

Distribution Network Design for Central Kitchen Expansion: A Decision-Making Case Study of Toko Bakmi Kita

Christian Wibisono^{1*}, Meditya Wasesa², Maria Magdalena Wahyuni Inderawati³, Marie Jane Jumawan Matero⁴

¹Master of Business Administration, School of Business and Management, Institut Teknologi Bandung, Bandung 40132, Indonesia

²School of Business and Management, Institut Teknologi Bandung, Bandung 40132, Indonesia

³Faculty of Bioscience, Technology, and Innovation, Atma Jaya Catholic University of Indonesia, Jakarta, 12930, Indonesia

⁴Faculty of School of Management, University of the Philippines Cebu, Cebu City, Philippines, Philippines

Article Info

Abstract

Article history:

Received
July 10, 2026

Accepted
October 10, 2026

Keywords:

Distribution network design, Central kitchen; K-Means clusterin, Logistics cost modellin, Analytic Hierarchy Process (AHP).

Multi-outlet food-service companies face growing logistics complexity as they expand, yet few studies integrate logistics cost analysis, capacity planning, and multi-criteria decision-making into distribution network design for small and medium-sized food-service enterprises in Indonesia. This study aims to determine the appropriate distribution network design to support Toko Bakmi Kita's expansion from one to ten outlets by 2029. As the existing Central Kitchen (CK) in Serang is projected to exceed its capacity, this research evaluates four alternative distribution network models by integrating financial and non-financial criteria. The study employs an explanatory single-case study design that integrates capacity analysis, logistics cost optimization, spatial analysis, and multi-criteria decision-making (AHP). The ten-outlet network requires 382.21 m² of CK production area and 140.00 m² of CK storage area. From a cost perspective, Scenario 3 (Optimal CK–Direct) is the most efficient, with a total logistics cost of approximately Rp2.08 billion per month and Rp181,464.28 per kilogram, a 2.05% saving over the baseline; demand variation has the greatest effect on cost. However, AHP identifies Scenario 2 (Existing CK–Hub) as the preferred overall alternative (priority 0.395048), because Service and Product Quality, Supply Reliability, and Supplier Proximity together account for more than 80% of the decision weight. The study presents an integrated decision-support framework for distribution network design in a small- to medium-sized Indonesian food-service company. By combining a cost-efficiency benchmark with multi-criteria evaluation, the study offers practical guidance for expansion decisions in Indonesian food-service SMEs and contributes an integrated, replicable framework to the limited literature in this context.

© 2026 by the authors. Submitted for possible open access publication under the terms and conditions of the



Creative Commons Attribution (CC BY) license (<http://creativecommons.org/licenses/by/4.0/>).

1. INTRODUCTION

The food and beverage (F&B) industry in Indonesia is one of the most dynamic sectors, driven by rapid urbanization, rising disposable incomes, and growing demand for consistent dining experiences. Badan Pusat Statistik data show that average weekly per-capita expenditure on food and beverages rose from a 2019 base of 100% to 120% by 2024, a steady upward trend in household food spending (Badan Pusat Statistik, 2025). At the same time, research indicates that restaurant chains that scale beyond seven outlets face increasing logistics complexity, fragmented procurement, and challenges in quality standardization (Jacobs & Chase, 2018).

*Corresponding author: Christian Wibisono
Email address: christianwibisono1992@gmail.com

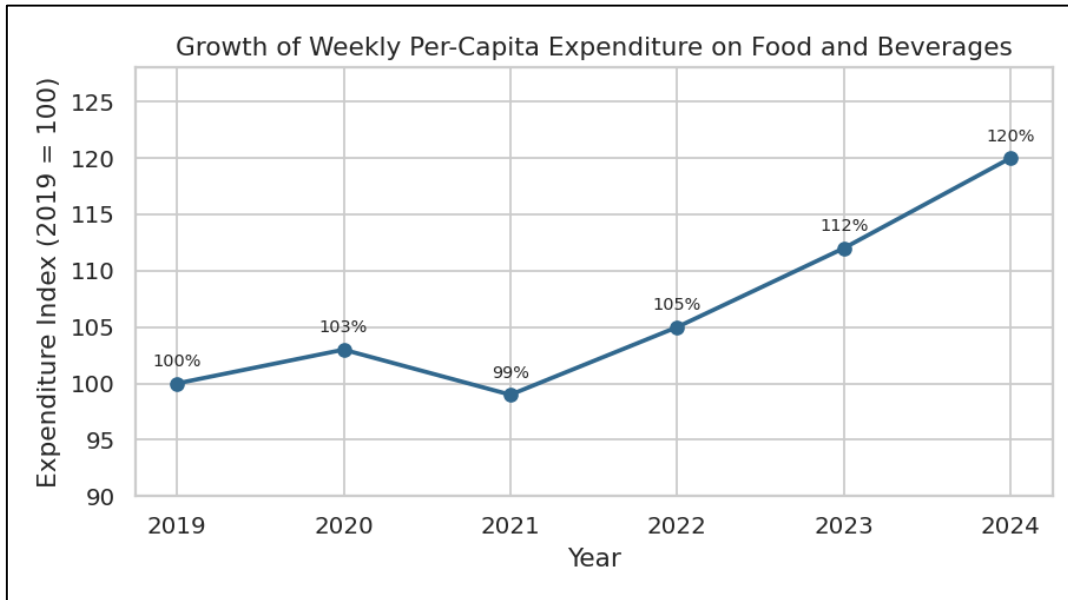


Figure 1.

Growth of weekly per-capita expenditure on food and beverages, 2019-2024

(Source: BPS)

To address these operational challenges, many multi-outlet restaurant chains adopt a Central Kitchen (CK), a dedicated production facility that prepares bulk or semi-finished products for distribution to outlets. Central kitchens enable economies of scale in procurement, standardization of recipes and quality processes, and reduction of equipment duplication at the outlet level (Apicbase, 2023; Fujii *et al.*, 2013). However, a central kitchen alone does not resolve all distribution challenges. As the outlet network grows geographically, the logistics structure connecting the CK to outlets must also evolve. Direct delivery from a single CK to multiple dispersed outlets increases route distance, transportation cost, and replenishment risk. Hub-and-spoke configurations, in which intermediate mini-hubs buffer inventory closer to outlet clusters, can improve service reliability but also introduce additional facility, investment, and inventory-holding costs (Chopra & Meindl, 2016).

Toko Bakmi Kita is a family-style restaurant founded in 2019 in Serang, Banten. It currently operates from one outlet with 180 seats and a Central Kitchen in Serang, and plans to expand to ten outlets by 2029 across Serang and the Greater Jakarta (Jabodetabek) area. This expansion places the company at a strategic decision point regarding both production capacity and distribution network design, as detailed in Section 2.

The company currently has no structured, data-driven framework for selecting the distribution network model that best balances total logistics cost with service reliability, product quality, and supply continuity. This study addresses that gap by integrating capacity planning, geospatial K-Means clustering, Python-based logistics cost modeling, sensitivity analysis, and the Analytic Hierarchy Process to evaluate four distribution network alternatives. Section 2 details the business issue and the specific research questions that guide the study.

Although distribution network design, capacity planning, and multi-criteria decision-making have each been studied extensively, prior work has largely treated them in isolation. Table 1 compares representative previous studies with the present study and highlights the research gap.

Table 1.

