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Model of Improved Set Covering Location Problem in Determining The LRT Musi Emas Feeder Stops: Route LRT DJKA Station - Plaju Terminal

Sisca Octarina[1], Fitri Maya Puspita[1], Evi Yuliza[1], Indrawati[1], Mawar Tasiah[1]

[1]*Department of Mathematics, Faculty of Mathematics and Natural Sciences, Sriwijaya University, Indralaya, 30662, Indonesia*
***Corresponding author**: sisca_octarina@unsri.ac.id

Abstract
This study aims to determine the optimal location of the LRT Musi Emas Feeder stops Corridor 5 in conjunction with the LRT DJKA Station-Plaju Terminal route. Light Rail Transit (LRT) is a rapid transit system that employs an integrated rail crossing model. At present, the LRT remains a primary mode of daily transportation for the residents of Palembang. One of the initiatives undertaken by the government to facilitate the utilization of LRT transportation is the provision of passenger transportation (feeder services). The positioning of the feeder stops remains suboptimal and needs more integration with existing public facilities. The distance between the stop locations is highly variable, with some nearby and others at considerable distances. This issue is addressed through the formulation of the Set Covering Problem (SCP) model, which encompasses the Set Covering Location Problem (SCLP) and Maximal Covering Location Problem (MCLP) models, as well as the development of the Improved SCLP model. The SCP model yields four optimal stop locations, which are significantly distant from the actual conditions at the site. In contrast, the Improved SCLP model identifies 48 optimal feeder stops mapped using Geographic Information System (GIS) software. This map of feeder stops could inform the Palembang City Transportation Agency's efforts to develop an integrated transportation management system.

Keywords
Feeder, Improved Set Covering Location Problem, LRT Musi Emas, Location, Set Covering Problem

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1. INTRODUCTION

Transportation is a fundamental tool humans utilize to facilitate the movement of goods and people from one location to another (Agustina et al., 2022). The role of transport is pervasive, exerting a significant influence on economic activity in both urban and rural settings. The provision of transport services is contingent upon the availability of public transportation (Sarwandy and Jonizar, 2023). In its infancy, public transport was confined to the interconnectivity of neighboring cities. However, it has since evolved to encompass inter-district, inter-provincial, and international connectivity. Public transport is a highly efficient and cost-effective mode of transportation. The growth of public transport can benefit society by enhancing accessibility, effectiveness, and sustainability in transportation (Kadarsa et al., 2023). Palembang is Indonesia's 11th most populous city, with a population of 1,577,788 out of 98 cities (Jamilah and Amanah, 2024). The necessity for mobility will inevitably continue to increase in conjunction with population growth. It is irrefutable that population growth exerts a considerable influence on the transport field. Palembang City will continue to experience an increase in population density due to the influx of migrants, resulting in an elevated demand for transportation services. The Palembang city government has implemented several measures to address the congestion issue. However, private vehicles remain the predominant mode of transportation for residents. One key strategy is enhancing public transport services (Kadarsa et al., 2023). In Palembang City, public transportation options are available, including public transportation, Trans Musi Bus, and Light Rail Transit (LRT) with special feeder services (Arliansyah, 2019). On July 15, 2018, President Joko Widodo inaugurated the Palembang City LRT public transport mode. To facilitate the movement of LRT from one location to another, the Palembang City government provides feeder services and supporting facilities in the vicinity of the station where LRT passengers disembark.

As stated by Jamilah and Amanah (2024), the introduction of feeders was intended to address the limitations of the existing transport system, which only extended to some areas of the city. The new feeders complement existing public transport options, such as Bus Rapid Transit (BRT), LRT, and Mass Rapid Transit (MRT). These services provide convenient direct access for individuals, particularly those who typically utilize private vehicles, to transition to public transport. The term 'feeder' is also used to describe a form of transport that plays a role in transporting passengers from the point of origin of their journey to the primary mode of transport that will convey them to their final destination (Arliansyah, 2019). The LRT Musi Emas feeder operates across seven corridors. Corridor 1 has a route from Talang Kelapa to Talang Beruk, Corridor 2 has a route from Asrama Haji to Sematang Borang, Corridor 3 has a route from Asrama Haji to Talang Betutu, Corridor 4 has a route from Polres Station to OPI Housing, Corridor 5 has a route from DJKA Station to Plaju Terminal, Corridor 6 has a route from RSUD Station to Sukawinatan, and Corridor 7 has a route from Bukit to Kamboja Stadium, passing Bumi Sriwijaya Station (Haris et al., 2024). A review of the field data indicates that the number of fleets allocated to each corridor varies by the length of the feeder route. At the time of writing, the city of Palembang is served by 57 units of LRT feeder transport. A total of 16 feeder units are scheduled to operate on a one-hour basis in corridors 1 and 2, while 5 feeder units are expected to operate on a one-hour basis in corridors 3 to 7 (Ismail et al., 2023). Daihatsu Luxio cars constitute a type of feeder vehicle with a capacity of nine individuals per fleet. Each feeder fleet is monitored by closed-circuit television (CCTV), which enables tracking its movements.

This study selected corridor 5, comprising the route from DJKA Station to Plaju Terminal, based on the findings of Zulkarnain et al. (2024), which indicated that the passenger frequencies at DJKA Station Stop and Plaju Terminal Stop are 231 and 182, respectively. The route has sufficient passengers to justify an increase in LRT occupancy. Furthermore, the route between DJKA Station and Plaju Terminal offers numerous intermodal connections and is close to traditional shopping centers. Additionally, the DJKA DEPO Bus Stop and OPI Bus Stop, situated between DJKA Station and Plaju Terminal, serve many passengers due to their proximity to recreational centers and hospitals. The area surrounding Tegal Binangun Street also comprises residential settlements. Furthermore, the Talang Petai housing estate, along with other residential areas in the Plaju subdistrict, such as Griya Darma Indah Housing and the populated area situated between DJKA station and Plaju Terminal, provide additional rationale for the selection of corridor 5 for investigation.

Issues about location optimization encompass optimization problems associated with the Set Covering Problem (SCP) model (Bangun et al., 2024; Filippi et al., 2021; Octarina et al., 2024a, 2022a; Syakina and Nurdiati, 2021; Turkoglu and Genevois, 2019). The SCP model is appropriate for location and allocation problems (Octarina et al., 2022b; Ríos-Mercado et al., 2021). The SCP is a classic combinatorial optimization problem with numerous practical applications (Daskin and Maass, 2019). The objective of the optimization problem is to minimize the number of locations of a facility while still serving all demands. SCP seeks to reduce the number of facility locations while serving all demand points (Bangun et al., 2022). SCP can be observed in everyday life, for example, in determining the number and location of bus stops, fire stations, hospitals, health centers, and so forth (Corberán et al., 2020; Cubillos and Wohlk, 2020; Octarina et al., 2024b, 2022a; Sitepu et al., 2019). As posited by Octarina et al. (2022a), SCP is comprised of multiple models, including the Set Covering Location Problem (SCLP) and the Maximal Covering Location Problem (MCLP). All models are interrelated, yet they possess distinct objective functions. SCLP is a distribution system problem that seeks to identify the optimal number of facility locations required to fulfill all demand points (Hashim et al., 2021). MCLP is a coverage-based model that aims to maximize the number of demand points served by a specified number of facility locations within a standard time frame (Vaezihir et al., 2021). The improved SCLP represents an evolution or development of the SCLP model to make it more practical and realistic by considering several relevant factors. In this context, the term "improved" is employed to denote a model that addresses the inherent weaknesses or limitations of the basic SCLP model. The objective is to develop an optimized, appropriate, and flexible model to fulfill real-world applications' requirements. The Improved SCLP model extends the original SCLP model to ensure that all nodes are covered while prioritizing those that are more needed or important (Lutter et al., 2017; Pereira and Averbakh, 2011; Zhang et al., 2017).

Previous research has discussed SCP (Espejo et al., 2023; Kwon et al., 2020; Octarina et al., 2022a; Ríos-Mercado et al., 2021; Vaezihir et al., 2021). Octarina et al. (2020) solved the issue of cutting stock using the SCP model in conjunction with the Greedy Randomized Adaptive Search Procedure (GRASP) method. Other research that addresses the issue of locating emergency service facilities using SCP and continues to employ the Uncertain Location Set Covering Problem (ULSCP) and Uncertain Maximal Covering Location Problem (UMCLP) has been conducted by Zhang et al. (2017). Bangun et al. (2022) researched utilizing Temporary Waste Disposal Sites (TWDS) for waste storage in Palembang, employing the Greedy Heuristic algorithm. In their 2022 research, Octarina et al. (2022a) present two models for identifying the optimal location of waste stations in the Seberang Ulu I District of Palembang City.

This study's issue is that multiple LRT Musi Emas Feeder stops are too close or distant. Because of the inconsistency in stop distances, greater attention must be devoted to the location of LRT feeder stop points to ensure optimal operation of the LRT Musi Emas feeder. In light of the background above, this research will investigate optimizing the placement of the LRT Musi Emas Feeder stops Corridor 5, employing the SCP and Improved SCLP models.

