Optimization of Cold Chain Distribution Network in Fisheries Logistics Using Green Field Analysis and Network Optimization: A Case Study of PT. X

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Abstract

The fisheries logistics system requires efficient cold chain management to maintain product quality while minimizing distribution costs. PT. X in Indramayu faces operational challenges, including low utilization of cold storage capacity, long distribution distances to major markets, and high logistics costs. This study aims to provide recommendations for the most operationally and financially advantageous distribution center (DC) location and network configuration. The research employs approach combined with Green Field Analysis (GFA) and Network Optimization (NO) using the anyLogistix software, with historical data from 2025 used as model inputs. The simulation results indicate that selecting an appropriate DC configuration can improve distribution efficiency, reduce total logistics costs, and enhance customer service levels without increasing operational risk. The novelty of this study lies in the application of integrated simulation as a strategic decision support tool in the fisheries industry. The practical implication of this research is the provision of a more effective and sustainable logistics network planning framework for cold storage operators in managing supply and demand uncertainty.

Keywords: *Fisheries logistics; cold storage; distribution center; system simulation; green field analysis; network optimization;*

INTRODUCTION

The fisheries sector plays a significant role in supporting food security and economic development, particularly in maritime countries such as Indonesia. Fisheries commodities are categorized as highly perishable products that require consistent temperature control throughout the supply chain to maintain quality. Ineffective cold chain management may result in product deterioration, increased spoilage levels, and higher logistics costs. Therefore, improving distribution network design, particularly determining optimal distribution center (DC) locations, has become increasingly important in enhancing logistics efficiency and customer service performance (Rahman et al., 2019; Rushton et al., 2022).

PT. X operates a cold storage facility located in Indramayu that serves as a consolidation center for fishermen's catch before distribution to major markets, particularly Jakarta and surrounding areas. However, operational performance indicates that the current logistics network has not yet achieved optimal efficiency. Historical operational data in 2025 show fluctuating cold storage utilization levels ranging from approximately 15% to 51%, indicating underutilization of storage capacity. Additionally, centralized distribution activities originating from Indramayu result in long transportation distances, higher distribution costs, and potential service constraints caused by limited refrigerated fleet capacity. Previous research highlights the importance of optimizing distribution network design in improving cold chain logistics performance. Shashi et al. (2021) demonstrated that integrated cold chain optimization significantly improves product quality while reducing logistics costs. Singh and Kumar (2022) emphasized that supply chain network evaluation can improve decision-making effectiveness when addressing demand uncertainty. Li et al. (2023) also reported that facility location optimization contributes to strengthening supply chain resilience and improving operational efficiency. Furthermore,

Alkahtani et al. (2024) stated that logistics network optimization improves service reliability and reduces operational risks in temperature-controlled distribution systems. Although studies related to cold chain optimization continue to grow, limited research focuses specifically on the integration of facility location planning and network configuration in fisheries logistics systems, particularly in developing countries where supply variability and infrastructure constraints remain critical challenges. Previous studies have primarily applied Green Field Analysis and Network Optimization to manufacturing, agri-food, and petroleum supply chains, demonstrating their effectiveness in minimizing logistics costs and improving network efficiency (Iskandar et al., 2022; Bounadi et al., 2024; Moqbel et al., 2025). However, empirical applications of these methods in fisheries logistics remain scarce. This research addresses this gap by applying Green Field Analysis (GFA) and Network Optimization (NO) using anyLogistix software to evaluate logistics network performance and identify more efficient distribution configurations, in line with recent studies that highlight the capability of anyLogistix in supporting strategic supply chain design and network optimization under complex and uncertain conditions (Iskandar et al., 2023; Longo et al., 2024).

This study aims to evaluate the operational effectiveness of the existing cold chain logistics system at PT. X, determine the optimal distribution center location based on supply and demand distribution, design an efficient distribution network configuration, and compare the operational and financial feasibility between existing and alternative distribution network scenarios. The results of this study are expected to provide data-driven decision support for improving logistics network planning and distribution performance.

