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The Genetic Algorithm Approach in Solving Set Covering Model to Determine The Temporary Waste Disposal Sites in Kemuning Sub-District Palembang

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Abstract. The location-allocation problem is part of Optimization. This problem determined the optimal location of many public facilities. One of the public facilities that must be optimized is the Temporary Waste Disposal Sites (TWDS). Palembang is one of the big cities on the Sumatra Island and consists of 18 Sub-Districts. Kemuning Sub-District is the Sub-District with the largest population in Palembang. Currently, the Kemuning Sub-District has six villages with 24 TWDS. The number of TWDS is still significantly less and does not match the population growth. The TWDS location is irregular, some are very far away, and some are close together. This research implemented the Genetic Algorithm in completing the Set Covering model. This model determined the optimal location of TWDS. Based on the results and discussion, from the available 24 TWDS, there are only nine optimal TWDS in the Kemuning Sub-District. So, this study recommends 6 TWDS in Pahlawan Village, 6 TWDS in 20 Ilir D II Village, and 7 TWDS each in Pipareja Village, Ario Kemuning Village, and Talang Aman Village.

Keywords: Location, Temporary Waste Disposal Sites, Set Covering Model, The Genetic Algorithm

INTRODUCTION

Palembang city consists of 18 Sub-Districts, of which Kemuning Sub-District is a Sub-District with a population density of 10,444 people/km^2. A dense population causes a lot of piles of garbage and problems for the environment. So far, the waste is stored in the Temporary Waste Disposal Sites (TWDS) before being transported to the Final Disposal Site (FDS). The waste problem in Palembang city is regulated by the Palembang Environment and Hygiene Service (DLHK). The location of TWDS so far is still very irregular, some are very close, and some are far from each other. TWDS location settings are essential so that there are no TWDS with accumulated garbage, while on the other hand, there are some empty TWDS. Determining the location in optimization is known as the Set Covering Problem (SCP). SCP aims to determine the number of facilities and locations covering a particular area [1]. SCP also minimizes the number of facility locations to serve all demand points [2]. Some SCP models are Set Covering Location Problem (SCLP), Maximum Covering Location Problem (MCLP), p-Center Location Problem, and p-Median Problem [3]. The SCLP model will minimize the number of facilities but serve all demand points [4]. The p-Median problem reduces the average distance between service facility locations and demand points [5].

Several previous studies regarding location determination using the SCP model have been carried out [2, 6–9]. Several heuristic methods to solve SCP were also developed by [10–14]. A new population is generated by optimizing the problem from the initial population. Applications of Genetic algorithms are determining airline tickets, the type of transportation mode, choosing lodging, optimizing public and population services [15]. According to [16], genetic

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algorithms can solve complex problems with a vast search space. Previous research on Genetic algorithms has been carried out by [15, 17–22].

There have been limited studies concerned with the Genetic algorithms approach in solving the SCP model. Therefore, this study formulated the SCLP model, p-Median Problem, and applied the Genetic algorithm to determine the optimal TWDS locations in the Kemuning Sub-District. The solution obtained is expected to optimize TWDS locations to serve all demand locations in the Kemuning Sub-District.

METHODS

The first step described the number of TWDS and villages in the Kemuning Sub-District and measured the distance between the TWDS in the Kemuning Sub-District. Then, we define the variables and parameters for the SCLP model and the p-Median Problem in the Kemuning Sub-District. All variables and parameters are used to formulate the SCP model, namely, SCLP and p-Median Problem. We solved the SCP model using the Lingo 18.0 software and the Genetic algorithms. At the final step, we analyse the final results obtained and make the conclusions.

RESULT AND DISCUSSION

This section explains the Genetic algorithm, the SCLP model, the p-Median Problem model, and the implementation of the Genetic algorithm in solving the p-Median Problem model.