Comparison of previous studies and the present study (research gap)

No	Study	Focus / Method	Gap Relative to This Study
1	Fujii <i>et al.</i> (2013)	Central-kitchen facility layout to cut logistics cost	Layout/cost only; no distribution-network scenario comparison or MCDM
2	Devin & Widaningrum (2021)	GIS-based central-kitchen location selection (Jabodetabek)	Location screening only; no logistics-cost model or capacity planning
3	Guidani <i>et al.</i> (2022)	Location-routing (MILP + heuristics) for catering networks	Cost/resilience optimisation only; non-financial managerial criteria not modelled
4	Liu (2023)	GIS + K-Means clustering for hub location	Spatial hub-siting only; no integrated cost model or AHP decision layer
5	Kurniawan <i>et al.</i> (2024)	AHP + math programming for mega-kitchen location	Location decision only; not combined with a full logistics-cost benchmark
6	This study	Capacity planning + K-Means + Python cost model + sensitivity + AHP	Integrates all three lenses (capacity, cost, MCDM) for an Indonesian food-service SME

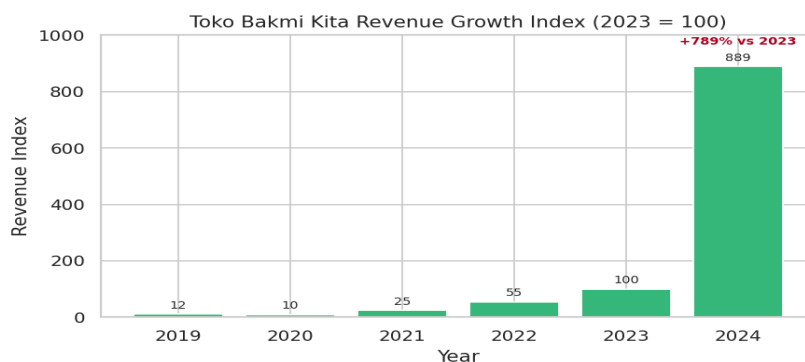
As Table 2 shows, existing studies emphasise cost or location optimisation and rarely combine quantitative logistics-cost modelling with a formal multi-criteria evaluation that also captures non-financial managerial priorities such as service quality and supply reliability. Studies that integrate all three lenses for a small- to medium-sized Indonesian food-service enterprise are especially scarce.

This study addresses that research gap. Its novelty and scientific contribution lie in integrating capacity planning, Python-based logistics cost modelling, and multi-criteria decision-making (AHP) into a single, comprehensive framework for distribution network design in a small- and medium-sized food-service enterprise (SME). By combining a cost-efficiency benchmark with a multi-criteria evaluation, the study explicitly reconciles the tension between the cost-optimal network and the network preferred once service quality and supply reliability are considered a reconciliation that cost-only or location-only studies cannot provide.

2. BACKGROUND PROBLEMS

2.1 Business Issue

Toko Bakmi Kita was established in 2019 in Serang, Banten, and has grown strongly over its first five years. In 2024, revenue was approximately 789% higher than in 2023, driven primarily by a move to a larger 180-seat outlet, which increased customer throughput and strengthened the brand locally. By 2024, the company had served more than one million portions and employed over 70 staff, providing a stable operational base for further growth.

**Figure 2.**

Toko Bakmi Kita revenue growth index
(Source: Internal)

Building on this momentum, Toko Bakmi Kita plans to expand from one to ten outlets by 2029 across Serang and the Greater Jakarta (Jabodetabek) area, with each new outlet seating 120–180 customers. Table 2 summarises the phased expansion plan. This shift from a single-region operation to a multi-region chain substantially increases the complexity of production planning, logistics, and service consistency.

Table 2.

Toko Bakmi Kita expansion plan to 2029 (Source: Internal)

Year	Location Plan	Capacity (Seats)
2026	Serang, Banten	180
	Grand Wisata, Bekasi Regency	120
	Graha Raya, South Tangerang	120
2027	West Bekasi	120
	Rawamangun, East Jakarta	120
	Harapan Indah City, Bekasi	120
2028	Cawang, East Jakarta	120
	Tebet, South Jakarta	120
2029	Karawang, West Java	120
	Daan Mogot, West Jakarta	120

The central problem is that the existing Central Kitchen (CK) in Serang cannot support this expansion. Historical data show that the CK has a maximum throughput of 2,722 kg per month and currently operates at about 83% utilization at the single existing outlet. As new outlets open, forecast production demand quickly overtakes this fixed capacity: utilization is projected to reach 140% in 2026 and climb to 421% by 2029, as summarised in Table 3 and illustrated in Figure 3.

Table 3.

Forecasted production demand vs current CK capacity (Source: Internal)

Year	Forecast Demand (kg/month)	CK Capacity (kg/month)	Utilisation (%)
2025	2,264.60	2,722	83%
2026	3,816.00	2,722	140%
2027	7,086.73	2,722	260%
2028	9,267.27	2,722	341%
2029	11,447.80	2,722	421%

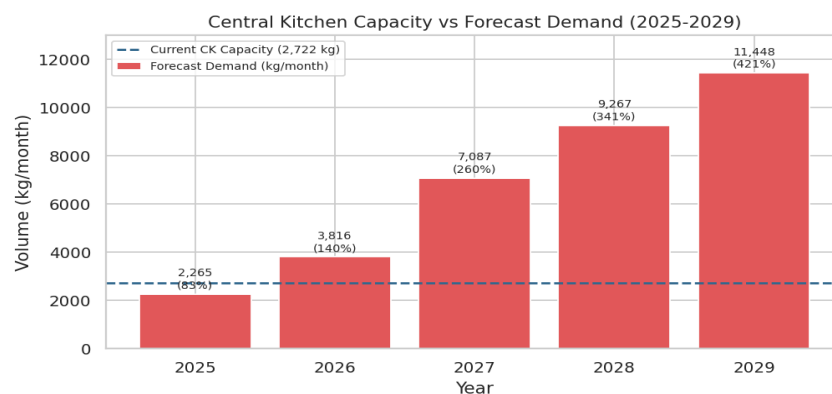


Figure 3.

Central kitchen capacity vs forecast demand, 2025-2029

(Source: Internal)

A sustained utilization above 421% is not operationally feasible. It would create production bottlenecks, inconsistent product quality, and late supply to outlets outcomes that directly erode brand trust and customer satisfaction. Capacity-management literature notes that utilization beyond roughly 80% already lengthens lead times, reduces flexibility, and raises breakdown risk, which is precisely the threshold the existing CK has reached.

A second, closely linked problem arises on the distribution side. As outlets move farther from Serang into Jabodetabek, delivery distances grow, raising logistics costs, increasing the risk of late deliveries, and adding operational burden on the CK. These pressures mirror industry findings that F&B chains scaling beyond about seven outlets struggle with quality standardization and rising logistics complexity, an effect amplified in markets such as Indonesia, where logistics costs are among the highest in Southeast Asia, and supplier fragmentation is high. At present, the company has no structured, data-driven framework for choosing between direct-delivery, hub-and-spoke, or hybrid distribution configurations that best balance total logistics cost against service reliability, product quality, and supply continuity.

To resolve this business issue CK capacity expansion together with distribution network design, the study is guided by three research questions:

1. What Central Kitchen and mini-hub capacity and facility requirements are needed to support Toko Bakmi Kita's expansion to ten outlets by 2029?
2. How do alternative distribution network models compare in terms of total logistics cost and cost per kilogram?
3. Which distribution network model is most appropriate when both logistics cost and non-financial criteria are evaluated using AHP?

