Available online at: http://publikasi.mercubuana.ac.id/index.php/ijiem

IJIEM (Indonesian Journal of Industrial Engineering & Management)

ISSN (Print) : 2614-7327 ISSN (Online) : 2745-9063

Analysis of Bottled Drinking Water Distribution Routes Using the Vehicle Routing Problem (Case Study: PT Sabina Tirta Utama Samarinda)

Nabila Nurlita*, Wahyuda, Dutho Suh Utomo

Faculty of Engineering, Mulawarman University, Jalan Sambaliung No.9, Samarinda City, East Kalimantan 75119 Indonesia

ARTICLE INFORMATION

Article history:

Received: 12 August 2024
Revised: 10 October 2024
Accepted: 20 January 2025

Category: Research paper

Keywords:
Routing
Vehicle routing problem
Saving matrix
Nearest neighbor
Insertion

DOI: 10.22441/ijiem.v6i2.29021

A B S T R A C T

PT Sabina Tirta Utama is a bottled drinking water production company located at Mas Penghulu street, Samarinda city. In addition to producing Bottled Drinking Water, this company also distributes its products to agents and end customers. The company has 4 units of Daihatsu Gran Max Pick Up vehicles that are used in the distribution of bottled drinking water with a maximum capacity of 200 boxes. The company's most customers are in Samarinda City. Because this company distributes its products, it must determine the route traveled to meet customer demand. One solution to overcome the problems at PT Sabina Tirta Utama Samarinda is to use the Vehicle Routing Problem, which is a method of solving distribution problems by considering the limited capacity of vehicles. In solving Vehicle Routing Problem, several methods are used, namely the Saving Matrix, Nearest Neighbor, and Insertion methods. Based on the research results, the total initial distribution distance is 117.53 km with an initial route of 10 routes and distribution costs of IDR979.417/month. In the Saving Matrix method, the total distance can be optimized to 107,55 km with 7 routes. After sorting customers using Nearest Neighbor, the total distance is 103,13 km, while the Insertion method gets a total distance of 90,24 km. Of the three methods, the most optimal total distance is 90,24 km, namely by using the Insertion method. So that the company can save a distance of 23% of the company's initial distance. Therefore, the company can save gasoline fuel costs from IDR979.417 to IDR752.000 with a difference of IDR227.417/month.

*Corresponding Author
Nabila Nurlita
E-mail: nabilanurlita14@gmail.com

1. INTRODUCTION

Distribution activities are crucial for companies in ensuring the timely delivery of products to customers. Proper product delivery requires accurate scheduling and routing, so that customers receive products that meet quality standards and within the requested timeframe. To improve effectiveness and efficiency in distribution activities, companies are involved in scheduling and routing within transportation systems. Distribution can be defined as a marketing activity aimed at facilitating or easing the process of delivering goods and services from producers to consumers, ensuring that the usage meets desired needs (Rani & Fitri, 2019). According to (Jatmiko & Asriati, 2023), a producer is an individual, organization, or other entity that manages the production process, from selecting raw materials to producing high-value and high-quality products for consumer use. PT. Sabina Tirta Utama Samarinda is one such producer of Bottled Drinking Water in Samarinda, with the Sabina mineral water brand. Sabina bottled water is only available in 220 ml glasses, packaged in boxes containing 48 glasses each. PT. Sabina Tirta Utama is located at Samarinda City, East Kalimantan. Besides producing bottled drinking water, the company also distributes its products to agents and end customers. PT. Sabina Tirta Utama has many customers across various regions, from Samarinda City to Bontang and East Kutai, with the majority of its customers located in Samarinda City. As the company distributes its products, it needs to determine the routes its fleet must take to meet customer demand, which is the purchase of bottled drinking water (in boxes).

The problem faced by PT. Sabina Tirta Utama Samarinda is that the company has 4 vehicles to operate with a fixed number of 24 customers, where each delivery often experiences overload due to the high demand from customers (box). This condition results in inconsistent distribution routes for each delivery. Therefore, the company wants to optimize the routes for distribution at PT. Sabina Tirta Utama Samarinda to minimize the distance traveled. A problem-solving strategy is needed to provide the best solution. An important aspect of distribution network design is decision-making about which locations to visit first. One solution to address the problem at PT. Sabina Tirta Utama Samarinda is to use the Vehicle Routing Problem (VRP) to solve distribution issues. The Vehicle Routing Problem (VRP) is suitable because it helps drivers determine the best routes for distributing goods to customers in Samarinda City, where the highest number of customers are located. The goal of the research at PT. Sabina Tirta Utama Samarinda is to generate the best route for distributing Bottled Drinking Water and minimizing the distance for distributing.

2. LITERATURE REVIEW

2.1 Supply Chain Management

Supply Chain Management is a series of approaches used to connect suppliers, manufacturers, warehouses, and stores efficiently, so that inventory can be produced and distributed accurately, to the appropriate locations, and at the right time. Its primary goal is to minimize the overall system costs while still meeting desired needs and service levels (Lukman, 2021).