The Genetic Algorithm

Chromosomes, crossovers, fitness values, and mutations are part of the Genetic algorithm. The Genetic algorithm starts with an initial population with several individuals, some of which can be encoded as binary strings called chromosomes. Each individual will be evaluated and given their fitness value. The advantages of each individual can be determined using the fitness value. New individuals are considered the best if the fitness value is significant (maximum) or the fitness value is small (minimum). These superior individuals will be passed down from generation to generation. The crossover process is the following process that includes the exchange of genes between two individuals to produce new individuals. Then the mutation process is carried out by changing the value of the gene in an individual. The population will be generated, analyzed, and then evaluated for the next generation with this process. In this study, the Genetic algorithm aims to find individuals or chromosomes with the minimum fitness value. We use Equation (1) to calculate the fitness value of each chromosome.

$$\text{fitness value} = \sum_{j=1}^{n} s_{ij} c_j \tag{1}$$

s_{ij} = binary value of the j^{th} column in the i^{th} chromosome
c_j = distance value of the j^{th} column

Selection is used to select individuals to be used in the interbreeding and mutation. The higher the fitness value of an individual (maximum case), the more likely it is to be selected, or the smaller the fitness value of an individual (minimum case), the more likely it is to be chosen. In this study, the selection method used is roulette wheel selection, where the individual or parent is selected based on their fitness value. The steps for the roulette wheel selection process are as follows:

a. Calculate the relative fitness value (p_i) with the formula (2)

$$p_i = \frac{\text{fitness value } (i)}{\text{total of fitness value}} \tag{2}$$

b. Calculate the cumulative fitness value (q_i) with the formula (3)

$$q_i = q_{(i-1)} + p_i \tag{3}$$

c. Generate random numbers in [0, 1] as much as the population size in the problem. Then select the i^{th} chromosome as the surviving chromosome using the rule:

$$q_{(i-1)} \le r_i \le p_i \tag{4}$$

The better the quality of a chromosome, the greater the chance of being selected as parents in the following process, namely crossover.

Crossover aims to find new values, combining two or more chromosomes to become a new chromosome. We exchange genetic information on the parent chromosome to replace some traits or characteristics on the resulting new chromosome [22]. In this study, the method used for the crossbreeding process is the one-point crossover method.

This method uses the crossover probability (PC). This study uses 0.25, then generates a random number (r) at [0, 1] and compares it with the PC value. If the r on the chromosome is less than the PC value, then the chromosome will be crossed. Then, to select the position to be crossed, the process of crossing is done by generating random numbers from 1 to n (chromosome length).

Mutations aim to get a new chromosome with the best fitness value by replacing several selected parent or parent chromosome genes. Mutation probability is used to determine the rate of mutation that occurs. A high mutation rate will cause the offspring to be more similar to the parent. A good mutation probability is in the range 0.01 – 0.3 [22]. The first step is to count the number of genes by multiplying the population size by the chromosome length. This study used 0.01 as the mutation probability (PM), then generated at [0,1] as many as the number of genes. Genes with a random number value (r) smaller than the predetermined PM value will undergo a mutation process.

The Set Covering Location Problem Model

The data used in this study are a list of TWDS names and their variables, a list of Villages names and their variables, and distance data from one TWDS to another TWDS in the Kemuning Sub-District.

TABLE 1. Definition of Each Variable of TWDS

Variable	Name of TWDS
a_1	TWDS Polda Park
a_2	TWDS Polda
a_3	TWDS Sudirman Street (Pahlawan Bus Stop)
a_4	TWDS Sudirman Street, Kebon Jeruk
a_5	TWDS Beside RSMH
a_6	TWDS Sudirman Street (Laboratorium RSUPMH)
a_7	TWDS Sudirman Street (Bank Sampah Ceria RSUPMH)
a_8	TWDS Sudirman Street in front of Pribumi Drug Store
a_9	TWDS Sudirman Street in front of Rosa Canteen
a_{10}	TWDS Sudirman Street in front of Graha Medika
a_{11}	TWDS Sudirman Street in front of K 24 Drug Store
a_{12}	TWDS Sudirman Street (Bank Mestika)
a_{13}	TWDS Mayor Salim Batubara Street Lr. Nurul Huda
a_{14}	TWDS Kebon Semai Market
a_{15}	TWDS Komp.Pol.H.M. Damsyik Street Madang Aspol
a_{16}	TWDS Kp. Burai Street (Beside Medical Faculty)
a_{17}	TWDS Sekip Ujung Market
a_{18}	TWDS Chinese Graveyard
a_{19}	TWDS Basuki Rahmad Street (in front of Pondok Pindang Burung)
a_{20}	TWDS Basuki Rahmad Street
a_{21}	TWDS Basuki Rahmad Street
a_{22}	TDS Kol. H. Burlian Street (Palimo Market)
a_{23}	TWDS Pahlawan Pagi Sore
a_{24}	TWDS Cambai Agung

