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Optimization of Distribution Routes for Srikandi MSMES in Samarinda Using VRP Method: A Comparative Study of CWS and CFRS

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ABSTRACT

This research aims to optimize the distribution route of snack products for UMKM Srikandi Samarinda using the Vehicle Routing Problem (VRP) approach. The main issues are high travel distances, fuel costs, and delivery times due to the absence of route optimization. Two VRP solution methods are compared: Clarke and Wright Savings (CWS) and Cluster First Route Second (CFRS). The CWS method reduces travel distance by combining routes based on the highest distance savings between customer points, maximizing vehicle capacity. The CFRS method groups customer points into clusters using the Sweep algorithm based on proximity to the depot and determines the visit sequence within each cluster using the Nearest Neighbor method. Results show CFRS achieves better distribution efficiency. On the first route, CFRS traveled 94.1 km using 7 liters of fuel (Rp88,550), while CWS traveled 113.7 km using 9 liters (Rp113,850). On the second route, both methods covered about 75 km with similar fuel costs (Rp75,900), but CFRS was more consistent in savings, with the highest efficiency at 63.28%. With a total fuel cost saving of Rp140,939 compared to the initial condition, CFRS is recommended as the optimal solution, capable of reducing distance, operational costs, and improving delivery effectiveness.

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1. Introduction

Optimal distribution requires structured, efficient routes to avoid wasting time and fuel. Good routes prevent unnecessary or repetitive paths and maximize vehicle capacity to carry products per market demand. This reduces delivery frequency, lowers costs, and improves logistics efficiency. Optimization methods like the Vehicle Routing Problem (VRP) are vital in modern distribution, helping SMEs plan cost- and time-efficient routes, improve delivery accuracy, and enhance labor and vehicle use. With optimal distribution, MSMEs can increase delivery frequency without much cost increase, respond faster to demand, and schedule more flexibly to customer needs.

Efficient distribution routes directly impact customer satisfaction by ensuring timely delivery and consistent service, which strengthen SMEs' reputations. This efficiency enables market expansion as SMEs can reach wider areas without significantly increasing distribution costs. Thus, optimal routes and cost efficiency are key strategies for competitiveness and sustainability. UMKM Srikandi

Samarinda is a fast-growing local business in East Kalimantan, known for its quality banana chips with high demand in Samarinda, Tenggarong, Balikpapan, and Penajam Paser Utara (PPU). Distribution uses Gran Max vehicles with a capacity of up to 4000 pieces per shipment.

The monthly fuel cost for the vehicle is around Rp3,000,000 and can increase if the route is inefficient. In the Samarinda area, deliveries are made from 10 AM to 5 or 6 PM with a daily fuel consumption of around Rp150,000. Meanwhile, for out-of-town deliveries such as to Tenggarong, Balikpapan, and PPU, they start at 6 AM and finish between 9–11 PM, with fuel costs around Rp300,000 per day. Although customers are not charged for shipping, the irregular routes cause vehicles to frequently travel the same paths, extending travel time and increasing operational costs.

The main problem for Srikandi MSMEs is sub optimal distribution routes, causing drivers to retrace paths or take detours, which increases fuel consumption, travel time, and working hours. This reduces delivery efficiency and raises overall costs, risking the SMEs' competitiveness in a growing market. Two VRP methods are compared: Clarke and Wright Savings (CWS) and Cluster First Route Second (CFRS). CWS is a heuristic that calculates savings from merging routes based on distance and time reductions while considering vehicle capacity.

CFRS separates clustering and routing by first grouping customers with the Sweep algorithm based on their angle from the depot, then ordering deliveries within clusters using the Nearest Neighbor method. This method is effective in dispersed areas by focusing on nearby clusters first. CWS excels in route efficiency and fuel savings, while CFRS offers flexibility in large, unevenly distributed regions. This study, titled "Optimization of Distribution Routes for Srikandi Samarinda SMEs Using the Vehicle Routing Problem (VRP) Method: A Comparative Study of Clarke and Wright Savings (CWS) and Cluster First Route Second (CFRS)," aims to provide solutions for optimal routes, cost reduction, shorter travel times, and improved customer satisfaction and competitiveness.