The remainder of this section reviews the theoretical foundations underpinning the analytical methods used to answer these questions.

2.2 Distribution Network Design and Central Kitchen Operations

Distribution network design involves strategic decisions on the number, location, and role of facilities, and the flow patterns between them, with the overall objective of balancing total logistics cost against service performance (Jacobs & Chase, 2018; Heizer *et al.*, 2020). Classical network archetypes – direct shipment, hub-and-spoke, and hybrid configurations – each involve different trade-offs between transportation cost, facility investment, inventory holding, and service responsiveness (Ballou, 2004; Chopra & Meindl, 2016). In food and beverage supply chains, these trade-offs are intensified by product perishability, strict temperature requirements, and the need for consistent quality across outlet locations (Heizer *et al.*, 2017).

The concept of a central kitchen as the upstream production node in a multi-outlet food service network has been empirically supported. Fujii *et al.* (2013) found that centralised production kitchens in Japan reduced logistics expenses while improving food safety and standardisation. Devin and Widaningrum (2021) demonstrated that facility location, capacity planning, and distribution model selection jointly determine overall cost and service performance in food production operations. Guidani *et al.* (2022) showed that location and routing decisions must be considered together for cost efficiency and resilience in catering networks. Mini hubs, used as downstream storage-only decoupling points between the CK and outlet clusters, can improve replenishment reliability and buffer demand variability, but increase total facility, investment, and holding cost (Chopra & Meindl, 2016).

2.3 Geospatial Analysis and K-Means Clustering

K-Means is a widely used unsupervised machine-learning algorithm that partitions a set of geographic points into k mutually exclusive clusters by minimising within-cluster sum of squared Euclidean distances (MacQueen, 1967). In logistics, K-Means has been applied to segment customers into geographically compact service territories and to identify candidate hub locations at cluster centroids (Liu, 2023; Rasulov, 2024). The number of clusters is determined using the Elbow Method, which plots the within-cluster sum of squares against successive values of k and identifies the point at which the marginal improvement diminishes (MacQueen, 1967). In the context of F&B distribution, K-Means provides a systematic and computationally accessible basis for mini-hub placement and outlet assignment, linking the spatial pattern of demand to network structure (Devin & Widaningrum, 2021; Adji Candra *et al.*, 2024).

2.4 Logistics Cost Modelling and Sensitivity Analysis

Total logistics cost is decomposed into facility-related cost (rental, CAPEX allocation, OPEX, labour, utilities), inventory holding cost (a function of coverage days and holding cost per kilogram per day), and transportation cost (route distance, vehicle capacity, trip frequency, variable cost per kilometre, toll, driver cost) (Jacobs & Chase, 2018; Heizer *et al.*, 2020). Routing heuristics such as cluster-first, route-second are commonly used in practice when exact optimization is not feasible, providing consistent cost estimates across scenarios (Devin & Widaningrum, 2021). Sensitivity analysis identifies which parameters create the greatest cost exposure and assesses whether scenario rankings remain stable as assumptions change (Saltelli *et al.*, 2008; Ballou, 2004).

2.5 Analytic Hierarchy Process

The Analytic Hierarchy Process (AHP) is a structured multi-criteria decision-making method that decomposes a decision problem into a hierarchy of goals, criteria, and alternatives, and derives priority weights through pairwise comparisons using a ratio scale (Saaty, 1980). A Consistency Ratio below 0.10 indicates that the pairwise judgments are sufficiently coherent for synthesis (Saaty, 2008). AHP has been applied extensively in logistics and supply chain management, including facility location selection and distribution network design, because it allows quantitative cost data to be integrated with qualitative managerial preferences regarding service quality, operational control, and supply reliability (Parnell *et al.*, 2013). In the context of food service network design, AHP helps the final recommendation account for the full set of managerial priorities, not cost minimization alone (Kurniawan *et al.*, 2024).

The conceptual framework of this study integrates these four streams. Starting from the business context of multi-outlet expansion and CK capacity pressure, the framework applies capacity planning to convert demand forecasts into facility requirements, geospatial K-Means to generate distribution scenarios, Python-based logistics cost modeling to evaluate cost performance, sensitivity analysis to assess robustness, and AHP to integrate cost and non-financial criteria into a final distribution network recommendation.

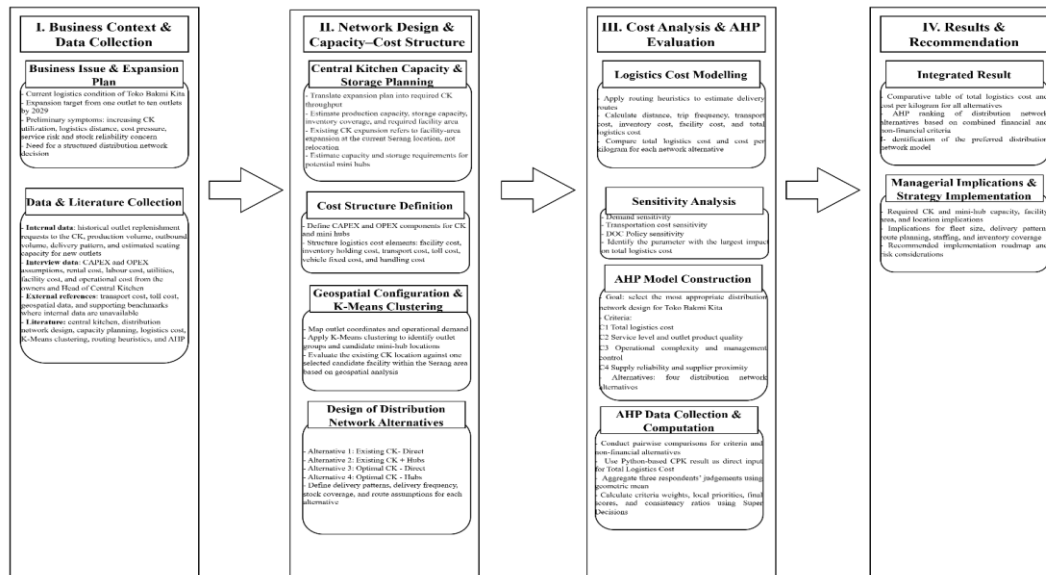


Figure 4.
Conceptual framework

3. METHODS

This study employs an explanatory single-case study design that combines quantitative modelling with qualitative managerial input. The case organisation is Toko Bakmi Kita, selected because it represents a typical small-to-medium Indonesian F&B chain facing a transition from single-outlet to multi-outlet operations, where both CK capacity and distribution network design become critical strategic decisions.

An explanatory single-case study design is chosen because the research question is a "how" and "why" question, how alternative distribution networks compare and why one is preferred once cost and non-financial criteria are considered for which case study is the most appropriate strategy (Yin, 2018). A single case is suitable here because the aim is analytical depth rather than statistical generalisation: the study builds and validates an integrated decision-support framework within one real expansion decision. Toko Bakmi Kita was selected as a representative (typical) case because it exhibits the defining conditions of the phenomenon of interest a growing Indonesian food-service SME with an existing central kitchen, a concrete multi-outlet expansion plan, and a capacity constraint that forces a distribution-network decision while also offering full access to internal operational, financial, and managerial data, which many comparable firms do not provide.