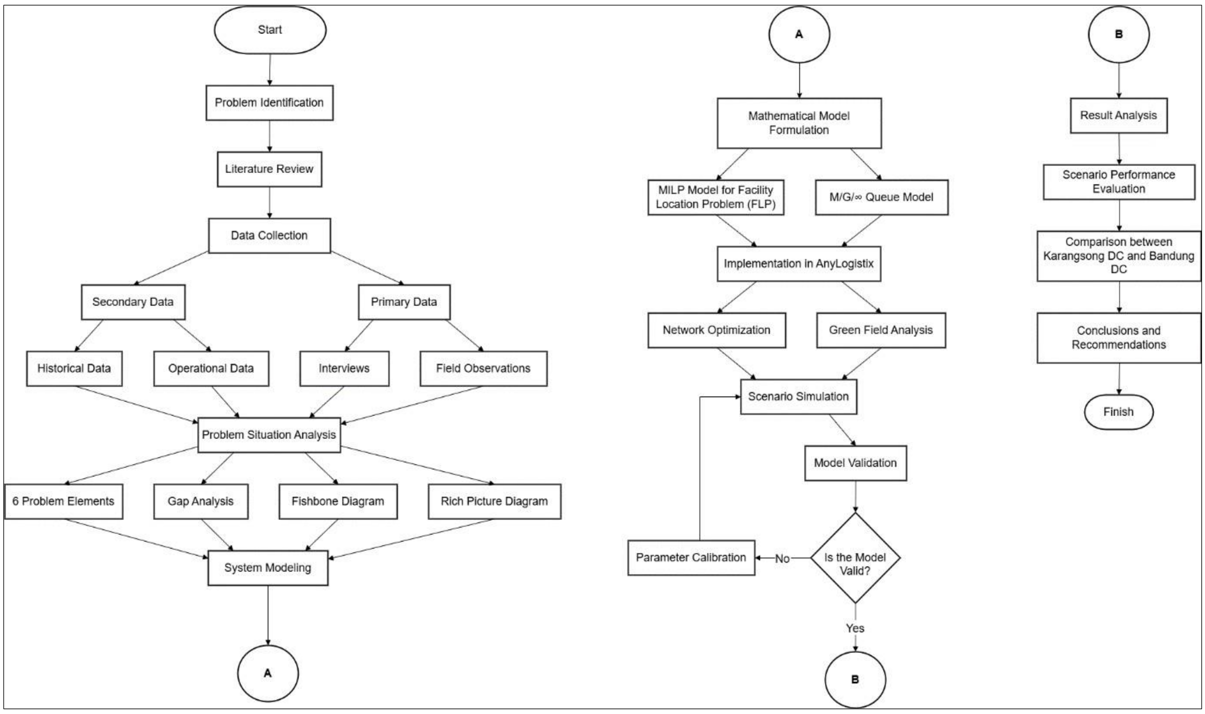
The originality of this study lies in the application of integrated facility location analysis and logistics network optimization specifically in fisheries cold chain operations. Unlike conventional distribution planning approaches, this research incorporates demand variability, supply uncertainty, and transportation capacity limitations in evaluating network configuration strategies. This study contributes to supply chain management literature while providing practical recommendations for cold storage operators to improve operational efficiency and sustainability in fisheries logistics systems.

RESEARCH METHODS

This study adopts a quantitative research approach using logistics network modeling and optimization to analyze the marine product distribution system of PT. X. The research is conducted as a case study in order to examine an actual operational logistics network and to generate results that are directly applicable to managerial decision-making. The quantitative approach enables objective evaluation of system performance based on measurable indicators, including total logistics cost, facility utilization, and network profitability. The analytical framework is designed to ensure replicability by clearly defining the scope of analysis, data inputs, and optimization procedures.

The population of this study encompasses the entire logistics system of PT. X related to marine product handling, covering inbound supply from fishermen, cold storage operations, and outbound distribution to customers. The object of the study is the cold chain distribution network operated by PT. X, with the main facility located at Cold Storage Karangsong, Indramayu, West Java. The logistics network analyzed consists of supply points representing fish landing and collection areas, a distribution center represented by the existing cold storage facility and potential alternative locations, and demand points representing customers primarily located in Jakarta and its surrounding regions. These components form an integrated network that determines product flows and associated logistics costs.

The research sample is based on historical operational data of PT. X collected from January to November 2025. This period is selected to capture seasonal variations in fish supply and customer demand, thereby providing a representative depiction of the system's operational characteristics. The data include inbound and outbound product volumes, cold storage capacity and utilization levels, transportation costs, handling costs, selling prices of marine products, and geographical location data for supply and demand points. The scope of the data is limited to core logistics activities, namely receiving, storage, and distribution processes, while upstream fishing operations and downstream retail activities are excluded to maintain analytical focus.



