution generated by machines, noise caused by machine operation, traffic congestion, consumption of fossil energy (petroleum), it is necessary to choose to use Light Rail Transit transportation facilities.

The increase in population and development of Manado City which is not followed by an increase in road supply causes congestion, as a solution, alternative modes of public transportation are developed that can accommodate many passengers so as to reduce the use of private vehicles. Researchers who conducted the study have developed a cortidor route plan for the Light Rail Transit Passenger Demand Potential Study in Manado City based on the criteria that have been reviewed are as follows:

a) The results of the analysis of movement generation and attraction in the form of desire lines
b) Topography and terrain conditions
c) Land Use Condition
d) Physical Condition of the Land
e) Environmental Impact
f) Light Rail Transit network system

The Service Potential in the form of Demand for Light Rail Transit in Manado City based on the results of the destination origin survey can be seen on the desire line by providing the following results:

**Table 2.** Number of Movements within Manado City as a Result of Origin-Destination Survey

| No. | Movement | Number of Movements | Total Respondents | Percentage of Movement |
|---|---|---|---|---|
| 1 | Kecamatan Wenang to Kecamatan Sario | 34 | 435 | **7.798%** |
| 2 | Malalayang sub-district to Sario sub-district | 20 | 435 | **4.587%** |
| 3 | Singkil sub-district to Wenang sub-district | 19 | 435 | **4.358%** |
| 4 | Wenang sub-district to Malalayang sub-district | 19 | 435 | **4.358%** |
| 5 | Malalayang sub-district to Wenang sub-district | 18 | 435 | **4.128%** |
| 6 | Tikala sub-district to Wenang sub-district | 16 | 435 | **3.670%** |
| 7 | Sario sub-district to Wenang sub-district | 15 | 435 | **3.440%** |
| 8 | Mapanget sub-district to Wenang sub-district | 14 | 435 | **3.211%** |
| 9 | Wanea sub-district to Wenang sub-district | 14 | 435 | **3.211%** |

| | | | | |
|---|---|---|---|---|
| 10 | Tuminting sub-district to Wenang sub-district | 12 | 435 | **2.752%** |
| 11 | Bunaken sub-district to Wenang sub-district | 11 | 435 | **2.523%** |
| 12 | Paal Dua Sub-district to Wenang Sub-district | 11 | 435 | **2.523%** |

*(Source: Analysis Result 2024)*

Based on the results of the origin - destination survey analysis as shown in the table above, it can be concluded that the largest potential movement in the city of Manado occurs in the movement of Wenang sub-district to Sario sub-district with a percentage of 7,798% of the total movements that occur. The second largest movement occurred in Malalayang sub-district to Sario sub-district with a percentage of 4.587% of the total movement that occurred. The third largest movement occurred in Singkil sub-district to Wenang sub-district with a percentage of 4,358% of the total movements that occurred.

Based on these conditions, the corridor for the opening of the *Light Rail Transit* line follows the priority of the largest generation and pull according to the following order:

1) Potential Priority service 1 corridor Kecamatan Wenang to Kecamatan Sario
2) Potential Priority service 2 corridor Malalayang sub-district to Sario sub-district
3) Potential Priority service 3 corridor Singkil sub-district to Wenang sub-district
4) Potential Priority service 4 corridor Kecamatan Wenang to Kecamatan Malalayang
5) Potential Priority service 5 corridor Malalayang sub-district to Wenang sub-district
6) Potential Priority service 6 corridor Tikala sub-district to Wenang sub-district
7) Potential Priority service 7 corridor Sario sub-district to Wenang sub-district
8) Potential Priority service 8 corridor Mapanget sub-district to Wenang sub-district
9) Potential Priority service 9 corridor Wanea sub-district to Wenang sub-district
10) Potential Priority service 10 Tuminting sub-district to Wenang sub-district corridor
11) Potential Priority service 11 Bunaken to Wenang sub-district corridor
12) Potential Priority service 12 Paal Dua sub-district to Wenang sub-district corridor
13) And so on until all sub-districts are connected.

**Concept of *Light Rail Transit* Line in Manado City**

Based on the origin of destination data above, the *Light Rail Transit* Line Concept in Manado City is determined as in the table below.

**Table 1**. Station and Concept of *Light Rail Transit* Line in Manado City

| No. | Route/Trace | Long (meters) | Station |
|---|---|---|---|
| | | | **Manado Zero Point Station** |
| 1 | Segment 1 | 1900 | |

| | | | |
|---|---|---|---|
| | | | **Paal Dua Station 1** |
| 2 | Segment 2 | 1000 | |
| | | | **Paal Dua Station 2** |
| 3 | Segment 3 | 3500 | |
| | | | **Manado - Bitung Toll Gate Station** |
| 4 | Segment 4 | 1200 | |
| | | | **Manado Station - North Minahasa** |
| 5 | Segment 5 | 2400 | |
| | | | **Mapanget Station** |
| 6 | Segment 6 | 5400 | |
| | | | **Airport Station** |
| | Total Length | 15400 | |

