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OPTIMIZATION OF SALAK FRUIT DISTRIBUTION ROUTES WITH *VEHICLE ROUTING PROBLEM* (VRP) USING *CLARKE AND WRIGHT SAVING'S*

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ABSTRACT

The problem in the Romaromi expedition which is addressed to Padangsidimpuan City, South Tapanuli Regency, Marancar District, precisely in Sugi Julu village which produces salak fruit is that the delivery of goods is done manually and irregularly where the goods are sent from the warehouse to the customer, and back to the warehouse, so it will cost a lot of time and also costs. Furthermore, to determine the allocation of consumers among existing routes, the sequence of routes that are able to go to all consumers from the specified route from vehicles that are able to pass all routes. Based on the problem in question, this study was made with a vehicle routing problem using Clarke and Wright savings or saving matrix by completing the calculation of savings measured from the many reductions between distance traveled and time used, involving nodes also making it one of the best route paths based on the greatest savings value, namely the distance traveled from the starting point to the intended end point. From the results obtained in data processing using Clarke and wright savings as many as 14 distribution routes. This shows that the Clarke and wright savings algorithm can minimize distance and also save company expenses.
Keywords: Distribution, Salak, VRP, Clarke and Wright Savings

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PRELIMINARY

Distribution is often still the biggest obstacle, especially in industries that produce largely. Distribution is a marketing activity to facilitate product marketing from the hands of sellers to buyers (Zulkarnaen et al., 2020). Distribution is related to individuals and individuals as well as groups with individuals (Dewantara, 2020). There is added value in the distribution process, such as the process of goods delivered to the location where consumers are, the time when consumers need a product, completeness of tools, and costs that must be optimal (Arifuddin, Wisnubroto, & Parwati, 2017). Distribution or often called distribution is one of the important tools in the field of marketing and is also the process of distributing products from sellers to customers. Good distribution and delivery are important so that products can be delivered to customers on time and in good condition (Muhammad, Bakhtiar, & Rahmi, 2017)

One of the distribution applications is the distribution of salak fruit, precisely at the romaromi expedition which is addressed in Padangsidimpuan City, South Tapanuli Regency, Marancar District, precisely in Sugi Julu Village which produces salak fruit. Based on the author's observations, the delivery of goods is done manually and irregularly where the goods are sent from the warehouse to the customer, and back again to the warehouse so that it takes a lot of time and costs. Distribution costs that are one of the problems can be solved using vehicle routing problem (vrp) optimization where this method can balance routes and minimize distribution costs. Vehicle routing problem (vrp) is a combinatorial optimization problem of route determination that can be applied to distribution arrangements (Hadhiatma & Purbo, 2017). If the route chosen is optimal, the distribution system becomes more effective and efficient because it will pass a route with a minimal distance, so that parts involving distance are minimal, such as transportation costs, travel time, the level of pollution produced, and the energy spent (Sitorus, Jenderal, & Perhubungan, 2017)

This delivery route problem is included in the vehicle route problem (vrp) where a number of vehicles with limited vehicle carrying capacity must serve as many customer requests as are expected to get routes with minimum distribution costs. The transport vehicle starts the journey from the depot and then visits several points in a certain group (Fatma, Kartika, & Nur Madyanti, 2022) The problem of determining routes for distribution shipments involves a set of routes and vehicles centered on one or more warehouses to serve consumers scattered in various delivery places for their respective needs is called the vehicle route problem (vrp). one variant of the vehicle routing problem that considers 2 types of services, namely delivery and product pickup at once when visiting a consumer (Garside & Cahyanti, 2018). The purpose of the vehicle route equation in distribution is to obtain the best route and some of the indicators and means of transportation that have been found before. The optimal route is to be able to solve various operational problems and have minimal time and total mileage in meeting consumer demand for the transportation equipment used to have a pegged amount (Siraj & Astuti, 2020).

To overcome these problems, an effective method is used in overcoming the problem, namely by using the Clarke and Wright Savings algorithm. The Clarke and Wright Savings algorithm is often called the distance or time saving method because it is a procedure for selecting as many distribution routes as possible based on each procedure chosen in order to obtain optimal route results. The Clarke and Wright Savings algorithm makes savings calculations calculated from how much reduction in mileage or time used, also nodes make it an optimal path based on the largest savings value, namely the distance traveled from the starting point to the intended end point (Zamah S. H., 2019).