2.2 Distribution

Distribution is a crucial aspect of service in a company. The distribution process bears significant responsibility in fulfilling customer demands. On the other hand, distribution is directly related to delivery time, travel routes, delivery speed, and indirectly affects the stability of the product. Various considerations regarding these parameters influence customer trust in the related products, thus requiring methods to optimize the parameters associated with the distribution process (Novianti et al., 2021). According to (Winarno & Arifin, 2019), distribution is an essential instrument in trade, where proper distribution provides benefits to all parties involved. An effective and efficient distribution process is as important as other instruments in achieving customer satisfaction. As competition in the industry increases, companies are required to develop better distribution strategies. One such strategy is to plan and determine the appropriate routes so that products reach customers in the correct quantities and at low costs. Therefore, companies must choose truly optimal distribution routes.

2.3 Transportation

The transportation problem is a part of operations research that deals with minimizing transportation costs from one location to another. This issue arises when someone seeks to find the best way to distribute goods from multiple supply locations to multiple demand locations. Every industry aims to minimize transportation costs, necessitating problem-solving strategies that can provide optimal solutions (Irvana Arofah & Gesthantiara, 2021).

According to (Natalin et al., 2021), transportation refers to the process of moving goods from one place to another, starting from the beginning of the supply chain until reaching the consumer. The transportation or logistics segment is a crucial aspect in enhancing supply chain performance, with significant impacts on responsiveness and efficiency within the supply chain. When a company aims to achieve optimal responsiveness, the transportation costs required will also increase. Conversely, if the goal is efficiency, the company can reduce transportation costs, although responsiveness might decrease.

2.4 Vehicle Routing Problem

According to (Hanifah et al., 2020), the problem of vehicle routing, commonly known as the Vehicle Routing Problem (VRP), involves planning efficient trips for a number of vehicles used to transport people or goods, whether for delivery or pickup. In simple terms, VRP is a distribution problem aimed at finding a set of optimal routes for a number of vehicles with specific capacities, operating from one or more depots to serve customers. Each destination or stop should be served only once, considering vehicle capacity for each delivery, with the goal of minimizing the required costs, particularly in terms of reducing the total distance traveled.

2.4.1 Vehicle routing problem for bottled drinking water

The vehicle routing problem for bottled drinking water involves issues related to market demand where the total demand along a route must not exceed the vehicle's capacity. The goal is to ensure that the routes taken by the vehicles can deliver on time with the vehicle's maximum capacity, so that the vehicles operate optimally and optimize the routes for distribution.

2.5 Saving Matrix Method

According to (Sutrisno et al., 2023), the strategy used involves first clustering customers based on their regions using a cluster-first, route-second approach. With this approach, customers are grouped before determining the routes, which can enhance the efficiency of route planning by creating preliminary routes. This helps reduce trial and error in the process. Several steps to implement the Saving Matrix include the following: (1) Determine the distance from the depot or warehouse to all existing customers. Additionally, it is necessary to determine the distances between each pair of customers. (2) Calculate the Saving Matrix using the following formula

$$S_{ab} = C_{ga} + C_{gb} - C_{ab} \ldots\ldots\ldots\ldots\ldots\ldots (2.1)$$

(3) Analyze the distances and routes based on the Saving Matrix to identify each route. The largest saving matrix values are selected first to create new routes, with the new routes formed considering the maximum capacity of the vehicles. (4) Arrange customers using the Nearest Neighbour and Insertion methods. The optimal route value is calculated by summing the distance from the depot to the final customer and back to the depot.

2.6 Nearest Neighbour Method

According to (Arfana Perdana et al., 2021), the goal of the Nearest Neighbour method is to find the shortest route, ensuring that goods distribution can be carried out optimally. Optimality in this context includes the quantity of goods delivered, delivery time, and the distance traveled efficiently. The Nearest Neighbour method is the simplest approach to solving the traveling salesman problem. This method consists of several steps, including: (1) Selecting a starting point and choosing the delivery outlets, (2) Creating a distance matrix, which depicts the locations of the outlets and the distances between them, (3) Next, choosing the next destination to visit, considering only the point that is closest to the previously visited point, and (4) After all points have been visited or connected, closing the route by returning to the starting point.

2.7 Insertion Method

According to (Suryani et al., 2018), the Insertion Method is used to find the optimal distance of a distribution route by inserting routes into a subtour of the distribution path to minimize the distribution distance. The steps in route sequencing using the Insertion Method are: (1) Start by connecting the first city to the last city, (2) Create a subtour between these two cities, meaning the journey starts from the first city and ends at the first city, e.g., (1,3) to (3,2) to (2,1), (3) Replace one of the connections (arcs) between two cities with a combination of two arcs, specifically arc (i,j) with arc (i,k) and arc (k,j), where k is chosen from the distance not yet included in the subtour and with the smallest additional value. The distance is then obtained through Equation 2.2.

Jik+Jkj–Jij…..…………………..…….(2.2)

(4) Repeat step 3 until all cities are included in the subtour.

2.8 Total Shipping Cost

According to (Tjaja & Saiful, 2021), total cost calculation includes the expenses that the company must incur to deliver to several locations. This calculation aims to determine the total cost resulting from route creation using the applied method. Details of the total shipping cost calculation can be found in the formula 2.3.

Raw material cost = price per liter of fuel × fuel usage ratio ………………………….(2.3)

3. RESEARCH METHOD

flowchart of activities provides a sequential explanation of the steps involved in completing a research study. Primary data refers to data obtained directly by the researcher without intermediaries. In the research on PT. Sabina Tirta Utama Samarinda, primary data includes interviews with company representatives, the distance from the company to customers, and the distances between customers using Google Maps. Secondary data can be obtained through intermediary media or from existing sources, whether published or unpublished, related to the research, such as company profiles, customer addresses, vehicle numbers, initial company routes, and other documents. The stages for completing this research can be seen in Figure 1.