TABLE 2. Definition of Each Variable of Village

d_{ij}	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	0	280	500	800	1700	1800	2200	1600	1610	1630	1640	1900	2600	2800	2200	1800	2600	4400	350	600	620	2100	2300	1800
2	280	0	350	650	1300	1400	2000	1400	1410	1500	1510	1800	2500	3500	2000	1600	2400	4500	850	1300	1290	1100	1000	1300
3	500	350	0	300	950	1050	1700	1100	1110	1130	1140	1400	2100	3700	1700	1200	2600	5000	950	1200	1210	1300	1200	1300
4	800	650	300	0	650	750	1400	800	810	850	860	1100	1800	2000	1400	950	2200	5400	2800	3100	3110	4600	1800	1300
5	1700	1300	950	650	0	100	1300	140	150	170	180	450	1200	1700	950	1300	2400	5700	2200	2400	2410	2200	2200	2500
6	1800	1400	1050	750	100	0	1200	240	250	270	280	450	1700	1600	1100	750	2000	6200	2200	2400	2410	2300	2300	2500
7	2200	2000	1700	1400	1300	1200	0	1100	1090	1070	1060	1200	1100	1100	450	450	1800	5100	3000	3200	3210	2900	2600	2200
8	1600	1400	1100	800	140	240	1100	0	10	30	40	350	1000	1500	800	1100	2300	5500	2000	2300	2310	2400	2900	2400
9	1610	1410	1110	810	150	250	1090	10	0	20	30	300	990	1490	790	1090	2290	5490	1990	2990	2300	2410	2890	2390
10	1630	1500	1130	850	170	270	1070	30	20	0	10	280	970	1470	750	1070	2200	5470	1970	2200	2210	2430	2870	2370
11	1640	1510	1140	860	180	280	1060	40	30	10	0	270	960	1460	740	1060	2190	5460	1960	2190	2200	2440	2860	2360
12	1900	1800	1400	1100	450	450	1200	350	300	280	270	0	800	1200	700	1100	2300	5200	2700	2900	2910	2700	3700	3100
13	2600	2500	2100	1800	1200	1700	1100	1000	990	970	960	800	0	450	600	1100	1800	4500	2800	3000	3010	3400	3000	2800
14	2800	3500	3700	2000	1700	1600	1100	1500	1490	1470	1460	1200	450	0	600	1100	1300	4000	3400	3200	3190	3600	2500	2100
15	2200	2000	1700	1400	950	1100	450	800	790	750	740	700	600	600	0	450	1900	4600	2700	2900	2910	3000	2300	2000
16	1800	1600	1200	950	1300	750	450	1100	1090	1070	1060	1100	1100	1100	450	0	1400	4100	2800	3000	3010	2500	2200	1800
17	2600	2400	2600	2200	2400	2000	1800	2300	2290	2200	2190	2300	1800	1300	1900	1400	0	2800	2200	2000	1990	3200	1400	1200
18	4400	4500	5000	5400	5700	6200	5100	5500	5490	5470	5460	5200	4500	4000	4600	4100	2800	0	3800	4700	4710	4500	3500	3900
19	350	850	950	2800	2200	2200	3000	2000	1990	1970	1960	2700	2800	3400	2700	2800	2200	3800	0	240	250	1100	3000	1500
20	600	1300	1200	3100	2400	2400	3200	2300	2990	2200	2190	2900	3000	3200	2900	3000	2000	4700	240	0	20	1900	1400	2500
21	620	1290	1210	3110	2410	2410	3210	2310	2300	2210	2200	2910	3010	3190	2910	3010	1990	4710	250	20	0	1890	1410	2510
22	2100	1100	1300	4600	2200	2300	2900	2400	2410	2430	2440	2700	3400	3600	3000	2500	3200	4500	1100	1900	1890	0	3100	2600
23	2300	1000	1200	1800	2200	2300	2600	2900	2890	2870	2860	3700	3000	2500	2300	2200	1400	3500	3000	1400	1410	3100	0	350
24	1800	1300	1300	1300	2500	2500	2200	2400	2390	2370	2360	3100	2800	2100	2000	1800	1200	3900	1500	2500	2510	2600	350	0