To ensure the credibility of the qualitative input, data were validated through triangulation across three sources: internal operational records (production and outbound volumes), owner-provided financial assumptions (CAPEX and OPEX), and semi-structured interviews. Interview outputs and model assumptions were confirmed with respondents in a member-checking step before being used in the models. Three informants were engaged the two owners and the Head of Central Kitchen which is justified on the basis that these three individuals hold the complete set of strategic, financial, and operational knowledge required for the decision; they are the only decision makers who set expansion strategy and approve capital investment, so they constitute the full relevant decision-making population rather than a sample of it. Their judgements also form the pairwise-comparison inputs for the AHP model, aggregated using the geometric mean and verified through consistency-ratio checks ($CR < 0.10$).

Figure 5 presents the research methodology flow. After identifying the business problem and reviewing literature, the study proceeds through four analytical stages: (1) capacity and facility requirement analysis, (2) geospatial K-Means clustering and scenario generation, (3) Python-based logistics cost modelling and sensitivity analysis, and (4) AHP-based multi-criteria evaluation. The qualitative stream, conducted through semi-structured interviews with two owners and one Head of Central Kitchen, provides operational and financial assumptions that validate and inform the quantitative models. The AHP questionnaire elicits managerial judgements on the relative importance of four decision criteria and the relative performance of the four alternatives under non-financial criteria.

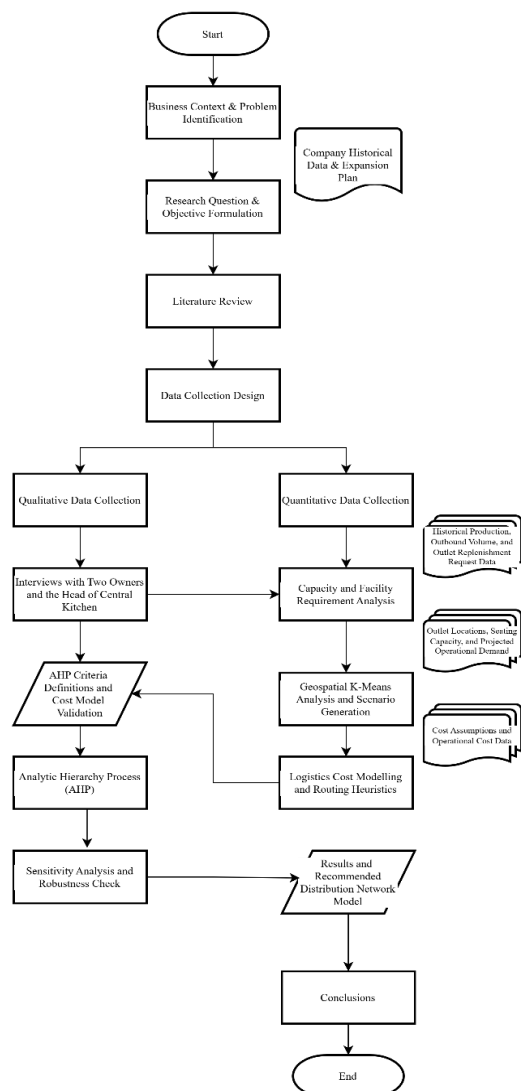


Figure 5.
Research methodology flow

3.1 Data Collection

Quantitative data include five months of historical production and outbound volume from the existing CK (June 2025 – October 2025), planned outlet locations for 2026–2029, estimated seating capacities, and owner-provided CAPEX and OPEX assumptions. Geospatial data provide the coordinates of the existing CK, planned outlets, and candidate mini-hub locations. Cost parameters for the Python logistics model including rental rates, vehicle capacity, variable cost per kilometre, toll cost, unloading time, average speed, and

holding cost are derived from interview inputs and secondary references where internal data are unavailable.

Table 4.

Projected 2029 network demand by outlet

Location	Capacity (Seats)	Demand (kg/month)
Serang, Banten	180	1,635.40
Grand Wisata, Bekasi	120	1,090.27
Graha Raya, South Tangerang	120	1,090.27
West Bekasi	120	1,090.27
Rawamangun, East Jakarta	120	1,090.27
Harapan Indah City, Bekasi	120	1,090.27
Cawang, East Jakarta	120	1,090.27
Tebet, South Jakarta	120	1,090.27
Karawang, West Java	120	1,090.27
Daan Mogot, West Jakarta	120	1,090.27
Grand Total	1,260	11,447.80

(Sumber: Pengolahan Data)

3.2 Data Analysis Methods

Capacity planning translates the 2029 network demand into production and storage area requirements using empirical throughput density and storage density ratios derived from the existing CK. A daily planning throughput is set at one standard deviation above the projected average demand, and a design production area is calculated at 80% utilization to maintain an operational buffer. CK storage area is sized using a 14-day inventory coverage target; mini-hub storage is sized using 8 days (7 operational plus 1 safety day).

K-Means clustering is applied to the planned outlet coordinates and demand to identify outlet service zones and mini-hub candidate locations. The Elbow Method determines the optimal number of clusters. The geospatial output, combined with management input, defines four distribution network scenarios: Scenario 1 (Existing CK–Direct), Scenario 2 (Existing CK–Hub), Scenario 3 (Optimal CK–Direct), and Scenario 4 (Optimal CK–Hub).

A Python-based logistics cost model estimates monthly facility costs, CAPEX allocation, OPEX, inventory holding costs, and transportation costs for each scenario, using the same parameters and routing heuristics across scenarios. Haversine distances are adjusted by a road multiplier of 1.3. Sensitivity analysis assesses the effects of demand and transportation cost variations, as well as changes to the inventory coverage policy, on total logistics cost and scenario ranking.

The total logistics cost (TLC) of each scenario is computed as the sum of five cost components: facility cost, CAPEX allocation, operating cost (OPEX), inventory holding cost, and transportation cost. The cost components are formulated as follows.

$$C_{facility,s} = \sum f (Af \times C_{rent,f}) \dots\dots\dots (1)$$

$$C_{CAPEX,s} = \sum f (CAPEXf / Lf) \dots\dots\dots (2)$$

$$C_{OPEX,s} = C_{Labour,s} + C_{utilities,s} + C_{handling,s} + C_{maintenance,s} \dots\dots\dots (3)$$

$$C_{Holding,s} = \sum n (Qn,day \times Dn \times hn) \dots\dots\dots (4)$$

$$C_{transport,s} = \sum r [(dr \times fr \times c_{km}) + (fr \times c_{toll,r}) + (fr \times c_{driver,r})] \dots\dots\dots (5)$$

$$TLCs = C_{facility,s} + C_{CAPEX,s} + C_{OPEX,s} + C_{Holding,s} + C_{transport,s} \dots\dots\dots (6)$$

$$CPKs = TLCs / Qs,total \dots\dots\dots (7)$$

Where A_f is the required floor area of facility f and $C_{rent,f}$ is the cost per square metre; $CAPEX_f$ is the investment for facility f and L_f its useful life in months; Q_n , day is daily volume at node n , D_n the days of inventory coverage, and h_n the holding cost per kilogram; dr is the round-trip distance of route r , fr the monthly frequency, c_{km} the vehicle operating cost per kilometre, $c_{toll,r}$ the toll cost per trip, and $c_{driver,r}$ the driver cost per trip; and Q_s , total is the total monthly demand served by scenario s . The resulting CPKs value is used directly as the quantitative input for the Total Logistics Cost criterion in the AHP model.