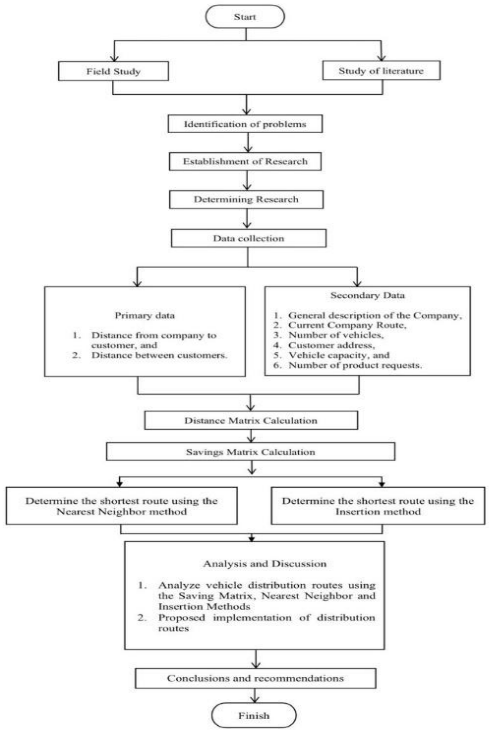

Figure 1. Flowchart analysis stages

4. RESULT AND DISCUSSION

PT. Sabina Tirta Utama produces bottled drinking water in 220 ml cup sizes. The company has 4 vehicles for distributing goods to each customer. The company uses Daihatsu Gran Max Pick Up vehicles with a maximum capacity of 200 boxes, and the interior dimensions of the vehicle are 235 cm in length and 158 cm in width. The delivery routes are determined based on the maximum capacity that can be carried formultiple customer orders, without a fixed route for each customer in the goods distribution process.

4.1 Customer Data

In the initial phase of the research, customer data is required to determine the number of points to be visited in the goods distribution process. By identifying customer location points, the data will be processed using the Saving Matrix, Nearest Neighbour, and Insertion methods. The customer data used is from regular customers as of February 2024, with the assumption that there are no changes to the list of names and addresses of regular customers at PT. Sabina Tirta Utama Samarinda, as shown in Table 1.

Table 1. Sabina customers

No	Name	Addres	Code	Demand (Box)
1	Rafa Store	Kh Harun Nafsi Street	A1	30
2	Deden Store	Kh Harun Nafsi Street	A2	20
3	Enong Store	Bung tomo Street	A3	60
4	Abu Hazam Store	Raudah Street	A4	60
…	…	…	…	..
24	Layang – Layang Store	Niaga Baru Street	A24	125

4.2 Company's Initial Route Data

Information on the initial distribution routes at PT. Sabina Tirta Utama Samarinda was obtained through interviews with the company's drivers. This data is used for comparison purposes in order to find the most optimal distribution route. Below are the company's initial distribution routes.

Table 2. Route allocation

Vehicle	Route	Route Allocation	Total Capacity (Box)	Distance Traveled (km)
1	1	G → A24 → A11 → G	160	19,70
	2	G → A13 → A4 → A19 → G	180	18,41
2	3	G → A21 → A3 → G	180	13,20
	4	G → A22 → A6 → A2 → A12 → G	175	17,96
3	5	G → A18 → A1 → G	155	9,40
	6	G → A10 → A8 → A16 → G	90	12,80
	7	G → A7 → A10 → A14 → G	70	16,15
4	8	G → A15 → A17 → G	120	2,55
	9	G → A23 → A9 → G	140	5,40
	10	G → A20 → A5 → G	100	1,96
		Total distance traveled		117,53

From Table 2 above, the total distance for the initial distribution is 117.53 km, with 10 initial distribution routes using 4 Daihatsu Gran Max Pick Up vehicles. This data will be used for comparison with the proposed routes, which will be processed using the Saving Matrix, Nearest Neighbour, and Insertion methods.

4.3 Cost Data

From Table 2, the total distance for goods distribution is 117.53 km. The fuel commonly used by the company is gasoline, with a price of IDR10,000 per liter. The total distance for one distribution is 117.53 km, and with a fuel ratio of 1:6, it means that 19.59 liters of gasoline are used. Therefore, the cost of gasoline is calculated as follows:

Fuel cost = 19.59 liters × IDR10,000/liter
= IDR195,883

Monthly fuel cost = 5 weeks × IDR195,883
= IDR979,417

4.4 The Distance Matrix

The number of Sabina customers distributed across the Samarinda area is managed by the company's drivers. To calculate the distance between customers, Google Maps is used, starting from the warehouse (G). Using the distance data from the distribution starting point to each customer, as well as the distance between each customer, a distance matrix is obtained that covers all the distribution points being studied. The distance matrix is used to determine the distance between one location and another. The distance matrix for all distribution points, measured in kilometers, is shown in Table 3.