TABLE 3. The Distance Between Each TWDS

Variable	Name of Village
b_1	Sekip Jaya
b_2	Pahlawan
b_3	20 Ilir D II
b_4	Pipareja
b_5	Talang Aman
b_6	Ario Kemuning

According to the Environment and Hygiene Service of the City of Palembang and the Regulation of the Minister of Public Works of the Republic of Indonesia Number 03/PRT/M/2013 Article 32, the optimal distance required between one TWDS to another is 500 m. The distance data (in meters) from one TWDS to another were obtained with the help of Google Maps and a field survey conducted on January 13, 2021.

The SCLP model is used to optimize the number of TWDS in the Kemuning Sub-District but can serve all demand points. The SCLP model is shown in Equation (5) and constraints (6)-(19).

Minimize

$$Z_{sclp} = a_1 + a_2 + a_3 + a_4 + a_5 + a_6 + a_7 + a_8 + a_9 + a_{10} + a_{11} + a_{12} + a_{13} + a_{14} + a_{15} + a_{16} + a_{17} + a_{18} + a_{19} + a_{20} + a_{21} + a_{22} + a_{23} + a_{24} \quad (5)$$

Subject to

$$a_1 + a_2 + a_3 + a_{19} \geq 1 \quad (6)$$
$$a_1 + a_2 + a_3 \geq 1 \quad (7)$$
$$a_1 + a_2 + a_3 + a_4 \geq 1 \quad (8)$$
$$a_3 + a_4 \geq 1 \quad (9)$$
$$a_5 + a_6 + a_8 + a_9 + a_{10} + a_{11} + a_{12} \geq 1 \quad (10)$$
$$a_7 + a_{15} + a_{16} \geq 1 \quad (11)$$
$$a_{13} + a_{14} \geq 1 \quad (12)$$
$$a_{17} \geq 1 \quad (13)$$
$$a_{18} \geq 1 \quad (14)$$
$$a_1 + a_{19} + a_{20} + a_{21} \geq 1 \quad (15)$$
$$a_{19} + a_{20} + a_{21} \geq 1 \quad (16)$$
$$a_{22} \geq 1 \quad (17)$$
$$a_{23} + a_{24} \geq 1 \quad (18)$$
$$a_1, a_2, a_3, a_4, a_5, a_6, a_7, a_8, a_9, a_{10}, a_{11}, a_{12}, a_{13}, a_{14}, a_{15}, a_{16}, a_{17}, a_{18}, a_{19}, a_{20}, a_{21}, a_{22}, a_{23}, a_{24} \geq 0 \text{ and integer} \quad (19)$$

The objective function (5) aims to minimize the location facility to cover the demand point. Constraints (6) to (18) ensure that each demand point can be met by at least one facility or boundary model for a demand point distance of 500 meters. Constraint (19) states that each variable must be non-negative and integer. The optimal solution and the optimal variables of SCLP can be seen in Table 4 and Table 5, respectively.

From the results of Lingo 18.0 in Table 4, it can be seen in Solver Type that this model used the Branch and Bound method with an objective value of 9, which means the number of optimal TWDS is 9. Generated Memory Used (GMU) indicates that the amount of memory allocation used is equal to 28K. Elapsed Runtime (ER) shows the total time used to generate and complete the model is 1 second. Based on Table 5, the candidate of TWDS must be in 9 locations as follows: TWDS Sudirman Street (Pahlawan Bus Stop), TWDS Sudirman Street (Bank Mestika), TWDS Kebon Semai Market, TWDS Kp. Burai Street (Beside Medical Faculty), TWDS Sekip Ujung Market, TWDS Chinese Graveyard, TWDS Basuki Rahmad Street (in front of Pondok Pindang Burung), TWDS Kol. H. Burlian Street (Palimo Market), and TWDS Cambai Agung.