Optimization is a computational problem that aims to find the best solution from several solutions by meeting a number of limitations (Devita & Wibawa, 2020). Optimization is the acquisition of one of the best actions on the problem of decision of available resources (Fitri, 2018). Of course, this will be very in accordance with economic principles that are oriented to always reduce spending to produce maximum output. This optimization is also important because competition is very tight in all existing fields (Ujianto & Maringka, 2018).

METHODS

Vehicle Routing Problem (VRP) & *Clarke and Wright Savings Algorithm*

The problem of vehicle routes is the problem of choosing distribution transportation routes involving a set of routes and vehicles centered on one or more warehouses to serve consumers scattered in various transportation places with their respective needs. According to Toth and Virgo here are some characteristics in the matter of vehicle routes:

1. The transport expedition starts and stops at the warehouse.
2. There are a number of places that all need to be visited and fulfilled the request is exactly once.
3. If the capacity of the transportation equipment has been used and cannot serve the next area, the transportation equipment can return to the warehouse to meet the capacity of the transportation equipment and serve the next area.

The objectives of the following VRP are as follows:

1. Minimize global shipping costs, related to mileage and fixed costs associated with conveyance.
2. Adjust the route during the expedition time as well as the cargo of the conveyance.
3. Minimizing compensation costs due to dissatisfaction from consumers, such as the arrival of goods not on time (Kusuma & Sumiati, 2020).

The availability of these depots aims to minimize the distance between consumers and depots, so that consumers can be served by vehicles originating from depots close to them (Making, Silalahi, & Bukhari, 2018) Vehicles that serve customers for parts start from the depot, move to each customer and return again to the depot Vehicles that move from i to j incur cij travel costs (Purnomo, 2017).

The Clarke and wright savings algorithm or savings matrix is a procedure for selecting a number of distribution routes at each step that are exchanged to obtain optimal route results. The Clarke and wright savings algorithm or often referred to as the savings method that calculates distance or time savings calculated from how much reduction in distance traveled and time used by involving nodes and making it an optimal route path based on the largest savings value, namely the distance traveled from the starting point to the intended end point. Saving matrix is a matrix from the results of calculating distances and routes contained in the matrix (Maulidiah et al., 2019).(Maulidiah, Jono, & Ramli, 2019) Saving matrix is used in determining the distribution route of products to customers in determining the sequence of distribution routes traversed by a number of transportation equipment in accordance with the capacity of the equipment the transport (Ahmad & Muharram, 2018).

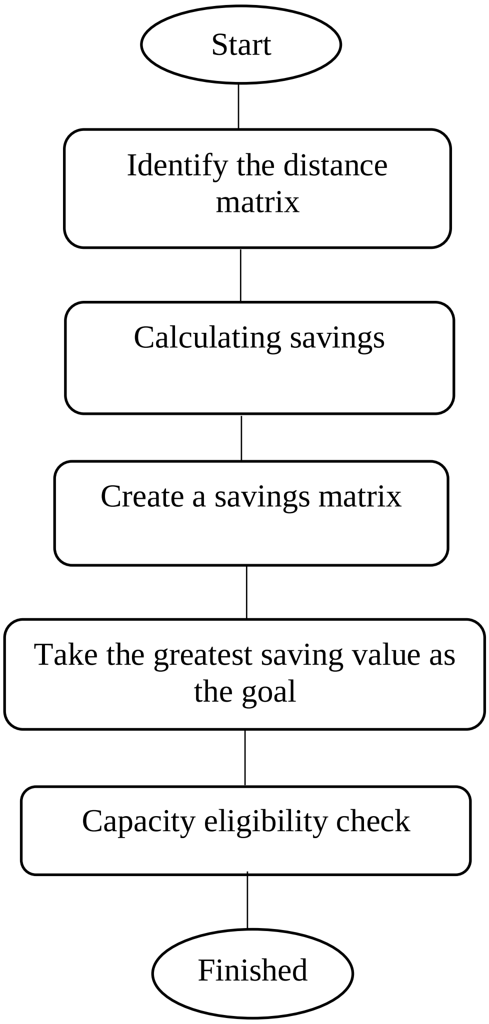

Figure 1. Research Design

Here are the steps on this method:

1. Determine the total maximum capacity of the means of transportation and the distribution of the means of transportation to the freight forwarder for consumers.
2. Using a distance matrix that is from the depot at points and between points. Calculate the value of savings (S_{ij}) in the form of mileage from two vehicles that replace into one vehicle to serve nodes *i* and *j*.

   $$S_{ij} = C_{0i} + C_{0j} - C_{ij} \qquad (1)$$

3. The savings matrix, the usual description of the savings matrix that Clarke and wright have raised.
4. Specifies two routes by which routes can be combined into a single path. The calculation of the maximum savings taken then determines the closest route from the previous path.
5. Specifies a cell where two directions can be combined into one path.