*(Source: Analysis Result, 2024)*

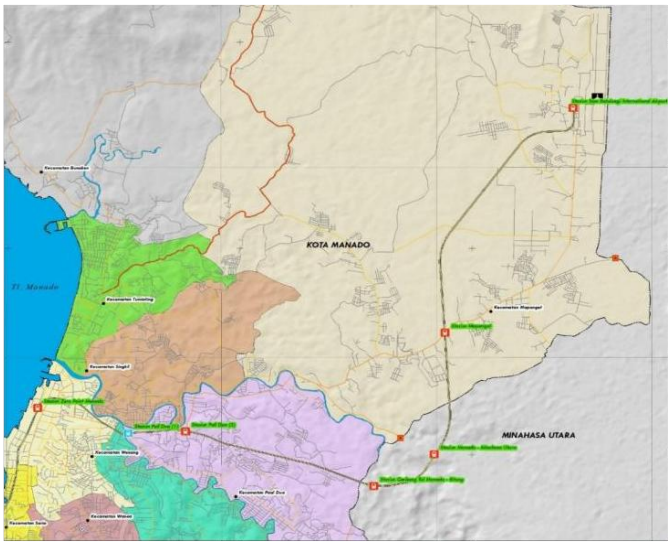


**Figure 1**. Concept of *Light Rail Transit* Line in Manado City with a length of 15400 meters. *(Source: Analysis Result 2024)*

As a comparison with the City of Jakarta, the *Light Rail Transit* line is 11800 meters long or 11.8 km long with a total of 9 stations, with flat type terrain conditions. The documentation of *Light Rail Transit* in Jakarta City is as follows.

**Figure 4.2** Example of Jakarta *Light Rail Transit*
*(Source: Jakarta LRT Website, 2022)*

For *Light Rail Transit* in Manado City, the total length of the *Light Rail Transit* line concept for the Malalayang - *Zero Point* Manado line is 8,450 meters or 8.45 km long with a total of 8 stations and for the *Zero Point* Manado - Sam Ratulangi *International Airport* line is 15,400 meters or 15.4 km long with a total of 7 stations, with flat type terrain conditions.


**Figure 5.** *Light Rail Transit* Concept in Manado City
*(Source: Analysis Result 2024)*

**Opportunities for *Light Rail Transit* in Manado City**

**1. Light Rail Transit**

*Advantages* are as follows:

1) *Environmental friendly*
2) *Free of traffic*

3) *Aesthetic consideration*
4) Minimum Land Use (*Minimum land acquisition*)
5) *Mass Rapid* Transit mode
6) *Light Rail Transit Systems are* designed to be *grade-separated* from other modes so that they do not interfere with other traffic (*Light Rail Transit is, by design, a grade-separated system. They do not interfere with existing transport modes*).
7) *Provide rapid and convenient service* for daily commuters (people who commute daily and do not stay overnight) - (*Provide rapid and convenient service for daily commuters*)
8) *Pride*

The concept of the *Light Rail Transit* Line is compared with the *existing* city transportation in Manado City as in the table below.

**Table 4.2** Station and Concept of *Light Rail Transit* Line in Manado City

| No. | Route/Trace | Long (meters) | Station | Existing City Transport Route in this Segment |
|---|---|---|---|---|
| | | | Station Zero Point Manado | |
| 1 | Segment 1 | 1900 | Paal Dua Station 1 | Route: (City Center - Paal Dua P.P) number of active vehicles 148 units. |
| 2 | Segment 2 | 1000 | Paal Dua Station 2 | Route: (City Center - Paal Dua P.P) number of active vehicles 148 units. |
| 3 | Segment 3 | 3500 | Manado - Bitung Toll Gate Station | Route: (Paal Dua - Polytechnic P.P) number of active vehicles 48 units. |
| | | | | Route: (Paal Dua - P.P Field) number of active vehicles 112 units. |
| | | | | Route: (Paal Dua - Airmadidi P.P) number of active vehicles 25 units. |
| 4 | Segment 4 | 1200 | Manado Station - North Minahasa | No routes |
| 5 | Segment 5 | 2400 | Mapanget Station | No routes |
| 6 | Segment 6 | 5400 | Sam Ratulangi International Airport Station | Route: (Paal Dua - P.P Field) number of active vehicles 112 units. |

| | |
|---|---|
| Tot. Length | 15400 |

*(Source: Analysis Result 2024)*

**2. Existing City Transportation**

Existing city transportation routes in the proposed *Light Rail Transit (LRT)* service corridor are:

1) Route: (City Center - Paal Dua P.P) number of active vehicles 148 units .
2) Route: (Paal Dua - Polytechnic P.P) number of active vehicles 48 units.
3) Route: (Paal Dua - P.P. Field) number of active vehicles 112 units.
4) Route: (Paal Dua - Airmadidi P.P) number of active vehicles 25 units.