TABLE 4. The Optimal Solution of SCLP

Solver Status	
Model Class	*PILP*
State	*Global Optimal*
Objective	9
Infeasibility	0
Iterations	0
Extended Solver Status	
Solver Type	*Branch and Bound*
Best Objective	9
Objective Bound	9
Steps	0
Active	0
Update Interval	2
GMU (K)	28
ER (sec)	1

TABLE 5. The Optimal Variables of SCLP

Variable	Value	Variable	Value	Variable	Value
a_1	0	a_9	0	a_{17}	1
a_2	0	a_{10}	0	a_{18}	1
a_3	1	a_{11}	0	a_{19}	1
a_4	0	a_{12}	1	a_{20}	0
a_5	0	a_{13}	0	a_{21}	0
a_6	0	a_{14}	1	a_{22}	1
a_7	0	a_{15}	0	a_{23}	0
a_8	0	a_{16}	1	a_{24}	1

The p-Median Problem Model

The p-Median Problem model used TWDS data and Villages service demands in the Kemuning Sub-District. Table 6 shows the optimal TWDS locations obtained from the SCLP model.

TABLE 6. Candidate of The Optimal TWDS Locations

TWDS Locations	Variable
TWDS Sudirman Street (Pahlawan Bus Stop)	a_3
TWDS Sudirman Street (Bank Mestika)	a_{12}
TWDS Kebon Semai Market	a_{14}
TWDS Kp. Burai Street (Beside Medical Faculty)	a_{16}
TWDS Sekip Ujung Market	a_{17}
TWDS Chinese Graveyard	a_{18}
TWDS Basuki Rahmad Street (in front of Pondok Pindang Burung)	a_{19}
TWDS Kol. H. Burlian Street (Palimo Market)	a_{22}
TWDS Cambai Agung	a_{24}

From Table 6, the optimal TWDS locations are TWDS Sudirman Street (Pahlawan Bus Stop) (a_3), TWDS Sudirman Street (Bank Mestika) (a_{12}), and so on until (a_{24}). The distance data between the villages and the TWDS is shown in Table 7.

TABLE 7. Distance Data Between The Villages and The TWDS

d_{ij}	3	12	14	16	17	18	19	22	24
1	1600	1400	1100	500	1100	3800	3300	3200	1500
2	1300	1900	2100	1200	1600	3700	1300	2900	550
3	2200	2500	1300	1400	70	2700	2500	4000	1400
4	5000	5200	4000	4200	2800	400	4100	4000	3400
5	2700	4500	3000	3900	1800	2400	1900	2100	1700
6	2200	3500	3500	3300	2300	2700	1200	1100	1300

Table 7 states that the distance from Sekip Jaya Village (b_1) to the TWDS Sudirman Street (Pahlawan Bus Stop) (a_3) is 1,600 meter, and so on until the distance from Ario Kemuning Village (b_6) to the TWDS Cambai Agung (a_{24}) is 1,300 meter. By using the data in Table 7, the p-Median Problem model is shown in Equation (20) with Constraints (21)-(37).