2. Literature Review

Distribution is the activity of delivering products from producers to consumers, facilitating delivery and transferring ownership. This activity creates added value in the form of utility, place, and time, and forms the flow of distribution channels in the marketing process. (Rachmat et al., 2023).

Roads as transportation infrastructure must be in ideal condition to ensure the comfort, smoothness, and safety of users. The highway is a transportation route on the Earth's surface with varying shapes and constructions according to soil conditions, used by people and vehicles for fast and easy mobility. In accordance with the Republic of Indonesia Law Number 38 of 2004 concerning roads, the classification of roads based on their roles and functions is as follows:

Table 1. Road classification

Function Road	Street Class	Main Function	Maximum Axis Length	Example Usage
Artery	I	Main route connecting major cities	≤ 10 tons	Toll road, main national road.
	II	Main intercity connecting route	≤ 8 tons	Major provincial roads, connecting cities/regencies.
Collector	IIIA	Connector between areas within a city	≤ 8 tons	Road connecting the city with the village or subdistrict.
	IIIB	Connector between local areas and small regions	≤ 6 tons	Collector road to industrial or local distribution areas.
Local	IIIC	Access to settlements or small areas	≤ 5 tons	Roads in residential areas or remote rural areas.

Source: Republic of Indonesia Law Number 38 of 2004 concerning roads

Supply Chain Management is a conceptual approach that encompasses the entire material management process, providing orientation to the process of supplying, producing, and distributing products to consumers. (Yusuf & Soedianto, 2022).

Vehicle Routing Problem (VRP) is one of the problems in the applied field in the real world. The issue discussed concerns customer preferences, where each customer has a known level of demand. Customers want goods or documents to be shipped from node 0, called the depot, to another depot (Ary, 2022).

Saving Matrix is one of the methods that can be used in route optimization to improve distribution efficiency. This method works by combining several delivery destinations into one vehicle, thereby reducing the number of trips required and optimizing fleet usage (Andriyanto & Falevi, 2024).

$$S\ (X, Y) = (G, X) + (G, Y) – (X, Y)$$

Explanation:
S (X, Y) = The savings value from the pair of node X to node Y,
(G, X) = The distance from the warehouse to node X,
(G, Y) = The distance from the warehouse to node Y, and
(X, Y) = The distance between node X and node Y.

VRP can be solved using a heuristic approach. The solutions obtained from the heuristic method are of quite good quality with a short computation time. One of them is the Clarke and Wright Savings (CWS) method, often referred to as the Saving Matrix method. (Sinaga et al., 2022).

The Clarke and Wright Saving Heuristic method was discovered by Clarke and Wright in 1964 and is known as the savings method. This is a route exchange procedure to achieve better results. The advantage lies in the ease of modifying delivery constraints, capacity, and the number of vehicles. (Engraini et al., 2020).

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

Explanation:
S_{ij} = Distance savings.

d_{0i}= The distance from the warehouse to consumer i

d_{0j}= Distance from the warehouse to the consumer j.

d_{ij} = The distance between consumer i and j.

The Cluster First, Route Second method in the Sweep algorithm divides VRP optimization into two stages: clustering delivery points by polar angle relative to the depot considering vehicle capacity, then determining routes within each cluster. Data collected includes customer addresses, demand, vehicle number and capacity, polar coordinates, and travel distance, using Google Maps and GeoGebra. The process starts with determining depot and customer coordinates, then forming routes with Sweep and Nearest Neighbor algorithms—Sweep clusters points, Nearest Neighbor selects the nearest points sequentially to minimize distance, time, and costs (Ruben & Imran, 2020).

The Sweep algorithm is a simple, fast clustering method for VRP, chosen here for its ability to solve complex problems efficiently. It follows the Cluster First, Route Second principle by grouping delivery points by location before routing within clusters (Rahmadini et al., 2023).