Picture 1 Research Flowchart

Data collection is conducted using both primary and secondary sources. Primary data are obtained through structured interviews with management and operational personnel of PT. X to understand operational procedures, cost structures, and logistical constraints. Secondary data are gathered from internal company records, including inventory reports, transportation cost documentation, and sales data. Prior to analysis, all data undergo verification, consistency checking, and preprocessing, including unit standardization, aggregation of product flows, and validation against operational constraints, to ensure suitability for modeling and optimization.

Data analysis is performed using logistics network optimization techniques, namely Green Field Analysis and Network Optimization. Green Field Analysis is applied to determine the optimal location of a distribution center based solely on the spatial distribution of supply and demand, without considering existing facilities.

Table 1. Locations

No	Location	Latitude	Longitude
1.	Pasar Ikan Modern Muara Baru	-6.110196	106.801675
2.	Pasar Induk Kramat Jati	-6.273298	106.869469
3.	Distributor Bandung A	-6.91474	107.60981
4.	Distributor Bandung B	-6.9146	107.5873
5.	Retail Pangandaran	-7.6673	108.64037
6.	Pabrik Jambal A	-6.33441	108.35952
7.	Pabrik Jambal B	-6.31528	108.35884
8.	Pelabuhan Karangsong (Supplier)	-6.3269	108.3736
9.	*Cold storage* Karangsong	-6.3265	108.3739

The objective is to minimize total transportation and logistics costs by identifying the most strategically efficient location. Subsequently, Network Optimization is employed to evaluate alternative distribution network configurations that incorporate existing facilities. The optimization model is formulated as a mixed-integer linear programming problem with the objective of minimizing total logistics cost, which includes fixed facility costs, transportation costs, and handling costs, subject to supply, demand, and capacity constraints. The results of the optimization provide a quantitative basis for comparing distribution center scenarios and selecting the most economically viable logistics network configuration.

RESULTS AND DISCUSSION

Data Collection

This section delineates the comprehensive dataset acquired for subsequent analytical processing within the scope of this investigation. Experimental data were systematically collected from the case study organization over a one-month observation period, encompassing both primary and secondary data sources. The following enumeration presents the essential data categories that have been compiled and utilized for the research methodology, each serving specific functions within the Green Field Analysis (GFA) and Network Optimization (NO) simulation frameworks.

1. Supplier and Cold Storage Karangsong Location

The supplier information constitutes a fundamental component of the supply chain network configuration, encompassing the geographical coordinates and logistical parameters essential for distribution center optimization. In this investigation, Palabuhan Karangasong serves as the primary supplier facility, positioned at latitude -6.5269 and longitude 108.8736, while the cold storage facility is located at latitude -6.3265 and longitude 108.8739. These geographical coordinates are critical inputs for the Green Field Analysis (GFA) methodology, as they enable the computational determination of optimal distribution center placement through distance minimization algorithms. The spatial relationship between supplier location and potential distribution centers directly influences transportation costs, delivery lead times, and overall supply chain efficiency, thereby constituting a pivotal consideration in facility location decision-making processes.

Table 2. Supplier and DC Karangsong

Location	Latitude	Longitude
Pelabuhan Karangsong (Supplier)	-6.3269	108.3736
Cold storage Karangsong	-6.3265	108.3739

2. Customer Location

Table 3. Customer Location

No	Customer Name	Latitude	Longitude
1.	Pasar Ikan Modern Muara Baru	-6.110196	106.801675
2.	Pasar Induk Kramat Jati	-6.273298	106.869469
3.	Distributor Bandung A	-6.91474	107.60981
4.	Distributor Bandung B	-6.9146	107.5873
5.	Retail Pangandaran	-7.6673	108.64037
6.	Pabrik Jambal A	-6.33441	108.35952
7.	Pabrik Jambal B	-6.31528	108.35884

The customer location dataset comprises comprehensive geographical information for twenty-two distinct commercial entities, predominantly consisting of hospitality establishments and food service providers distributed throughout the Jakarta metropolitan region. Each customer entry is precisely defined by latitude and longitude coordinates, facilitating accurate spatial analysis within the Anylogistix simulation environment. This geospatial data serves as a critical input parameter for the GFA algorithm, which utilizes customer positioning to calculate the center-of-gravity point that minimizes aggregate transportation distances and associated logistics costs. The customer base encompasses diverse establishment types, including hotels such as Pasar Ikan Modern Muara Baru, retail distributors designated as Distributor Bandung A and B, and food processing facilities including Retail Pangandaran and multiple Pabrik Jambal locations, collectively representing the demand nodes within the supply chain network architecture.

