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RESEARCH ARTICLE | FEBRUARY 16 2024

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AIP Conf. Proc. 3046, 020010 (2024)
https://doi.org/10.1063/5.0194636

Optimization of Temporary Disposal Facilities Location with Set Covering Problem Model and Ant Colony Optimization Algorithm in Ilir Barat I District Palembang

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Abstract. The waste problem in Ilir Barat I District arises due to the prominent population of residents who settle. Extensive population results in an increase in the volume of waste produced. Temporary disposal facilities (TDF) are the government's effort to overcome the waste problem. The locations of TDF in Ilir Barat I District are irregular. Therefore this study aims to determine the optimal location of TDF in the Ilir Barat I District by formulating the set covering problem (SCP) model. SCP models developed in this research include the set covering location problem (SCLP) and p-center location problem. We used LINGO programming for the exact approach and the ant colony optimization (ACO) algorithm for the heuristic approach. There are 27 TDF spread across six sub-districts in Ilir Barat I District. From the formulation of the SCP model and the implementation of the ACO algorithm, there are 15 optimal TDF locations in Ilir Barat I District. Based on the results obtained, this study recommends an ACO algorithm for determining the optimal location of TDF because the solution of the ACO algorithm can meet the whole demand point in Ilir Barat I District. The optimal TDF in Ilir Barat I District is TDF Jl. Demang Lebar Daun Titik Sampah Halte infront of Kantor Perdagangan Kota, TDF opposite PS, TDF Jl. Puncak Sekuning, TDF Jl. Bintan beside Bank Mandiri, TDF Jl. Natuna beside BPN, TDF Jl. Angkatan 45 Titik Sampah Simpang Lorong Harisan, TDF Jl. Angkatan 45 Titik Sampah infront of Lorong Persatuan, TDF Jl. Angkatan 45 Titik Sampah opposite Lorong Kejora (Lorong Harapan), TDF Jl. Angkatan 45 infront of Jl. Sang Merah Putih, TDF Simpang Jl. Kaca Piring, TDF Jl. Soekarno Hatta Titik Sampah Simpang Jembatan Kancil Putih, TDF Jl. Demang Lebar Daun Titik Sampah Halte Retensi Brimob, TDF Siguntang, TDF Jl. Srijaya Negara beside Jl. Jaya Sempurna, and TDF Jl. Srijaya Negara Pasar Padang Selasa. All TDF can meet the demand in each sub-district in Ilir Barat I District.

INTRODUCTION

The yearly increase in the number of residents in Palembang city coincides with an increase in the volume of waste produced. Alfian and Phelia [1] revealed that the large population and the diversity of activities in big cities are one of the causes of the emergence of waste problems. Ilir Barat I District has the second highest population in Palembang City. More residents occupying an area will produce more waste [2]. The rate of trash that continues to increase every year is not accompanied by an increase in waste management by the government, so the waste problem still needs to be overcome.

Proceeding of the 7th National Conference on Mathematics and Mathematics Education (SENATIK)
AIP Conf. Proc. 3046, 020010-1–020010-14; https://doi.org/10.1063/5.0194636
Published by AIP Publishing. 978-0-7354-4834-6/$30.00

Through the environment and hygiene service (DLHK), Palembang City Government provides TDF to overcome the problem of accumulated waste. The TDF aims to reduce the volume and impact caused by the debris. Improper location of TDF can result in excessive landfilling. Therefore, determining TDF's location is one of the critical indicators in the waste management system. Optimizing location placement is one of the optimization problems [3]. SCP model is an optimization problem to determine the location and number of TDF [4]. SCP is an integer programming model called integer linear programming (ILP), where some or all variables are integers. In everyday life, the SCP model includes: allocating tasks assigned to machines, sharing work with employees, optimizing facility locations to obtain optimal results, and assigning vehicle routes to TDF to maximize distance and cost [5].

We can solve the SCP model using various models, including SCLP and the p-center location problem. SCLP is an optimization model that aims to place the location of a facility along with its number to meet all demand points [6]. Meanwhile, the p-center location problem is an optimization model that aims to determine the location of facilities to minimize the maximum travel distance where each facility must cover all demand points [4]. A p-center location problem is a minimax facility location problem to plan the location of public facilities such as hospitals, fire stations, and other facilities [7].

One of the heuristic methods that can solve SCP [8][9][10][11][12][13][14][15] is ACO. ACO is a heuristic mainly used to solve complex combinatorial optimization problems. The ACO algorithm is adopted from the behavior of ant colonies when searching for food [16]. Ant colonies can find the shortest passage from a food source to their nest using pheromones traces [17]. Pheromones communicate with other ants so that the next ants can follow the route that contains pheromones, and the ants will form the shortest route.

Some previous studies on SCP are in determining the location of public facilities [18][19][20][21][22], including Sitepu *et al*. [6], who optimizes the area of emergency installation locations of hospitals in Palembang City with the SCLP model that recommends five emergency installation locations to meet all demand points. Ayudhya [23] examined the location of humanitarian aid facilities in Nakhon Sri Thammarat and Phatthalung Provinces using the p-Center model. The research result is we need one center of humanitarian assistance in Phra Phrom, two in Mueng Phatthalung and Mueng Nakhon Sri Thammarat, and three h Syukriah *et al*. [24] drafting syrup distribution routes at UD. Bireuen Rice Flower with ACO algorithm. The best route in Bireuen is ant line 7, with a total distance of 105.3 km, while the best route in Lhokseumawe is ant line 10, with a total distance of 122.5 km.

Based on the background, this study discusses optimizing the location of TDF in Ilir Barat I. This study formulated an SCP model including SCLP and p-center location problems that were solved using the LINGO 13.0 application. The SCLP model can minimize the number of TDF to cover all demand points in each sub-district. Then we implemented the ACO algorithm to determine the route and optimal TDF in Ilir Barat I District. Using a broader structure in the ACO algorithm helps find acceptable solutions at this stage of the research process. The solution in this research can become a consideration for DLHK Palembang City in determining the optimal TDF in Ilir Barat I District and a reference for further study in selecting the waste transportation routing.

METHOD

The first step in this study is retrieving distance data between each TDF in Ilir Barat I District from DLHK Palembang City and presented in a data table. Next, we define TDF and sub-district data variables in Ilir Barat I District. We formulate an SCP model consisting of an SCLP model and a p-center location problem model, then find the solution of the model by using the LINGO 13.0 application. For the heuristic approach, we implement the ACO algorithm to determine the optimal location of TDF. The final steps are to analyze the results of the SCP model and ACO algorithm to get the optimal location of TDF in Ilir Barat I District.

RESULT AND DISCUSSION

This section explains the SCLP model, the p-center location problem model, and the implementation of the ACO algorithm.

The Set Covering Location Problem Model

The definition of variables for TDF in Ilir Barat I District annotated with x_j, where $j = 1,2,3,\ldots,27$, we can check it in Table 1. Table 1 states that the variable x_j can be worth 0 or 1. Variable value 1 if the TDF exists and is optimal and placed on site j , while it is worth 0 if the TDF exists but is not optimal and is not placed on site j . The definition of variables for each sub-district in Ilir Barat I District annotated with y_i, where $i = a, b, c, d, e$, we can see it in Table 2.