Table 3. The distance matrix

	G	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17	A18	A19	A20	A21	A22	A23	A24
G	0,00	3,80	1,70	4,50	9,10	0,30	1,60	3,50	6,20	2,30	7,00	9,20	0,50	3,00	0,45	0,65	2,50	0,25	2,00	8,90	0,06	6,40	6,50	2,60	10,10
A1	5,60	0,00	3,90	5,00	9,40	5,90	3,70	1,80	6,30	6,10	3,30	11,90	5,40	6,60	6,00	6,20	6,10	5,10	3,30	9,20	5,60	6,70	6,80	6,20	10,80
A2	1,90	2,30	0,00	4,00	8,30	2,20	0,15	2,10	5,40	2,40	5,60	10,40	1,80	2,90	2,40	2,60	2,50	1,50	0,55	8,20	2,00	5,70	5,70	2,50	9,80
A3	3,70	4,10	4,40	0,00	5,40	4,00	4,30	3,80	2,40	2,60	4,10	7,90	3,50	1,70	4,10	4,30	2,60	3,70	4,00	5,20	3,70	2,70	2,70	2,70	6,80
A4	8,70	7,20	7,70	5,00	0,00	9,00	7,50	6,90	3,90	7,60	7,20	3,60	8,50	6,60	9,10	9,30	7,60	8,70	7,10	0,21	8,70	2,70	2,70	7,70	2,40
A5	0,30	4,10	2,00	4,60	9,20	0,00	1,90	3,80	6,20	2,00	7,30	9,50	0,80	3,00	0,15	0,35	2,30	0,55	2,30	9,00	0,24	6,40	6,60	2,40	10,40
A6	1,80	2,20	0,15	3,80	8,20	2,10	0,00	2,00	5,20	2,30	5,50	10,30	1,70	2,80	2,30	2,40	2,40	1,40	0,40	8,00	1,90	5,50	5,60	2,40	9,60
A7	3,80	1,60	2,10	3,20	7,60	4,10	1,90	0,00	4,60	4,30	4,80	10,10	3,60	4,70	4,20	4,40	4,30	3,30	1,50	7,40	3,80	4,90	5,00	4,40	9,00
A8	6,60	5,10	5,60	3,00	4,00	6,90	5,40	4,90	0,00	5,50	5,10	6,50	6,50	4,60	7,10	7,30	5,60	6,60	5,00	3,80	6,70	1,30	1,40	5,70	5,40
A9	1,80	4,50	2,40	2,70	7,30	2,00	2,30	4,30	4,30	0,00	6,00	9,80	1,60	1,10	1,80	2,20	0,80	1,80	2,70	7,10	1,80	4,60	4,70	0,85	8,70
A10	6,80	3,70	5,60	3,10	7,50	7,10	5,40	3,50	4,50	5,70	0,00	10,00	6,60	4,80	7,40	7,40	5,70	6,80	5,00	7,30	6,80	4,80	4,80	5,80	8,90
A11	8,10	10,30	9,70	8,10	4,20	8,40	9,00	10,10	7,00	9,40	10,30	0,00	8,00	9,80	8,60	8,10	9,40	8,10	9,40	4,00	8,20	5,80	5,90	9,50	1,60
A12	0,16	3,70	1,60	4,40	9,70	0,50	1,50	3,40	6,10	2,40	6,90	9,10	0,00	2,90	0,60	0,80	2,40	0,16	1,90	8,80	0,22	6,40	6,40	2,50	10,00
A13	3,30	4,90	4,00	1,50	5,70	3,60	3,90	4,60	3,20	2,20	4,80	8,70	3,10	0,00	3,70	3,90	2,20	3,30	4,20	6,00	3,30	3,50	3,50	2,30	7,60
A14	0,45	4,20	2,10	4,40	9,00	0,15	2,00	4,00	6,00	1,80	7,50	9,70	0,95	2,90	0,00	0,40	2,20	0,70	2,40	8,80	0,40	6,30	6,40	2,20	10,40
A15	0,65	4,40	2,30	4,80	9,40	0,40	2,20	4,20	6,40	2,20	7,70	9,80	1,10	3,30	0,40	0,00	2,60	0,90	2,60	9,20	0,60	6,70	6,80	2,60	10,70
A16	1,00	3,80	1,70	3,60	8,20	1,30	1,60	3,60	5,20	1,00	6,90	10,00	0,85	2,10	1,50	1,70	0,00	1,00	2,00	8,00	1,10	5,50	5,60	0,06	9,60
A17	1,00	4,00	2,00	4,30	8,90	1,50	1,80	3,80	5,90	2,20	7,30	9,00	0,80	2,70	1,60	1,40	2,30	0,00	2,20	8,70	1,20	6,30	6,30	2,30	9,80
A18	2,20	1,80	0,55	3,40	7,80	2,50	0,40	1,60	4,80	2,70	5,10	10,30	2,10	3,20	2,70	2,80	2,80	1,80	0,00	7,60	2,30	5,10	5,20	2,80	9,20
A19	9,50	7,40	7,80	5,20	0,18	9,20	7,70	7,20	4,10	7,80	7,40	3,50	9,40	6,90	10,00	10,10	7,80	9,00	7,30	0,00	9,60	2,90	2,90	7,90	2,40
A20	0,59	3,80	1,80	4,60	9,20	0,24	1,60	3,60	6,20	2,20	7,10	9,30	0,55	3,00	0,40	0,60	2,60	0,30	2,00	9,00	0,00	6,50	6,60	2,70	10,10
A21	6,80	5,30	5,80	3,10	2,80	7,10	5,60	5,10	2,00	5,70	5,30	5,40	6,70	4,80	7,30	7,50	5,80	6,80	5,20	2,70	6,90	0,00	0,07	5,80	4,30
A22	6,90	5,40	5,90	3,20	3,00	7,20	5,70	5,20	2,10	5,80	5,40	5,50	6,70	4,90	7,30	7,50	5,90	6,90	5,30	2,80	6,90	0,07	0,00	5,90	4,40
A23	1,00	3,70	1,70	3,50	8,20	1,30	1,60	3,50	5,20	1,00	6,90	9,90	0,80	2,00	1,40	1,60	0,80	1,00	2,00	8,00	1,00	5,50	5,50	0,00	9,60
A24	9,60	9,20	9,70	7,00	3,10	9,90	9,50	9,00	5,90	9,60	9,20	1,50	9,40	8,70	10,00	9,50	9,70	9,60	9,10	3,00	9,60	4,80	4,80	9,70	0,00