The Nearest Neighbor method adds the closest customer to the route; if no feasible position exists due to capacity or time windows, a new route is created similarly. Distances from warehouse to stores and between stores are arranged in a distance matrix for processing, created with Google Maps (Wulandari, 2020).

3. Methodology

Data obtained from interviews with the owner of UMKM Srikandi Samarinda includes the company profile, address and customer demand, number and capacity of vehicles, as well as travel distance from Google Maps and GeoGebra. Distribution is carried out using 1 Gran Max car with a 1298 cc engine, a carrying capacity of 4000 pcs (200 kg), and a 43-liter tank with an efficiency of 13.5 km/liter. The luggage volume of 5.69 m³ theoretically accommodates 47 boxes, but the optimal arrangement only allows for 32 boxes, with a space efficiency of 85%–100%.

The distribution cost is calculated based on Pertamax consumption of Rp12,650/liter. The first distribution (131.4 km) cost Rp123,085, and the second (220.55 km) Rp206,701. This data was processed using the CWS and CFRS methods to determine the most efficient route. As a result, UMKM Srikandi Samarinda obtained an optimal route and reduced operational costs.

4. Results and Discussion

A comparison was made between the Clarke and Wright Savings (CWS) method and the Cluster First Route Second (CFRS) method in the application of the Vehicle Routing Problem (VRP) to determine the optimal distribution route. The analysis includes total distance (km), travel time (hours), operational costs (Rp), cost savings (%), reduction in travel time (%), and increase in delivery frequency.

Determining the optimal distribution route using the Clarke and Wright Savings (CWS) method and the Cluster First Route Second (CFRS) method aims to minimize the travel distance and fuel costs for Srikandi Samarinda's MSME vehicles. Here is the proposed route table for each method.

Table 2. Proposed distribution rote

Indicator	Distribution			
	Clarke and Wright Savings		Cluster First Route Second	
	Rute I	Rute II	Rute I	Rute II
Total route distance (km)	113,7	80,05	94,1	75,35
Total Pertalite requirements (liter)	9	6	7	6
Pertalite Fuel Cost (Thousands Rp)	113.850	75.900	88.550	75.900
Percentage cost savings (%)	7,5%	63,28%	28,1%	63,28%

Maps are also useful in grouping distribution areas, such as in the Cluster First Route Second (CFRS) method, as well as in efficiently merging routes, such as in the Clarke and Wright Savings (CWS) method. Route visualization through maps facilitates evaluation and adjustments if necessary, and supports decision-making in choosing the fastest, shortest, or most cost-effective routes.The map display for the first and second distribution of UMKM Keripik Pisang Srikandi is shown in the image below, which illustrates the distribution nodes that have been organized into an efficient route.

Based on the distribution data for the first (I) and second (II) routes, the Cluster First Route Second (CFRS) method demonstrates greater efficiency than the Clarke and Wright Savings (CWS) method in terms of travel distance and fuel consumption. In the first route, CFRS has a shorter distance (94.1 km) compared to CWS (113.7 km). Fuel consumption is also lower, at 7 liters versus 9 liters, with more economical fuel costs (Rp 88,550 thousand versus Rp 113,850 thousand). The fuel cost savings with CFRS reach 28.1%, higher than CWS's 7.5%. On the second route, both methods show relatively balanced results: CFRS covers 75.35 km, slightly shorter than CWS's 80.05 km. Both require 6 liters of fuel, with identical costs of Rp 75,900,000 and equal cost savings of 63.28%. These results indicate that CFRS is more efficient in optimizing distribution routes, especially for the first

route, offering shorter distances and lower fuel consumption than CWS. This suggests that the CFRS method is more effective in reducing operational costs and enhancing distribution efficiency.