Regulation of the Minister of Public Works of the Republic of Indonesia Number 03/PRT/M/2013 concerning the Implementation of Waste Infrastructure and Facilities in Handling Household Waste and Similar Waste of Household Waste in Article 32 states that the technical requirements for the distance between TDF are less than or equal to 500 meters. Table 3 shows the distance between TDF in Ilir Barat I District in meters obtained from the DLHK Palembang City.

TABLE 1. Variables definition for TDF in Ilir Barat I District.

Variable	Name of TDF
x_1	TDF Jl. PDAM Kelurahan Bukit Lama
x_2	TDF Jl. Sultan Mansyur
x_3	TDF Perumahan Polygon
x_4	TDF Siguntang
x_5	TDF Jl. Demang Lebar Daun Titik Sampah Halte infront of Kantor Perdagangan Kota
x_6	TDF Jl. Srijaya Negara beside Jl. Jaya Sempurna
x_7	TDF Jl. Srijaya Negara Pasar Padang Selasa
x_8	TDF Jl. Natuna beside BPN
x_9	TDF Jl. Bintan beside Bank Mandiri
x_{10}	TDF Sampah Liar Simpang 5 DPRD Provinsi in front of RM. Pindang Kuyung
x_{11}	TDF Jl. Puncak Sekuning
x_{12}	TDF Jl. Aerobik in front of Kantor DPD GOLKAR
x_{13}	TDF Simpang Jl. Kaca Piring
x_{14}	TDF opposite PS
x_{15}	TDF Jl. Kapten A. Rivai Lorong Karya
x_{16}	TDF Jl. Angkatan 45 in front of Jl. Sang Merah Putih
x_{17}	TDF Jl. Angkatan 45 Titik Sampah in front of Lorong Persatuan
x_{18}	TDF Jl. Angkatan 45 Titik Sampah opposite Lorong Kejora (Lorong Harapan)
x_{19}	TDF Jl. Angkatan 45 Titik Sampah Simpang Lorong Harisan
x_{20}	TDF Jl. Demang Lebar Daun Titik Sampah Halte Retensi Brimob
x_{21}	TDF beside Kantor Keuangan
x_{22}	TDF Jl. Demang Lebar Daun Titik in front of Kantor Capil
x_{23}	TDF Jl. Soekarno Hatta Titik Sampah Simpang Jembatan Kancil Putih
x_{24}	TDF Jl. Inspektur Marzuki Titik Sampah Simpang Lorong Pakjo
x_{25}	TDF Lapas Anak Pakjo
x_{26}	TDF Komplek Rutan Pakjo
x_{27}	TDF Jl. Anwar Arsad in front of Indomaret

TABLE 2. Definition of variables for Sub-District in Ilir Barat I District.

Variable	Variable Description
y_a	Bukit Lama Sub-District
y_b	Bukit Baru Sub-District
y_c	26 Ilir D. I Sub-District
y_d	Lorok Pakjo Sub-District
y_e	Demang Lebar Daun Sub-District
y_f	Siring Agung Sub-District

TABLE 3. Distance between TDF in Ilir Barat I District.

$d_{j,j}$	1	2	3	4	5	6	7	8	9	10	11	12	13
1	0	450	2600	2000	3000	3400	3800	3400	3600	4500	4100	4200	4700
2	450	0	2300	1550	2550	2950	3350	3400	3600	7400	4400	4990	5400
3	2600	2300	0	3800	1900	2300	2700	6000	6200	6750	7100	7340	8640
4	2000	1550	3800	0	1000	1400	1800	1800	2000	2700	2300	2400	1800
5	3000	2550	1900	1000	0	2400	2800	3600	3800	4700	4300	4400	3800
6	3400	2950	2300	1400	2400	0	400	2000	2200	3100	2700	2800	2500
7	3800	3350	2700	1800	2800	400	0	3300	3500	4050	4400	4640	5940
8	3400	3400	6000	1800	3600	2000	3300	0	200	750	1100	1340	2640
9	3600	3600	6200	2000	3800	2200	3500	200	0	550	900	1140	2440
10	4500	7400	6750	2700	4700	3100	4050	750	550	0	350	590	1890
11	4100	4400	7100	2300	4300	2700	4400	1100	900	350	0	240	1540
12	4200	4990	7340	2400	4400	2800	4640	1340	1140	590	240	0	1300
13	4700	5400	8640	1800	3800	2500	5940	2640	2440	1890	1540	1300	0
14	5100	5900	6800	2400	4000	3100	6440	3140	2940	2390	2040	1800	500
15	3100	3100	5800	1300	3200	1600	3100	850	1100	2790	2440	2200	2100
16	4700	5400	6100	1900	3300	2600	6040	2740	2540	1990	1640	1400	1900
17	5900	5300	5900	3100	3100	3800	4700	3200	4590	4040	3690	3450	1700
18	5100	5800	6500	2200	3600	2900	4400	2300	2300	4220	1800	1900	800
19	5600	5000	5600	2800	2800	3500	4400	2900	2900	4340	2500	2500	2450
20	5600	5000	5600	2800	2800	3500	4400	2900	2800	4840	2400	2500	1400
21	4600	4000	4600	3500	1800	3200	3400	3600	3500	5240	3100	3200	2000
22	3900	3300	3900	3600	1100	2500	2700	4200	4100	6240	3700	3800	2700
23	4100	3500	2700	3700	1300	2700	2900	5300	5200	5900	5600	5700	4600
24	6900	6100	5400	5700	4000	5500	5600	5800	5800	7200	5000	5100	3900
25	7100	6500	6400	5300	4300	5700	5900	5300	5300	6500	4500	4600	3500
26	6700	6300	6300	4900	3900	5300	5500	5000	4900	6200	4100	4200	3100
27	5600	4900	5600	4000	2700	4200	4300	4100	4000	5600	3600	3700	2500