To be able to calculate the effect of how many city transportation passengers will switch to Light Rail Transit, it requires a Load Factor calculation. Determine Load Factor Number of Tracks: (City Center - Paal Dua P.P) number of active vehicles 148 units and (Paal Dua - Lapangan P.P) number of active vehicles 112 units. Load Factor is the ratio between existing demand and available supply that is reviewed on the entire length of the route. Divided into several zones on a route. The division of the zone looks at several parameters including distance, population density and locations where there are activities related to the interests of many people. The following is the division of the Pasar 45 - Paal 2 and Paal 2 - Field route zones.

**Table 5.** Division of Vehicle Zones for the Pasar 45 - Paal 2 Route

| Directions | Zone Name | From | To | **Distance from STA 0 (m)** |
|---|---|---|---|---|
| Market 45 - Paal 2 (A) | Zone 1 A | Article 45 | Komo outside | 1775.11 |
| | Zone 2 A | Komo outside | The Outer Dendengan | 852.94 |
| | Zone 3 A | The Outer Dendengan | Paal 2 | 263.69 |
| Total Distance | | | | 2891.74 |
| Paal 2 - Pasar 45 (B) | Zone 1 B | Paal 2 | The Outer Dendengan | 263.69 |
| | Zone 2 B | The Outer Dendengan | Tikala | 852.94 |
| | Zone 3 B | Tikala | Market 45 | 1386.9 |
| Total Distance | | | | 2503.53 |

*(Source: Analysis Result 2024)*

**Table 6.** Division of Vehicle Zones for Paal 2 - Field Route

| Directions | Zone Name | From | To | **Distance from STA 0 (m)** |
|---|---|---|---|---|
| Paal 2 - Field (A) | Zone 1 A | Paal 2 | Ex Giant Kairagi | 2622.8 |
| | Zone 2 A | Ex Giant Kairagi | Lippo Plaza | 1798.94 |
| | Zone 3 A | Lippo Plaza | Paniki Jaya | 3335.5 |
| | Zone 4 A | Paniki Jaya | Field | 3040.21 |
| Total Distance | | | | 10797.45 |
| Field - Paal 2 (B) | Zone 1 B | Field | Paniki Jaya | 2622.8 |
| | Zone 2 B | Paniki Jaya | Lippo Plaza | 1798.94 |
| | Zone 3 B | Lippo Plaza | Ex Giant Kairagi | 3335.5 |
| | Zone 4 B | Ex Giant Kairagi | Paal 2 | 3040.21 |
| Total Distance | | | | 10797.45 |

*(Source: Analysis Result 2024)*

From the table, it can be seen that there is a difference in distance between the direction of Pasar 45 - Paal 2 and the direction of Paal 2 - Pasar 45. This happens because vehicles do not go through the same route on some roads.

### 3. The Effect of *Light Rail Transit* in Manado City in Reducing the Number of City Transportation Vehicles

It can be seen that the *average Load Factor* is **0.416**. This means that the availability of Public Transport on the route City Center 45 - Paal Dua - Field is still sufficient. There is a fairly frequent pattern of passenger turnover in each zone. This is partly because almost every zone of this route has facilities related to the needs of many people, especially in the fields of trade and health services.

It can be seen that the existing load factor is only 0.416 with the number of vehicles operating every day with the route City Center 45 - Paal Dua - Field the number of active vehicles is 260 units, based on the results of the LF analysis should be at least 0.6, meaning that there has been an excess number of vehicles on the route.

If the number of vehicles operating in a day is (148 + 112) = 260 vehicles, and in a day 11 trips with 9 passengers, the number of passengers transported in a day for the route City Center - Paal Dua - Field is 0.416 x 260 x 10 x 11 = 11,897 people. For the Effect of *Light Rail Transit* in Manado City in Reducing the Number of City Transportation Vehicles, this *Light Rail Transit* can reduce the number of passengers who ride city transportation by 3501 people, while for city transportation vehicles by 15398 / (10 x 11 x 0.416) = 336.49 = 336 vehicles. If this Light Rail Transit has been

operating it can reduce the number of vehicles by 336 units on the Pusar Kota - Paal Dua - Field route.

## CONCLUSION

Based on the results of the data analysis, the following conclusions can be drawn: The results of the analysis show that the factors affecting the generation of family movements in Manado City include family composition, the number of family members working, and the number of family members studying, with a multiple linear equation Y=1.394+0.888X1 and an $R^2$ value of 82.4%. The majority of trips were made to Wenang Sub-district (31.19%), with the largest potential movement from Wenang Sub-district to Sario Sub-district (7.798%). Based on these results, the Light Rail Transit (LRT) corridor prioritization is suggested to follow the order of Wenang, Tikala, Mapanget, and Paal Dua sub-districts. The LRT route is planned to have 7 stations with a total length of 15,400 meters. The LRT is estimated to reduce the number of public vehicles by 336 units, offering environmental and comfort benefits. Suggestions include improved land use in Wenang sub-district and continuation of the research to the Pre-Feasibility Study stage for economic, social, environmental, and technical aspects, including geological surveys.

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