Minimize

$$Z_{P-Median} = 1600\, b_{1,3} + 1400\, b_{1,12} + 1100\, b_{1,14} + 500\, b_{1,16} + 1100\, b_{1,17} + 3800\, b_{1,18} + 3300\, b_{1,19} + 3200\, b_{1,22} + 1500\, b_{1,24} + 1300\, b_{2,3} + 1900\, b_{2,12} + 2100\, b_{2,14} + 1200\, b_{2,16} + 1600\, b_{2,17} + 3700\, b_{2,18} + 1300\, b_{2,19} + 2900\, b_{2,22} + 550\, b_{2,24} + 2200\, b_{3,3} + 2500\, b_{3,12} + 1300\, b_{3,14} + 1400\, b_{3,16} + 70\, b_{3,17} + 2700\, b_{3,18} + 2500\, b_{3,19} + 4000\, b_{3,22} + 1400\, b_{3,24} + 5000\, b_{4,3} + 5200\, b_{4,12} + 4000\, b_{4,14} + 4200\, b_{4,16} + 2800\, b_{4,17} + 400\, b_{4,18} + 4100\, b_{4,19} + 4000\, b_{4,22} + 3400\, b_{4,24} + 2700\, b_{5,3} + 4500\, b_{5,12} + 3000\, b_{5,14} + 3900\, b_{5,16} + 1800\, b_{5,17} + 2400\, b_{5,18} + 1900\, b_{5,19} + 2100\, b_{5,22} + 1700\, b_{5,24} + 2200\, b_{6,3} + 3500\, b_{6,12} + 3500\, b_{6,14} + 3300\, b_{6,16} + 2300\, b_{6,17} + 2700\, b_{6,18} + 1200\, b_{6,19} + 1100\, b_{6,22} + 1300\, b_{6,24} \quad (20)$$

Subject to

$$b_{1,3} + b_{1,12} + b_{1,14} + b_{1,16} + b_{1,17} + b_{1,18} + b_{1,19} + b_{1,22} + b_{1,24} = 1 \quad (21)$$

$$b_{2,3} + b_{2,12} + b_{2,14} + b_{2,16} + b_{2,17} + b_{2,18} + b_{2,19} + b_{2,22} + b_{2,24} = 1 \quad (22)$$

$$b_{3,3} + b_{3,12} + b_{3,14} + b_{3,16} + b_{3,17} + b_{3,18} + b_{3,19} + b_{3,22} + b_{3,24} = 1 \quad (23)$$

$$b_{4,3} + b_{4,12} + b_{4,14} + b_{4,16} + b_{4,17} + b_{4,18} + b_{4,19} + b_{4,22} + b_{4,24} = 1 \quad (24)$$

$$b_{5,3} + b_{5,12} + b_{5,14} + b_{5,16} + b_{5,17} + b_{5,18} + b_{5,19} + b_{5,22} + b_{5,24} = 1 \quad (25)$$

$$b_{6,3} + b_{6,12} + b_{6,14} + b_{6,16} + b_{6,17} + b_{6,18} + b_{6,19} + b_{6,22} + b_{6,24} = 1 \quad (26)$$

$$a_3 + a_{12} + a_{14} + a_{16} + a_{17} + a_{18} + a_{19} + a_{22} + a_{24} = 9 \quad (27)$$

$$b_{1,3}, b_{2,3}, b_{3,3}, b_{4,3}, b_{5,3}, b_{6,3} \leq a_3 \quad (28)$$

$$b_{1,12}, b_{2,12}, b_{3,12}, b_{4,12}, b_{5,12}, b_{6,12} \leq a_{12} \quad (29)$$

$$b_{1,14}, b_{2,14}, b_{3,14}, b_{4,14}, b_{5,14}, b_{6,14} \leq a_{14} \quad (30)$$

$$b_{1,16}, b_{2,16}, b_{3,16}, b_{4,16}, b_{5,16}, b_{6,16} \leq a_{16} \quad (31)$$

$$b_{1,17}, b_{2,17}, b_{3,17}, b_{4,17}, b_{5,17}, b_{6,17} \leq a_{17} \quad (32)$$

$$b_{1,18}, b_{2,18}, b_{3,18}, b_{4,18}, b_{5,18}, b_{6,18} \leq a_{18} \quad (33)$$

$$b_{1,19}, b_{2,19}, b_{3,19}, b_{4,19}, b_{5,19}, b_{6,19} \leq a_{19} \quad (34)$$

$$b_{1,22}, b_{2,22}, b_{3,22}, b_{4,22}, b_{5,22}, b_{6,22} \leq a_{22} \quad (35)$$

$$b_{1,24}, b_{2,24}, b_{3,24}, b_{4,24}, b_{5,24}, b_{6,24} \leq a_{24} \quad (36)$$