2. EXPERIMENTAL SECTION

2.1 Methods

This research employed data from the LRT Musi Emas Feeder Corridor 5 and used LINGO 13.0 software for calculations. The following steps were required for the completion of this research:

1. The coordinate point data collected from each LRT Musi Emas Feeder stops Corridor 5 is then presented in tabular form.
2. The distance between the LRT Musi Emas Feeder stops Corridor 5 was measured utilizing Google Maps.
3. Variables and parameters data must also be designated for each LRT Musi Emas Feeder stops Corridor 5.
4. Formulated the SCP model, which consists of the SCLP and MCLP models. The SCLP model is as follows:
   a) Minimize:

$$Z_{\text{SCLP}} = \sum_{n \in N} M_n \tag{1}$$

   Subject to:

$$\sum_{n \in N} M_n \geq 1, \quad \forall n \in N \tag{2}$$

$$M_n \in \{0, 1\}, \quad \forall n \in N \tag{3}$$

   where:
   - Z_{SCLP} = The objective function of the SCLP model
   - N = The set of indices for facility locations
   - Decision variable: $M_n = \begin{cases} 1, & \text{if the facility is located at the } n\text{-th location} \\ 0, & \text{otherwise} \end{cases}$

   b) The MCLP model is as follows:

$$\text{Maximize: } Z_{\text{MCLP}} = \sum_{n \in N} J_n \tag{4}$$

   Subject to:

$$\sum_{n \in N} M_n = p \tag{5}$$

$$J_n \leq \sum_{n \in N} M_n, \quad \forall n \in N \tag{6}$$

$$J_n \in \{0, 1\}, \quad \forall n \in N \tag{7}$$

$$M_n \in \{0, 1\}, \quad \forall n \in N \tag{8}$$

   where:
   - Z_{MCLP} = The objective function of the MCLP model
   - p = The number of facility locations
   - Decision variable: $J_n = \begin{cases} 1, & \text{if the demand location} n \in N \text{ is covered} \\ 0, & \text{otherwise} \end{cases}$
5. The SCP model was solved using LINGO 13.0.
6. The Improved SCLP model should be formulated to allocate the number p of facilities according to the following Equations (9) to (13):

   Minimize:

$$Z_{\text{ISCLP}} = \sum_{n=1}^{N} M_n + \sum_{n'=1}^{N'} M_{n'} \tag{9}$$

   Subject to:

$$\sum_{n=1}^{N} M_n \geq 1 \tag{10}$$

$$\sum_{n=1}^{N} M_n + \sum_{n'=1}^{N'} M_{n'} \geq K \tag{11}$$

$$M_n \in \{0, 1\}, \quad \forall n \in N \tag{12}$$

$$M_{n'} \in \{0, 1\}, \quad \forall n' \in N' \tag{13}$$

   where:
   Z_{ISCLP} = The objective function in the Improved SCLP model
   N = The set of indices indicating the location of facilities
   N' = The set of indices indicating the location of additional facilities Decision variables:

$$M_n = \begin{cases} 1, & \text{if the demand point at location } n \text{ is covered} \\ 0, & \text{otherwise} \end{cases}$$

$$M_{n'} = \begin{cases} 1, & \text{if the demand point at location } n' \text{ is covered} \\ 0, & \text{otherwise} \end{cases}$$

7. The optimal solution for the Improved SCLP model should be identified with the assistance of LINGO 13.0.
8. A comparative analysis of the final location results between the SCP and the Improved SCLP models is required.
9. The objective is to identify the optimal location for the LRT Musi Emas Feeder stops Corridor 5.
10. Make the conclusion.

3. RESULT AND DISCUSSION

This section describes the data, variable definitions, and distances between the LRT Musi Emas Feeder stops Corridor 5. The data obtained from the web indicate that there are 36 stopping points. However, following a field survey conducted on June 7, 2024, four stops were removed, and 11 new stops were identified. The data can be seen in Table 1.

Table 1 states that the variable M_1 defines the stop point at LRT DJKA A Station, the variable M_2 defines the stop point at Opi Mall A, and so on until the variable M_{43} defines the stop point at LRT DJKA B Station. Data on the distance between the stop points of the LRT Musi Emas Feeder Corridor 5 can be seen in Table 2 to Table 4.

Tables 2 to 4 present data on the distance between the stops of the LRT Musi Emas Feeder Corridor 5. This data

Table 1. List of The LRT Musi Emas Feeder Stops Corridor 5

Variable	Name of The Stops	Coordinate Point
M_1	LRT DJKA A Station	-3.031179,104.790122°
M_2	Opi Mall A	-3.034616,104.79231°
M_3	Depo LRT DJKA A	-3.038882,104.795074°
M_4	Palm Springs A Housing	-3.038817,104.795804°
M_5	Wilona A Cluster	-3.036913,104.796751°
M_6	Lavender A Residence	-3.034662,104.797865°
M_7	Palmera A Building	-3.031836,104.799308°
M_8	Panji A Lane	-3.028991,104.800859°
M_9	228 A Primary School	-3.026992,104.802375°
M_{10}	Reza A Store	-3.02533,104.803704°
M_{11}	230 A Primary School	-3.023322,104.805359°
M_{12}	Pete A Lane	-3.021912,104.806462°
M_{13}	BSI Sport Center A	-3.020534,104.807591°
M_{14}	Mosque A Lane	-3.017385,104.810037°
M_{15}	Tegal Binangun A Health Centre	-3.014631,104.812302°
M_{16}	Fitra Abadi A High School	-3.012004,104.81439°
M_{17}	Tegal Binangun A Market	-3.007855,104.817586°
M_{18}	Tegal Binangun A Fuel Station	-3.006018,104.81824°
M_{19}	Aman A Lane	-3.00446,104.817762°
M_{20}	555 Thai Tea A	-3.002964,104.817217°
M_{21}	Honda Plaju A	-2.999247,104.815502°
M_{23}	Honda Plaju B	-2.999552, 104.815646°
M_{24}	555 Thai Tea B	-3.002658, 104.817128°
M_{25}	Aman B Lane	-3.004356, 104.817864°
M_{26}	Tegal Binangun B Fuel Station	-3.005735, 104.81833°
M_{27}	Tegal Binangun B Market	-3.007824, 104.817709°
M_{28}	Fitra Abadi B High School	-3.011774, 104.814651°
M_{29}	Tegal Binangun B Health Centre	-3.01433, 104.812599°
M_{30}	Mosque B Lane	-3.017464, 104.81008°
M_{31}	BSI Sport Center B	-3.02025, 104.807961°
M_{32}	Pete B Lane	-3.022136, 104.806525°
M_{33}	230 B Primary School	-3.023247, 104.80544°
M_{34}	Reza B Store	-3.025238, 104.803928°
M_{35}	228 B Primary School	-3.027358, 104.802178°
M_{36}	Panji B Lane	-3.028317, 104.801463°
M_{37}	Palmera B Building	-3.031722, 104.799546°
M_{38}	Lavender B Residence	-3.034416, 104.798125°
M_{39}	Wilona B Cluster	-3.036777, 104.796938°
M_{40}	Palm Springs B Housing	-3.038831, 104.795942°
M_{41}	Depo DJKA B	-3.03904, 104.795154°
M_{42}	Opi Mall B	-3.034934, 104.792403°
M_{43}	LRT DJKA B Station	-3.031439, 104.790052°

was collected using the Google Maps application to facilitate measuring the distance of each stop point. The data highlighted in yellow indicates that the distance between stops is ≤1000 meters. The value M_1,M_2 denotes the distance between stop 1 (LRT DJKA Station A) and stop 2 (Opi Mall A) which is 450 meters. This pattern continues for M_{43},M_{43}.

3.1 Formulation of The SCLP Model of LRT Musi Emas Feeder Corridor 5

This stage determines the stopping point of the LRT Musi Emas Feeder Corridor 5 by formulating the SCLP model. The SCLP model can be seen in Model (14) with Constraint (15) to Constraint (45).