The Clarke and wright savings algorithm calculates the savings of the amount that can be minimized, such as the distance traveled, time, and cost used to combine nodes that create one optimal path. The calculation method is not to measure distance, as a benchmark, but to calculate time in order to get the largest savings calculation so that it is defined as an optimal path (Winarno & Arifin, 2019).

RESULT AND DISCUSSION

This data is data obtained from salak farmers in the Padangsidimpuan area, precisely in Sugi Julu village, Marancar District, on January 19, 2023. There were 14 agents, the data was analyzed using the Clarke and Wright savings method with the help of Microsoft Exel. In searching for longitude and latitude found on google maps, the steps are as follows:

1. Open google maps your cellphone or computer
2. Enter the adress in the search field provided to find out the longitude and latitude points
3. To improve the accuracy of the place where you want to know the coordinates, enlarge the map view on the cellphone or computer screen
4. Press and hold the desired location until a pin appears. Later the longitude and latitude will appear in the adress bar column

For example, marancar district, sugi julu village, google maps shows the coordinates of 1.51998.920027. From that point, it can be seen that the latitude is indicated at the first coordinate, which is 1.51998. While the longitude is shown in the second coordinate, namely 9.20017.

Table 1. Store Data

No	Address	Demand	Latitude	Longitude
0	Marancar Subdistrict, Sugi Julu Village	150	1,51998	9,20027
1	West Angkola District Koje Village Hamlet 1 Parsalakan Jl. Sibolga Km 8	167	1,42254	9,18127
2	West Angkola District, Padang Julu Village	200	1,53435	9,17029
3	West Angkola Subdistrict, Sibangkua Village	230	1,42160	9,18807
4	West Angkola Subdistrict, Tanjunggale Sialego Hamlet	125	1,47490	9,11306
5	Sangkumpal Bonang Botanical Market	118	1,37731	9,27015
6	Impres Sadabuan Market	267	1,39115	9,25518
7	Simirik Batunadua	178	1,43427	9,30141
8	Post Kota Jalan Merdeka No.5	112	1,37710	9,27134
9	Palopat Maria Jl. Padangsidimpuan No.18	134	1,41181	9,22294
10	Dalihan Natolu Traditional Market Jl. Sudirman Sadabuan	247	1,39160	9,25524
11	East Angkola District Sosopan Pargarutan	143	1,45727	9,31766
12	Sihitang Padangsidimpuan	165	1,34954	9,29098
13	South Angkola District Tapian Nauli	189	1,36509	9,13483
14	Jl. Imam Bonjol Aek Tampang	196	1,37110	9,27788

The table above is the coordinates or addresses of the 14 agents, in the initial route the ompany has 2 routes where the routes consist of the following:

Table 2. Initial Route

Route	Route Order	Distance
1	0-14-4-3-7-1-10-6-0	95,19
2	0-8-2-11-12-13-5-9-0	112,75
	Total	207,94

Based on the results of interviews with the company, the wages for drivers and assistants are the same, namely Rp. 85,000, and the meal costs Rp. 15,000/person. For diesel transportation fuel, the current price is IDR 6,800/liter (the distance for one liter is 9.4 km). The results of finding distribution costs from the company are as follows:The example of finding distribution costs is as follows:

Distribution cost = Number of vehicles (Driver and kernek salaries) + (Fuel costs x $\frac{Total\ distance}{Km/Liter}$) + (Driver's meal money and kernek))

= 1 (2 x 85.000) + (6.800 x $\frac{Total\ distance}{Km/Liter}$) + (2 x 15.000)

= 1 (170.000 + (6.800 x $\frac{207{,}94\ Km}{9{,}4\ Km/Liter}$) + 30.000)

= 170.000 + 150.424 + 30.000

= Rp.350.424,-.