$d_{j,j}$	14	15	16	17	18	19	20	21	22	23	24	25	26	27
1	5100	3100	4700	5900	5100	5600	5600	4600	3900	4100	6900	7100	6700	5600
2	5900	3100	5400	5300	5800	5000	5000	4000	3300	3500	6100	6500	6300	4900
3	6800	5800	6100	5900	6500	5600	5600	4600	3900	2700	5400	6400	6300	5600
4	2400	1300	1900	3100	2200	2800	2800	3500	3600	3700	5700	5300	4900	4000
5	4000	3200	3300	3100	3600	2800	2800	1800	1100	1300	4000	4300	3900	2700
6	3100	1600	2600	3800	2900	3500	3500	3200	2500	2700	5500	5700	5300	4200
7	6440	3100	6040	4700	4400	4400	4400	3400	2700	2900	5600	5900	5500	4300
8	3140	850	2740	3200	2300	2900	2900	3600	4200	5300	5800	5300	5000	4100
9	2940	1100	2540	4590	2300	2900	2800	3500	4100	5200	5800	5300	4900	4000
10	2390	2790	1990	4040	4220	4340	4840	5240	6240	5900	7200	6500	6200	5600
11	2040	2440	1640	3690	1800	2500	2400	3100	3700	5600	5000	4500	4100	3600
12	1800	2200	1400	3450	1900	2500	2500	3200	3800	5700	5100	4600	4200	3700
13	500	2100	1900	1700	800	2450	1400	2000	2700	4600	3900	3500	3100	2500
14	0	400	1400	1650	1830	1950	2450	2850	3850	5750	5200	5200	4400	3700
15	400	0	1000	1250	1430	1550	2050	2450	3450	5350	7950	5600	5200	4300
16	1400	1000	0	250	430	550	1050	1450	2450	4350	3800	3400	3000	2100
17	1650	1250	250	0	180	300	800	1200	2200	4100	3700	3600	2900	2300
18	1830	1430	430	180	0	120	620	1020	2020	3920	3200	2700	2700	1800
19	1950	1550	550	300	120	0	500	900	1900	3800	3100	3900	3100	2000
20	2450	2050	1050	800	620	500	0	400	1400	3300	2800	2700	2300	1200
21	2850	2450	1450	1200	1020	900	400	0	1000	2900	3100	2600	2200	1100
22	3850	3450	2450	2200	2020	1900	1400	1000	0	1900	4500	5700	3800	2600
23	5750	5350	4350	4100	3920	3800	3300	2900	1900	0	2600	3800	3600	4800
24	5200	7950	3800	3700	3200	3100	2800	3100	4500	2600	0	1200	850	2000

$d_{i,j}$	14	15	16	17	18	19	20	21	22	23	24	25	26	27
25	5200	5600	3400	3600	2700	3900	2700	2600	5700	3800	1200	0	400	1200
26	4400	5200	3000	2900	2700	3100	2300	2200	3800	3600	850	400	0	1300
27	3700	4300	2100	2300	1800	2000	1200	1100	2600	4800	2000	1200	1300	0

Table 3 shows that the distance between the first and the second TDF is 450 m, between the first and the third TDF is 2,600 m, and so on. The SCLP model is shown in Equation (1) and Constraint (2) to (24).

Minimize Z_{SCLP} that is expressed in Equation (1).

$$Z_{SLCP} = x_1+x_2+x_3+x_4+x_5+x_6+x_7+x_8+x_9+x_{10}+x_{11}+x_{12}+x_{13}+x_{14}+x_{15}+x_{16}+x_{17}+x_{18}+x_{19}+x_{20}+x_{21}+x_{22}+x_{23}+x_{24}+x_{25}+x_{26}+x_{27} \quad (1)$$

Subject to:

$$x_1 + x_2 \geq 1 \quad (2)$$

$$x_3 \geq 1 \quad (3)$$

$$x_4 \geq 1 \quad (4)$$

$$x_5 \geq 1 \quad (5)$$

$$x_6 + x_7 \geq 1 \quad (6)$$

$$x_8 + x_9 \geq 1 \quad (7)$$

$$x_{10} + x_{11} \geq 1 \quad (8)$$

$$x_{10} + x_{11} + x_{12} \geq 1 \quad (9)$$

$$x_{11} + x_{12} \geq 1 \quad (10)$$

$$x_{13} + x_{14} \geq 1 \quad (11)$$

$$x_{13} + x_{14} + x_{15} \geq 1 \quad (12)$$

$$x_{14} + x_{15} \geq 1 \quad (13)$$

$$x_{16} + x_{17} + x_{18} \geq 1 \quad (14)$$

$$x_{16} + x_{17} + x_{18} + x_{19} \geq 1 \quad (15)$$

$$x_{17} + x_{18} + x_{19} + x_{20} \geq 1 \quad (16)$$

$$x_{19} + x_{20} + x_{21} \geq 1 \quad (17)$$

$$x_{20} + x_{21} \geq 1 \quad (18)$$

$$x_{22} \geq 1 \quad (19)$$

$$x_{23} \geq 1 \quad (20)$$

$$x_{24} \geq 1 \quad (21)$$

$$x_{25} + x_{26} \geq 1 \quad (22)$$

$$x_{27} \geq 1 \quad (23)$$

$$x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8, x_9, x_{10}, x_{11}, x_{12}, x_{13}, x_{14}, x_{15}, x_{16}, x_{17}, x_{18}, x_{19}, x_{20}, x_{21}, x_{22}, x_{23}, x_{24}, x_{25}, x_{26}, x_{27} \in \{0,1\} \quad (24)$$

Equation (1) is an objective function to minimize the number of candidates for TDF to meet demand points in the Ilir Barat I District. Constraint (2) to (23) ensure that at least one facility is selected to meet each demand point. Constraint (24) is an integer binary constraint. The SCLP model of Ilir Barat I District completed by LINGO 13.0 yielded a value Z_{SCLP} =15 with $x_2 = x_3 = x_4 = x_5 = x_7 = x_9 = x_{11} = x_{14} = x_{18} = x_{20} = x_{22} = x_{23} = x_{24} = x_{26} = x_{27} = 1$ as the optimal solution. The location of the optimal TDF candidates results from the SCLP model in Ilir Barat I District, which amounts to 15 TDF, including TDF Jl. Sultan Mansyur, TDF Perumahan Polygon, TDF Siguntang, TDF Jl. Demang Lebar Daun Titik Sampah Halte in front of Kantor Perdagangan Kota, TDF Jl. Srijaya Negara Pasar Padang Selasa, TDF Jl. Bintan beside Bank Mandiri, TDF Jl. Puncak Sekuning, TDF opposite PS, TDF Jl. Angkatan 45 Titik Sampah opposite Lorong Kejora (Lorong Harapan), TDF Jl. Demang Lebar Daun Titik Sampah Halte Retensi Brimob, TDF Jl. Demang Lebar Daun Titik in front of Kantor Capil, TDF Jl. Soekarno Hatta Titik Sampah Simpang Jembatan Kancil Putih, TDF Jl. Inspektur Marzuki Titik Sampah Simpang Lorong Pakjo, TDF Komplek Rutan Pakjo, and TDF Jl. Anwar Arsad in front of Indomaret.

The p-Center Location Problem Model

The p-center location problem model uses optimal TDF location data obtained from the completion of the SCLP model and demand point data in the form of sub-district data in the Ilir Barat I District.

TABLE 4. The optimal TDF from the SCLP model.