4.4 Saving Matrix

The Saving Matrix Method is used to determine distribution routes with a certain number of vehicles while considering the maximum capacity of each vehicle. If, during merging, the capacity exceeds the vehicle's capacity, a new route must be formed. This grouping process continues until all customers are allocated to routes without exceeding the vehicle's capacity.

Use Table 3 to see the distances between customers; an example of how to calculate the savings matrix is as follows.

S (1,2) = C (G,1) + C (G,2) – C (1,2)
= 3.80 km + 1.70 km – 3.90 km
= 1.60 km

The customer distance matrix in kilometers for PT. Sabina Tirta Utama Samarinda can be found in Table 4 as follows.

Table 4. Saving matrix

	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17	A18	A19	A20	A21	A22	A23	A24
A1	0,00	1,60	3,30	3,50	1,80	1,70	5,50	3,70	0,00	7,50	1,10	1,10	0,20	1,75	1,75	0,20	1,05	2,50	3,50	1,74	3,50	3,50	0,20	3,10
A2	3,20	0,00	2,20	2,50	0,20	3,15	3,10	2,50	1,60	3,10	0,50	0,40	1,80	0,25	0,25	1,70	0,45	3,15	2,40	0,24	2,40	2,50	1,80	2,00
A3	4,20	1,80	0,00	8,20	0,80	1,80	4,20	8,30	4,20	7,40	5,80	1,50	5,80	0,85	0,85	4,40	1,05	2,50	8,20	0,86	8,20	8,30	4,40	7,80
A4	5,70	3,10	8,60	0,00	0,40	3,20	5,70	11,40	3,80	8,90	14,70	1,10	5,50	0,45	0,45	4,00	0,65	4,00	17,79	0,46	12,80	12,90	4,00	16,80
A5	0,00	0,00	0,20	0,20	0,00	0,00	0,00	0,30	0,60	0,00	0,00	0,00	0,30	0,60	0,60	0,50	0,00	0,00	0,20	0,12	0,30	0,20	0,50	0,00
A6	3,20	3,15	2,30	2,50	0,20	0,00	3,10	2,60	1,60	3,10	0,50	0,40	1,80	0,25	0,15	1,70	0,45	3,20	2,50	0,24	2,50	2,50	1,80	2,10
A7	5,70	3,10	4,80	5,00	0,30	3,20	0,00	5,10	1,50	5,70	2,60	0,40	1,80	0,25	0,25	1,70	0,45	4,00	5,00	0,24	5,00	5,00	1,70	4,60
A8	4,90	2,30	7,70	11,30	0,40	2,40	4,80	0,00	3,00	8,10	8,90	0,20	4,60	0,45	0,45	3,10	0,15	3,20	11,30	0,44	11,30	11,30	3,10	10,90
A9	1,60	1,60	4,10	4,10	0,60	1,60	1,50	4,20	0,00	3,30	1,70	1,20	4,20	0,95	0,75	4,00	0,75	1,60	4,10	0,56	4,10	4,10	4,05	3,70
A10	7,10	3,10	8,40	8,60	0,20	3,20	7,00	8,70	3,60	0,00	6,20	0,90	5,20	0,05	0,25	3,80	0,45	4,00	8,60	0,26	8,60	8,70	3,80	8,20
A11	2,70	1,20	5,60	14,10	1,10	1,80	2,60	8,40	2,10	5,90	0,00	1,70	2,40	1,05	1,75	2,30	1,35	1,80	14,10	1,06	9,80	9,80	2,30	17,70
A12	0,60	0,60	0,60	0,10	0,30	0,60	0,60	0,60	0,40	0,60	0,60	0,00	0,60	0,35	0,35	0,60	0,59	0,60	0,60	0,34	0,50	0,60	0,60	0,60
A13	1,90	0,70	6,00	6,40	0,30	0,70	1,90	6,00	3,10	5,20	3,50	0,40	0,00	0,25	0,25	3,30	0,05	0,80	5,90	0,24	5,90	6,00	3,30	5,50
A14	0,05	0,05	0,55	0,55	0,60	0,05	0,05	0,65	0,95	0,05	0,05	0,00	0,55	0,00	0,70	0,75	0,00	0,05	0,55	0,11	0,55	0,55	0,85	0,15
A15	0,05	0,05	0,35	0,35	0,55	0,05	0,05	0,45	0,75	0,05	0,05	0,05	0,35	0,70	0,00	0,55	0,00	0,05	0,35	0,11	0,35	0,35	0,65	0,05
A16	2,50	2,50	3,40	3,40	1,50	2,50	2,40	3,50	3,80	2,60	1,70	2,15	3,40	1,45	1,45	0,00	1,75	2,50	3,40	1,46	3,40	3,40	5,04	3,00
A17	0,05	0,05	0,45	0,45	0,95	0,05	0,05	0,55	0,35	0,05	0,45	0,05	0,55	0,90	0,50	0,45	0,00	0,05	0,45	0,89	0,35	0,45	0,55	0,55
A18	4,00	3,15	3,10	3,30	0,20	3,20	3,90	3,40	1,60	3,90	0,90	0,40	1,80	0,25	0,15	1,70	0,45	0,00	3,30	0,24	3,30	3,30	1,80	2,90
A19	5,30	2,80	8,20	17,82	0,00	2,80	5,20	11,00	3,40	8,50	14,60	0,00	5,00	0,65	0,55	3,60	0,15	3,60	0,00	0,64	12,40	12,50	3,60	16,60
A20	0,06	0,04	0,04	0,04	0,12	0,06	0,04	0,06	0,16	0,04	0,04	0,01	0,06	0,11	0,11	0,04	2,29	1,76	6,96	0,00	0,04	0,04	0,04	0,06
A21	4,90	2,30	7,80	12,70	0,40	2,40	4,80	10,60	3,00	8,10	10,20	0,20	4,60	0,45	0,45	3,10	0,15	3,20	12,60	0,44	0,00	12,83	3,20	12,20
A22	4,90	2,30	7,80	12,60	0,40	2,40	4,80	10,60	3,00	8,10	10,20	0,30	4,60	0,35	0,35	3,10	0,15	3,20	12,60	0,34	12,83	0,00	3,10	2,60
A23	2,70	2,60	3,60	3,50	1,60	2,60	2,60	3,60	3,90	2,70	1,90	2,30	3,60	1,65	1,65	4,30	1,85	2,60	3,50	1,66	3,50	3,60	0,00	3,1
A24	4,70	2,10	7,60	16,10	0,50	2,20	4,60	10,40	2,80	7,90	17,80	1,20	4,40	0,55	1,25	2,90	0,75	3,00	16,00	0,56	11,70	11,80	3,00	0,00