The distance matrix or distance calculation is a calculation of the distance between two nodes that reviews the bond of angles and distances. The equation of distance is as follows:

d= $\sqrt{(lat_1 - lat_2)^2 + (long_1 - long_2)^2}$ x 111.322 (1)

Information:

d : Distance

Lat : Latitude

Long : Longitude (Longitude of the earth) For example, the following calculation of the distance from the depot to the first agent point can be seen below. The latitude and longitude values of each agent are shown below:

$d(i,j) = \sqrt{(lat_1 - lat_2)^2 + (long_1 - long_2)^2}$ x 111,322

= $\sqrt{(0{,}09744)^2 + (0{,}019)^2}$ x 111.322

= $\sqrt{(0{,}0094945536)^2 + (0{,}000361)^2}$ x 111.322

= $\sqrt{0{,}0098555536}$ x 111.322

= 0.0992751409 x 111.322

= 11.05 km (29 km)

So the distance from the depot to the first agent using the Euclidean distance equation is 11.05km. However, because the system of picking up goods is carried out by road trip, the calculation of distance must take into account the presence or absence of directions that can be crossed on four-wheeled conveyances. Therefore, the calculation of the distance from depot to each agent and agent to other agents is searched with the help of Google Maps. The distance matrix is calculated that the distance between the depot expedition and the agent is related to each other, also the distance between agents to the depot and to other agents is regular. The calculation of this distance matrix will get a new distance matrix with the distance that has been calculated. After the distance matrix with the saving matrix method, the transportation load will be calculated for each route to be recommended (Supardi & Sianturi, 2020).

Table 3. Distance Matrix

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
0,00	11,05	3,70	11,04	10,93	17,69	15,59	14,76	17,76	12,30	15,55	14,82	21,49	18,72	18,69
11,05	0,00	12,51	0,76	9,57	11,10	8,94	13,44	11,23	4,79	8,93	15,67	14,67	8,22	12,18
3,70	12,51	0,00	12,71	9,19	20,72	18,53	18,36	20,81	14,85	18,49	18,51	24,57	19,25	21,77
11,04	0,76	12,71	0,00	10,24	10,38	8,20	12,70	10,51	4,03	8,19	14,96	13,99	8,64	11,47
10,93	9,57	9,19	10,24	0,00	20,59	18,36	21,45	20,71	14,10	18,34	22,86	24,23	12,46	21,68
17,69	11,10	20,72	10,38	20,59	0,00	2,27	7,23	0,13	6,51	2,30	10,35	3,86	15,13	1,10
15,59	8,94	18,53	8,20	18,36	2,27	0,00	7,04	2,38	4,26	0,05	10,13	6,11	13,71	3,37
14,76	13,44	18,36	12,70	21,45	7,23	7,04	0,00	7,19	9,09	7,00	3,13	9,50	20,08	7,50
17,76	11,23	20,81	10,51	20,71	0,13	2,38	7,19	0,00	6,63	2,41	10,31	3,77	15,26	0,99
12,30	4,79	14,85	4,03	14,10	6,51	4,26	9,09	6,63	0,00	4,24	11,70	10,27	11,10	7,61
15,55	8,93	18,49	8,19	18,34	2,30	0,05	7,00	2,41	4,24	0,00	10,09	6,14	13,73	3,40
14,82	15,67	18,51	14,96	22,86	10,35	10,13	3,13	10,31	11,70	10,09	0,00	12,36	22,79	10,57
21,49	14,67	24,57	13,99	24,23	3,86	6,11	9,50	3,77	10,27	6,14	12,36	0,00	17,47	2,81
18,72	8,22	19,25	8,64	12,46	15,13	13,71	20,08	15,26	11,10	13,73	22,79	17,47	0,00	15,94
18,69	12,18	21,77	11,47	21,68	1,10	3,37	7,50	0,99	7,61	3,40	10,57	2,81	15,94	0,00