Variable	Name of TDF
x_2	TDF Jl. Sultan Mansyur
x_3	TDF Perumahan Polygon
x_4	TDF Siguntang
x_5	TDF Jl. Demang Lebar Daun Titik Sampah Halte in front of Kantor Perdagangan Kota
x_7	TDF Jl. Srijaya Negara Pasar Padang Selasa
x_9	TDF Jl. Bintan beside Bank Mandiri
x_{11}	TDF Jl. Puncak Sekuning
x_{14}	TDF opposite PS
x_{18}	TDF Jl. Angkatan 45 Titik Sampah opposite Lorong Kejora (Lorong Harapan)
x_{20}	TDF Jl. Demang Lebar Daun Titik Sampah Halte Retensi Brimob
x_{22}	TDF Jl. Demang Lebar Daun Titik in front of Kantor Capil
x_{23}	TDF Jl. Soekarno Hatta Titik Sampah Simpang Jembatan Kancil Putih
x_{24}	TDF Jl. Inspektur Marzuki Titik Sampah Simpang Lorong Pakjo
x_{26}	TDF Komplek Rutan Pakjo
x_{27}	TDF Jl. Anwar Arsad in front of Indomaret

Table 4 shows all optimal TDF locations in Ilir Barat I District from the SCLP model, which are notated by x_j, where j = 2, 3, 5, 7, 9, 11, 14, 18, 20, 22, 23, 24, 26, 27. It means TDF Jl. Sultan Mansyur, TDF Perumahan Polygon, and so on until TDF Jl. Anwar Arsad in front of Indomaret are optimal TDF. The request point uses sub-district data in Ilir Barat I District, which we can it in Table 2. Meanwhile, we show the distance data from the request point to the optimal TDF location in Table 5.

TABLE 5. The distance between the sub-district and the optimal TDF from the SCLP model.

d_{ij}	2	3	4	5	7	9	11	14	18	20	22	23	24	26	27
a	1100	1800	2400	1300	2000	3600	3600	4300	4200	3600	2300	2600	4900	4900	4000
b	4400	3700	3700	2400	3700	5100	4900	5700	4900	4300	3000	1100	2800	3600	3900
c	2900	4400	850	2500	1200	700	1000	1500	2500	2900	2800	3400	5000	4500	3500
d	3300	4700	1000	2400	1500	950	800	1200	1200	1700	1800	3400	3700	3200	2200
e	3800	3500	2800	1600	2700	3400	3300	3600	2600	2000	750	1600	2600	2900	2000
f	5300	4700	3900	3100	4000	4300	4100	4300	3300	2700	2100	2200	750	1600	1800

Table 5 shows that the distance between sub-district a to the second TDF is 1,100 m, between sub-district a to the third TDF is 1,800 m, and so on. The formulation of the p-center location problem model is

Minimize the objective function that is expressed by Equation (25).

$$Z_{\text{p-center}} = L \tag{25}$$

Subject to

$$y_{a,2} + y_{a,3} + y_{a,4} + y_{a,5} + y_{a,7} + y_{a,9} + y_{a,11} + y_{a,14} + y_{a,18} + y_{a,20} + y_{a,22} + y_{a,23} + y_{a,24} + y_{a,26} + y_{a,27} = 1 \tag{26}$$

$$y_{b,2} + y_{b,3} + y_{b,4} + y_{b,5} + y_{b,7} + y_{b,9} + y_{b,11} + y_{b,14} + y_{b,18} + y_{b,20} + y_{b,22} + y_{b,23} + y_{b,24} + y_{b,26} + y_{b,27} = 1 \tag{27}$$

$$y_{c,2} + y_{c,3} + y_{c,4} + y_{c,5} + y_{c,7} + y_{c,9} + y_{c,11} + y_{c,14} + y_{c,18} + y_{c,20} + y_{c,22} + y_{c,23} + y_{c,24} + y_{c,26} + y_{c,27} = 1 \tag{28}$$

$$y_{d,2} + y_{d,3} + y_{d,4} + y_{d,5} + y_{d,7} + y_{d,9} + y_{d,11} + y_{d,14} + y_{d,18} + y_{d,20} + y_{d,22} + y_{d,23} + y_{d,24} + y_{d,26} + y_{d,27} = 1 \tag{29}$$

$$y_{e,2} + y_{e,3} + y_{e,4} + y_{e,5} + y_{e,7} + y_{e,9} + y_{e,11} + y_{e,14} + y_{e,18} + y_{e,20} + y_{e,22} + y_{e,23} + y_{e,24} + y_{e,26} + y_{e,27} = 1 \tag{30}$$

$$y_{f,2} + y_{f,3} + y_{f,4} + y_{f,5} + y_{f,7} + y_{f,9} + y_{f,11} + y_{f,14} + y_{f,18} + y_{f,20} + y_{f,22} + y_{f,23} + y_{f,24} + y_{f,26} + y_{f,27} = 1 \tag{31}$$

$$x_2 + x_3 + x_4 + x_5 + x_7 + x_9 + x_{11} + x_{14} + x_{18} + x_{20} + x_{22} + x_{23} + x_{24} + x_{26} + x_{27} = 15 \tag{32}$$

$$\begin{aligned} &1100 y_{a,2} + 1800 y_{a,3} + 2400 y_{a,4} + 1300 y_{a,5} + 2000 y_{a,7} + 3600 y_{a,9} + 3600 y_{a,11} + 4300 y_{a,14} \\ &+ 4200 y_{a,18} + 3600 y_{a,20} + 2300 y_{a,22} + 2600 y_{a,23} + 4900 y_{a,24} + 4900 y_{a,26} + 4000 y_{a,27} \le L \end{aligned} \tag{33}$$

$$\begin{aligned} &4400 y_{b,2} + 3700 y_{b,3} + 3700 y_{b,4} + 2400 y_{b,5} + 3700 y_{b,7} + 5100 y_{b,9} + 4900 y_{b,11} + 5700 y_{b,14} \\ &+ 4900 y_{b,18} + 4300 y_{b,20} + 3000 y_{b,22} + 1100 y_{b,23} + 2800 y_{b,24} + 3600 y_{b,26} + 3900 y_{b,27} \le L \end{aligned} \tag{34}$$

$$\begin{aligned} &2900 y_{c,2} + 4400 y_{c,3} + 850 y_{c,4} + 2500 y_{c,5} + 1200 y_{c,7} + 700 y_{c,9} + 1000 y_{c,11} + 1500 y_{c,14} \\ &+ 2500 y_{c,18} + 2900 y_{c,20} + 2800 y_{c,22} + 3400 y_{c,23} + 5000 y_{c,24} + 4500 y_{c,26} + 3500 y_{c,27} \le L \end{aligned} \tag{35}$$

$$\begin{aligned} &3300 y_{d,2} + 4700 y_{d,3} + 1000 y_{d,4} + 2400 y_{d,5} + 1500 y_{d,7} + 950 y_{d,9} + 800 y_{d,11} + 3600 y_{d,14} \\ &+ 1200 y_{d,18} + 1700 y_{d,20} + 1800 y_{d,22} + 3400 y_{d,23} + 3700 y_{d,24} + 3200 y_{d,26} + 2200 y_{d,27} \le L \end{aligned} \tag{36}$$

$$\begin{aligned} &3800 y_{e,2} + 3500 y_{e,3} + 2800 y_{e,4} + 1600 y_{e,5} + 2700 y_{e,7} + 2400 y_{e,9} + 3300 y_{e,11} + 3600 y_{e,14} \\ &+ 2600 y_{e,18} + 2000 y_{e,20} + 750 y_{e,22} + 1600 y_{e,23} + 2600 y_{e,24} + 2900 y_{e,26} + 2000 y_{e,27} \le L \end{aligned} \tag{37}$$