Table 2. The Distance between The Stop Points of the LRT Musi Emas Feeder Corridor 5 (Part 1) in Meter

M_n,M_n	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	0	450	1000	1200	1400	1700	2100	2400	2700	2900	3200	3400	3600	4100	3700
2	450	0	550	700	1000	1300	1600	2000	2200	2500	2800	3000	3200	3600	4000
3	1000	550	0	160	400	700	1000	1400	1700	1900	2200	2400	2600	3000	3400
4	1200	700	160	0	240	550	850	1200	1500	1700	2000	2200	2400	2900	3300
5	1400	1000	400	240	0	290	650	1000	1300	1500	1800	2000	2200	2600	3000
6	1700	1300	700	550	290	0	350	700	1000	1200	1500	1700	1900	2400	2800
7	2100	1600	1000	850	650	350	0	350	650	900	1200	1400	1600	2000	2400
8	2400	2000	1400	1200	1000	700	350	0	280	500	800	1000	1200	1600	2000
9	2700	2200	1700	1500	1300	1000	650	280	0	240	550	750	900	1400	1800
10	2900	2500	1900	1700	1500	1200	900	500	240	0	290	500	700	1100	1500
11	3200	2800	2200	2000	1800	1500	1200	800	550	290	0	200	400	850	1200
12	3400	3000	2400	2200	2000	1700	1400	1000	750	500	200	0	200	650	1000
13	3600	3200	2600	2400	2200	1900	1600	1200	900	700	400	200	0	450	850
14	4100	3600	3000	2900	2600	2400	2000	1600	1400	1100	850	650	450	0	400
15	3700	4000	3400	3300	3000	2800	2400	2000	1800	1500	1200	1000	850	400	0
16	4100	4400	3800	3600	3400	3100	2800	2400	2100	1900	1600	1400	1200	800	350
17	4700	5000	4400	4200	4000	3700	3400	3000	2700	2500	2200	2000	1800	1400	1000
18	4900	5200	4600	4500	4200	4000	3600	3300	3000	2700	2400	2200	2000	1600	1200
19	5100	5400	4800	4700	4400	4100	3800	3400	3200	2900	2600	2400	2200	1800	1400
20	5300	5600	5000	4800	4600	4300	4000	3600	3300	3100	2800	2600	2400	2000	1600
21	5800	6000	5500	5300	5100	4800	4400	4100	3800	3500	3300	3100	2900	2400	2000
22	6200	6500	5900	5800	5500	5300	4500	4500	4300	4000	3700	3500	3300	2900	2500
23	5700	6000	5400	5300	5000	4700	4000	4000	3800	3500	3200	3000	2800	2400	2000
24	5300	5600	5000	4900	4600	4400	3600	3600	3400	3100	2800	2600	2400	2000	1600
25	6000	6200	5700	5500	5300	5000	4300	4300	4000	3700	3500	3300	3100	2600	2200
26	5000	5200	4700	4500	4300	4000	3300	3300	3000	2800	2500	2300	2100	1700	1200
27	4700	5000	4400	4200	4000	3700	3000	3000	2700	2500	2200	2000	1800	1400	1000
28	4100	4400	3800	3700	3400	3200	2500	2500	2200	1900	1600	1400	1300	850	400
29	3800	4000	3500	3300	3100	2800	2100	2100	1800	1600	1300	1100	900	450	50
30	3300	3600	3000	2900	2600	2400	1600	1600	1400	1100	850	650	450	20	400
31	2900	3200	2600	2500	2200	2000	1600	1300	1000	750	450	250	50	400	800
32	2700	2900	2400	2200	2000	1700	1300	1000	700	450	180	20	210	650	1100
33	2500	2800	2200	2000	1800	1500	1200	800	550	300	20	190	400	850	1200
34	2200	2500	1900	1800	1500	1300	900	550	260	20	270	450	650	1100	1500
35	1900	2200	1600	1500	1200	1000	600	230	50	280	550	750	1000	1400	1800
36	1800	2100	1500	1300	1100	800	450	100	180	400	700	900	1100	1500	1900
37	2100	1600	1100	900	650	400	40	350	650	850	1200	1400	1600	2000	2400
38	1700	1300	700	550	300	50	300	700	1000	1200	1500	1700	1900	2300	2700
39	1400	1000	400	260	30	270	600	1000	1200	1500	1800	2000	2200	2600	3000
40	1200	750	180	20	240	550	850	1200	1500	1700	2000	2200	2400	2900	3300
41	1000	600	20	140	400	650	1000	1400	1600	1900	2200	2400	2600	3000	3400
42	500	40	550	700	950	1200	1600	1900	2200	2400	2700	2900	3100	3600	4000
43	350	450	1000	1200	1400	1700	2000	1700	1900	2200	2500	2700	2900	3300	3700

Minimize

$$Z_{SCLP} = \sum_{n=1}^{43} M_n \tag{14}$$

Subject to

$$\sum_{n=1}^{3} M_n + \sum_{n=41}^{43} M_n \geq 1 \tag{15}$$

$$\sum_{n=1}^{5} M_n + \sum_{n=39}^{43} M_n \geq 1 \tag{16}$$

$$\sum_{n=1}^{7} M_n + \sum_{n=38}^{43} M_n \geq 1 \tag{17}$$

$$\sum_{n=2}^{7} M_n + \sum_{n=37}^{42} M_n \geq 1 \tag{18}$$

$$\sum_{n=2}^{8} M_n + \sum_{n=37}^{42} M_n \geq 1 \tag{19}$$

Table 3. The Distance between The Stop Points of the LRT Musi Emas Feeder Corridor 5 (Part 2) in Meter

M_n,M_n	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1	4100	4700	4900	5100	5300	5800	6200	5700	5300	6000	5000	4700	4100	3800	3300
2	4400	5000	5200	5400	5600	6000	6500	6000	5600	6200	5200	5000	4400	4000	3600
3	3800	4400	4600	4800	5000	5500	5900	5400	5000	5700	4700	4400	3800	3500	3000
4	3600	4200	4500	4700	4800	5300	5800	5300	4900	5500	4500	4200	3700	3300	2900
5	3400	4000	4200	4400	4600	5100	5500	5000	4600	5300	4300	4000	3400	3100	2600
6	3100	3700	4000	4100	4300	4800	5300	4700	4400	5000	4000	3700	3200	2800	2400
7	2800	3400	3600	3800	4000	4400	4500	4000	3600	4300	3300	3000	2500	2100	1600
8	2400	3000	3300	3400	3600	4100	4500	4000	3600	4300	3300	3000	2500	2100	1600
9	2100	2700	3000	3200	3300	3800	4300	3800	3400	4000	3000	2700	2200	1800	1400
10	1900	2500	2700	2900	3100	3500	4000	3500	3100	3700	2800	2500	1900	1600	1100
11	1600	2200	2400	2600	2800	3300	3700	3200	2800	3500	2500	2200	1600	1300	850
12	1400	2000	2200	2400	2600	3100	3500	3000	2600	3300	2300	2000	1400	1100	650
13	1200	1800	2000	2200	2400	2900	3300	2800	2400	3100	2100	1800	1300	900	450
14	800	1400	1600	1800	2000	2400	2900	2400	2000	2600	1700	1400	850	450	20
15	350	1000	1200	1400	1600	2000	2500	2000	1600	2200	1200	1000	400	50	400
16	0	600	850	1000	1200	1700	2100	1600	1200	3100	3200	3500	4000	4400	4800
17	600	0	260	450	600	1100	1500	1000	650	1300	280	10	550	900	1400
18	850	260	0	180	350	800	1300	800	400	1200	30	240	800	1200	1600
19	1000	450	180	0	180	650	1100	600	210	1300	150	450	1000	1300	1800
20	1200	600	350	180	0	450	950	400	40	170	350	600	1200	1500	2000
21	1700	1100	800	650	450	0	500	40	400	650	800	1100	1600	2000	2400
22	2100	1500	1300	1100	950	500	0	300	700	900	1100	1300	1900	2300	2700
23	1600	1000	800	600	400	40	300	0	400	600	750	1000	1600	1900	2400
24	1200	650	400	210	40	400	700	400	0	210	350	650	1200	1600	2000
25	3100	1300	1200	1300	170	650	900	600	210	0	170	450	1000	1400	1800
26	3200	280	30	150	350	800	1100	750	350	170	0	270	850	1200	1600
27	3500	10	240	450	600	1100	1300	1000	650	450	270	0	550	900	1400
28	4000	550	800	1000	1200	1600	1900	1600	1200	1000	850	550	0	350	800
29	4400	900	1200	1300	1500	2000	2300	1900	1600	1400	1200	900	350	0	450
30	4800	1400	1600	1800	2000	2400	2700	2400	2000	1800	1600	1400	800	450	0
31	1200	1700	2000	2200	2400	2800	3100	2800	2400	2200	2000	1800	1200	850	400
32	1400	2000	2300	2400	2600	3100	3400	3000	2700	2500	2300	2000	1500	1100	650
33	1600	2200	2400	2600	2800	3200	3500	3200	2800	2600	2500	2200	1600	1300	800
34	1900	2500	2700	2900	3100	3500	3800	3500	3100	2900	2700	2500	1900	1600	1100
35	2200	2800	3000	3200	3400	3800	4100	3800	3400	3200	3000	2800	2200	1900	1400
36	2300	2900	3200	3300	3500	4000	4200	3900	3500	3400	3200	2900	2400	2000	1500
37	2800	3300	3600	3800	4000	4400	4700	4400	4000	3800	3600	3400	2800	2400	2000
38	3100	3700	3900	4100	4300	4700	5000	4700	4300	4100	4000	3700	3100	2800	2300
39	3400	4000	4200	4400	4600	5000	5300	5000	4600	4400	4200	4000	3400	3100	2600
40	3600	4200	4500	4700	4800	5300	5600	5300	4900	4700	4500	4200	3700	3300	2900
41	3800	4400	4600	4800	5000	5400	5700	5400	5000	4800	4600	4400	3800	3500	3000
42	4300	4900	5200	5400	5500	6000	6300	6000	5600	5400	5200	4900	4400	4000	3600
43	4100	4700	4900	5100	5300	5700	6000	5700	5300	5100	4900	4700	4100	3800	3300