Table 4. Savings Matrix

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	0													
2	2,25	0												
3	21,32	2,03	0											
4	12,41	5,44	11,72	0										
5	17,63	0,67	18,34	8,03	0									
6	17,70	0,76	18,42	8,15	31,01	0								
7	12,37	0,10	13,10	4,24	25,21	23,31	0							
8	17,59	0,66	18,29	7,98	35,32	30,97	25,33	0						
9	18,56	1,16	19,31	9,13	23,48	23,63	17,98	23,44	0					
10	17,67	0,76	18,39	8,13	30,93	31,09	23,31	30,90	23,61	0				
11	10,20	0,00	10,89	2,88	22,15	20,28	26,44	22,27	27,12	20,28	0			
12	17,88	0,62	18,54	8,19	35,31	30,97	26,75	35,49	23,71	30,90	23,95	0		
13	21,55	3,17	21,11	17,18	21,28	20,60	13,40	21,23	24,88	20,54	10,74	22,74	0	
14	17,56	0,63	18,26	7,94	35,27	30,91	25,94	35,47	17,27	30,84	22,94	37,38	21,47	0

The calculation of this distance matrix will get a new distance matrix with the distance that has been calculated. After the distance matrix with the saving matrix method, the transportation load will be calculated for each route to be recommended (Supardi & Sianturi, 2020). Savings matrix or called the savings method that meets the calculation of savings is calculated starting from as much as the reduction in mileage used. Measuring the calculation of savings (Sij) in the form of mileage on two means of transportation that deliver into one means of transportation to serve points i and j ((Zamah, 2019)

$$S_{ij} = C_{0i} + C_{0j} - C_{ij} \quad (1)$$

For example, for the calculation of measurable savings as much as mileage reduction can be seen as follows:

$S_{ij} = C_{0i} + C_{0j} - C_{ij}$

12 = 11.05 + 3.7 – 12.51

= 2.25

So, the savings for the calculation of measurable savings as much as the reduction in mileage is 2.25%.

Table 5. Largest Savings Matrix by Sorting Routes

No	Route	Result	Demand	Capacity (kg)	No	Route	Result	Demand	Capacity (kg)
1.	14,12	37,38	361	3000	45.	9,3	19,31	364	3000
2.	12,8	35,49	277	3000	46.	9,1	18,56	301	3000
3.	14,8	35,47	308	3000	47.	12,3	18,54	395	3000
4.	8,5	35,32	230	3000	48.	6,3	18,42	497	3000
5.	12,5	35,31	283	3000	49.	10,3	18,39	477	3000
6.	14,5	35,27	314	3000	50.	5,3	18,34	348	3000
7.	10,6	31,09	514	3000	51.	8,3	18,29	342	3000
8.	6,5	31,01	385	3000	52.	14,3	18,26	426	3000
9.	8,6	30,97	379	3000	53.	9,7	17,98	312	3000
10.	12,6	30,97	432	3000	54.	12,1	17,88	332	3000
11.	10,5	30,93	365	3000	55.	6,1	17,70	434	3000
12.	14,6	30,91	463	3000	56.	10,1	17,67	414	3000
13.	10,8	30,90	359	3000	57.	5,1	17,63	285	3000
14.	12,10	30,90	412	3000	58.	8,1	17,59	279	3000
15.	14,10	30,84	443	3000	59.	14,1	17,56	363	3000
16.	12,7	26,75	343	3000	60.	13,4	17,18	314	3000
17.	11,7	26,44	321	3000	61.	11,9	15,42	277	3000
18.	14,7	25,94	374	3000	62.	13,7	13,40	367	3000
19.	8,7	25,33	290	3000	63.	7,3	13,10	408	3000
20.	7,5	25,21	296	3000	64.	4,1	12,41	292	3000
21.	12,11	23,95	308	3000	65.	7,1	12,37	345	3000
22.	9,6	23,63	401	3000	66.	4,3	11,72	355	3000
23.	10,9	23,61	381	3000	67.	11,3	10,89	373	3000
24.	12,9	23,53	299	3000	68.	13,11	10,74	332	3000
25.	9,5	23,48	252	3000	69.	11,1	10,20	310	3000
26.	9,8	23,44	246	3000	70.	9,4	9,13	259	3000
27.	14,9	23,38	330	3000	71.	12,4	8,19	290	3000
28.	7,6	23,31	445	3000	72.	6,4	8,15	292	3000
29.	10,7	23,31	425	3000	73.	10,4	8,13	372	3000
30.	14,11	22,94	339	3000	74.	5,4	8,03	243	3000
31.	13,12	22,74	354	3000	75.	8,4	7,98	237	3000
32.	11,8	22,27	255	3000	76.	14,4	7,94	321	3000
33.	11,5	22,15	261	3000	77.	4,2	5,44	325	3000
34.	13,1	21,55	356	3000	78.	7,4	4,24	303	3000
35.	14,13	21,47	385	3000	79.	13,2	3,17	389	3000
36.	3,1	21,32	390	3000	80.	11,4	2,88	268	3000
37.	13,5	21,28	307	3000	81.	2,1	2,25	367	3000
38.	13,8	21,23	301	3000	82.	3,2	2,03	430	3000
39.	13,3	21,11	419	3000	83.	9,2	1,16	334	3000
40.	13,6	20,60	456	3000	84.	6,2	0,76	467	3000
41.	13,10	20,54	436	3000	85.	10,2	0,76	447	3000
42.	11,6	20,28	410	3000	86.	5,2	0,67	318	3000
43.	11,10	20,28	390	3000	87.	8,2	0,66	312	3000
44.	13,9	19,92	419	3000	88.	14,2	0,63	396	3000