4.5 Allocating Vehicle Routes with the Saving Matrix Method

Allocating customers into distribution routes with vehicle determination is a method to maximize distance savings. The criteria for determining routes based on the Saving Matrix method involve combining several routes such that the total delivery for those routes does not exceed the vehicle capacity of the company. The process of merging customers into a single route begins with the largest savings value, as the goal is to maximize these savings, making it the first destination. This is followed by the second largest distance, and so on, down to the smallest distance, while considering the vehicle capacity. The route allocation based on the Saving Matrix method can be seen in Table 5 as follows.

Table 5. Saving matrix

Vehicle	Route	Delivery Sequence	Demand (Box)	Total Distance (km)
1	1	A19 A4 A11	195	21,88
	2	A24 A10 A8 A13	195	31,70
2	3	A21 A3 A7	200	17,10
	4	A22 A1 A16	190	19,00
3	5	A23 A6 A2 A14	195	7,20
	6	A18 A9 A15 A12	195	8,16
4	7	A20 A17 A5	200	2,41

4.6 Sorting Customers with the Nearest Neighbour Method

Sorting customers in the distribution route for PT. Sabina Tirta Utama Samarinda using the Nearest Neighbour method starts from the initial depot point. Next, find the customer who is closest to the depot. Then, evaluate which customer is nearest to the previously visited customer to ensure that the obtained route is more optimal, with a shorter or maximal distance compared to the route obtained using the Saving Matrix method.

For example, sorting the customer route in the distribution using the Nearest Neighbour method on the first route obtained from the Saving Matrix method would be G → A19 → A4 → A11 → G, starting from the depot to the customer locations with the minimum distance.

Distance from G

G → A19	**8,90 km**	destination 1
G → A4	9,10 km	
G → A11	9,20 km	

After identifying the closest point from the depot (G), which is at customer A19, the next step is to find the customer location nearest to A19. This can be seen as follows.

Distance from A19

A19 → A4	**0,20 km**	destination 2
A19 → A11	3,50 km	

Thus, the closest point from customer A19 is customer A4. Next, the location nearest to customer A4 is identified, as shown below.

Distance from A4

A4 → A11	**3,60 km**	destination 3

From the point of customer A11, the return distance from the last customer, which is customer A11, back to the depot (G) is then calculated, as shown below.
Distance from A11
A11 → G **8,10 km** return

From the above calculation, the route that the vehicle will follow is G → A19 → A4 → A11 → G ith a total distance of 20.78 km. The following shows the results of route formation using the Nearest Neighbour method.

Here are the results of route formation using the Nearest Neighbour method.

Table 6. Route formation using the nearest neighbour method

No	Route Allocation	Vehicle	Total Load (Box)	Distance Traveled *Nearest Neighbour* (km)
1	G → A19 → A4 → A11 → G	1	195	20,78
2	G → A8 → A24 → A10 → A13 → G		195	29,80
3	G → A7 → A3 →A21 → G	2	200	16,20
4	G → A16 → A1 →A22 → G		190	20,00
5	G → A14 → A6 → A2 → A23 → G	3	195	6,10
6	G → A12 → A15 → A9 → A18 → G		195	8,40
7	G → A20 → A17 → A5 → G	4	200	1,85

4.7 Sorting Customers with the Insertion Method

Method is used to find the optimal distance for a distribution route by minimizing the distribution distance through inserting routes into the subtour of the distribution path.

