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Food Distribution Models to Determine Distribution Routes, Distances, and Costs

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Abstract

The agricultural sector is vital to Indonesia's economy, requiring continuous development to address population growth and technological advancements for increased agricultural production. A persistent challenge lies in the uneven distribution of rice due to inefficiencies in current distribution systems, resulting in supply shortages in deficit areas. To address this, an efficient food distribution model is essential to ensure equitable allocation and delivery. This study develops a distribution model using the Saving Matrix and Nearest Neighbor methods to optimize rice distribution from commodity warehouses to nine storage points in Serang Regency. The proposed model focuses on minimizing costs by determining efficient routes, distances, and resource allocations. The results identify three optimal routes spanning a total distance of 294.5 km, utilizing three towing trucks with a capacity of 45 tons each. Implementation of the model reduces daily distribution costs to IDR. 1,934,866, compared to the previous IDR. 2,785,000, achieving a cost saving of IDR. 940,134 per day. This substantial efficiency improvement demonstrates the model's potential to address distribution challenges and support equitable rice allocation. By ensuring cost-effective and optimal transportation, the proposed model provides a practical solution to enhance food distribution systems in Indonesia, addressing key issues in agricultural logistics.

Keywords: Rice Distribution, Saving Matrix & Nearest Neighbor Method, Agricultural Logistics Efficiency

I. INTRODUCTION

The agricultural sector holds a critical role in driving Indonesia's economic development, contributing significantly to the nation's GDP and serving as the backbone of livelihoods for a large portion of its population. As the population grows, the demand for food rises, necessitating continuous development in agriculture to increase production and productivity. Technological advancements must be integrated into this sector to address the challenges of limited arable land, climate change, and resource constraints. Beyond its economic contributions, agriculture is central to national welfare as it directly influences food security, poverty alleviation, and rural development. It serves as a benchmark for a nation's prosperity, particularly in meeting its population's food consumption needs. Among agricultural commodities, food crops are particularly significant, not only because they are essential to the diet of Indonesians but also because they align with the government's objectives of achieving food self-sufficiency [1], [2]. Thus, food crops occupy a strategic position in the nation's development agenda.

Achieving sustainable food security is a multidimensional task that involves ensuring the adequacy, stability, and safety of food supplies. Adequacy involves producing sufficient quantities of food to meet the population's needs, while stability ensures a consistent supply of food despite seasonal and economic fluctuations. Safety and quality, on the other hand, guarantee that food is both nutritious and fit for consumption. However, even if food production is adequate, issues often arise in the distribution system, where inefficiencies can lead to shortages in certain regions [3], [4]. This imbalance between surplus and deficit areas underscores the importance of developing robust distribution networks. Effective food distribution not only ensures that all regions have access to food but also reduces post-harvest losses and ensures affordability. Key factors that influence food distribution include the number and capacity of transportation fleets, the distance between supply and demand points, and the costs associated with these logistics.

Despite efforts to improve distribution networks, significant challenges persist in ensuring that all regions, especially remote and underdeveloped areas, receive adequate food supplies. For instance, rice, as Indonesia's staple food, requires a highly efficient distribution system to meet its widespread demand [5], [6]. However, the current distribution processes are often fragmented and lack systematic planning, resulting in inefficiencies and inequities. Some regions experience oversupply, leading to waste, while others face deficits that compromise food security. In the case of Serang Regency, these inefficiencies highlight the need for a structured distribution model that optimizes the movement of rice from commodity warehouses to nine strategically located warehouses. Such a model must not only address logistical challenges but also align with broader objectives of regional equity and cost efficiency. Developing this model involves understanding regional demand patterns, transportation infrastructure, and operational costs to create an effective and sustainable distribution network.