The AHP model evaluates the four scenarios against four criteria: Total Logistics Cost (C1), Service and Product Quality (C2), Operational Complexity and Control (C3), and Supply Reliability and Supplier Proximity (C4). Pairwise comparisons from three respondents are aggregated using the geometric mean. For C1, the inverse of CPK is normalised directly from the Python model result. Consistency ratios are checked using Super Decisions software; values below 0.10 are considered acceptable.

4. INTERPRETATION OF FINDINGS

4.1 Capacity and Facility Requirement Analysis

The current CK operates at 83% utilisation with a monthly throughput capacity of 2,722 kg, compared with a projected average network demand of 11,447.80 kg per month for the full ten-outlet configuration. Including a planning buffer based on historical demand variability ($CV = 13.86\%$), the planning monthly demand is 13,034.47 kg. With 26 CK operating days per month, the planning daily throughput is 501.33 kg/day, compared with the current average daily output of 62.9 kg/day – approximately an eightfold increase.

Using the empirical throughput density of 1.44 kg/m²/day from the existing 60 m² production area, and applying the 2029 average daily throughput of 440.30 kg/day as the sizing basis, the required production area at 100% utilisation is 305.94 m². Adjusting for an 80% utilisation target yields a design production area of 382.21 m². The CK storage area is sized using the existing storage density of 44.03 kg/m² and a 14-day coverage target, yielding a required storage area of 140.00 m² and a total CK area of 522.21 m². Table 5 summarises the key capacity results.

Table 5.

Central kitchen capacity and facility requirements

Parameter	Value
Average monthly network demand – 10 outlets (kg)	11,447.80
Planning monthly demand (kg)	13,034.47
Average daily throughput – sizing basis (kg/day)	440.30
CK production area – design (m ²)	382.21
CK storage area (m ²)	140.00
Mini-hub inventory coverage (days)	8

4.2 Geospatial K-Means Analysis

K-Means clustering is applied to the coordinates and demand of the ten planned outlets. The Elbow Method identifies $k = 3$ as the practical optimum: WCSS decreases sharply from $k = 1$ to $k = 3$, after which the marginal improvement diminishes substantially. Three mini-hub candidates are identified from the K-Means output: Karawang (West Java), Tebet (South Jakarta), and Serang (Banten). The Tebet cluster has the highest assigned demand, at 8,722.16 kg/month, reflecting the concentration of planned outlets in the Jakarta–Bekasi corridor. Table 6 presents the mini-hub assignment results

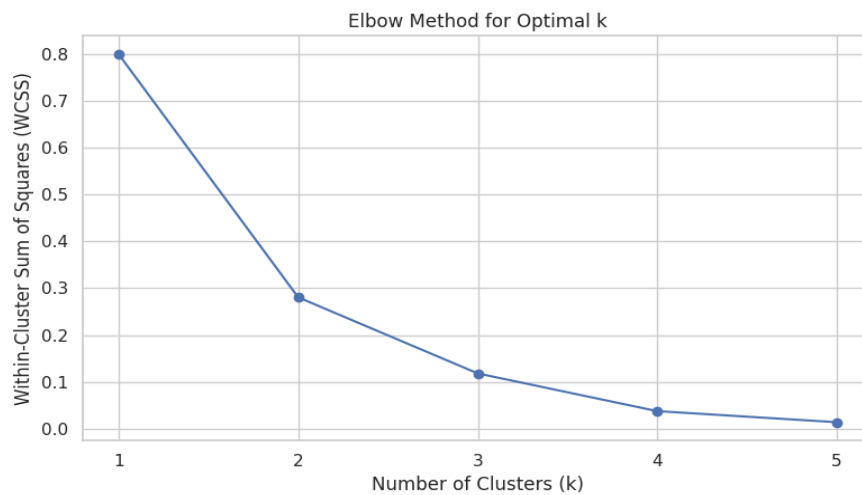


Figure 6.
Elbow method for optimal k

Table 6.
Mini-hub assignment result from K-Means

Mini-Hub Location	Assigned Demand (kg/month)	Latitude	Longitude
Karawang, West Java	1,090.27	-6.30649	107.29285
Tebet, South Jakarta	8,722.16	-6.23580	106.85246
Serang, Banten	1,635.40	-6.12352	106.16769

Based on these clusters, four distribution network scenarios are constructed: Scenario 1 uses the existing CK in Serang delivering directly to all outlets; Scenario 2 uses the existing CK supplying the three K-Means mini hubs, which then serve nearby outlet clusters; Scenario 3 assumes the CK operates from a geospatially selected candidate location within the Serang area and delivers directly to all outlets; and Scenario 4 uses the optimal CK candidate location supplying the three mini hubs, which serve nearby clusters.

4.3 Logistics Cost Analysis

Before the logistics cost is computed, the model establishes the input parameters for facility capacity, inventory coverage, transportation, and cost assumptions. These parameters are derived from internal operational data, interviews with the owners and the Head of the Central Kitchen, manual calculations, and secondary references when internal data are unavailable. Table 7 lists the key parameters used in the Python-based logistics cost simulation.

Table 7.
Model parameters used in the Python logistics cost simulation

Parameter	Value	Use in Model
production_density_kg_sqm_day	1.44 kg/m ² /day	Converts daily demand into required CK production area
storage_density_kg_sqm	44.03 kg/m ²	Converts inventory level into required storage area
utilization_factor	0.8	Adjusts production area to reflect effective capacity
rental_rate_serang	Rp35,602/m ² /month	Facility rental cost for the existing CK scenario
rental_rate_geo_optimal	Rp53,151/m ² /month	Facility rental cost for the Optimal CK scenario
ck_capex_per_sqm_monthly	Rp1,250,000/m ² /month	Monthly CK investment allocation

Table 7. (Continued)

Model parameters used in the Python logistics cost simulation

Parameter	Value	Use in Model
minihub_capex_per_sqm_monthly	Rp1,250,000/m ² /month	Monthly mini-hub investment allocation
holding_cost_kg_day	Rp21/kg/day	Inventory holding cost
doc_ck_direct	14 days	CK inventory coverage for direct scenarios
doc_ck_hub	14 days	CK inventory coverage for hub scenarios
doc_hub_customer	8 days	Mini-hub inventory coverage
days_active	26 days/month	Converts monthly demand into daily demand
max_working_hours_per_day	12 hours/day	Vehicle working-time constraint
avg_speed_kmh	52 km/hour	Converts distance into travel time
unloading_time_per_stop_hour	1.5 hour/stop	Adds unloading time to route cycle time
road_multiplier	1.3	Converts Haversine distance to road-adjusted distance
toll_matrix_cost_per_km	Rp1,494/km	Estimates toll cost
vehicle_capacity_kg	2,500 kg/vehicle	Determines trip requirement
variable_cost_per_km	Rp910/km	Distance-based transport cost
daily_fixed_cost_veh	Rp304,459/vehicle/day	Daily fixed vehicle cost

The Python-based logistics cost model evaluates the four scenarios using consistent parameters. Table 8 presents the comparative logistics cost results. Scenario 3 produces the lowest total logistics cost of Rp2,077,372,202.86 per month and the lowest cost per kilogram of Rp181,464.28/kg. Compared with the baseline Scenario 1, Scenario 3 reduces monthly logistics costs by Rp43,525,904.14, or approximately 2.05%, driven primarily by lower transportation costs of Rp97,141,594 versus Rp140,667,498 in Scenario 1.

Table 8.