Here is an example of sorting customer routes in a distribution using the Insertion Method on the first route, which is G → A19 → A4 → A11 → G starting from the depot to the customer locations with the minimum distance.

Select point G as the starting point or depot, then choose the customer with the closest distance by inserting each customer into the first route formed, as shown in Table 5:
A19 G → A19 → G 18,40 km
A4 G → A4 → G 17,80 km
A11 G → A11 → G **17,30 km**

After identifying the closest point from the depot (G), which is at customer A11, select the customer with the closest distance to both the depot (G) and customer A11. Customer A19 is found to have the minimum distance, so insert customer A19 as follows.
G → A11 → G
G → A11 (*Insertion* A19) **3,20 km**
A11 → G (*Insertion* A19) 5,40 km

Since the insertion of A19 between A11 → G as a shorter distance, the selected route is G → A19 → A11 → G ith a distance of 3.20 km. Next, insert customer A4 because it is the last customer not yet inserted.
G → A19 → A11 → G
G → A19 (*Insertion* A4) 0,41 km
A19 → A11 (*Insertion* A4) **0,28 km**
A11 → G (*Insertion* A4) 4,80 km

rom the above calculation, the route the vehicle will follow is G → A19 → A4 → A11 → G with a total distance of 20.78 km. The results of route formation using the Insertion Method are as follows.

Here are the results of route formation using the Insertion Method.

Table 7. Route formation using the insertion method

No	Route Allocation	Vehicle	Total Load (Box)	Distance Traveled *Insertion* (km)
1	G → A19 → A4 → A11 → G	1	195	20,78
2	G → A13 → A8 → A24 → A10 → G		195	21,20
3	G → A7 → A21 → A3 → G	2	200	15,20
4	G → A16 → A22 → A1 → G		190	17,30
5	G → A14 → A2 → A6 → A23 → G	3	195	6,10
6	G → A15 → A9 → A18 → A12 → G		195	7,81
7	G → A20 → A17 → A5 → G	4	200	1,85

4.8 Total Distribution Route Distance

Based on the data processing for creating distribution routes for PT Sabina Tirta Utama using the Saving Matrix, Nearest Neighbour, and Insertion methods, the resulting route savings are obtained. This can be seen in the following table.

Table 8. Comparison of distribution route distances

Route	Route Allocation	Distance Traveled (km)	Method
1	G → A19 → A4 → A11 → G	21,88	Saving Matrix
2	G → A24 → A10 → A8 → A13 → G	31,70	
3	G → A21 → A3 →A7 → G	17,10	
4	G → A22 → A1 → A16 → G	19,00	
5	G → A23 → A6 → A2 → A14 → G	7,20	
Route	Route Allocation	Distance Traveled (km)	Method
6	G → A18 → A9 → A15 → A12 → G	8,16	
7	G → A20 → A17 → A5 → G	2,51	
	Total Distance Traveled	**107,55**	
1	G → A19 → A4 → A11 → G	20,78	Nearest Neighbour
2	G → A8 → A24 → A10 → A13 → G	29,80	
3	G → A7 → A3 →A21 → G	16,20	
4	G → A16 → A1 →A22 → G	20,00	
5	G → A14 → A6 → A2 → A23 → G	6,10	
6	G → A12 → A15 → A9 → A18 → G	8,40	
7	G → A20 → A17 → A5 → G	1,85	
	Total Distance Traveled	**103,13**	
1	G → A19 → A4 → A11 → G	20,78	Insertion
2	G → A13 → A8 → A24 → A10 → G	21,20	
3	G → A7 → A21 → A3 → G	15,20	
4	G → A16 → A22 → A1 → G	17,30	
5	G → A14 → A2 → A6 → A23 → G	6,10	
6	G → A15 → A9 → A18 → A12 → G	7,81	
7	G → A20 → A17 → A5 → G	1,85	
	Total Distance Traveled	**90,24**	

From Table 8 above, it can be concluded that among the three methods—Saving Matrix, Nearest Neighbour, and Insertion—used for distributing packaged drinking water for Sabina, with the use of 4 Daihatsu Gran Max Pick-Up vehicles, the distance traveled can be minimized to 90.24 km using the Insertion method. The fuel used is gasoline, priced at IDR10.000 per liter. The ratio used in this study is for the Daihatsu Gran Max Pick-Up, which is

1:6, meaning 1 liter of gasoline covers 6 km, resulting in a fuel consumption of 15.04 liters. Therefore, the fuel cost incurred is:
Fuel cost
= 15,04 liters × IDR10,000/liter
= IDR150.400

Monthly fuel cost
= 5 weeks × IDR150.400
= IDR752,000

Based on the above calculations, the company can save on gasoline costs from IDR 979.417 to IDR752.000, resulting in a savings of IDR227.417 per month.

From the table above, it can be seen that the distance savings with customer sequencing using the Saving Matrix method is 106.45 km with 7 routes, compared to the initial company distance of 117.53 km with 10 routes. Thus, the company can determine an optimal distance saving in the distribution of PT Sabina Tirta Utama Samarinda of 11.08 km or 9% from the initial distance.