3. Customer Demand

The demand profile delineates monthly consumption requirements for frozen fish products across the customer network, expressed in kilogram units and disaggregated by product variety and customer entity. Principal product categories include Ikan Manyung, Ikan Capmur, Ikan Tenggiri, Ikan Tongkol, each characterized by distinct demand magnitudes ranging from 4,089 kg to 24,856 kg per month across different customers. Notably, Pasar Ikan Modern Muara Baru exhibits the highest aggregate demand at 15,239 kg monthly for Ikan Manyung, while Distributor Bandung A demonstrates diversified demand across multiple product lines with requirements spanning 4,089 kg to 20,894 kg. This demand data constitutes an essential input for both GFA and Network Optimization (NO) methodologies, as it influences the optimal distribution center location through demand-weighted distance calculations and enables accurate capacity planning and inventory management parameters within the simulation framework.

Table 4. Customer Demand

No	Customer Name	Fish	Demand/Month (kg)
1.	Pasar Ikan Modern Muara Baru	Ikan Manyung	15,239
		Ikan Campur	24,856
		Ikan Tenggiri	3,780
2.	Pasar Induk Kramat Jati	Ikan Campur	22,395
		Ikan Tenggiri	16,440
		Ikan Manyung	4,089
3.	Distributor Bandung A	Ikan Tongkol	6,573
		Ikan Manyung	20,894
		Ikan Campur	14,042
		Ikan Tenggiri	8,604
4.	Distributor Bandung B	Ikan Tenggiri	7,559
		Ikan Tongkol	6,826
		Ikan Campur	11,600
5.	Retail Pangandaran	Ikan_Campur	18,885
		Ikan_Manyung	16,490
6.	Pabrik Jambal A	Ikan Tenggiri	21,561
		Ikan Tongkol	9,903
7.	Pabrik Jambal B	Ikan Tongkol	3,456

4. Product

The product specification matrix articulates the economic parameters governing four principal frozen fish varieties within the supply chain model, specifically delineating selling prices and procurement costs denominated in Indonesian Rupiah (IDR) per kilogram. The product portfolio encompasses Ikan Manyung (selling price: IDR 4.45; buying price: IDR 1.56), Ikan Capmur (selling price: IDR 1.65; buying price: IDR 1.1), Ikan Tenggiri (selling price: IDR 4.15; buying price: IDR 2.69), and Ikan Tongkol (selling price: IDR 1.8; buying price: IDR 1.56), each exhibiting distinct profit margins that influence the overall economic viability of alternative distribution scenarios.

These price differentials are instrumental in calculating the objective function within the Network Optimization analysis, as they determine revenue generation potential and gross margin contributions under various distribution center location alternatives, thereby enabling comparative profitability assessment across the existing, alternative, and GFA-derived distribution center configurations.

Table 5. Product

No	Fish	Selling Price (USD)	Buying Price (USD)
1.	Ikan Manyung	4.45	1.56
2.	Ikan Campur	1.65	1.1
3.	Ikan Tenggiri	4.15	2.69
4.	Ikan Tongkol	1.8	1.36

5. Additional Data

The additional data encompasses supplementary operational and financial parameters requisite for the Network Optimization (NO) formulation and simulation execution within the Anylogistix software environment. This dataset comprises temporal specifications including order intervals and analytical time periods, facility-related fixed costs for alternative distribution center configurations, and unit conversion factors essential for volumetric calculations. Transportation cost structures are delineated through both fixed delivery charges and distance-based variable costs across different distribution routes, complemented by vehicle specification parameters encompassing capacity constraints and operational speed limitations. These supplementary parameters serve as critical inputs for the optimization algorithm, enabling comprehensive scenario comparisons and facilitating accurate profitability assessments across the proposed distribution center alternatives.