To address these issues, employing advanced logistical methodologies such as the Saving Matrix and Nearest Neighbor methods offers promising solutions. The Saving Matrix approach minimizes transportation costs by identifying the most efficient routes for delivery and determining the optimal use of available transportation fleets. By calculating the savings achieved through route optimization, this method ensures that the distribution process operates with maximum cost-effectiveness [7], [8], [9]. On the other hand, the Nearest Neighbor method simplifies route planning by prioritizing the closest delivery point to the last visited location, reducing travel distance and improving time efficiency. Combining these two methods allows for a comprehensive approach to distribution, addressing both cost and time constraints. Additionally, the integration of technology, such as geographic information systems (GIS), further enhances the precision and reliability of these models, ensuring that distribution aligns with demand patterns and logistical capacities.

The successful implementation of such a food distribution model requires the active involvement of government agencies and regional business entities. Their role extends beyond policymaking to include the provision of infrastructure, such as storage facilities, transportation fleets, and digital systems for monitoring and management. In the context of rice distribution, government support in building and maintaining commodity warehouses and transportation networks is crucial for ensuring smooth operations. Similarly, partnerships with local business entities can enhance the efficiency of the supply chain, creating a collaborative framework that benefits both producers and consumers. By addressing these logistical challenges through systematic planning and innovative methods, Indonesia can build a resilient food distribution system that not only reduces costs but also promotes equitable access to food resources, contributing to national food security and economic stability.

II. METHOD

This study adopts a quantitative research approach, a method that emphasizes the systematic collection and analysis of numerical data to identify patterns, test hypotheses, and derive well-founded conclusions. Quantitative methods are particularly advantageous for examining measurable phenomena and providing objective, replicable insights supported by statistical evaluations. The reliance on numerical data ensures a high degree of precision and reliability, making this approach ideal for addressing operational challenges in structured systems such as logistics and distribution. In this study, the methodology is applied to evaluate and enhance the rice distribution processes undertaken by Regionally Owned Enterprises (BUMD) in Banten Province. Specifically, the research focuses on the operational activities in Serang Regency during 2023, a period marked by increasing attention to food supply chain efficiency and regional food security. By using a quantitative lens, this research aims to present evidence-based recommendations for improving the distribution performance of BUMD and similar organizations.

The research was carried out over a three-month period, from January to March 2024, with a structured data collection process designed to ensure the accuracy and relevance of the information gathered. The data collection techniques included structured interviews and direct field observations, each tailored to capture different dimensions of the distribution process. The interviews were conducted with key employees of BUMD, such as logistics managers, operational staff, and decision-makers, to obtain detailed insights into the organization’s current practices, logistical strategies, and challenges in rice distribution. These interviews provided qualitative depth that complemented the numerical data collected. In addition, direct observations were performed to document real-time distribution activities, such as route planning, loading and unloading processes, and delivery timelines. This observational method allowed the researchers to identify inefficiencies and practical bottlenecks that might not have been apparent through interviews alone.

To ensure a robust analysis, the data collected during the research phase were processed using two well-established methods: the saving matrix and the nearest neighbor techniques. The saving matrix method is a widely used optimization tool in logistics management that reduces transportation costs by consolidating delivery routes. This method calculates potential savings in distance and time by comparing alternative routes and identifying combinations that minimize redundancy and overlap. Meanwhile, the nearest neighbor method was employed to determine the most efficient sequence of distribution points by selecting the closest location at each step of the delivery route. This approach is particularly useful for addressing the classic "traveling salesman problem" in logistics, ensuring that distances traveled are minimized while maintaining timely deliveries. By integrating these analytical techniques, this study provides a comprehensive framework for evaluating and optimizing the operational efficiency of the rice distribution process in Serang Regency.

The significance of this research extends beyond the immediate context of BUMD in Banten Province. Efficient rice distribution is a critical factor in maintaining regional food security, especially in areas with high population density and significant demand for staple foods. This study seeks to contribute to the broader discourse on supply chain management by presenting practical applications of optimization techniques in a real-world setting. The findings are expected to offer actionable recommendations for improving not only the sustainability and effectiveness of BUMD’s operations but also the broader efficiency of regional food distribution systems.