$$b_{1,3}, b_{2,3}, b_{3,3}, b_{4,3}, b_{5,3}, b_{6,3}, b_{1,12}, b_{2,12}, b_{3,12}, b_{4,12}, b_{5,12}, b_{6,12}, b_{1,14}, b_{2,14}, b_{3,14}, b_{4,14}, b_{5,14}, b_{6,14}, b_{1,16}, b_{2,16}, b_{3,16}, b_{4,16}, b_{5,16}, b_{6,16}, b_{1,17}, b_{2,17}, b_{3,17}, b_{4,17}, b_{5,17}, b_{6,17}, b_{1,18}, b_{2,18}, b_{3,18}, b_{4,18}, b_{5,18}, b_{6,18}, b_{1,19}, b_{2,19}, b_{3,19}, b_{4,19}, b_{5,19}, b_{6,19}, b_{1,22}, b_{2,22}, b_{3,22}, b_{4,22}, b_{5,22}, b_{6,22}, b_{1,24}, b_{2,24}, b_{3,24}, b_{4,24}, b_{5,24}, b_{6,24} \geq 0 \text{ and integer} \quad (37)$$

Based on data from the demand location, each demand location is grouped with the nearest facility location so that the distance traveled is minimum. Based on Lingo 18.0, the results are shown in Table 8.

TABLE 8. The Optimal Solution of p-Median Problem Model

Solver Status	
Model Class	*PILP*
State	*Global Optimal*
Objective	3900
Infeasibility	0
Iterations	0
Extended Solver Status	
Solver Type	*Branch and Bound*
Best Objective	3900
Objective Bound	3900
Steps	0
Active	0
Update Interval	2
GMU (K)	46
ER (sec)	1

In Table 8, it can be seen in the Solver Type that the method used in this case is the Branch and Bound method with an objective value of 3,900, which means that the total minimum distance from the demand point to the facility is 3,900 meters. Generated Memory Used (GMU) shows the amount of memory allocation used, 46K, and Elapsed Runtime (ER) shows the total time used to create and complete the model, which is 1 second.

The optimal solution for the p-Median Problem model is

1. The demand in Sekip Jaya Village (b_1) is located at TWDS Kp. Burai Street (Beside Medical Faculty) (a_{16}).
2. The demand in Pahlawan Village (b_2) is located at TWDS Basuki Rahmad Street (In front of Pondok Pindang Burung) (a_{19}).
3. The demand in 20 ilir D II Village (b_3) is located at TWDS Sekip Ujung Market (a_{17}).
4. The demand in Pipareja Village (b_4) is located at TWDS Chinese Graveyard (a_{18}).
5. The demand in Talang Aman Village (b_5) is located at TWDS Cambai Agung (a_{24}).
6. The demand in Ario Kemuning Village (b_6) is located at TWDS Kol. H. Burlian Street (Palimo Market) (a_{22}).

The Implementation of Genetic Algorithm

The first step is to build a population initialization, evaluate the fitness value, carry out the selection process, cross-breed between chromosomes, and the mutation process. From the process, new chromosomes are obtained and will calculate the fitness value for each chromosome. The Genetic algorithm process can be carried out in several iterations, expressed in terms of generation. The iteration will stop if each generation has a higher fitness value.

Table 9 is the initial population obtained from the initialization of the mileage data contained in Table 3. In this case, the initial population data generated is the distance data between each TWDS, as shown in Table 3. The mileage data contained in the row entries are chromosomes, and those contained in the column entries are the number of genes. In this study, the initial population was formed from 24 chromosomes and 24 genes. The value for each gene in the population will be initialized into a series of binary numbers (0 and 1). Gene is worth 0 if the distance travelled is >500 meters and is worth 1 if the distance travelled is less than or equals 500 meters.

From the Genetic algorithm results in the first generation, second generation, and third generation, it can be seen that the fitness value of the selected chromosome as the optimal solution for each generation is shown in Table 10. In Table 10, it can be seen that the fitness value of the chromosomes selected as the optimal solution in each generation is getting bigger. Therefore, the Genetic algorithm process on this problem stops in the third generation. This research looks for the minimum fitness value so that the optimal solution is the first generation's solution. Table 11 shows the optimal TWDS in the Kemuning Sub-District according to the Genetic algorithm.