$$\sum_{n=3}^{9} M_n + \sum_{n=35}^{41} M_n \geq 1 \tag{20}$$

$$\sum_{n=3}^{10} M_n + \sum_{n=34}^{41} M_n \geq 1 \tag{21}$$

$$\sum_{n=5}^{12} M_n + \sum_{n=32}^{39} M_n \geq 1 \tag{22}$$

$$\sum_{n=6}^{13} M_n + \sum_{n=31}^{38} M_n \geq 1 \tag{23}$$

$$\sum_{n=7}^{13} M_n + \sum_{n=31}^{37} M_n \geq 1 \tag{24}$$

$$\sum_{n=8}^{14} M_n + \sum_{n=30}^{36} M_n \geq 1 \tag{25}$$

$$\sum_{n=8}^{15} M_n + \sum_{n=30}^{36} M_n \geq 1 \tag{26}$$

$$\sum_{n=9}^{15} M_n + \sum_{n=29}^{35} M_n \geq 1 \tag{27}$$

Table 4. The Distance between The Stop Points of the LRT Musi Emas Feeder Corridor 5 (Part 3) in Meter

M_n,M_n	31	32	33	34	35	36	37	38	39	40	41	42	43
1	2900	2700	2500	2200	1900	1800	2100	1700	1400	1200	1000	500	350
2	3200	2900	2800	2500	2200	2100	1600	1300	1000	750	600	40	450
3	2600	2400	2200	1900	1600	1500	1100	700	400	180	20	550	1000
4	2500	2200	2000	1800	1500	1300	900	550	260	20	140	700	1200
5	2200	2000	1800	1500	1200	1100	650	300	30	240	400	950	1400
6	2000	1700	1500	1300	1000	800	400	50	270	550	650	1200	1700
7	1600	1300	1200	900	600	450	40	300	600	850	1000	1600	2000
8	1300	1000	800	550	230	100	350	700	1000	1200	1400	1900	1700
9	1000	700	550	260	50	180	650	1000	1200	1500	1600	2200	1900
10	750	450	300	20	280	400	850	1200	1500	1700	1900	2400	2200
11	450	180	20	270	550	700	1200	1500	1800	2000	2200	2700	2500
12	250	20	190	450	750	900	1400	1700	2000	2200	2400	2900	2700
13	50	210	400	650	1000	1100	1600	1900	2200	2400	2600	3100	2900
14	400	650	850	1100	1400	1500	2000	2300	2600	2900	3000	3600	3300
15	800	1100	1200	1500	1800	1900	2400	2700	3000	3300	3400	4000	3700
16	1200	1400	1600	1900	2200	2300	2800	3100	3400	3600	3800	4300	4100
17	1700	2000	2200	2500	2800	2900	3300	3700	4000	4200	4400	4900	4700
18	2000	2300	2400	2700	3000	3200	3600	3900	4200	4500	4600	5200	4900
19	2200	2400	2600	2900	3200	3300	3800	4100	4400	4700	4800	5400	5100
20	2400	2600	2800	3100	3400	3500	4000	4300	4600	4800	5000	5500	5300
21	2800	3100	3200	3500	3800	4000	4400	4700	5000	5300	5400	6000	5700
22	3100	3400	3500	3800	4100	4200	4700	5000	5300	5600	5700	6300	6000
23	2800	3000	3200	3500	3800	3900	4400	4700	5000	5300	5400	6000	5700
24	2400	2700	2800	3100	3400	3500	4000	4300	4600	4900	5000	5600	5300
25	2200	2500	2600	2900	3200	3400	3800	4100	4400	4700	4800	5400	5100
26	2000	2300	2500	2700	3000	3200	3600	4000	4200	4500	4600	5200	4900
27	1800	2000	2200	2500	2800	2900	3400	3700	4000	4200	4400	4900	4700
28	1200	1500	1600	1900	2200	2400	2800	3100	3400	3700	3800	4400	4100
29	850	1100	1300	1600	1900	2000	2400	2800	3100	3300	3500	4000	3800
30	400	650	800	1100	1400	1500	2000	2300	2600	2900	3000	3600	3300
31	0	260	450	700	1000	1200	1600	1900	2200	2500	2600	3200	2900
32	260	0	170	450	750	900	1300	1700	2000	2200	2400	2900	2700
33	450	170	0	280	600	700	1200	1500	1800	2100	2200	2700	2500
34	700	450	280	0	300	450	900	1200	1500	1800	1900	2500	2200
35	1000	750	600	300	0	130	600	900	1200	1500	1600	2200	1900
36	1200	900	700	450	130	0	450	800	1100	1300	1500	2000	1800
37	1600	1300	1200	900	600	450	0	350	650	900	1000	1600	2100
38	1900	1700	1500	1200	900	800	350	0	290	550	700	1200	1700
39	2200	2000	1800	1500	1200	1100	650	290	0	260	400	1000	1400
40	2500	2200	2100	1800	1500	1300	900	550	260	0	180	750	1200
41	2600	2400	2200	1900	1600	1500	1000	700	400	180	0	550	1000
42	3200	2900	2700	2500	2200	2000	1600	1200	1000	750	550	0	450
43	2900	2700	2500	2200	1900	1800	2100	1700	1400	1200	1000	450	0

$$\sum_{n=11}^{16} M_n + \sum_{n=28}^{33} M_n \geq 1 \tag{28}$$

$$\sum_{n=12}^{17} M_n + \sum_{n=27}^{31} M_n \geq 1 \tag{29}$$

$$\sum_{n=14}^{19} M_n \geq 1 \tag{30}$$

$$\sum_{n=15}^{20} M_n + M_{24} + \sum_{n=26}^{29} M_n \geq 1 \tag{31}$$

$$\sum_{n=16}^{21} M_n + \sum_{n=23}^{24} M_n + \sum_{n=26}^{28} M_n \geq 1 \tag{32}$$

$$\sum_{n=17}^{27} M_n \geq 1 \tag{33}$$

$$\sum_{n=18}^{26} M_n \geq 1 \tag{34}$$

$$\sum_{n=20}^{25} M_n \geq 1 \tag{35}$$

$$\sum_{n=20}^{28} M_n \geq 1 \tag{36}$$

$$\sum_{n=17}^{21} M_n + \sum_{n=23}^{28} M_n \geq 1 \tag{37}$$

$$M_{15} + \sum_{n=17}^{20} M_n + \sum_{n=23}^{29} M_n \geq 1 \tag{38}$$

$$\sum_{n=14}^{15} M_n + \sum_{n=17}^{19} M_n + \sum_{n=25}^{30} M_n \geq 1 \tag{39}$$

$$\sum_{n=13}^{15} M_n + M_{17} + \sum_{n=27}^{31} M_n \geq 1 \tag{40}$$

$$\sum_{n=11}^{15} M_n + \sum_{n=28}^{33} M_n \geq 1 \tag{41}$$

$$\sum_{n=6}^{12} M_n + \sum_{n=32}^{38} M_n \geq 1 \tag{42}$$

$$\sum_{n=4}^{10} M_n + \sum_{n=34}^{41} M_n \geq 1 \tag{43}$$

$$\sum_{n=1}^{7} M_n + \sum_{n=37}^{43} M_n \geq 1 \tag{44}$$

$$M_n \in \{0, 1\}, \quad n = 1, 2, 3, \ldots, 43 \tag{45}$$

Based on the SCLP model, the objective function (14) states the minimum number of LRT Musi Emas Feeder stops Corridor 5. Constraints (15) - (44) state the limit for each demand point with a travelling distance less than equal to 1000 m. Constraint (45) shows that each variable in the SCLP model has a value of 0 or 1. The value is 0 if the facility is not placed at location n. Value 1 if the facility is placed at location n where $n = 1, 2, 3, \ldots 43$. The optimal solution of the SLCP model with LINGO 13.0 is presented in Table 5. The Solver Status results indicate that the Model Class is Pure Integer Linear Programming (PILP), which signifies that the model belongs to the category of pure integer programming. The state displays global optimal results with an objective function value of 4. The value of infeasibility is 0, indicating that the equation with multiple constraints has yielded a feasible solution. The iteration count is 22, signifying that the model has undergone 22 iterations. The Extended Solver Status displays the Solver Type as Branch and Bound, derived from the optimal solution of 4 with an Interval of 2, Generator Memory Used of 39K, and Elapsed Runtime of 0 sec.