Moreover, by combining theoretical insights with empirical data, this research provides a valuable case study that can inform future efforts to address logistical challenges in the agricultural sector, thereby enhancing overall welfare and resilience within local communities as in the following research flowchart:

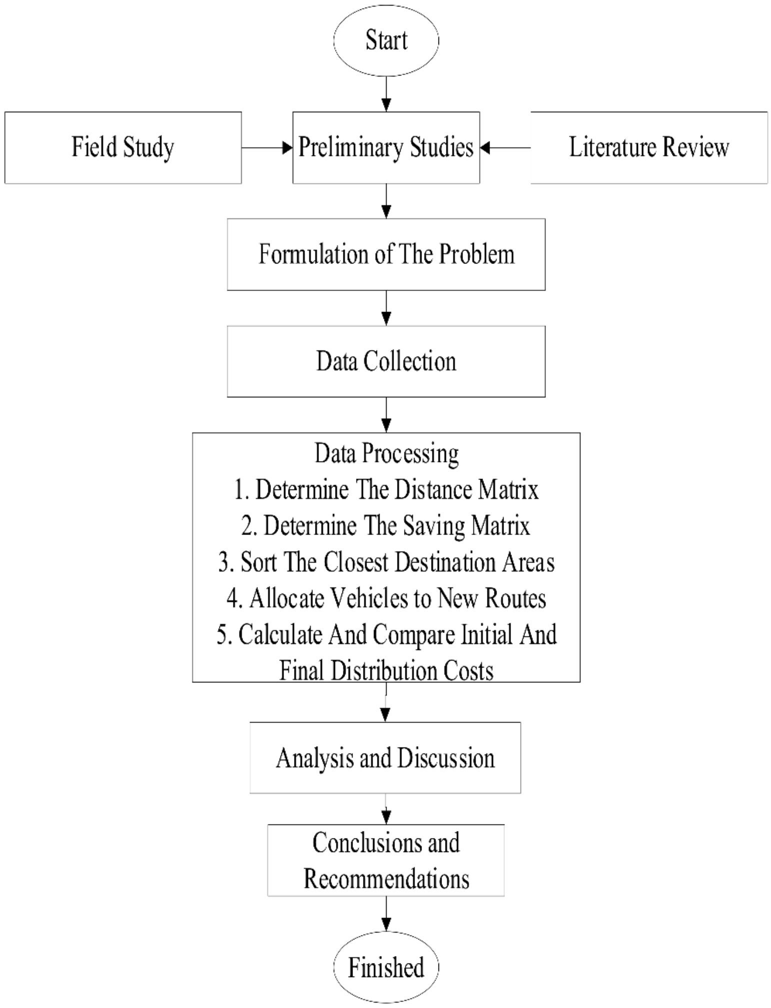

Figure 1 Research Flowchart

Figure 1 shows that this study begins with preliminary research, which consists of both field studies and literature reviews. The field studies involve direct observations and site visits to understand the rice distribution process, while the literature review examines existing research and theoretical frameworks related to distribution logistics and optimization methods. Following the preliminary phase, the problem formulation is set up, with the primary aim being to figure out an efficient and effective distribution route for rice. This step is crucial in addressing logistical challenges, ensuring that the distribution process minimizes time, cost, and resource consumption. Data collection is then carried out to gather both primary and secondary data. Primary data is collected through direct observations and interviews with key personnel involved in the distribution process, providing insights into real-world practices and challenges. Secondary data is obtained by reviewing company records, reports, and other relevant documents that provide context and historical data on the distribution operations. The next step involves data processing, where two methods are applied: the saving matrix and nearest neighbor techniques. These methods are used to analyze the collected data and propose the most effective distribution route that refines the logistics process. Finally, an analysis and discussion of the data processing results are conducted. This phase focuses on evaluating the proposed distribution routes, considering factors such as vehicle carrying ability, travel distances, and time efficiency to decide the most optimal solution for rice distribution. Through this systematic approach, the study aims to provide actionable recommendations for improving distribution efficiency.Data collection is carried out in the form of data related to research such as shipping destination data, and the amount of rice demand.