Table 6. Additional Data

Order Interval	30 days
Time Period	January 1st - December 31st, 2026
Other Costs (NO Karangsong DC)	USD 967/day
Other Costs (NO Bandung DC)	USD 1.161/day
Unit Conversions	0.0013 m^3
Cost Calculation Parameters	
NO Karangsong DC – All Customers	Fixed delivery (USD 228/trip) (FTL)
	Distance-based with fixed cost (1.36 * distance + 314 per trip (FTL)
NO Bandung DC – All Customers	Fixed delivery (USD 250/trip) (FTL)
	Distance-based with fixed cost (13 * distance + 250 per trip (FTL)
Variable Cost Transportation	USD 0.058/km (Truck Standar) USD 0.10/km (Truck HDL)
Fixed Cost Transportation	CS Karangsong – Jakarta: 228.5 USD
	CS Karangsong – Bandung: 207.6 USD
	CS Karangsong – Pangandaran: 207.6 USD
	CS Karangsong – Indramayu: 89.0 USD
Truck Capacity	10,000 kg (Truck HDL)
	8,000 kg (Truck Standar)
Vehicle Speed	60 km/h (Truck HDL)
	70 km/h (Truck Standar)

Data Processing

1. Green Field Analysis Experiment

Picture 2. Distribution Network

Picture 2 illustrates the distribution network configuration used in the Greenfield Analysis (GFA) experiment. In this scenario, Pelabuhan Karangsong is defined as the origin or supply point, representing the main source of product flow. The Greenfield Analysis Distribution Center (GFA DC) is modeled as a potential facility whose location is to be optimally determined by the AnyLogistix software. All customers are considered as demand points and are directly served by the selected DC location. This network structure enables the evaluation of an optimal Distribution Center location without considering existing facilities, thereby allowing the model to identify the most cost-efficient and geographically suitable DC placement based solely on demand distribution, transportation costs, and other relevant parameters.

2. Network Optimization Experiment (DC Bandung)

The Network Optimization experiment with DC Bandung is conducted to evaluate the operational and financial performance of the distribution network when the GFA-derived DC location is implemented. In this scenario, product flows originate from Pelabuhan Karangsong, are consolidated at the Bandung DC, and then distributed to all customer locations. The optimization model incorporates transportation costs, facility operating costs, and demand fulfillment constraints to generate a realistic assessment of system performance.

The simulation results show that DC Bandung provides relatively efficient outbound distribution due to its proximity to a significant portion of customer demand. Shorter average delivery distances to local markets contribute to improved responsiveness and service level reliability. However, this advantage is offset by increased inbound transportation costs, as products must be transported over longer distances from the coastal supplier to the inland DC. Additionally, the operational costs of maintaining a cold storage facility in an urban, highland area further increase total system costs.

3. Network Optimization Experiment (DC Karangsong)

The Network Optimization experiment with DC Karangsong focuses on evaluating the performance of the existing distribution center located near the primary supplier. In this configuration, the proximity between the supplier and the DC significantly reduces inbound transportation distance and cost. Products are either directly distributed or handled through a cross-docking mechanism, which minimizes storage time and preserves product quality.

Simulation outcomes demonstrate that the DC Karangsong scenario achieves lower total logistics costs compared to the DC Bandung alternative. The reduction in inbound transportation expenses and the absence of major new facility investments contribute to a more cost-efficient network structure. Although outbound distribution distances to certain customers are longer, these additional costs remain relatively small when compared to the savings generated on the supply side of the network.

In terms of profitability and operational robustness, DC Karangsong outperforms the alternative scenario. The model indicates higher profit margins and greater resilience to variations in key parameters such as fuel prices and demand fluctuations. Furthermore, the existing infrastructure and established distribution routes enhance operational stability. These results confirm that maintaining DC Karangsong as the primary distribution hub is the most economically and operationally viable option for the current marine product distribution system.

Experiment Analysis

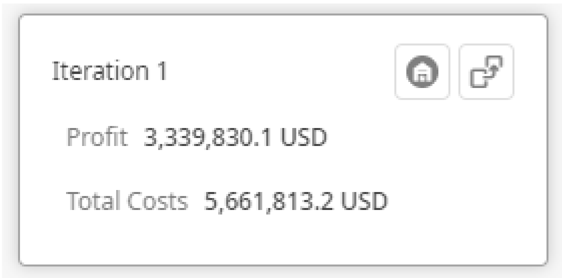
1. GFA DC (DC Bandung)

Picture 3. GFA Experiment Results

The Greenfield Analysis (GFA) scenario aims to identify the optimal location of a Distribution Center (DC) without considering existing facilities. The input parameters used in the GFA scenario are derived from previously collected data, including demand, product characteristics, customer distribution, and other relevant variables. These parameters were subsequently input into the AnyLogistix software for analysis; a more detailed description of the input data is provided in Appendix 2. Based on the simulation results of the GFA scenario, the optimal location for the Distribution Center of PT. X was determined. The AnyLogistix analysis indicates that the optimal DC location is situated at a latitude of −6.912 and a longitude of 107.609.