Comparative logistics cost across scenarios

Scenario	Total Logistics Cost/Month (Rp)	CPK (Rp/kg)	Mini-Hub Count	Rank
S1: Existing CK – Direct	2,120,898,107	185,266.39	0	2
S2: Existing CK – Hub	2,435,606,171	212,757.02	3	4
S3: Optimal CK – Direct	2,077,372,203	181,464.28	0	1
S4: Optimal CK – Hub	2,403,372,755	209,941.34	3	3

Hub-based scenarios (S2, S4) generate higher total logistics costs because the savings in transportation costs are more than offset by additional mini-hub facility costs (Rp200,000,524), investment costs (Rp100,000,262), and inventory holding costs. CK facility cost and CK investment cost are the largest cost components across all scenarios because every scenario requires the same CK production and storage capacity.

4.4 Sensitivity Analysis

Sensitivity analysis is applied to three parameters: demand variation, transportation cost variation, and inventory coverage (DOC) policy. Table 9 presents the TLC range for each parameter across scenarios. Demand variation produces the largest TLC range across all scenarios, confirming that demand uncertainty is the dominant cost driver. DOC policy variation creates a stronger impact on hub-based scenarios (TLC range Rp1,061,718,369) than on direct scenarios (Rp533,351,331) because inventory is distributed across both CK and mini-hub levels. Variation in transportation costs has the smallest effect. Scenario 3 shows the lowest or joint-lowest cost exposure across the three parameters tested.

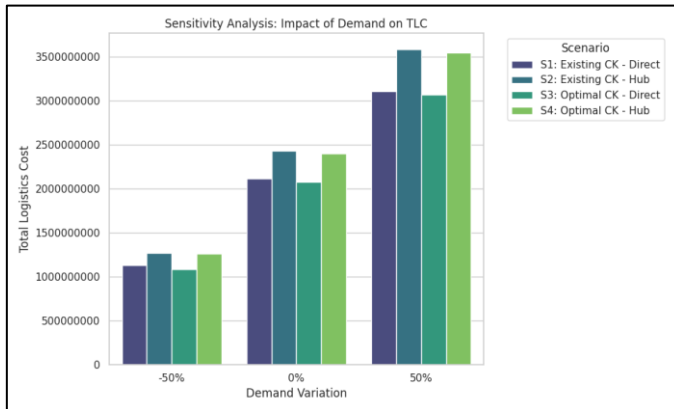


Figure 7.
Sensitivity analysis – impact of demand on TLC

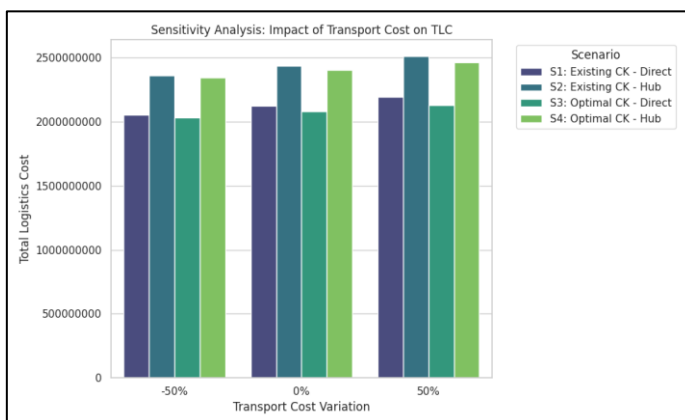


Figure 8.
Sensitivity analysis – impact of transport cost on TLC

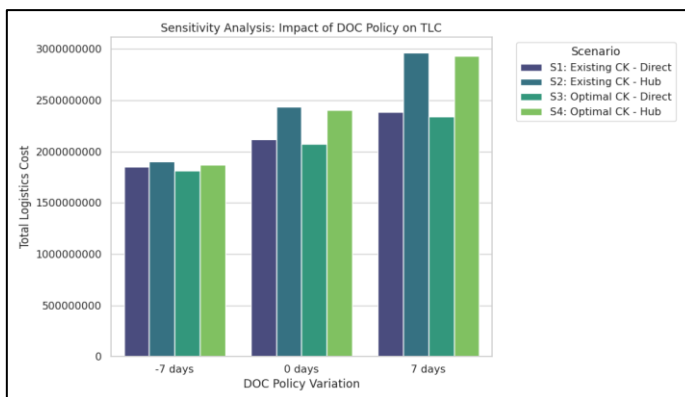


Figure 9.
Sensitivity analysis – impact of DOC policy on TLC

4.5 AHP-Based Multi-Criteria Evaluation

The AHP model evaluates the four distribution network scenarios against four criteria: Total Logistics Cost (C1), Service and Product Quality (C2), Operational Complexity and Control (C3), and Supply Reliability and Supplier Proximity (C4). Pairwise comparison inputs are collected from three internal decision makers – two owners and one Head of Central Kitchen – and aggregated using the geometric mean method.

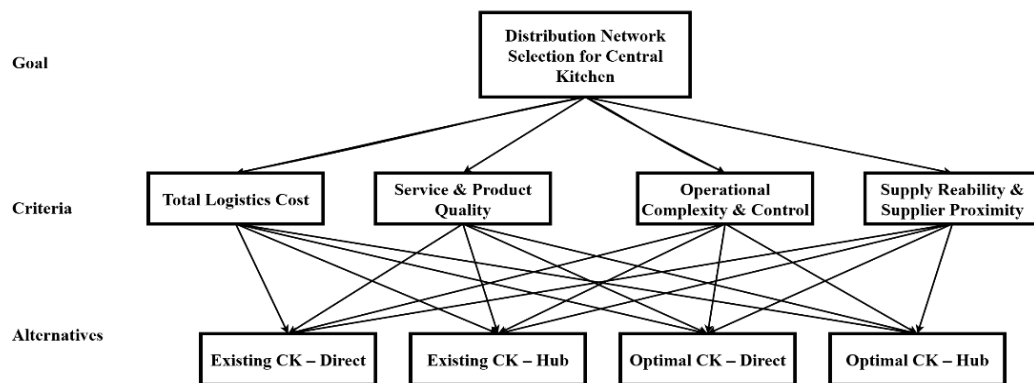


Figure 10.
AHP decision hierarchy for distribution network selection

Table 10.
AHP criteria weight results

Criterion	Weight	Rank
Service and Product Quality	0.421876	1
Supply Reliability and Supplier Proximity	0.407305	2
Total Logistics Cost	0.110602	3
Operational Complexity and Control	0.060217	4

Service and Product Quality receives the highest weight of 0.421876, followed by Supply Reliability and Supplier Proximity at 0.407305. These two non-financial criteria together make up more than 80% of the total decision weight. Total Logistics Cost, despite being the focus of the cost model, receives a weight of only 0.110602.