Table 1 Rice Demand Data

No	Shipping Destination Warehouse	Demand (Ton)
1	Warehouse 1	17
2	Warehouse 2	13
3	Warehouse 3	12
4	Warehouse 4	15
5	Warehouse 5	15
6	Warehouse 6	16
7	Warehouse 7	9
8	Warehouse 8	15
9	Warehouse 9	9

After data collection is complete, the next step that will be carried out is the processing of data that has been obtained. Data processing is carried out based on *the Saving Matrix* and *Nearest Neighbor methods*. First, the identification savings matrix; the first step in data processing is to identify the matrix. Savings based on the formula: S(x,y) = J(P,x)+J(P,Y)-J(x,y) -- J refer to Distance; P means Warehouse or Factory; x & y refers to Purpose area x and destination area y; S(x,y) means Matrix distance saving. Indeed, the distance data used for this calculation is derived from the manufacturer's distance to the delivery destination areas. This step is crucial for identifying potential savings in transportation routes by evaluating the combined distances between different points in the distribution network. Following the identification of the Savings Matrix, the next task is to allocate cities to routes based on the calculated savings. This step involves selecting the pair of destinations that offer the highest savings and combining them, with the aim of minimizing overall travel distances. The allocation process continues by focusing on the highest savings values, optimizing the route planning for efficiency. The data used in this stage is the distance savings calculated through the previous Savings Matrix step.

Once the cities have been allocated to routes, the next phase involves determining the final distribution route by applying the Nearest Neighbor method. This sequencing technique is designed to minimize the total distance traveled by the distribution vehicles. The goal of this method is to ensure that each stop is made in the most efficient order, reducing travel time and fuel consumption. The final sequence of routes is the one that offers the shortest overall distance while still fulfilling all delivery requirements. After determining the optimal sequence of delivery routes, the next step is to allocate the appropriate number of vehicles to these routes. The allocation is based on the amount of goods required to be transported along each route, considering the vehicle's capacity. This step ensures that the vehicles used for distribution are appropriately matched to the demand on each route, preventing underutilization or overloading. Finally, the distribution costs are calculated based on the results from the Savings Matrix and Nearest Neighbor methods. This includes both the initial and final distribution costs, taking into account factors such as transportation distances and vehicle utilization. A comparison is then made between the various routes to identify the one that offers the lowest overall distribution cost. This step is crucial for ensuring cost-efficiency in the distribution process, allowing for the selection of the most economical route that meets all operational requirements.

III. Results and Discussion

The primary vehicle used for rice distribution in Serang Regency is the Trenton Truck, which has a largest load capacity of 45 tons (45,000 kg). This vehicle is specifically chosen for its ability to transport large volumes of rice, ensuring that the distribution process can meet the demand across the region efficiently. Given the significant quantities of rice that need to be moved, Trenton Truck's robust carrying capacity is crucial for maintaining a consistent supply to various warehouses. The choice of this vehicle, however, is not only based on its load capacity but also on its suitability for the distances involved in the transportation network within the region.

The identification of the Savings Matrix, as presented in Table 1, plays a vital role in enhancing the overall logistical operation by providing a framework for refining transportation routes. The matrix presents data on the distances between commodity warehouses and shipping destination warehouses, which is essential for planning and executing an efficient distribution strategy. By analyzing these distances, it becomes possible to name the most cost-effective routes that minimize travel time and fuel consumption, thereby reducing overall transportation costs. For example, shorter distances between warehouses result in reduced travel times, which directly impacts fuel usage and vehicle wear and tears. The savings generated from these optimizations can be large, contributing to more sustainable and cost-effective rice distribution.

This Savings Matrix is not only important for route optimization but also crucial for improving the efficiency of the entire supply chain. By integrating this matrix into logistical planning, the rice distribution system in Serang Regency can be fine-tuned to reduce operational costs, enhance the speed of delivery, and ensure that rice reaches its intended destinations promptly and in the best condition. The data provided in Table 1 serves as a valuable tool for making informed decisions on distribution strategies and for continually improving the efficiency of the transportation process.