$$\begin{aligned} &5300 y_{f,2} + 4700 y_{f,3} + 3900 y_{f,4} + 3100 y_{f,5} + 4000 y_{f,7} + 4300 y_{f,9} + 4100 y_{f,11} + 4300 y_{f,14} \\ &+ 3300 y_{f,18} + 2700 y_{f,20} + 2100 y_{f,22} + 2200 y_{f,23} + 750 y_{f,24} + 1600 y_{f,26} + 1800 y_{f,27} \le L \end{aligned} \tag{38}$$

$$y_{a,2}, y_{b,2}, y_{c,2}, y_{d,2}, y_{e,2}, y_{f,2} \le x_2 \tag{39}$$

$$y_{a,3}, y_{b,3}, y_{c,3}, y_{d,3}, y_{e,3}, y_{f,3} \le x_3 \tag{40}$$

$$y_{a,4}, y_{b,4}, y_{c,4}, y_{d,4}, y_{e,4}, y_{f,4} \leq x_4 \tag{41}$$

$$y_{a,5}, y_{b,5}, y_{c,5}, y_{d,5}, y_{e,5}, y_{f,5} \leq x_5 \tag{42}$$

$$y_{a,7}, y_{b,7}, y_{c,7}, y_{d,7}, y_{e,7}, y_{f,7} \leq x_7 \tag{43}$$

$$y_{a,9}, y_{b,9}, y_{c,9}, y_{d,9}, y_{e,9}, y_{f,9} \leq x_9 \tag{44}$$

$$y_{a,11}, y_{b,11}, y_{c,11}, y_{d,11}, y_{e,11}, y_{f,11} \leq x_{11} \tag{45}$$

$$y_{a,14}, y_{b,14}, y_{c,14}, y_{d,14}, y_{e,14}, y_{f,14} \leq x_{14} \tag{46}$$

$$y_{a,18}, y_{b,18}, y_{c,18}, y_{d,18}, y_{e,18}, y_{f,18} \leq x_{18} \tag{47}$$

$$y_{a,20}, y_{b,20}, y_{c,20}, y_{d,20}, y_{e,20}, y_{f,20} \leq x_{20} \tag{48}$$

$$y_{a,22}, y_{b,22}, y_{c,22}, y_{d,22}, y_{e,22}, y_{f,22} \leq x_{22} \tag{49}$$

$$y_{a,23}, y_{b,23}, y_{c,23}, y_{d,23}, y_{e,23}, y_{f,23} \leq x_{23} \tag{50}$$

$$y_{a,24}, y_{b,24}, y_{c,24}, y_{d,24}, y_{e,24}, y_{f,24} \leq x_{24} \tag{51}$$

$$y_{a,26}, y_{b,26}, y_{c,26}, y_{d,26}, y_{e,26}, y_{f,26} \leq x_{26} \tag{52}$$

$$y_{a,27}, y_{b,27}, y_{c,27}, y_{d,27}, y_{e,27}, y_{f,27} \leq x_{27} \tag{53}$$

$$y_{a,2}, y_{b,2}, y_{c,2}, y_{d,2}, y_{e,2}, y_{f,2}, y_{a,3}, y_{b,3}, y_{c,3}, y_{d,3}, y_{e,3}, y_{f,3}, y_{a,4}, y_{b,4}, y_{c,4}, y_{d,4}, y_{e,4}, y_{f,4}, y_{a,5}, y_{b,5}, y_{c,5}, y_{d,5}, y_{e,5}, y_{f,5}, y_{a,7}, y_{b,7}, y_{c,7}, y_{d,7}, y_{e,7}, y_{f,7}, y_{a,9}, y_{b,9}, y_{c,9}, y_{d,9}, y_{e,9}, y_{f,9}, y_{a,11}, y_{b,11}, y_{c,11}, y_{d,11}, y_{e,11}, y_{f,11}, y_{a,14}, y_{b,14}, y_{c,14}, y_{d,14}, y_{e,14}, y_{f,14}, y_{a,18}, y_{b,18}, y_{c,18}, y_{d,18}, y_{e,18}, y_{f,18}, y_{a,20}, y_{b,20}, y_{c,20}, y_{d,20}, y_{e,20}, y_{f,20}, y_{a,22}, y_{b,22}, y_{c,22}, y_{d,22}, y_{e,22}, y_{f,22}, y_{a,23}, y_{b,23}, y_{c,23}, y_{d,23}, y_{e,23}, y_{f,23}, y_{a,24}, y_{b,24}, y_{c,24}, y_{d,24}, y_{e,24}, y_{f,24}, y_{a,26}, y_{b,26}, y_{c,26}, y_{d,26}, y_{e,26}, y_{f,26}, y_{a,27}, y_{b,27}, y_{c,27}, y_{d,27}, y_{e,27}, y_{f,27} \in \{0,1\} \tag{54}$$

$$x_2, x_3, x_4, x_5, x_7, x_9, x_{11}, x_{14}, x_{18}, x_{20}, x_{22}, x_{23}, x_{24}, x_{26}, x_{27} \in \{0,1\} \tag{55}$$

$$L \geq 0 \tag{56}$$

Equation (25) is an objective function of minimizing the maximum distance between the request point and the location of the TDF in the Ilir Barat I District. Constraints (26) to (31) stipulate that each request point has only one facility. Constraint (32) displays the number of placements of TDF locations. Constraints (33) to (38) state that the travel distance from the request point to the candidate's location must be less than the maximum travel distance. Constraints (39) to (53) indicate that the facility may include a demand point. Constraints (54) and (55) state that each variable in the p-center location problem model is binary in value. Constraint (56) states that the maximum travel distance should be non-negative.

The optimal solution of the p-center location problem model is $y_{a,2} = y_{b,23} = y_{c,9} = y_{d,11} = y_{e,22} = y_{f,24} = 1$ which means: 1) The demand in the Bukit Lama Sub-District (y_a) will be placed at TDF Jl. Sultan Mansyur (x_2); 2) The demand in the Bukit Baru Sub-District (y_b) will be placed at TDF Jl. Soekarno Hatta Titik Sampah Simpang Jembatan Kancil Putih (x_{23}); 3) The demand in the 26 Ilir D. I Sub-District (y_c) will be placed at TDF Jl. Bintan beside Bank Mandiri (x_9); 4) The demand in the Lorok Pakjo Sub-District (y_d) will be placed at TDF Jl. Puncak Sekuning (x_{11}); 5) The demand in the Demang Lebar Daun Sub-District (y_e) will be placed at TDF Jl. Demang Lebar Daun Titik in front of Kantor Capil (x_{22}); and 6) The demand in the Siring Agung Sub-District (y_f) will be placed at TDF Jl. Inspektur Marzuki Titik Sampah Simpang Lorong Pakjo (x_{24})

The Implementation of The Ant Colony Optimization Algorithm

The first step of the ACO algorithm is to calculate the visibility value. The data used is the distance data between TDF in Ilir Barat I District, contained in Table 3. The visibility calculation is obtained by Equation (57).

$$\eta_{ij} = \frac{1}{d_{j,j}} \tag{57}$$

Where $\eta_{i,j}$ is the visibility between facility i to facility j and $d_{j,j}$ is the travel distance between facility j.