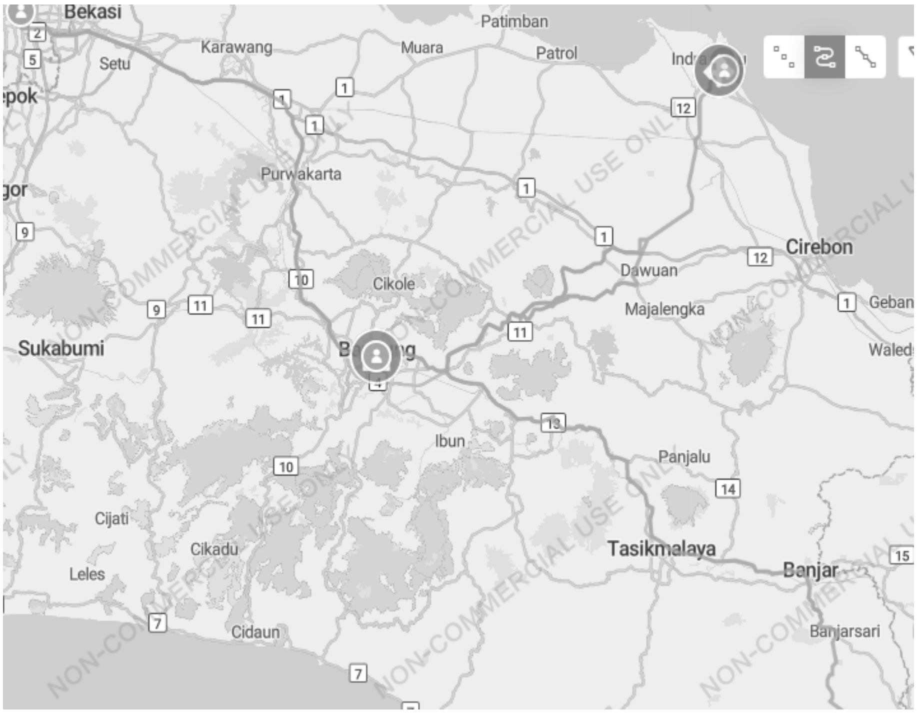
2. NO Experiment Results (GFA DC Bandung)

The Network Optimization experiment for the GFA DC Bandung configuration yielded quantifiable performance metrics across multiple operational and financial dimensions through iterative computational analysis.



Picture 4. Profit NO (GFA DC Bandung)

The simulation results, as presented in iteration 1, demonstrate an objective function value (profit) of 3,339,850.1 USD with corresponding total costs amounting to 5,661,813.2 USD, indicating the economic viability of this distribution center location alternative.



Picture 5. NO Experiment Results (GFA DC Bandung)

The geographical visualization illustrates the optimized distribution network topology, wherein the GFA DC Bandung serves as the central hub with established transportation routes extending to geographically dispersed customer locations across the western Java region, characterized by distribution pathways connecting major metropolitan areas and peripheral demand nodes.

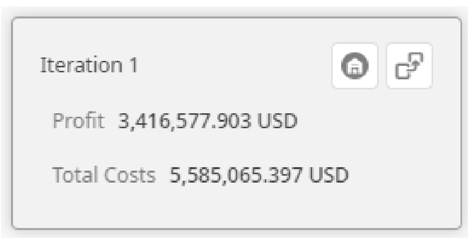
Table 7. NO Experiment Results (GFA DC Bandung)

Supply Cost	-4,961,927.88 USD
Revenue	9,001,643.3 USD
Transportation Cost	-699,461.555 USD
Other Cost	-423.765 USD
Objective (Profit)	3,339,830.1 USD

The detailed cost structure delineation reveals supply costs of -4,961,927.88 USD, revenue generation of 9,001,643.3 USD, transportation expenditure of -699,461.555 USD, and facility-related other costs of -423.765 USD, collectively contributing to the calculated profit objective of 3,339,850.1 USD, thereby validating the financial feasibility of the GFA-derived distribution center location.

3. NO Experiment Results (GFA DC Karangsong)

Network Optimization experiment for the DC Karangasong alternative was executed to establish a comparative baseline against the GFA-derived distribution center location, employing identical methodological parameters and demand scenarios.