Table 2 Data on the Distance of Commodity Warehouses with Shipping Destination Warehouses

No	Distance	Commodity Warehouse	1	2	3	4	5	6	7	8	9
1	Warehouse 1 (Ciomas)	27	0								
2	Warehouse 2 (Ciruas)	3,5	29	0							
3	Warehouse 3 (chicken)	22	48	19	0						
4	Warehouse 4 (Bojonegara)	28	39	29	47	0					
5	Warehouse 5 (Tunjung)	21	34	20	26	44	0				
6	Warehouse 6 (Cinangka)	52	26	54	72	46	58	0			
7	Warehouse 7 (Tanara)	26	52	23	28	40	39	76	0		
8	Warehouse 8 (Kramatwatu)	14	27	21	37	13	30	43	31	0	
9	Warehouse 9 (Mancak)	33	21	37	55	22	50	26	52	18	0

Table 2 presents data on the distances between various commodity warehouses and their corresponding shipping destination warehouses. The table is structured with each row representing a specific warehouse (labeled 1 to 9), and the columns indicating the distance from the respective commodity warehouses to all other destination warehouses. For example, Warehouse 1 (Ciomas) is located 27 km from Warehouse 2 (Ciruas), while Warehouse 2 (Ciruas) is 29 km away from Warehouse 1, and so on. The distances range from as short as 3.5 km (between Warehouse 2 and Warehouse 1) to as long as 72 km (between Warehouse 6 and Warehouse 4). These distance metrics are crucial for optimizing distribution routes, reducing transportation costs, and improving efficiency by selecting the shortest or most cost-effective paths for shipment between these warehouses. The following is the example of determining the savings matrix from Warehouse (1) to Warehouse (2):

$$S(x,y) = J(P,x) + J(P,y) - J(x,y)$$
$$S(1,2) = 27 + 3,5 - 29$$
$$= 1.5 \text{ km}$$

Therefore, the saving matrix from Warehouse (1) to Warehouse (2) is 1.5 km. Based on the same formula, the distance saving matrix is obtained as follows:

Table 3 Distance Saving Matrix

No	Distance	Route	1	2	3	4	5	6	7	8	9
1	Warehouse 1 (Ciomas)	1	0								
2	Warehouse 2 (Ciruas)	2	1,5	0							
3	Warehouse 3 (chicken)	3	1	6,5	0						
4	Warehouse 4 (Bojonegara)	4	16	2,5	3	0					
5	Warehouse 5 (Tunjung)	5	14	4,5	17	18	0				
6	Warehouse 6 (Cinangka)	6	53	1,5	2	34	15	0			
7	Warehouse 7 (Tanara)	7	1	6,5	20	14	8	2	0		
8	Warehouse 8 (Kramatwatu)	8	14	-3,5	-1	29	5	23	9	0	
9	Warehouse 9 (Mancak)	9	39	-0,5	0	39	4	59	7	29	0
	Demand per day (ton)		**17**	**13**	**12**	**15**	**15**	**16**	**9**	**15**	**9**

Table 3 outlines the distances between commodity warehouses (1 to 9) and their corresponding shipping destination warehouses, alongside the daily demand in tons for each warehouse. The matrix provides key data for optimizing the transportation routes to minimize overall distribution costs. Each row corresponds to a warehouse, with the second column listing the warehouse's respective number, followed by the distances to other warehouses. For example, Warehouse 1 (Ciomas) is located 1 km from Warehouse 2 (Ciruas), while Warehouse 5 (Tunjung) is 14 km away from Warehouse 1. The negative values in the table, such as -3.5 km between Warehouse 8 (Kramatwatu) and Warehouse 2 (Ciruas), may represent data inconsistencies or errors, which need to be addressed to ensure accurate route planning.

Additionally, the table includes the daily demand in tons for each warehouse. For instance, Warehouse 1 (Ciomas) has a daily demand of 17 tons, and Warehouse 2 (Ciruas) has a daily demand of 13 tons. This information is essential for balancing the transportation load, ensuring that the distribution process aligns with the demand at each warehouse, and minimizing transportation inefficiencies. The Distance Saving Matrix is a critical tool for decision-making, helping to identify the most efficient and cost-effective routes for distribution by analyzing both distance and demand. Based on the distance saving matrix table above, the next step is to group delivery destinations based on the largest savings matrix.