With customer sequencing using the Nearest Neighbour method, the distance is 103.13 km with 7 routes. Thus, the company can determine the optimal distance achievable in the distribution of PT Sabina Tirta Utama Samarinda as 14.40 km or 12% from the initial distance, saving 3.32 km or 3% compared to the Saving Matrix method.

For route determination based on the Insertion method, a total distance of 90.24 km is obtained. Therefore, the distance can be maximized by 27.29 km or 23% from the initial company distance. This method saves 16.21 km or 15% compared to the Saving Matrix method and 12.89 km or 12% compared to the Nearest Neighbour method.

Among the three methods, the most optimal total distance is 90.24 km using the Insertion method with 7 routes, as calculated above. The company distributes Sabina Bottled Drinking Water using 4 Daihatsu Gran Max Pick-Up trucks with a maximum vehicle capacity of 200 box.

5. CONCLUSION

The total distance calculated using the Vehicle Routing Problem method is 90.24 km, compared to the company's initial distribution distance of 117.53 km. Thus, the company can save 23% in distance by using the Insertion method. As a result, the company can reduce gasoline costs from IDR979,417 to IDR752,000, saving IDR 227,417

REFERENCE

Arfana Perdana, V., Fatimah Hunusalela, Z., & Teja Prasasty, A. (2021). Penerapan Metode Saving Matrix Dan Algoritma Nearest Neighbor Dalam Menentukan Rute Distribusi Untuk Meminimalkan Biaya Transportasi Pada PT. XYZ. *JATI UNIK : Jurnal Ilmiah Teknik Dan Manajemen Industri*, *4*(2), 91–105. https://doi.org/10.30737/jatiunik.v4i2.1000

Hanifah, Eka Wijayanti, D., Thobirin, A., & Wahyu Prasetyo, P. (2020). Menentukan Rute Kendaran Pengangkut Sampah Kota Yogyakarta dengan Algoritma Cheapest Insertion Heuristic Modifikasi Route Construction. *Jurnal Fourier*, *9*(2), 85–95. https://doi.org/10.14421/fourier.2020.92.85-95

Irvana Arofah, & Gesthantiara, N. N. (2021). Optimasi Biaya Distribusi Barang dengan Menggunakan Model Transportasi. *JMT : Jurnal Matematika Dan Terapan*, *3*(1), 1–9. https://doi.org/10.21009/jmt.3.1.1

Jatmiko, H., & Asriati, N. (2023). Perilaku Produsen Berbasis Sumber Daya Manusia dalam Dunia Industri. *Jurnal Alwatzikhoebillah : Kajian Islam, Pendidikan, Ekonomi, Humaniora*, *9*(2), 288–298. https://doi.org/10.37567/alwatzikhoebillah.v9i2.1714

Lukman, S. (2021). *Supply Chain Management* (Edisi 1). CV. Cahaya Bintang Cemerlang.

Natalin, J. N., Ardiansyah, M. N., Giri, P., & Kusuma, A. (2021). Perancangan Rute Distribusi Pengiriman Barang Menggunakan Model Mixed Integer

Linear Programming Untuk Meminimasi Biaya Transportasi Pada Pt Xyz Designing of Goods Delivery Distribution Routes Using Model Mixed Integer Linear Programming To Minimize Trans. *E-Proceeding of Engineering*, *8*(5), 8032–8045.

Ningrum, N. K., & Alfiatunningsih, I. (2023). Supply Chain Management UMKM Tape Singkong di Kota. *NBER Working Papers*, *4*(2), 204–217. http://www.nber.org/papers/w16019

Novianti, Kamila, A. N., Febrianti, S., & Fauzi, M. (2021). Penerapan Metode Saving Matrix Sebagai Program Pengurangan Biaya Distribusi Di Perusahaan Kosmestik. *Jurnal Ilmiah Teknik Dan Manajemen Industri*, *1*(01), 23–34. https://taguchi.lppmbinabangsa.id/index.php/home

Pujawan, I., N., & Mahendrawathi. 2017, Supply Chain Management, Edisi Ketiga, Yogyakarta: Andi Offset.

Rani, R., & Fitri, J. (2019). Analisis Perencanaan dan Pendistribusian Solar dalam Meminimalkan Biaya Transportasi Pada PT. Remata Jaya Abadi Medan. *Jurnal Bisnis Corporate*, *4*(2), 122–138. http://www.nber.org/papers/w16019

Suryani, Kartika Rahayu Kuncoro, D., & Dianati Fathimahhayati, L. (2018). Perbandingan Penerapan Metode Nearest Neighbour dan Insertion untuk Penentuan Rute Distribusi Optimal Produk Roti pada UKM Hasan Bakery Samarinda. *Profisiensi*, *6*(1), 41–49.

Sutrisno, Arifin, J., & Pramudya, A. (2023). Business Process Improvement Rute Distribusi Menggunakan VRP dengan Pendekatan Strategi Cluster First Route Second (Studi kasus CV Bintang Globalindo Karawang). *Jurnal Serambi Engineering*, *8*(2), 5543–5552.

Winarno, H., & Arifin, S. (2019). Penentuan Rute Distribusi Produk Yang Optimal Dengan Menggunakan Clarkle and Wright Saving Heuristik. *Journal Industrial Manufacturing*, *4*(1), 13–26. https://doi.org/10.31000/jim.v4i1.1240