The optimal solution for the LRT Musi Emas Feeder stops Corridor 5 is at 4 stopping points, namely $M_{17} = M_{25} = M_{32} = M_{41}$ which are located as follows:

1. Tegal Binangun A Market
2. Aman B Lane
3. Pete B Lane
4. Depo DJKA B

Table 5. Optimal Solution of The SCLP Model

Solver Status	
Model Class	PILP
State	Global Opt
Objective	4
Infeasibility	0
Iteration	22
Extended Solver Status	
Solver Type	Branch and Bound
Best Objective	4
Objective Bound	4
Steps	0
Active	0
Update Interval	2
Generator Memory Used (K)	39
Elapsed Runtime (sec)	0

3.2 Formulation of The MCLP Model of LRT Musi Emas Feeder Corridor 5

This stage determines the LRT Musi Emas Feeder stops Corridor 5 by formulating the MCLP model. The MCLP model formulation aims to maximize the demand point with the specified coverage distance. Table 6 defines the LRT Musi Emas Feeder stops Corridor 5.

Based on Table 6, J_1 defines the variable for stopping point at LRT DJKA A Station, J_2 defines the variable for stopping point at Opi Mall A, and so on until J_{43} defines the variable for stopping point at LRT DJKA B Station. The formulation of the MCLP model is as Model (46) with Constraints (47) to (92). Maximize

$$Z_{MCLP} = \sum_{n=1}^{43} J_n \tag{46}$$

Subject to:

$$\sum_{n=1}^{43} M_n = 4 \tag{47}$$

$$\sum_{n=1}^{3} M_n + \sum_{n=41}^{43} M_n \geq J_1 \tag{48}$$

$$\sum_{n=1}^{5} M_n + \sum_{n=39}^{43} M_n \geq J_2 \tag{49}$$

$$\sum_{n=1}^{7} M_n + \sum_{n=38}^{43} M_n \geq J_3 \tag{50}$$

$$\sum_{n=2}^{7} M_n + \sum_{n=37}^{42} M_n \geq J_4 \tag{51}$$

$$\sum_{n=2}^{8} M_n + \sum_{n=37}^{42} M_n \geq J_5 \tag{52}$$

Table 6. Variable Definition of The LRT Musi Emas Feeder Stops Corridor 5

Variable	The Stopping Points
J_1	LRT DJKA A Station
J_2	Opi Mall A
J_3	Depo LRT DJKA A
J_4	Palm Springs A Housing
J_5	Wilona A Cluster
J_6	Lavender A Residence
J_7	Palmera A Building
J_8	Panji A Lane
J_9	228 A Primary School
J_{10}	Reza A Store
J_{11}	230 A Primary School
J_{12}	Pete A Lane
J_{13}	BSI Sport Center A
J_{14}	Mosque A Lane
J_{15}	Tegal Binangun A Health Centre
J_{16}	Fitra Abadi A High School
J_{17}	Tegal Binangun A Market
J_{18}	Tegal Binangun A Fuel Station
J_{19}	Aman A Lane
J_{20}	555 Thai Tea A
J_{21}	Honda Plaju A
J_{22}	Plaju Terminal
J_{23}	Honda Plaju B
J_{24}	555 Thai Tea B
J_{25}	Aman B Lane
J_{26}	Tegal Binangun B Fuel Station
J_{27}	Tegal Binangun B Market
J_{28}	Fitra Abadi B High School
J_{29}	Tegal Binangun B Health Centre
J_{30}	Mosque B Lane
J_{31}	BSI Sport Center B
J_{32}	Pete B Lane
J_{33}	230 B Primary School
J_{34}	Reza B Store
J_{35}	228 B Primary School
J_{36}	Panji B Lane
J_{37}	Palmera B Building
J_{38}	Lavender B Residence
J_{39}	Wilona B Cluster
J_{40}	Palm Springs B Housing
J_{41}	Depo DJKA B
J_{42}	Opi Mall B
J_{43}	LRT DJKA B Station

$$\sum_{n=3}^{9} M_n + \sum_{n=35}^{41} M_n \geq J_6 \tag{53}$$

$$\sum_{n=3}^{10} M_n + \sum_{n=34}^{41} M_n \geq J_7 \tag{54}$$

$$\sum_{n=5}^{12} M_n + \sum_{n=32}^{39} M_n \geq J_8 \tag{55}$$

$$\sum_{n=6}^{13} M_n + \sum_{n=31}^{38} M_n \geq J_9 \tag{56}$$

$$\sum_{n=7}^{13} M_n + \sum_{n=31}^{37} M_n \geq J_{10} \tag{57}$$

$$\sum_{n=8}^{14} M_n + \sum_{n=30}^{36} M_n \geq J_{11} \tag{58}$$

$$\sum_{n=8}^{15} M_n + \sum_{n=30}^{36} M_n \geq J_{12} \tag{59}$$

$$\sum_{n=9}^{15} M_n + \sum_{n=29}^{35} M_n \geq J_{13} \tag{60}$$

$$\sum_{n=11}^{16} M_n + \sum_{n=28}^{33} M_n \geq J_{14} \tag{61}$$

$$\sum_{n=12}^{17} M_n + \sum_{n=27}^{31} M_n \geq J_{15} \tag{62}$$

$$\sum_{n=14}^{19} M_n \geq J_{16} \tag{63}$$

$$\sum_{n=15}^{20} M_n + M_{24} + \sum_{n=26}^{29} M_n \geq J_{17} \tag{64}$$

$$\sum_{n=16}^{21} M_n + \sum_{n=23}^{24} M_n + \sum_{n=26}^{28} M_n \geq J_{18} \tag{65}$$

$$\sum_{n=16}^{21} M_n + \sum_{n=23}^{24} M_n + \sum_{n=26}^{28} M_n \geq J_{19} \tag{66}$$

$$\sum_{n=17}^{27} M_n \geq J_{20} \tag{67}$$

$$\sum_{n=18}^{26} M_n \geq J_{21} \tag{68}$$

$$\sum_{n=20}^{25} M_n \geq J_{22} \tag{69}$$

$$\sum_{n=17}^{27} M_n \geq J_{23} \tag{70}$$

$$\sum_{n=17}^{27} M_n \geq J_{24} \tag{71}$$

$$\sum_{n=20}^{28} M_n \geq J_{25} \tag{72}$$

$$\sum_{n=17}^{21} M_n + \sum_{n=23}^{28} M_n \geq J_{26} \tag{73}$$

$$M_{15} + \sum_{n=17}^{20} M_n + \sum_{n=23}^{29} M_n \geq J_{27} \quad (74)$$

$$\sum_{n=14}^{15} M_n + \sum_{n=17}^{19} M_n + \sum_{n=25}^{30} M_n \geq J_{28} \quad (75)$$

$$\sum_{n=13}^{15} M_n + M_{17} + \sum_{n=27}^{31} M_n \geq J_{29} \quad (76)$$

$$\sum_{n=11}^{15} M_n + \sum_{n=28}^{33} M_n \geq J_{30} \quad (77)$$

$$\sum_{n=9}^{15} M_n + \sum_{n=29}^{35} M_n \geq J_{31} \quad (78)$$

$$\sum_{n=8}^{14} M_n + \sum_{n=30}^{36} M_n \geq J_{32} \quad (79)$$

$$\sum_{n=8}^{14} M_n + \sum_{n=30}^{36} M_n \geq J_{33} \quad (80)$$

$$\sum_{n=7}^{13} M_n + \sum_{n=31}^{37} M_n \geq J_{34} \quad (81)$$

$$\sum_{n=6}^{13} M_n + \sum_{n=31}^{38} M_n \geq J_{35} \quad (82)$$

$$\sum_{n=6}^{12} M_n + \sum_{n=32}^{38} M_n \geq J_{36} \quad (83)$$

$$\sum_{n=4}^{10} M_n + \sum_{n=34}^{41} M_n \geq J_{37} \quad (84)$$

$$\sum_{n=3}^{9} M_n + \sum_{n=35}^{41} M_n \geq J_{38} \quad (85)$$

$$\sum_{n=2}^{8} M_n + \sum_{n=37}^{42} M_n \geq J_{39} \quad (86)$$

$$\sum_{n=2}^{7} M_n + \sum_{n=37}^{42} M_n \geq J_{40} \quad (87)$$

$$\sum_{n=1}^{7} M_n + \sum_{n=37}^{43} M_n \geq J_{41} \quad (88)$$

$$\sum_{n=1}^{5} M_n + \sum_{n=39}^{43} M_n \geq J_{42} \quad (89)$$

$$\sum_{n=1}^{3} M_n + \sum_{n=41}^{43} M_n \geq J_{43} \quad (90)$$

$$M_n \in \{0, 1\}, \quad n = 1, 2, \ldots, 43 \quad (91)$$

$$J_n \in \{0, 1\}, \quad n = 1, 2, \ldots, 43 \quad (92)$$

Model (46) and Constraints (47) - (92) are MCLP model formulations that can be explained as follows:

1. Model (46) is the objective function to maximize the LRT Musi Emas Feeder stops Corridor 5.
2. Constraint (47) is a constraint stating that 4 stopping points will be operated.
3. Constraints (48) - (90) are constraints that state the limits for each stopping point at locations $J_1 - J_{43}$.
4. Constraints (91) and Constraints (92) are constraints that ensure that all solutions are binary, i.e., solutions that are 0 or 1. If it is 0, it means that the stopping point is not operated. If it is 1, then the stopping point is operated.