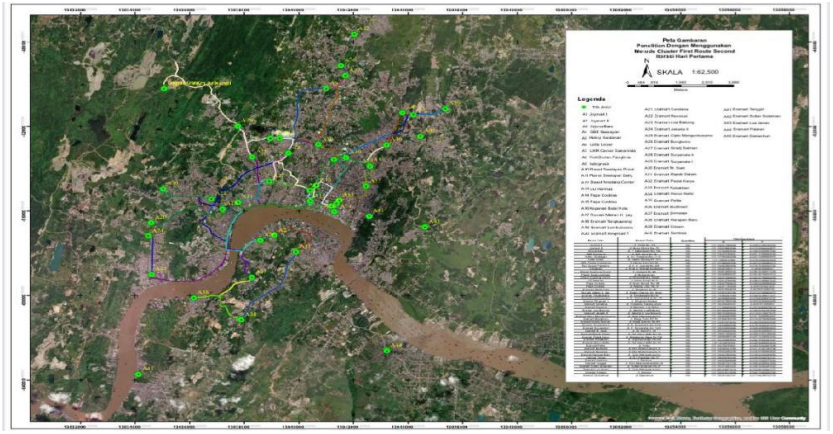

Figure 1. First distribution map

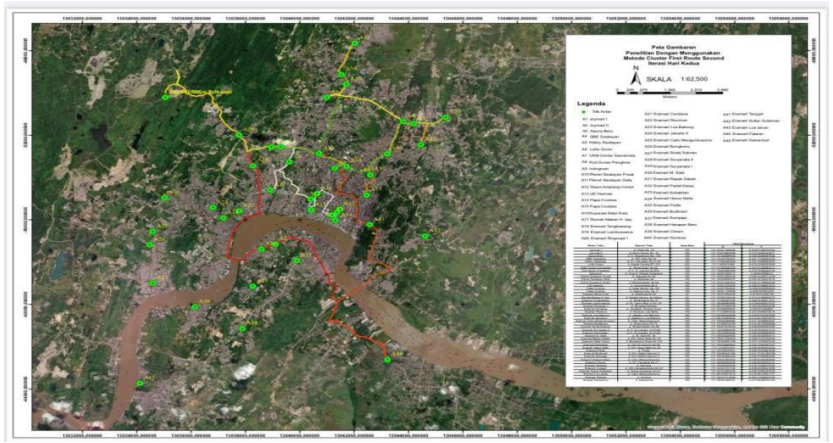

Figure 2. Second distribution map

5. Conclusion

Based on the analysis results, the Cluster First Route Second method provides the best efficiency in operational costs and fuel consumption compared to the Clarke and Wright Savings, with a total distance of 94.1 km (I) and 75.35 km (II), fuel consumption of 7 liters (I) and 6 liters (II), and fuel costs of Rp 88,550 thousand (I) and Rp 75,900 thousand (II), making it the most optimal method for the distribution of Srikandi Samarinda's MSME products.

The comparison of the implementation of both methods shows that Cluster First Route Second results in shorter travel distances and lower fuel costs compared to Clarke and Wright Savings, with cost savings efficiency of 28.1% (I) and 63.28% (II). Meanwhile, Clarke and Wright Savings (CWS) has a longer travel distance, namely 113.7 km (I) and 80.05 km (II), with higher fuel consumption.

The optimal route recommended for UMKM Srikandi Samarinda is by applying the Cluster First Route Second method, as it can optimize deliveries with greater cost savings and more efficient fuel usage, thereby supporting more effective and sustainable distribution. The optimal route arrangement is D - A28 - A29 - A27 - A8 - A15 - A12 - A16 - A14 - A3 - A13 - A11 - A41 - A42 - A31 - A26 - A2 - A25 - A38 - A34 - A21 - A18 - A22 - A30 - A20 - A24 - A23 - A43 - D for the first day's distribution, and then D - A17 - A6 - A7 - A1 - A33 - A35 - A40 - A5 - A39 - A45 - A4 - A9 - A37 - A36 - A32 - A19 - A10 - A44 - D for the second day's distribution.

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