No	Route	Result	Demand	Capacity (kg)
89.	12,2	0,62	365	3000
90.	7,2	0,10	378	3000
91.	11,2	0,00	343	3000

After sorting the routes with the largest savings matrix value, the optimal new route sequence is obtained, with the order Distance matrix - Savings matrix - Sort routes with the largest savings matrix value - New routes are fulfilled (from the largest order and must not return to the same point). By using *the Clarke and wright savings* algorithm becomes more efficient and only has 1 route. The following are the new routes, which are as follows:

Table 6. New Routes

Route	Route Order	Distance
1	0-14-12-8-5-10-6-11-7-13-1-9-3-4-2-0	101,27

Currently, salak farmers in Padangsidimpuan City, precisely in Sugi Julu Village, distribute salak fruit products to all consumers with 1 delivery, so there is 1 vehicle used in distributing salak fruit products. As for the type of vehicle used L300 with a vehicle capacity of 2,500 kilograms / vehicle. The following is the calculation of the amount of distribution costs per day, among others:

Driver Salary = Rp. 85.000,-

Kernek = Rp. 85.000,-

Fuel (Solar) = Rp. 6.800,-/Liter

Food Allowance =Rp. 15.000,-/Person

The example of finding distribution costs is as follows:

Distribution Cost = Number of conveyances (Driver salary and kenek + Fuel cost + Driver's meal money and kernek)

$$= 1\ ((2 \times 85.000) + (6.800 \times \frac{Total\ distance}{9{,}4\ Km/Liter}) + (2 \times 15.000)$$

$$= 1\ (170.000 + (6.800 \times \frac{Total\ distance}{9{,}4\ Km/Liter}) + (30.000)$$

$$= 170.000 + 73.259 + 30.000$$

= Rp. 273. 259,-

Based on the route using *the Clarke and Wright Savings* algorithm and also route improvements from the company, the percentage of total mileage savings is obtained below:

$$= \frac{The\ total\ distance\ of\ the\ company's\ route - Total\ distance\ of\ clarke\ and\ wright\ saving\ route}{The\ total\ distance\ of\ the\ company's\ route} \times 100\%$$

$$= \frac{207{,}94 - 101{,}27}{207{,}94} \times 100\%$$

= 51.29%

Thus, the percentage of total route distance savings value was 51.29%. This shows that *the Clarke and wright savings* algorithm can minimize distance and also save company expenses. The following is another study that has simirlarly titled methods and result “Determining The Shortest Route Using The Clarke and Wright Savings Algorithm Method”. In his research, using the clarke and wright savings method to find distribution routes, expenditure cost used for distribution, and have a saving value from the costs incurred by the previous company (Damayanti et al., 2021)

CONCLUSION

Research on optimizing the distribution of salak fruit conducted in Padangsidimpuan, using the clarke and wright savings method, where there are constraints on distribution costs and route determination, this research aims to minimize distribution costs and to find optimal routes. Savings from the initial mileage of 2.08% over the route traveled as well as on distribution costs of 3.5%. Meanwhile, the savings from new mileage using the *Clarke algorithm and wright savings* amounted to 1.01% over the route traveled and on distribution costs amounted to 2.73%. So that the new distribution route is more optimal than the initial distribution route. Thus, the percentage of total route distance savings value was 51.29%. This shows that *the Clarke and wright savings* algorithm can minimize distance and also save company expenses..

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