The optimal solution of the MCLP model with LINGO 13.0 can be seen in Table 7.

Table 7. The Optimal Solution of The MCLP Model

Solver Status	
Model Class	PILP
State	Global Opt
Objective	43
Infeasibility	0
Iteration	13
Extended Solver Status	
Solver Type	Branch and Bound
Best Objective	43
Objective Bound	43
Steps	0
Active	0
Update Interval	2
Generator Memory Used (K)	55
Elapsed Runtime (sec)	0

All of the optimal stopping points can be seen in Figure 1.

Table 8. The Optimal Solution of The Improved SCLP Model

Solver Status	
Model Class	PILP
State	Global Opt
Objective	48
Infeasibility	0
Iteration	60
Extended Solver Status	
Solver Type	Branch and Bound
Best Objective	48
Objective Bound	48
Steps	0
Active	0
Update Interval	2
Generator Memory Used (K)	88
Elapsed Runtime (sec)	0

From the solution and Figure 1, it means that all the demand points are covered, and there are 4 optimal stopping points, as follows:

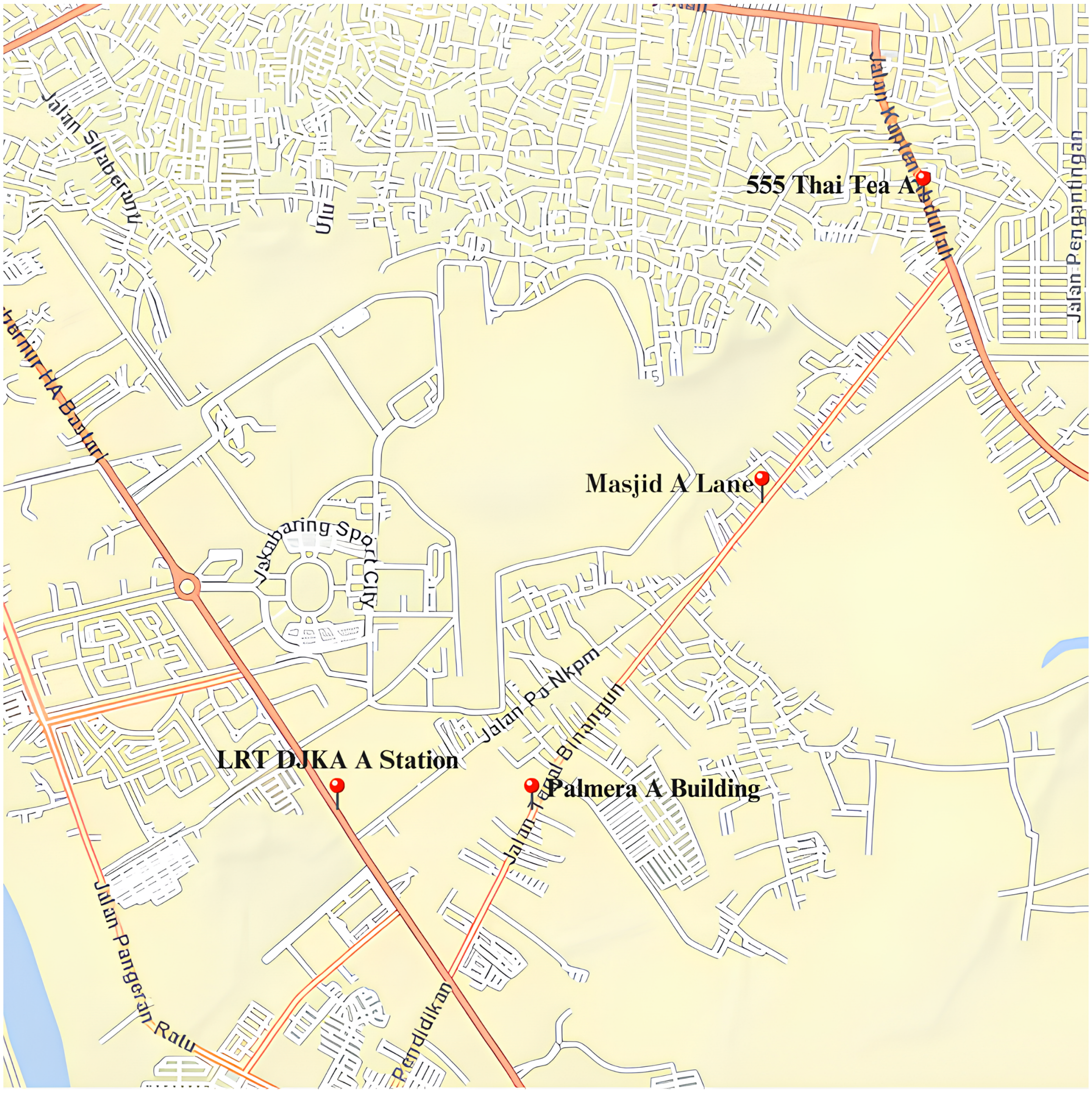

Figure 1. The Optimal Stopping Points Based on The MCLP Model

1. LRT DJKA A Station
2. Palmera A Building
3. Masjid A Lane
4. 555 Thai Tea A

3.3 Formulation of The Improved SCLP Model of LRT Musi Emas Feeder Corridor 5

The purpose of the Improved SCLP model is to minimize the number of LRT Musi Emas Feeder stops Corridor 5 and determine where to add feeder stops. The Improved SCLP model is formulated as follows: Minimize

$$Z_{\text{ISCLP}} = \sum_{n=1}^{43} M_n + \sum_{n=1}^{43} M'_n \tag{93}$$

Subject
Constraints (15) to (44)

$$\sum_{n=1}^{3} M_n + \sum_{n=41}^{43} M_n + 2M'_2 + M'_{13} + 2M'_{16} + M_{20} + M'_{22} + 2M'_{24} + 2M'_{25} + 2M'_{27} + M'_{29} + M'_{41} \geq 43 \tag{94}$$

$$\sum_{n=1}^{5} M_n + \sum_{n=39}^{43} M_n + 2M'_2 + 2M'_{16} + M'_{21} + M'_{22} + 2M'_{24} + 2M'_{25} + 2M'_{27} + M'_{36} + 2M'_{41} \geq 43 \tag{95}$$

$$\sum_{n=1}^{7} M_n + \sum_{n=38}^{43} M_n + 2M'_2 + 2M'_{16} + M'_{20} + M'_{22} + 2M'_{24} + 2M'_{25} + 2M'_{27} + M'_{29} + 2M'_{41} \geq 43 \tag{96}$$