Table 4 Grouping Shipping Destinations Based on the Largest Matrix

No	Distance	Route	1	2	3	4	5	6	7	8	9
1	Warehouse 1 (Ciomas)	1	0								
2	Warehouse 2 (Ciruas)	2	1,5	0							
3	Warehouse 3 (chicken)	3	1	6,5	0						
4	Warehouse 4 (Bojonegara)	4	16	2,5	3	0					
5	Warehouse 5 (Tunjung)	5	14	4,5	17	18	0				
6	Warehouse 6 (Cinangka)	6	53	1,5	2	34	15	0			
7	Warehouse 7 (Tanara)	7	1	6,5	20	14	8	2	0		
8	Warehouse 8 (Kramatwatu)	8	14	-3,5	-1	29	5	23	9	0	
9	Warehouse 9 (Mancak)	9	39	-0,5	0	39	4	59	7	29	0
	Demand per day (ton)		**17**	**13**	**12**	**15**	**15**	**16**	**9**	**15**	**9**

After getting the matrix value, the first step is to group the routes based on the largest matrix between the delivery destination locations and combine the number of goods to be sent until they reach the transport limit of the vehicle used. Table 3 it can be seen ending with 3 routes, namely in the group of route 1, route 2 and route 3. Route group 1: Warehouse 9, Warehouse 6 and Warehouse 1, Route group 2 : Warehouse 8, Warehouse 4 and Warehouse 5 Route group 3: Warehouse 7, Warehouse 3 and Warehouse 2.

The next step is to determine the order of visits using the *nearest neighbor* method. The *nearest neighbor* method is principally to choose a delivery destination which, if added to an existing route, will result in a minimum distance. Then the allocation of vehicles is carried out based on the number of requests and the carrying capacity of the vehicles used.

a. Route group 1 : commodity warehouse – Warehouse 1 (Ciomas) – Warehouse 9 (Mancak) – Warehouse 6 (Cinangka) – commodity Warehouse = 126 km
   Total goods shipped according to demand = 17 tons + 9 tons + 16 tons = 42 tons
   Based on these results, route group 1 uses 1 tronton truck type vehicle because the amount of goods sent is 45 tons.
   Estimated delivery time:
   Known:
   Distance = 126 km
   Speed = 25 km/h
   Time to get on/off goods in the warehouse = 60 minutes/1 hour
   W = J : K
   W = 126 km : 25 km/jam
   W = 5 hours 04 minutes
   Delivery Time = 5 hours 04 minutes + 1 hour (Estimated drop off) = 6 hours 04 minutes

b. Route group 2 : Commodity warehouse – Warehouse 8 – Warehouse 4 – Warehouse 5 – Commodity warehouse = 92 km
Total rice shipped according to request = 15 kg + 15 kg + 15 kg = 45 kg
Based on these results, route group 1 uses 1 tronton truck type vehicle because the amount of goods sent is 45 tons.
Estimated delivery time:
Known:
Distance = 92 km
Speed = 25 km/h
Time to get on/off goods in the warehouse = 60 minutes/1 hour
W = J : K
W = 92 km : 25 km/jam
W = 4 hours 08 minutes
Delivery Time = 4 hours 08 minutes + 1 hour (Estimated drop off) = 5 hours 08 minutes.

c. Route group 2 : Commodity warehouse – Warehouse 2 – Warehouse 3 – Warehouse 7 – Commodity warehouse = 76.5 km
Total rice shipped on request = 13 kg + 12 kg + 9 kg = 34 kg
Based on these results, route group 1 uses 1 tronton truck type vehicle because the number of goods sent is 34 tons.
Estimated delivery time:
Known:
Distance = 76.5 km
Speed = 25 km/h
Time to get on/off goods in the warehouse = 60 minutes/1 hour
W = J : K
W = 76,5 km : 25 km/jam
W = 3 hours 06 minutes
Delivery Time = 3 hours 06 minutes + 1 hour (Estimated drop off) = 4 hours 06 minutes.