Main Network: AHP Super Decision.sdm: ratings: Weighted Super Matrix						
Clusters	Nodes	1. Best Alternative	1.Total Logistics Cost	2. Service &Product Quality	3. Operational Complexity & control	4. Supply reability & supplier proximity
1.Goal	1. Best Alternative	0.000000	0.000000	0.000000	0.000000	0.000000
2. Criteria	1.Total Logistics Cost	0.110602	0.000000	0.000000	0.000000	0.000000
	2. Service &Product Quality	0.421876	0.000000	0.000000	0.000000	0.000000
	3. Operational Complexity & control	0.060217	0.000000	0.000000	0.000000	0.000000
	4. Supply reability & supplier proximity	0.407305	0.000000	0.000000	0.000000	0.000000
3. Alternative	1. CK Serang -> All Outlet	0.000000	0.264735	0.213875	0.583878	0.075494
	2. CK Serang -> Hubs -> outlets	0.000000	0.230769	0.598357	0.074929	0.276401
	3. CK Geo Optimal -> all Outlet	0.000000	0.270729	0.097452	0.270875	0.075494
	4. CK GeoOptimal -> hubs -> outlet	0.000000	0.233766	0.090317	0.070317	0.572611

Figure 11.
Super Decisions weighted super matrix output

Table 11.
Alternative weight results by criterion

Alternative	Total Logistics Cost	Service & Product Quality	Operational Complexity & Control	Supply Reliability & Supplier Proximity
S1: Existing CK–Direct	0.264735	0.213875	0.583878	0.075494
S2: Existing CK–Hub	0.230769	0.598357	0.074929	0.276401
S3: Optimal CK–Direct	0.270729	0.097452	0.270875	0.075494
S4: Optimal CK–Hub	0.233766	0.090317	0.070317	0.572611

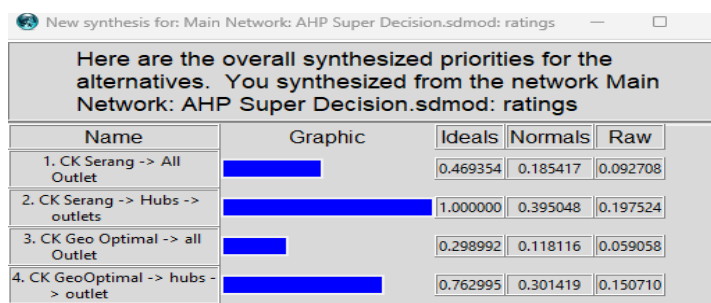
All pairwise comparison matrices achieve consistency ratios below 0.10 (criteria matrix: 0.04971; Service and Product Quality: 0.09585; Operational Complexity and Control: 0.08237; Supply Reliability and Supplier Proximity: 0.09334), confirming acceptable judgement consistency.

Table 12.

Final AHP synthesis and ranking

Alternative	Normalised Priority	Rank
S2: Existing CK – Hub	0.395048	1
S4: Optimal CK – Hub	0.301419	2
S1: Existing CK – Direct	0.185417	3
S3: Optimal CK – Direct	0.118116	4

Scenario 2 (Existing CK–Hub) achieves the highest final priority of 0.395048 because it scores highest under Service and Product Quality (local priority 0.598357), which carries the greatest decision weight. Despite Scenario 3's superior cost performance, its low scores under service and supply criteria result in the lowest final AHP priority (0.118116). The gap between the Python cost ranking (Scenario 3 first) and the AHP ranking (Scenario 2 first) reflects a clear trade-off by management: they accept higher logistics costs in return for better outlet service reliability, more consistent products, and steadier downstream stock availability as the outlet network grows.

**Figure 12.**

Final AHP synthesis output from Super Decisions

5. DISCUSSION

The findings reveal a deliberate divergence between the cost-optimal solution and the strategically preferred solution. The Python logistics cost model ranks Scenario 3 (Optimal CK–Direct) first on pure cost efficiency, whereas the AHP synthesis ranks Scenario 2 (Existing CK–Hub) first once non-financial criteria are considered. This gap is not a contradiction but rather the central managerial insight of the study: the choice of distribution network depends on how much weight decision-makers place on service and supply performance relative to cost.

Because Service and Product Quality (0.421876) and Supply Reliability and Supplier Proximity (0.407305) together account for more than 80% of the decision weight, the mini-hub configuration's advantage on downstream availability and service consistency outweighs its higher logistics cost. In practical terms, management accepts an incremental monthly cost over the cost-optimal benchmark in exchange for buffered inventory closer to the Jakarta–Bekasi outlet cluster, more reliable replenishment, and steadier product quality as the network scales. The sensitivity analysis reinforces this reasoning: demand variation is the dominant cost driver, so a configuration that buffers demand at mini hubs reduces the operational risk that matters most during expansion.

These results are consistent with prior work showing that facility location, capacity, and distribution model selection jointly determine cost and service performance in food-service networks (Devin & Widaningrum, 2021; Guidani *et al.*, 2022), and that multi-criteria methods such as AHP are well-suited to reconciling quantitative cost data with qualitative

managerial priorities (Parnell *et al.*, 2013; Kurniawan *et al.*, 2024). The study's contribution is to demonstrate how a cost-efficiency benchmark and a multi-criteria evaluation can be used together, rather than in isolation, to guide a real expansion decision in a small-to-medium Indonesian F&B company.

The divergence between the cost-optimisation result (Scenario 3) and the AHP result (Scenario 2) deserves closer interpretation. In cost- or location-focused studies such as Fujii *et al.* (2013), Devin and Widaningrum (2021), and Kurniawan *et al.* (2024), the recommended configuration is typically the one that minimises cost or distance, because non-financial criteria are not modelled explicitly. In this study, the direct-delivery network is likewise the cheapest, which is consistent with those findings; the difference is that once service quality and supply reliability are weighted through AHP, the hub-based network becomes preferred. This shows that a purely cost-optimal recommendation can reverse when managerial priorities are made explicit — a nuance that single-lens studies cannot capture. The result aligns with Parnell *et al.* (2013), who argue that multi-criteria methods are needed precisely where cost and qualitative objectives conflict, and it extends prior food-service network studies by quantifying the cost premium (about 2%) that management is willing to pay for higher service reliability.

Table 13 summarises why the cost-optimisation result (Scenario 3) and the AHP result (Scenario 2) diverge.

Table 13.

Reasons for the difference between the cost-optimisation and AHP results

Aspect	Cost Model (Python)	AHP Evaluation	Reason for the Difference
Top-ranked scenario	S3: Optimal CK–Direct (Rank 1)	S2: Existing CK–Hub (Rank 1)	Cost model ranks on TLC/CPK only; AHP adds non-financial criteria
Key metric	TLC Rp2,077 bn/month; CPK Rp181,464/kg (2.05% saving)	Normalised priority 0.395048 (S2) vs 0.118116 (S3) Cost only 0.110602	Cheapest network (S3) scores lowest once service/supply are weighted
Decision weight	Implicitly 100% on cost	Service Quality 0.421876 Supply Reliability 0.407305 (>80%)	Management values service and supply far more than cost
S3 weakness	Best on cost	Low on Service Quality (0.097452) and Supply Reliability (0.075494)	Direct delivery gives no downstream buffer near outlet clusters
S2 strength	Higher cost (hub facility, CAPEX, holding)	Highest Service Quality (0.598357) Strong Supply Reliability	Mini hubs buffer inventory closer to the Jakarta–Bekasi cluster
Interpretation	Cost-efficiency benchmark	Strategically preferred network	Management accepts ~2% cost premium for reliability and quality

Managerially, the findings imply that Toko Bakmi Kita should not select its distribution network on logistics cost alone. Because service quality and supply reliability jointly carry more than 80% of the decision weight, the hub-based Scenario 2 is the more defensible choice for protecting brand consistency and product availability during expansion, provided the firm can absorb the modest cost premium. The framework also gives management a repeatable tool: as the outlet map or cost assumptions change, the capacity, cost, and AHP modules can be re-run to re-evaluate the preferred network, supporting a phased, evidence-based rollout rather than a one-off decision.