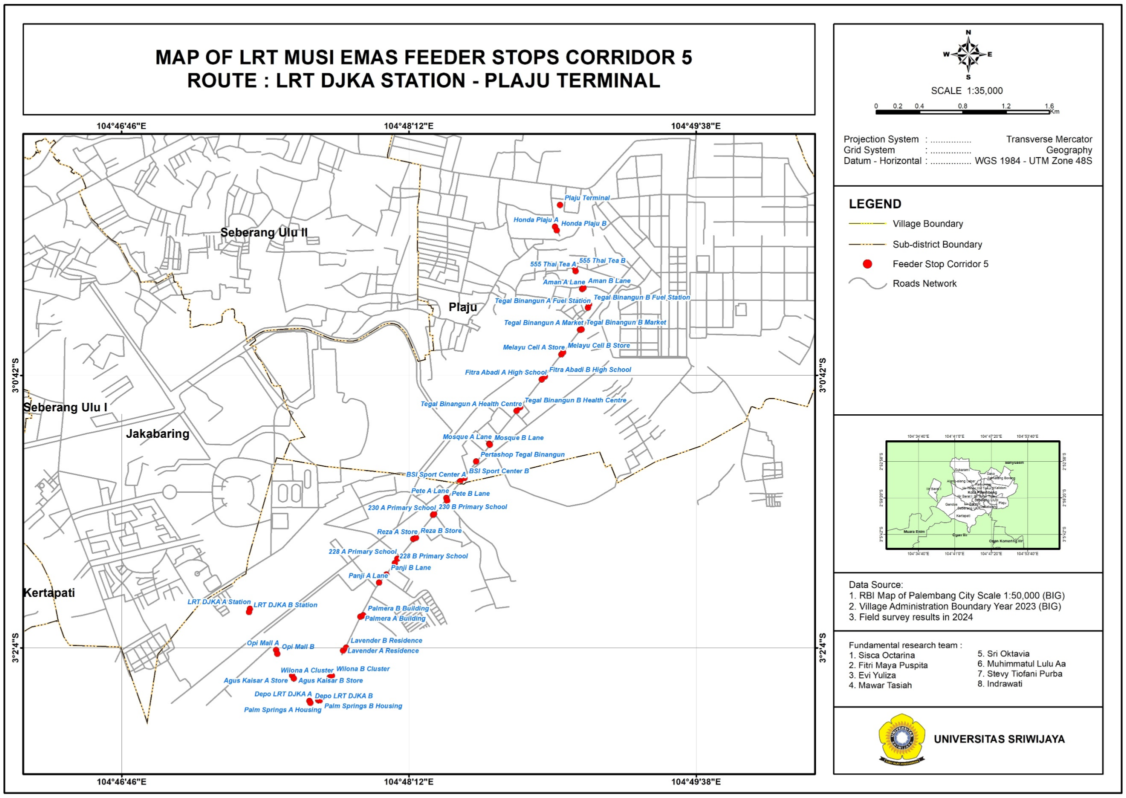

Figure 2. Maps of The Stopping Points of The LRT Musi Emas Feeder Corridor 5

$$\sum_{n=2}^{7} M_n + \sum_{n=37}^{42} M_n + M'_1 + 2M'_2 + M'_{13} + 2M'_{16} + M'_{20} + M'_{21} + M'_{22} + 2M'_{24} + 2M'_{25} + M'_{27} + 2M'_{41} + M'_{42} \geq 43 \quad (97)$$

$$\sum_{n=2}^{8} M_n + \sum_{n=37}^{42} M_n + 2M'_2 + 2M'_{16} + M'_{20} + M'_{22} + 2M'_{24} + 2M'_{25} + 2M'_{27} + M'_{29} + 2M'_{41} \geq 43 \quad (98)$$

$$\sum_{n=3}^{9} M_n + \sum_{n=35}^{41} M_n + 2M'_2 + M'_{13} + 2M'_{16} + M'_{20} + M'_{21} + 2M'_{22} + 2M'_{24} + 2M'_{25} + M'_{27} + 2M'_{41} + M'_{42} \geq 43 \quad (99)$$

$$\sum_{n=3}^{10} M_n + \sum_{n=34}^{41} M_n + 2M'_2 + 2M'_{16} + M'_{22} + 2M'_{24} + 2M'_{25} + M'_{27} + M'_{29} + 2M'_{41} \geq 43 \quad (100)$$

$$\sum_{n=5}^{12} M_n + \sum_{n=32}^{39} M_n + 2M'_2 + 2M'_{16} + M'_{20} + M'_{22} + 2M'_{24} + 2M'_{25} + M'_{27} + M'_{29} + M'_{41} + 2M'_{43} \geq 43 \quad (101)$$

$$\sum_{n=6}^{13} M_n + \sum_{n=31}^{38} M_n + M'_1 + M'_2 + M'_{13} + 2M'_{16} + M'_{20} + M'_{21} + M'_{22} + 2M'_{24} + 2M'_{25} + M'_{27} + 2M'_{41} + 2M'_{43} \geq 43 \quad (102)$$

$$\sum_{n=7}^{13} M_n + \sum_{n=31}^{37} M_n + 2M'_2 + 2M'_{16} + M'_{21} + M'_{22} + 2M'_{24} + 2M'_{25} + 2M'_{27} + M'_{29} + M'_{41} + 2M'_{43} \geq 43 \quad (103)$$

$$\sum_{n=8}^{14} M_n + \sum_{n=30}^{36} M_n + 2M'_2 + 2M'_{16} + M'_{20} + M'_{22} + 2M'_{24} + 2M'_{25} + 2M'_{27} + M'_{36} + M'_{41} + 2M'_{43} \geq 43 \quad (104)$$

$$\sum_{n=8}^{15} M_n + \sum_{n=30}^{36} M_n + 2M'_2 + 2M'_{16} + M'_{20} + M'_{22} + 2M'_{24} + 2M'_{25} + 2M'_{27} + M'_{36} + M'_{41} + 2M'_{43} \geq 43 \quad (105)$$

$$\sum_{n=9}^{15} M_n + \sum_{n=29}^{35} M_n + 2M'_2 + 2M'_{16} + M'_{20} + M'_{22} + 2M'_{24} + 2M'_{25} + M'_{27} + M'_{36} + M'_{41} + 2M'_{43} \geq 43 \quad (106)$$

Table 9. The Optimal Location of LRT Musi Emas Feeder Stops Corridor 5 Based on Improved SCLP Model

Stopping Point	Coordinate Points
LRT DJKA A Station	-3.031179,104.790122°
Opi Mall A	-3.034616,104.79231°
Agus Kaisar A Store	-3.0367335,104.7936380°
Depo LRT DJKA A	-3.038882,104.795074°
Palm Springs A Housing	-3.038817,104.795804°
Wilona A Cluster	-3.036913,104.796751°
Lavender A Residence	-3.034662,104.797865°
Palmera A Building	-3.031836,104.799308°
Panji A Lane	-3.028991,104.800859°
228 A Primary School	-3.026992,104.802375°
Reza A Store	-3.02533,104.803704°
230 A Primary School	-3.023322,104.805359°
Pete A Lane	-3.021912,104.806462°
BSI Sport Center A	-3.020534,104.807591°
Mosque A Lane	-3.017385,104.810037°
Tegal Binangun A Health Centre	-3.014631,104.812302°
Fitra Abadi A High School	-3.012004,104.81439°
Melayu Cell A Store	-3.009917,104.816028°
Tegal Binangun A Market	-3.007855,104.817586°
Tegal Binangun A Fuel Station	-3.006018,104.81824°
Aman A Lane	-3.00446,104.817762°
555 Thai Tea A	-3.002964,104.817217°
Honda Plaju A	-2.999247,104.815502°
Plaju Terminal	-2.997422,104.815913°
Honda Plaju B	-2.999552,104.815646°
555 Thai Tea B	-3.002658,104.817128°
Aman B Lane	-3.004356,104.817864°
Tegal Binangun B Fuel Station	-3.005735,104.81833°
Tegal Binangun B Market	-3.007824,104.817709°
Melayu Cell B Store	-3.009750,104.816167°
Fitra Abadi B High School	-3.011774,104.814651°
Tegal Binangun B Health Centre	-3.01433,104.812599°
Mosque B Lane	-3.017464,104.81008°
Pertashop Tegal Binangun	-3.0188611,104.8089444°
BSI Sport Center B	-3.02025,104.807961°
Pete B Lane	-3.022136,104.806525°
230 B Primary School	-3.023247,104.80544°
Reza B Store	-3.025238,104.803928°
228 B Primary School	-3.027358,104.802178°
Panji B Lane	-3.028317,104.801463°
Palmera B Building	-3.031722,104.799546°
Lavender B Residence	-3.034416,104.798125°
Wilona B Cluster	-3.036777,104.796938°
Palm Springs B Housing	-3.038831,104.795942°
Depo DJKA B	-3.03904,104.795154°
Agus Kaisar B Store	-3.0370000,104.7937778°
Opi Mall B	-3.034934,104.792403°
LRT DJKA B Station	-3.031439,104.790052°

$$\sum_{n=11}^{16} M_n + \sum_{n=28}^{33} M_n + M'_1 + 2M'_2 + 2M'_{16} + M'_{21} + M'_{22} + 2M'_{24} + 2M'_{25} + 2M'_{27} + M'_{36} + 2M'_{41} + 2M'_{43} \geq 43 \quad (107)$$

$$\sum_{n=12}^{17} M_n + \sum_{n=27}^{31} M_n + 2M'_2 + 2M'_{16} + M'_{21} + M'_{22} + 2M'_{24} + 2M'_{25} + 2M'_{27} + M'_{36} + 2M'_{41} \geq 43 \quad (108)$$

$$\sum_{n=14}^{19} M_n + 2M'_2 + 2M'_{16} + M'_{20} + M'_{22} + 4M'_{24} + M'_{27} + 8M'_{30} + M'_{36} + M'_{41} \geq 43 \quad (109)$$

$$\sum_{n=15}^{20} M_n + M_{24} + \sum_{n=26}^{29} M_n + 2M'_2 + 2M'_{16} + M'_{20} + M'_{22} + 2M'_{24} + 3M'_{25} + 2M'_{27} + M'_{29} + M'_{41} \geq 43 \quad (110)$$

$$\sum_{n=16}^{21} M_n + \sum_{n=23}^{24} M_n + \sum_{n=26}^{28} M_n + 2M'_2 + 2M'_{16} + M'_{21} + M'_{22} + 2M'_{24} + 3M'_{25} + 2M'_{27} + 2M'_{41} \geq 43 \quad (111)$$

$$\sum_{n=17}^{27} M_n + 2M'_2 + 2M'_{16} + M'_{22} + 3M'_{24} + 3M'_{25} + 2M'_{27} + M_{28} + M'_{29} + M'_{36} + 2M'_{41} \geq 43 \quad (112)$$