TABLE 9. Initial Population

Chromosome	Chromosome Value																							Fitness Value
a_1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1130
a_2	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	630
a_3	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1150
a_4	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	300
a_5	0	0	0	0	1	1	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1190
a_6	0	0	0	0	1	1	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	900
a_7	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	810
a_8	0	0	0	0	1	1	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	810
a_9	0	0	0	0	1	1	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	760
a_{10}	0	0	0	0	1	1	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	780
a_{11}	0	0	0	0	1	1	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	810
a_{12}	0	0	0	0	1	1	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	2100
a_{13}	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	450
a_{14}	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	450
a_{15}	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	900
a_{16}	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	900
a_{17}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
a_{18}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
a_{19}	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	840
a_{20}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	260
a_{21}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	270
a_{22}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
a_{23}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	350
a_{24}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	350

TABLE 10. The Fitness Value of TWDS in Each Generation

First Generation		Second Generation		Third Generation	
Chromosome	**Fitness Value**	**Chromosome**	**Fitness Value**	**Chromosome**	**Fitness Value**
a_2	630	a_2	6130	a_3	3010
a_5	3350	a_3	5800	a_4	5820
a_6	3300	a_4	5820	a_9	6070
a_7	3600	a_5	4600	a_{11}	2650
a_{10}	3260	a_9	6140	a_{13}	3800
a_{11}	2860	a_{10}	5880	a_{16}	900
a_{13}	2800	a_{11}	0	a_{20}	3440
a_{16}	4000	a_{19}	5700	a_{23}	7100
a_{17}	3100	a_{23}	4850	a_{24}	6000

TABLE 11. The Optimal TWDS from The Genetic Algorithm

Chromosome	Name of TWDS
a_2	TWDS Polda
a_5	TWDS Beside RSMH
a_6	TWDS Sudirman Street (Laboratorium RSUPMH)
a_7	TWDS Sudirman Street (Bank Sampah Ceria RSUPMH)
a_{10}	TWDS Sudirman Street in front of Graha Medika
a_{11}	TWDS Sudirman Street (In front of K 24 Drug store)
a_{13}	TWDS Mayor Salim Batubara Street Lr. Nurul Huda
a_{16}	TPS Kp. Burai Street (Beside Medical Faculty)
a_{17}	TPS Sekip Ujung Market

Based on the results of SCLP model, p-Median Problem model and the application of Genetic algorithm, we group the location of TWDS according to the Village in the Kemuning Sub-District that can be seen in Table 12.

TABLE 12. The Optimal TWDS in the Kemuning Sub-District

No	Village	Name of TWDS
1.	Pahlawan	TWDS Polda
2.	Sekip Jaya	TWDS Beside RSMH TWDS Sudirman Street (Laboratorium RSUPMH) TWDS Sudirman Street (Bank Sampah Ceria RSUPMH) TWDS Sudirman Street in front of Graha Medika TWDS Sudirman Street (In front of K 24 Drug Store) TWDS Mayor Salim Batubara Street Lr. Nurul Huda TWDS Kp. Burai Street (Beside Medical Faculty)
3.	20 Ilir D II	TWDS Sekip Ujung Market

Table 12 describes the grouping of TWDS by Villages using Genetic algorithm. Pahlawan Village consists of 1 optimal TWDS, Sekip Jaya Village consists of 7 optimal TWDS, 20 Ilir D II Village consists of 1 optimal TWDS. Pipa Reja Village, Ario Kemuning Village, and Talang Aman Village do not have any optimal TWDS. This research recommends building 6 TWDS in Pahlawan Village, 6 TWDS in 20 Ilir D II Village, and 7 TWDS for each in Pipareja, Ario Kemuning, and Talang Aman Villages.

CONCLUSION

From the formulation of Set Covering Location Problem model, p-Median Problem model, and the application of Genetic Algorithm for the Kemuning Sub-District, we obtained only nine optimal TWDS locations. The optimal TWDS from the solution of Set Covering Location Problem model, p-Median Problem model, and the application of Genetic algorithm has not been maximized, so it is necessary to build extra TWDS.

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