The visibility value between TDF in Ilir Barat I District can be seen in Table 6.

TABLE 6. Visibility between TDF in Ilir Barat I District.

η_i	1	2	3	4	5	6	7	8	9	10	11	12	13
1	0	0.00222	0.00038	0.00050	0.00033	0.00029	0.00026	0.00029	0.00028	0.00022	0.0002	0.00024	0.00021
2	0.00222	0	0.00043	0.00065	0.00039	0.00034	0.00030	0.00029	0.00028	0.00014	0.0002	0.00020	0.00019
3	0.00038	0.00043	0	0.00026	0.00053	0.00043	0.00037	0.00017	0.00016	0.00015	0.0001	0.00014	0.00012
4	0.00050	0.00065	0.00026	0	0.00100	0.00071	0.00056	0.00056	0.00050	0.00037	0.0004	0.00042	0.00056
5	0.00033	0.00039	0.00053	0.00100	0	0.00042	0.00036	0.00028	0.00026	0.00021	0.0002	0.00023	0.00026
6	0.00029	0.00034	0.00043	0.00071	0.00042	0	0.00250	0.00050	0.00045	0.00032	0.0003	0.00036	0.00040
7	0.00026	0.00030	0.00037	0.00056	0.00036	0.00250	0	0.00030	0.00029	0.00025	0.0002	0.00022	0.00017
8	0.00029	0.00029	0.00017	0.00056	0.00028	0.00050	0.00030	0	0.00500	0.00133	0.0009	0.00075	0.00038
9	0.00028	0.00028	0.00016	0.00050	0.00026	0.00045	0.00029	0.00500	0	0.00182	0.0011	0.00088	0.00041
10	0.00022	0.00014	0.00015	0.00037	0.00021	0.00032	0.00025	0.00133	0.00182	0	0.0028	0.00169	0.00053
11	0.00024	0.00023	0.00014	0.00043	0.00023	0.00037	0.00023	0.00091	0.00111	0.00286	0	0.00417	0.00065
12	0.00024	0.00020	0.00014	0.00042	0.00023	0.00036	0.00022	0.00075	0.00088	0.00169	0.0041	0	0.00077
13	0.00021	0.00019	0.00012	0.00056	0.00026	0.00004	0.00017	0.00038	0.00041	0.00053	0.0006	0.00077	0
14	0.00020	0.00017	0.00015	0.00042	0.00025	0.00032	0.00016	0.00032	0.00034	0.00042	0.0004	0.00056	0.00200
15	0.00032	0.00032	0.00017	0.00077	0.00031	0.00063	0.00032	0.00118	0.00091	0.00036	0.0004	0.00045	0.00048
16	0.00021	0.00019	0.00016	0.00053	0.00030	0.00038	0.00017	0.00036	0.00039	0.00050	0.0006	0.00071	0.00053
17	0.00017	0.00019	0.00017	0.00032	0.00032	0.00026	0.00021	0.00031	0.00022	0.00025	0.0002	0.00029	0.00059
18	0.00020	0.00017	0.00015	0.00045	0.00028	0.00034	0.00023	0.00043	0.00043	0.00024	0.0005	0.00053	0.00125
19	0.00018	0.00020	0.00018	0.00036	0.00036	0.00029	0.00023	0.00034	0.00034	0.00023	0.0004	0.00040	0.00041
20	0.00018	0.00020	0.00018	0.00036	0.00036	0.00029	0.00023	0.00034	0.00036	0.00021	0.0004	0.00040	0.00071
21	0.00022	0.00025	0.00022	0.00029	0.00056	0.00031	0.00029	0.00028	0.00029	0.00019	0.0003	0.00031	0.00050
22	0.00026	0.00030	0.00026	0.00028	0.00091	0.00040	0.00037	0.00024	0.00024	0.00016	0.0002	0.00026	0.00037
23	0.00024	0.00029	0.00037	0.00027	0.00077	0.00037	0.00034	0.00019	0.00019	0.00017	0.0001	0.00018	0.00022
24	0.00014	0.00016	0.00019	0.00018	0.00025	0.00018	0.00018	0.00017	0.00017	0.00014	0.0002	0.00020	0.00026

η_i	1	2	3	4	5	6	7	8	9	10	11	12	13
25	0.00014	0.00015	0.00016	0.00019	0.00023	0.00018	0.00017	0.00019	0.00019	0.00015	0.0002	0.00022	0.00029
26	0.00015	0.00016	0.00016	0.00020	0.00026	0.00019	0.00018	0.00020	0.00020	0.00016	0.0002	0.00024	0.00032
27	0.00018	0.00020	0.00018	0.00025	0.00037	0.00024	0.00023	0.00024	0.00025	0.00018	0.0002	0.00027	0.00040