$$\sum_{n=17}^{27} M_n + 2M'_2 + 2M'_{16} + M'_{21} + 2M'_{22} + 2M'_{27} + M'_{29} + M'_{36} + M'_{41} \geq 43 \quad (113)$$

$$\sum_{n=18}^{26} M_n + M'_2 + M'_{13} + 2M'_{16} + M'_{21} + M'_{27} + 2M'_{41} \geq 43 \quad (114)$$

$$\sum_{n=20}^{25} M_n + 2M'_2 + 2M'_6 + 2M'_{16} + M'_{21} + 2M'_{27} + M'_{36} + 2M'_{41} \geq 43 \quad (115)$$

$$\sum_{n=17}^{27} M_n + 2M'_2 + 2M'_6 + 2M'_{16} + 2M'_{27} + M'_{29} + M'_{36} + 2M'_{41} \geq 43 \quad (116)$$

$$\sum_{n=17}^{27} M_n + 2M'_2 + 2M'_6 + 2M'_{16} + 2M'_{27} + M'_{36} + 2M'_{41} \geq 43 \quad (117)$$

$$\sum_{n=20}^{27} M_n + M'_2 + 2M'_6 + M'_{13} + 2M'_{15} + 4M'_{16} + 3M'_{19} + 2M'_{27} + M_{28} + 2M'_{41} + 2M'_{43} \geq 43 \quad (118)$$

$$\sum_{n=17}^{21} M_n + \sum_{n=23}^{28} M_n + M'_2 + 2M'_6 + M'_{14} + 4M'_{15} + 6M'_{16} + 2M'_{27} + 2M'_{41} \geq 43 \quad (119)$$

$$M_{15} + \sum_{n=17}^{20} M_n + \sum_{n=23}^{29} M_n + 2M'_2 + 2M'_6 + 5M'_{15} + 7M'_{16} + M'_{20} + 2M'_{27} + M'_{29} + M'_{36} + M'_{41} \geq 43 \quad (120)$$

$$\sum_{n=14}^{15} M_n + \sum_{n=17}^{19} M_n + \sum_{n=25}^{30} M_n + 2M'_2 + 2M'_6 + 8M'_{15} + 7M'_{16} + 2M'_{27} + 2M'_{41} \geq 43 \quad (121)$$

$$\sum_{n=13}^{15} M_n + M_{17} + M'_2 + \sum_{n=27}^{31} M_n + 2M'_6 + 9M'_{15} + 7M'_{16} + M'_{20} + 2M'_{27} + M'_{41} \geq 43 \quad (122)$$

$$\sum_{n=11}^{15} M_n + \sum_{n=28}^{33} M_n + 2M'_2 + 2M'_6 + 9M'_{15} + 7M'_{16} + 2M'_{27} + M'_{36} + 2M'_{41} \geq 43 \quad (123)$$

$$\sum_{n=9}^{15} M_n + \sum_{n=29}^{35} M_n + 2M'_2 + M'_{16} + 2M'_{27} + 2M'_{41} \geq 43 \quad (124)$$

$$\sum_{n=8}^{14} M_n + \sum_{n=30}^{36} M_n + M'_2 + 2M'_{16} + M'_{20} + M'_{27} + M'_{41} \geq 43 \quad (125)$$

$$\sum_{n=8}^{14} M_n + \sum_{n=30}^{36} M_n + 2M'_2 + 2M'_{16} + 2M'_{27} + M'_{29} + M'_{36} + M'_{41} \geq 43 \quad (126)$$

$$\sum_{n=7}^{13} M_n + \sum_{n=31}^{37} M_n + 2M'_2 + 2M'_{16} + 2M'_{27} + M'_{29} + 2M'_{41} \geq 43 \quad (127)$$

$$\sum_{n=6}^{13} M_n + \sum_{n=31}^{38} M_n + 2M'_2 + 4M'_{16} + 2M'_{27} + M'_{29} + 2M'_{41} \geq 43 \quad (128)$$

$$\sum_{n=6}^{12} M_n + \sum_{n=32}^{38} M_n + 2M'_2 + 2M'_{16} + M'_{20} + M'_{27} + M'_{29} + 2M'_{41} \geq 43 \quad (129)$$

$$\sum_{n=4}^{10} M_n + \sum_{n=34}^{41} M_n + M'_1 + M'_2 + M'_{16} + 2M'_{27} + 2M'_{41} + M'_{42} \geq 43 \quad (130)$$

$$\sum_{n=3}^{9} M_n + \sum_{n=35}^{41} M_n + 2M'_2 + 2M'_{16} + 2M'_{27} + M'_{29} + M'_{41} + M'_{42} \geq 43 \quad (131)$$

$$\sum_{n=2}^{8} M_n + \sum_{n=37}^{41} M_n + 2M'_2 + 2M'_{16} + 2M'_{27} + M'_{29} + 2M'_{41} + M'_{42} \geq 43 \quad (132)$$

$$\sum_{n=2}^{7} M_n + \sum_{n=37}^{41} M_n + 2M'_2 + M'_{13} + 2M'_{16} + M'_{20} + M'_{27} + 2M'_{41} + M'_{42} \geq 43 \quad (133)$$

$$\sum_{n=1}^{7} M_n + \sum_{n=37}^{43} M_n + 2M'_2 + 2M'_{16} + 2M'_{27} + M'_{29} + M'_{36} + 2M'_{41} \geq 43 \quad (134)$$

$$\sum_{n=1}^{5} M_n + \sum_{n=39}^{43} M_n + 2M'_2 + M'_{13} + 2M'_{16} + M'_{20} + M'_{27} + 2M'_{41} \geq 43 \quad (135)$$

$$\sum_{n=1}^{3} M_n + \sum_{n=41}^{43} M_n + 2M'_2 + 2M'_{16} + 2M'_{27} + M'_{29} + 2M'_{41} \geq 43 \quad (136)$$

$$M_n \in \{0, 1\}, \quad \text{where } n = 1, 2, 3, \ldots, 43 \quad (137)$$

$$M'_n \in \{0, 1\}, \quad \text{where } n' = 1, 2, 3, \ldots, 43 \quad (138)$$

Model (93) and Constraints (15) - (44), Constraints (94)-(138) are the formulation of the Improved SCLP model which can be explained as follows:

1. Model (93) is the objective function to minimize the number of the LRT Musi Emas Feeder stops Corridor 5.
2. Constraints (15) - (44) are constraints M_n for each stopping point.
3. Constraints (94) - (136) are constraints for each uncertain stopping point M'_n.
4. Constraint (137) states that the decision variable M_n has the value 0 or 1.
5. Constraint (138) states that the variable M'_n has a binary value of 0 or 1.

The optimal solution of the Improved SCLP model can be seen in Table 8.

All stopping points with distance ≤ 1000 meter are optimal with 5 additional stops, which are explained as follows:

1. $M'_2 = 1$ means there is additional 1 stopping point between Opi Mall A stop and Depo LRT DJKA A stop.
2. $M'_{16} = 1$ means there is additional 1 stopping point between Fitra Abadi A High School stop and Tegal Binangun A Market stop.
3. $M'_{27} = 1$ means there is additional 1 stopping point between Tegal Binangun B Market stop and Fitra Abadi B High School stop.
4. $M'_{30} = 1$ means there is additional 1 stopping point between Mosque B Lane Stop and BSI Sport Center B stop.
5. $M'_{41} = 1$ means there is additional 1 stopping point between Depo DJKA B stop and Opi Mall B stop.

Following direct research into the field and the formulation of several models, a final analysis was conducted to synthesize the findings. The formulation of the SCP model, namely the SCLP model and the MCLP model, assisted by LINGO 13.0

software, yielded four optimal stopping point for the LRT Musi Emas Feeder Corridor 5. Moreover, Table 9 presents the optimal stops of the LRT Musi Emas Feeder Corridor 5, as determined by the Improved SCLP model.

Based on the data in Table 9, Figure 2 shows the optimal stop location mapping for the LRT Musi Emas Feeder Corridor 5.

4. CONCLUSIONS

The SCP model formulation, which includes the SCLP and MCLP models, only produces four optimal stop locations for the LRT Musi Emas Feeder Corridor 5. The optimal solutions obtained from these two models are very far from the actual conditions at the location. The Improved SCLP model formulation can not only be used to determine the optimal location of the feeder stops. Still, it can also determine whether additional points are needed on the LRT Musi Emas Feeder Corridor 5. After the evaluation, the researcher concluded that the Improved SCLP model formulation shows that the existing 43 feeder stop locations on Corridor 5 are currently optimal. Five additional stop points should be added to Corridor 5, namely at the stop points of Agus Kaisar A Store, Melayu Cell A Store, Melayu Cell B Store, Petrashop Tegal Binangun, and Agus Kaisar B Store. Therefore, the researcher recommends the solution in Table 9 to the Palembang city government as the optimal stopping points of the LRT Musi Emas Feeder Corridor 5. The optimal solution is expected to cover all demand in Corridor 5.

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