This study has several limitations that also define directions for future research. First, it is a single-case study, so the specific numerical results are context-bound and not statistically generalisable, although the integrated framework is transferable to other food-service SMEs. Second, the AHP weights rely on three internal decision makers; future work could widen the respondent base or apply fuzzy-AHP to capture judgement uncertainty. Third, the logistics cost model uses cluster-first, route-second heuristics and demand forecasts; incorporating exact vehicle-routing optimisation, stochastic demand, and perishability constraints would improve realism. Finally, validating the recommended network through an actual mini-hub pilot would provide empirical confirmation of the modelled trade-offs.

6. CONCLUSION

This study's integrated analytical framework addresses three research questions for Toko Bakmi Kita's distribution network design.

First, the capacity analysis determines that the current CK is insufficient for the planned expansion. The ten-outlet network requires a CK production area of 382.21 m² and a CK storage area of 140.00 m². Mini hubs serve as downstream inventory buffers, providing eight days of coverage. Three mini-hub service areas are identified around Tebet, Karawang, and Serang, with the Tebet/Jakarta–Bekasi cluster carrying the greatest assigned demand.

Second, Scenario 3 (Optimal CK–Direct) delivers the lowest total logistics cost of Rp2,077,372,202.86 per month and the lowest CPK of Rp181,464.28/kg, representing a 2.05% saving over the baseline Scenario 1. Hub-based scenarios incur higher costs because additional mini-hub facilities, investments, and holding costs exceed transportation savings. The analysis confirms that demand variation is the primary cost driver, and that Scenario 3 carries the lowest or joint-lowest cost exposure across the tested parameters.

Third, the AHP identifies Scenario 2 (Existing CK–Hub) as the preferred overall alternative with a normalized priority of 0.395048. Service and Product Quality (weight 0.421876) and Supply Reliability and Supplier Proximity (weight 0.407305) together represent more than 80% of the decision weight, making Scenario 2's strength under these criteria decisive. Although Scenario 2 incurs higher logistics costs than Scenario 3, management values the improvements in downstream product availability, service reliability, and brand consistency that the mini-hub configuration provides.

The overall conclusion is that Scenario 3 is the cost-efficiency benchmark, while Scenario 2 is the strategically preferred solution. The extra mini-hub cost is a deliberate investment in service continuity and product quality during expansion. A phased implementation starting in Q3 2026 – beginning with CK capacity preparation, followed by a controlled mini-hub pilot in the Tebet/Jakarta–Bekasi cluster, and scaling only after pilot evaluation – is recommended to align capital investment with demand growth and minimize financial risk.

Author Contributions: Christian Wibisono was responsible for the conceptualization, methodology, investigation, data curation, formal analysis, visualization, project administration, and preparation of the original draft. Meditya Wasesa contributed to the validation and critical review of the manuscript. Maria Magdalena Wahyuni Inderawati contributed to the validation and critical review of the manuscript. Marie Jane Jumawan-Matero contributed to the validation, review, and editing of the manuscript. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Conflict of Interest: The authors declare no conflict of interest.

Declaration of Generative AI Statement: During the preparation of this work, the authors used ChatGPT as an AI-assisted tool to improve the readability, language, and presentation of the manuscript, and to assist with the visual organization and readability of figures based on the authors' original research content and data. ChatGPT was not used to generate, analyze, or interpret research data, determine methodological decisions, research findings, or conclusions. The authors retained full control over the scientific content, data, methodology, and interpretation presented in the manuscript. All AI-assisted content and figures were carefully reviewed, verified, and edited by the authors as necessary. The authors take full responsibility for the content of the published article.

REFERENSI

- Apicbase. (2023). What is a central production kitchen and how does it work?. (<https://get.apicbase.com/central-production-kitchen/>). Di akses tanggal 1 Agustus 2026
- Badan Pusat Statistik. (2025). *Rata-rata pengeluaran per kapita seminggu menurut kelompok makanan minuman jadi, 2019–2024*. BPS-Statistics Indonesia. (<https://www.bps.go.id/>). Di akses tanggal 1 Agustus 2026
- Ballou, R. H. (2004). *Business logistics/supply chain management: Planning, organizing, and controlling the supply chain (5th ed.)*. Pearson.
- Chopra, S., & Meindl, P. (2016). *Supply chain management: Strategy, planning, and operation (6th ed.)*. Pearson.
- Devin, & Widaningrum, D. L. (2021). A GIS-based method for central kitchen location selection problem. *IOP Conference Series: Earth and Environmental Science*, 794(1), 012091.
- Fujii, N., Kaihara, T., Uemura, M., Nonaka, T., & Shimmura, T. (2013). Facility layout planning of central kitchen in food service industry: Application to the real-scale problem. In V. Prabhu, M. Taisch, & D. Kiritsis (Eds.), *Advances in production management systems: Sustainable production and service supply chains* (pp. 33–40). USA:State College.
- Guidani, B., Accorsi, R., Manzini, R., & Ronzoni, M. (2022). *Post-pandemic strategic planning of food catering production and distribution networks: A regional case study*. *Transportation Research Procedia*, 67, 46–55.
- Heizer, J., Render, B., & Munson, C. (2017). *Operations management: Sustainability and supply chain management (12th ed.)*. Pearson.
- Heizer, J., Render, B., & Munson, C. (2020). *Operations management: Sustainability and supply chain management (13th ed.)*. Pearson.
- Jacobs, F. R., & Chase, R. B. (2018). *Operations and supply chain management (15th ed.)*. McGraw-Hill Education.
- Kurniawan, A. C., Redi, A. A. N. P., Amarajaya, D., Hernawati, T. R., & Adipramana, I. D. G. Y. (2024). Optimal location selection for mega-kitchens in the network design of free lunch programs in Nusa Tenggara Barat. *Jurnal Serambi Engineering*, 9(4), 10577–10590.
- MacQueen, J. (1967). Some methods for classification and analysis of multivariate observations. *Proceedings of the Fifth Berkeley Symposium on Mathematical Statistics and Probability* (pp. 281–297). University of California Press.
- Parnell, G. S., Bresnick, T. A., Tani, S. N., & Johnson, E. R. (Eds.). (2013). *Handbook of decision analysis*. Wiley.
- Saaty, T. L. (1980). *The analytic hierarchy process: Planning, priority setting, resource allocation*. McGraw-Hill.
- Saaty, T. L. (2008). Decision making with the analytic hierarchy process. *International Journal of Services Sciences*, 1(1), 83–98.
- Saltelli, A., Ratto, M., Andres, T., Campolongo, F., Cariboni, J., Gatelli, D., Saisana, M., & Tarantola, S. (2008). *Global sensitivity analysis: The primer*. Wiley.
- Deng, A. (2023). Supply chain innovation in the catering industry: An assessment of the cost-effectiveness and sustainability of the central kitchen model. *Advances in Economics, Management and Political Sciences*, 65, 188–194.
- Rasulov, R. (2024). Optimization of direct supply chains in the restaurant industry: Addressing key challenges through technological innovation. *Economics of Development*, 23(3), 93–103.
- Liu, Y. (2023). A comprehensive analysis of the Chinese chain restaurant market: Success factors, challenges, and strategies for improvement. *BCP Business & Management*, 49, 700–706.
- Yin, R. K. (2018). *Case study research and applications: Design and methods (6th ed.)*. Sage.