$\eta_{i,j}$	14	15	16	17	18	19	20	21	22	23	24	25	26	27
1	0.00020	0.00032	0.00021	0.0001	0.00020	0.00018	0.00018	0.0002	0.00026	0.0002	0.00014	0.0001	0.00015	0.0001
2	0.00017	0.00032	0.00019	0.0001	0.00017	0.00020	0.00020	0.0002	0.00030	0.0002	0.00016	0.0001	0.00016	0.0002
3	0.00015	0.00017	0.00016	0.0001	0.00015	0.00018	0.00018	0.0002	0.00026	0.0003	0.00019	0.0001	0.00016	0.0001
4	0.00042	0.00077	0.00053	0.0003	0.00045	0.00036	0.00036	0.0002	0.00028	0.0002	0.00018	0.0001	0.00020	0.0002
5	0.00025	0.00031	0.00030	0.0003	0.00028	0.00036	0.00036	0.0005	0.00091	0.0007	0.00025	0.0002	0.00026	0.0003
6	0.00032	0.00063	0.00038	0.0002	0.00034	0.00029	0.00029	0.0003	0.00040	0.0003	0.00018	0.0001	0.00019	0.0002
7	0.00016	0.00032	0.00017	0.0002	0.00023	0.00023	0.00023	0.0002	0.00037	0.0003	0.00018	0.0001	0.00018	0.0002
8	0.00032	0.00118	0.00036	0.0003	0.00043	0.00034	0.00034	0.0002	0.00024	0.0001	0.00017	0.0001	0.00020	0.0002
9	0.00034	0.00091	0.00039	0.0002	0.00043	0.00034	0.00036	0.0002	0.00024	0.0001	0.00017	0.0001	0.00020	0.0002
10	0.00042	0.00036	0.00050	0.0002	0.00024	0.00023	0.00021	0.0001	0.00016	0.0001	0.00014	0.0001	0.00016	0.0001
11	0.00049	0.00041	0.00061	0.0002	0.00056	0.00040	0.00042	0.0003	0.00027	0.0001	0.00020	0.0002	0.00024	0.0002
12	0.00056	0.00045	0.00071	0.0002	0.00053	0.00040	0.00040	0.0003	0.00026	0.0001	0.00020	0.0002	0.00024	0.0002
13	0.00200	0.00048	0.00053	0.0005	0.00125	0.00041	0.00071	0.0005	0.00037	0.0002	0.00026	0.0002	0.00032	0.0004
14	0	0.00250	0.00071	0.0006	0.00055	0.00051	0.00041	0.0003	0.00026	0.0001	0.00019	0.0001	0.00023	0.0002
15	0.00250	0	0.00100	0.0008	0.00070	0.00065	0.00049	0.0004	0.00029	0.0001	0.00013	0.0001	0.00019	0.0002
16	0.00071	0.00100	0	0.0040	0.00233	0.00182	0.00095	0.0006	0.00041	0.0002	0.00026	0.0002	0.00033	0.0004
17	0.00061	0.00080	0.00400	0	0.00556	0.00333	0.00125	0.0008	0.00045	0.0002	0.00027	0.0002	0.00034	0.0004
18	0.00055	0.00070	0.00233	0.0055	0	0.00833	0.00161	0.0009	0.00050	0.0002	0.00031	0.0003	0.00037	0.0005
19	0.00051	0.00065	0.00182	0.0033	0.00833	0	0.00200	0.0011	0.00053	0.0002	0.00032	0.0002	0.00032	0.0005
20	0.00041	0.00049	0.00095	0.0012	0.00161	0.00200	0	0.0025	0.00071	0.0003	0.00036	0.0003	0.00043	0.0008
21	0.00035	0.00041	0.00069	0.0008	0.00098	0.00111	0.00250	0	0.00100	0.0003	0.00032	0.0003	0.00045	0.0009
22	0.00026	0.00029	0.00041	0.0004	0.00050	0.00053	0.00071	0.0010	0	0.0005	0.00022	0.0001	0.00026	0.0003
23	0.00017	0.00019	0.00023	0.0002	0.00026	0.00026	0.00030	0.0003	0.00053	0	0.00038	0.0002	0.00028	0.0002
24	0.00019	0.00013	0.00026	0.0002	0.00031	0.00032	0.00036	0.0003	0.00022	0.0003	0	0.0008	0.00118	0.0005
25	0.00019	0.00018	0.00029	0.0002	0.00037	0.00026	0.00037	0.0003	0.00018	0.0002	0.00083	0	0.00250	0.0008
26	0.00023	0.00019	0.00033	0.0003	0.00037	0.00032	0.00043	0.0004	0.00026	0.0002	0.00118	0.0025	0	0.0007
27	0.00027	0.00023	0.00048	0.0004	0.00056	0.00050	0.00083	0.0009	0.00038	0.0002	0.00050	0.0008	0.00077	0

Table 6 shows that the Visibility between the first and the second TDF is 0.00222. between the first and the third TDF is 0.00038, and so on. The next stage is the initialization of parameters which include the Intensity of the ant pheromone trace (τ_{ij}), the ant pheromone control constant (α), the visibility control setting (β), the number of ants (m), the ant pheromone evaporation constant (ρ), dan and the maximum number of cycles ($NC_{\max}$). Initialization of parameter values from ACO include $\tau_{ij} = 1, \alpha = 1, \beta = 1, m = 10, \rho = 0.5, NC_{\max} = 1$. Then proceed by generating a random number as the departure point according to the number of ants. The departure point is the starting point of each ant's travel route and is selected by generating a random number [1][25]. After that, it is continued by calculating the probability, which aims to determine the location of the TDF that will then be visited. Probability is calculated by Equation (58).

$$p_{i,j} = \frac{\left[\tau_{i,j}\right]^{\alpha}\left[\eta_{i,j}\right]^{\beta}}{\sum\left[\tau_{i,j}\right]^{\alpha}\left[\eta_{i,j}\right]^{\beta}}; j \notin \text{Tabu List} \tag{58}$$

Where $p_{i,j}$ is the p robability value of ants visiting facility i to facility j; $\tau_{i,j}$ is the intensity of ant pheromone trace; $\eta_{i,j}$ is the visibility between facility i to facility j; α is the ant pheromone control; β ia the visibility controller setting; and j is the facility location index.

The cumulative probability value (q_i) is calculated by summing the probability value ($p_{i,j}$) with the previous cumulative probability value (q_{i-1}). After that, it evokes a random number (r_i) at intervals [0,1] as many as the number of ants that have been initialized, and determines the condition of the random number for the selected facility visited next by the rule that is expressed in Equation (59).

$$q_{i-1} \leq r_i \leq q_i \tag{59}$$

Where r_i is the random number of ants i; q_i is the cumulative probability value of i; and q_{i-1} is the cumulative probability value of i-1.

The process continues by filling in the selected facilities' taboo list so the travel route can be formed. The process of selecting TDF and filling out taboo lists is repeated until the travel route is formed. The next stage is calculating the total distance of the travel route that all ants have traveled based on the taboo list. The data used in Table 3 as data on the distance between TDF in Ilir Barat I District. Ants with the minimum total distance are the optimal solution for this study. The total travel distance of each ant can be seen in Table 7.

Based on Table 7, the minimum travel route was found by ant 5 with a total distance of 58,040 meters. Therefore, the travel route of ants 5 becomes the optimal route of the ACO algorithm. By choosing 15 TDF from the optimal route, the optimal TDF location was obtained due to the ACO algorithm in Ilir Barat I, including TDF Jl. Demang Lebar Daun Titik Sampah Halte in front of Kantor Perdagangan Kota, TDF opposite PS, TDF Jl. Puncak Sekuning, TDF Jl. Bintan beside Bank Mandiri, TDF Jl. Natuna beside BPN, TDF Jl. Angkatan 45 Titik Sampah Simpang Lorong Harisan, TDF Jl. Angkatan 45 Titik Sampah in front of Lorong Persatuan, TDF Jl. Angkatan 45 Titik Sampah opposite Lorong Kejora (Lorong Harapan), TDF Jl. Angkatan 45 in front of Jl. Sang Merah Putih, TDF Simpang Jl. Kaca Piring, TDF Jl. Soekarno Hatta Titik Sampah Simpang Jembatan Kancil Putih, TDF Jl. Demang Lebar Daun Titik Sampah Halte Retensi Brimob, TDF Siguntang, TDF Jl. Srijaya Negara beside Jl. Jaya Sempurna, and TDF Jl. Srijaya Negara Pasar Padang Selasa.

TABLE 7. Total travel distance.