Picture 6. Profit NO (DC Karangsong)

The simulation output from iteration 1 indicates an objective function value (profit) of 3,416,577.903 USD with aggregate total costs of 5,585,065.397 USD, demonstrating superior financial performance relative to the GFA DC Bandung configuration.

Picture 7 NO Experiment Results (DC Karangsong)

The cartographic representation of the optimized network design illustrates the Karangasong-based distribution center positioned in the eastern region of West Java, necessitating extended distribution routes to service customer locations concentrated in the western metropolitan areas, as evidenced by the elongated transportation pathways depicted in the visualization.

Table 8 NO Experiment Results (DC Karangsong)

Supply Cost	-4,961,927.88 USD
Revenue	9,001,643.3 USD
Transportation Cost	-270,182.517 USD
Other Cost	-352,955 USD
Objective (Profit)	3,416,577.903 USD

The comprehensive cost breakdown encompasses supply costs of -4,961,927.88 USD, revenue generation of 9,001,643.3 USD, transportation costs of -270,182.517 USD reflecting the geographical proximity to supplier sources, and facility-related other costs of -352.955 USD, culminating in the calculated profit objective of 3,416,577.903 USD, thereby establishing this configuration as the financially optimal alternative based on profit maximization criteria.

Table 9. Comparison Results of NO (GFA DC Bandung) and NO (DC Karangsong)

In USD	NO (GFA DC Bandung)	NO (DC Karangsong)
Other Cost Facility/Day	1.161 USD	0.967 USD
Other Cost Facility/Year	-423.765 USD	-352,955 USD
Transportation Cost	-699,461.555 USD	-270,182.517 USD
Profit	3,339,830.1 USD	3,416,577.903 USD
Profit (%)	297.3 %	548.3 %

The comparative analysis between the two distribution center alternatives reveals differential performance across operational cost components and profitability metrics, providing empirical evidence for strategic facility location decision-making. The tabulated results demonstrate that NO (DC Karangasong) generates superior profit performance at 3,416,577.903 USD compared to NO (GFA DC Bandung) at 3,339,850.1 USD, representing a profit differential advantage of 548.3% when calculated relative to the baseline configuration. Facility-related fixed costs exhibit marginal variation, with GFA DC Bandung incurring 1.161 USD per day (423.765 USD annually) compared to DC Karangasong's 0.967 USD per day (352.955 USD annually), indicating comparable overhead expenditure structures. The most substantial divergence manifests in transportation cost parameters, wherein GFA DC Bandung incurs -699,461.555 USD contrasted with DC Karangasong's substantially lower -270,182.517 USD, attributable to the latter's geographical proximity to the Pelabuhan Karangasong supplier facility, thereby reducing aggregate distribution distances and associated logistics expenditures despite requiring extended customer delivery routes.

Table 10. GFA Experiment Results (DC Bandung)

	GFA DC
Total Distance (km)	1,289.845 km

The spatial efficiency metric derived from the GFA experiment quantifies the aggregate transportation distance required to service the complete customer network from the Bandung-based distribution center location. The total distance calculation of 1,289.845 km represents the cumulative spatial displacement encompassing both inbound supplier-to-distribution-center movements and outbound distribution-center-to-customer deliveries throughout the analytical time period. This distance metric serves as a critical input parameter for transportation cost estimation within the Network Optimization framework, directly influencing the variable cost component of logistics expenditure through distance-based calculation formulas. The relatively moderate total distance figure, when contextualized against the dispersed geographical distribution of customer demand nodes across the western Java region, suggests that the GFA-derived location achieves spatial centralization that balances proximity to high-density customer clusters while maintaining reasonable accessibility to the eastern supplier location, thereby optimizing the fundamental trade-off between inbound and outbound transportation efficiency.

CONCLUSION

This study demonstrates that the integration of Green Field Analysis and Network Optimization effectively enhances fisheries cold chain distribution performance. Simulation results indicate that although Bandung is identified as an alternative distribution center location, the Karangsong distribution center achieves superior performance, generating a profit of USD 3,416,577.903, compared to USD 3,339,830.1 for the Bandung scenario. Furthermore, the Karangsong configuration results in significantly lower transportation costs of USD 270,182.517, compared to USD 699,461.555 in the Bandung scenario. These findings highlight the importance of integrated network optimization in supporting cost efficient and sustainable logistics planning.

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