The analysis of the three route groups reveals that delivery times are influenced primarily by the distance traveled, with longer routes naturally resulting in longer delivery times. Despite differences in distance and shipment weight, a single Trenton truck is sufficient for all routes, showing that the truck's capacity is well-matched to the shipment requirements, leading to cost-effective operations. The time spent on loading and unloading at each warehouse also contributes to the overall delivery time, and any delays in this process could further extend the total time. Route Group 3, with its shorter distance and lighter load, presents an opportunity for optimization, as the truck's unused capacity could be used more efficiently by combining shipments. Overall, the analysis highlights the importance of route planning and load optimization in enhancing logistics efficiency and reducing operational costs.

The next step is to determine the cost of distributing rice: Included distribution costs are:

a. Labor Cost : Driver : IDR. 200.000,-
b. Fuel Cost: Tronton truck fuel cost: 1 liter solar = 1,5 km; Price of diesel per liter : IDR. 6.800,-
Cost calculation:
Route group 1 $= \frac{126}{1{,}5 \text{ km/liter}} xRp.6.800 = Rp.571.000,-$
Route group 2 $= \frac{92}{1{,}5 \text{ km/liter}} xRp.6.800 = Rp.417.066,-$
Route group 3 $= \frac{76{,}5}{1{,}5\frac{\text{km}}{\text{liter}}} xRp.6.800 = Rp.346.800,-$

Table 5 Total Rice Distribution Cost

Route	Distance	Type of vehicle used	fuel needs	Power Cost	Total
1	126 km	Truck Tronton	IDR.571.000,-	IDR.200.000,-	IDR.771.000,-
2	92 km	Truck Tronton	IDR.417.066,-	IDR.200.000,-	IDR.617.066,-
3	76.5 km	Truck Tronton	IDR.346.800,-	IDR.200.000,-	IDR.546.800,-
Total					**IDR.1.934.866,-**
Total Vehicles Required					**3**

Table 5 explores that Route Group 1, with the longest distance of 126 km, incurs the highest distribution cost (IDR 771,000), primarily due to higher fuel consumption. Route Group 2 (92 km) has a lower fuel cost, resulting in a total distribution cost of IDR 617,066, while Route Group 3 (76.5 km), being the shortest route, incurs the lowest total cost of IDR 546,800. The total distribution cost of IDR 1,934,866 for all three routes reflects the combined expense of fuel and labor, emphasizing the impact of travel distance on operational costs. The fuel cost is directly proportional to the distance traveled, while the labor cost remains constant. Additionally, the use of one vehicle per route highlights the efficiency of vehicle allocation, with no excess vehicle usage, which helps in controlling operational costs. In short, this analysis reveals the relationship between distance, fuel consumption, and total distribution cost. Longer routes inherently lead to higher costs, while shorter routes are more cost-efficient, making route optimization an important factor in reducing overall distribution expenses. Further optimization could involve adjusting vehicle usage based on cargo volume or consolidating deliveries to reduce the number of trips required.

IV. CONCLUSION

This study proposes three optimized rice distribution routes for Serang Regency, developed using the Frugal Matrix and Nearest Neighbor methods, to enhance efficiency and reduce the costs of the distribution system. The identified routes are Route group 1, which connects Warehouse 9, Warehouse 6, and Warehouse 1; Route group 2, which links Warehouse 8, Warehouse 4, and Warehouse 5; and Route 3, connecting Warehouse 7, Warehouse 3, and Warehouse 2. These routes were carefully selected for their minimal total distance, amounting to 294.5 km. The corresponding distribution costs for the three routes are IDR 771,000 for Route group 1, IDR 617,066 for Route group 2, and IDR 546,800 for Route group 3, resulting in a total cost of IDR 1,934,866. This represents a significant savings of IDR 940,134 compared to the previous distribution routes. These findings indicate that the proposed routes not only shorten travel distances but also optimize fuel usage and distribution efficiency. Implementing these optimized routes will help BUMD Serang Regency achieve considerable cost savings while enhancing logistical operations. To further refine the system, it is recommended that BUMD Serang Regency test these routes through simulations, considering potential real-world challenges and obstacles. This would ensure the routes are fully adaptable to practical conditions, allowing for continuous improvements in the distribution process and maximizing operational efficiency in the future.

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