Ant	Travel Route	Total Distance
1	18, 20, 11, 8, 9, 16, 17, 19, 4, 6, 23, 5, 2, 1, 25, 27, 26, 24, 10, 12, 13, 7, 22, 3, 15, 14, 21	59740
2	22, 20, 21, 14, 27, 15, 8, 9, 18, 17, 2, 1, 13, 11, 12, 10, 7, 4, 6, 25, 5, 23, 24, 16, 19, 26, 3	63900
3	18, 19, 5, 24, 23, 26, 8, 16, 15, 14, 11, 12, 10, 9, 13, 21, 20, 17, 1, 4, 7, 6, 25, 27, 3, 2, 22	59520
4	10, 9, 8, 15, 5, 18, 19, 17, 2, 4, 21, 11, 1, 25, 27, 20, 6, 7, 24, 26, 14, 16, 3, 13, 23, 22, 12	77060
5	5, 14, 11, 9, 8, 19, 17, 18, 16, 13, 23, 20, 4, 6, 7, 15, 2, 1, 21, 26, 25, 27, 24, 22, 12, 10, 3	58040
6	10, 4, 6, 7, 20, 16, 17, 13, 26, 23, 11, 12, 2, 1, 27, 9, 8, 19, 18, 24, 22, 5, 3, 15, 21, 25, 14	69450
7	3, 6, 12, 26, 24, 27, 18, 19, 10, 9, 8, 23, 5, 7, 15, 14, 20, 13, 21, 17, 16, 25, 1, 2, 22, 4, 11	59510
8	12, 11, 10, 14, 7, 4, 20, 13, 27, 17, 21, 18, 25, 26, 22, 2, 1, 9, 19, 15, 5, 23, 6, 16, 3, 8, 24	68840
9	26, 24, 3, 10, 7, 22, 15, 8, 20, 27, 21, 18, 12, 11, 6, 1, 2, 17, 19, 13, 4, 5, 14, 9, 16, 25, 23	66490
10	24, 3, 2, 15, 25, 21, 1, 17, 20, 19, 16, 18, 12, 14, 13, 22, 9, 5, 6, 26, 27, 11, 8, 10, 23, 7, 4	71630

There are differences in optimal location between the SCP model results and the implementation of the ACO algorithm. The optimal location by the SCP model is shown in Table 8.

TABLE 8. Location of optimal TDF based on SCP model.

Sub-District	Location of Optimal TDF
Bukit Lama	TDF Jl. Sultan Mansyur
	TDF Perumahan Polygon
	TDF Siguntang
	TDF Jl. Srijaya Negara Pasar Padang Selasa
Bukit Baru	TDF Jl. Demang Lebar Daun Titik Sampah Halte in front of Kantor Perdagangan Kota
Lorok Pakjo	TDF Jl. Bintan beside Bank Mandiri
	TDF Jl. Puncak Sekuning
	TDF opposite PS
	TDF Jl. Demang Lebar Daun Titik in front of Kantor Capil
Demang Lebar Daun	TDF Jl. Angkatan 45 Titik Sampah opposite Lorong Kejora (Lorong Harapan)
	TDF Jl. Demang Lebar Daun Titik Sampah Halte Retensi Brimob
Siring Agung	TDF Jl. Soekarno Hatta Titik Sampah Simpang Jembatan Kancil Putih
	TDF Jl. Inspektur Marzuki Titik Sampah Simpang Lorong Pakjo
	TDF Komplek Rutan Pakjo
	TDF Jl. Anwar Arsad in front of Indomaret

Table 8 shows the optimal location of TDF with the SCLP model based on the existing sub-district in Ilir Barat I District. We can see that: 1) Bukit Lama Sub-District consists of 4 optimal TDF; 2) Bukit Baru Sub-District consists of 1 optimal TDF; 3) Lorok Pakjo Sub-District consists of 4 optimal TDF; 4) Demang Lebar Daun Sub-District consists of 2 optimal TDF; 5) Siring Agung Sub-District consists of 4 optimal TDF; and 6) 26 Ilir D.I Sub-District does not have an optimal TDF. We can see the optimal location of the ACO algorithm implementation in Table 9.

TABLE 9. Location of optimal TDF based on the implementation of ACO algorithm.

Sub-District	Location of Optimal TDF
Bukit Lama	TDF Jl. Srijaya Negara beside Jl. Jaya Sempurna
	TDF Siguntang
	TDF Jl. Srijaya Negara Pasar Padang Selasa
Bukit Baru	TDF Jl. Demang Lebar Daun Titik Sampah Halte in front of Kantor Perdagangan Kota
26 Ilir D.I	TDF Jl. Natuna beside BPN
Lorok Pakjo	TDF Jl. Bintan beside Bank Mandiri
	TDF Jl. Puncak Sekuning
	TDF Seberang PS
	TDF Jl. Angkatan 45 in front of Jl. Sang Merah Putih
	TDF Simpang Jl. Kaca Piring
Demang Lebar Daun	TDF Jl. Angkatan 45 Titik Sampah opposite Lorong Kejora (Lorong Harapan)
	TDF Jl. Demang Lebar Daun Titik Sampah Halte Retensi Brimob
	TDF Jl. Angkatan 45 Titik Sampah Simpang Lorong Harisan
	TDF Jl. Angkatan 45 Titik Sampah in front of Lorong Persatuan
Siring Agung	TDF Jl. Soekarno Hatta Titik Sampah Simpang Jembatan Kancil Putih

Table 9 displays the optimal location of TDF with the implementation of the ACO algorithm based on the existing villages in the Ilir Barat I District. We can see that: 1) Bukit Lama Sub-District consists of 3 optimal TDF; 2) Bukit Baru Sub-District consists of 1 optimal TDF; 3) 26 Ilir D.I Sub-District consists of 1 optimal TDF; 4) Lorok Pakjo Sub-District consists of 5 optimal TDF; 5) Demang Lebar Daun Village consists of 4 optimal TDF; and 6) Siring Agung Village consists of 1 optimal TDF.

Based on the SCP model solution, one demand point does not have an optimal TDF, namely 26 Ilir D.I Sub-District. While in the results of the implementation of the ACO algorithm, all demand points have optimal TDF. Therefore, this study recommends a solution from the ACO algorithm because the solution of the ACO algorithm can meet all requests in Ilir Barat I District.

CONCLUSION

The SCP model consisting of SCLP and p-Center Location Problem, as well as the implementation of the ACO algorithm each, produced 15 optimal TDF locations in Ilir Barat I District. However, there are differences in the optimal area between the SCP model results and the implementation of the ACO algorithm. This study recommends the solution from the ACO algorithm because it can meet all requests in Ilir Barat I District, as seen in Table 9. For further research, we recommend implementing other heuristic methods, namely Genetic Algorithms, Greedy Heuristic, Hill Climbing, Simulated Annealing, Particle Swarm Optimization, and Firefly Optimization. In addition, it is necessary to pay attention to other factors, such as the amount of waste transported and the capacity of each TDF.

ACKNOWLEDGMENTS

DIPA of Public Service Agency of Universitas Sriwijaya 2022 funded this research and publication of this article. SP DIPA-023.17.2.677515/2022, on December 13, 2021. Under the Rector's Decree Number: 0109/UN9.3.1/SK/2022, on April 28, 2022.

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