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SERVICE WORKSHOP LOCATION SELECTION USING NETWORK-BASED MCLP AND MULTI-CRITERIA DECISION ANALYSIS: INTEGRATING ACCESSIBILITY, INDUSTRIAL SUITABILITY, AND FLOOD RISK ASSESSMENT IN EAST JAVA

PEMILIHAN LOKASI BENGKEL LAYANAN MENGGUNAKAN MCLP BERBASIS JARINGAN DAN ANALISIS KEPUTUSAN MULTI-KRITERIA: MENGINTEGRASIKAN AKSESIBILITAS, KESESUAIAN INDUSTRI, DAN PENILAIAN RISIKO BANJIR DI JAWA TIMUR

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ABSTRACT

This study addresses the strategic problem of service facility location for small and medium enterprises (SMEs) operating in geographically diverse and risk-prone regions, using a spatial decision-support framework. The research focuses on PT Cahaya Amanah Nusantara (PT CAN), an Indonesian SME providing refrigeration repair and maintenance services, and applies a quantitative geospatial analysis design. Data were derived from OpenStreetMap road networks, historical service request records, administrative spatial data, and managerial assessments. The analysis was conducted in three stages. First, service coverage was evaluated through travel-time-based accessibility analysis under Service-Level Agreement (SLA) constraints, and optimal candidate locations were identified using the Maximal Covering Location Problem (MCLP) with a single-facility objective. Second, the selected locations were assessed based on strategic geographic and environmental factors, including industrial activity density and flood risk exposure. Third, a Multi-Criteria Decision Analysis (MCDA) using the Weighted Linear Combination (WLC) method integrated accessibility performance, environmental risk, and strategic suitability based on managerial weighting preferences. The results indicate that Kabupaten Gresik achieved the highest composite score of 0.937016, reflecting strong SLA performance and high strategic attractiveness, despite a relatively low environmental contribution. The findings demonstrate that the proposed framework provides a transparent, logic-based, and easily interpretable decision-making tool for ranking service facility locations and evaluating trade-offs between efficiency, alignment, and robustness. This study contributes an open-source, SME-oriented geospatial decision-support approach for facility location planning in heterogeneous and risk-sensitive environments.

Keywords: *Small And Medium Enterprises, Geographic Information Systems, Service-Level Agreement, Maximal Covering Location Problem, Weighted Linear Combination, Facility Location*

ABSTRAK

Penelitian ini membahas masalah strategis penentuan lokasi fasilitas layanan bagi usaha kecil dan menengah (UKM) yang beroperasi di wilayah geografis yang beragam dan berisiko tinggi, menggunakan kerangka kerja dukungan keputusan spasial. Penelitian ini berfokus pada PT Cahaya Amanah Nusantara (PT CAN), sebuah UKM Indonesia yang menyediakan layanan perbaikan dan pemeliharaan pendingin, dan menerapkan desain analisis geospasial kuantitatif. Data diperoleh dari jaringan jalan OpenStreetMap, catatan permintaan layanan historis, data spasial administratif, dan penilaian manajerial. Analisis dilakukan dalam tiga tahap. Pertama, cakupan layanan dievaluasi melalui analisis aksesibilitas berbasis waktu perjalanan dengan batasan Perjanjian Tingkat Layanan (SLA), dan lokasi kandidat optimal diidentifikasi menggunakan Masalah Lokasi Penutup Maksimal (MCLP) dengan tujuan fasilitas tunggal. Kedua, lokasi yang dipilih dievaluasi berdasarkan faktor geografis dan lingkungan strategis, termasuk kepadatan aktivitas industri dan paparan risiko banjir. Ketiga, Analisis Keputusan Multi-Kriteria (MCDA) menggunakan metode Kombinasi Linier Berbobot (WLC) mengintegrasikan kinerja aksesibilitas, risiko lingkungan, dan kesesuaian strategis berdasarkan preferensi bobot manajerial. Hasil penelitian menunjukkan bahwa Kabupaten Gresik meraih skor komposit tertinggi sebesar 0.937016, mencerminkan kinerja SLA yang kuat dan daya tarik strategis yang tinggi, meskipun kontribusi lingkungan relatif rendah. Temuan ini menunjukkan bahwa kerangka kerja yang diusulkan menyediakan alat pengambilan keputusan yang transparan, berbasis logika, dan mudah diinterpretasikan untuk peringkat lokasi fasilitas layanan serta evaluasi trade-off antara efisiensi, keselarasan, dan ketahanan. Studi ini menyumbangkan pendekatan

dukungan keputusan geospasial sumber terbuka yang berorientasi pada UMKM untuk perencanaan lokasi fasilitas di lingkungan heterogen dan sensitif risiko.
Kata kunci: Usaha Mikro, Kecil, dan Menengah (UMKM), Sistem Informasi Geografis (SIG), Perjanjian Tingkat Layanan (SLA), Masalah Lokasi Penutup Maksimal, Kombinasi Linier Berbobot, Lokasi Fasilitas

INTRODUCTION

Small and Medium Enterprises (SMEs) play a critical role in supporting Indonesia's industrial ecosystem, particularly as service providers for large-scale manufacturing and consumer goods sectors. One such sector is refrigeration repair and maintenance, which is essential for the food and beverage industry, ice cream production, and cold storage operations. In these industries, service efficiency, responsiveness, and reliability directly affect production continuity and contractual performance. As competition intensifies and customer requirements become more stringent, SMEs operating in technical service sectors are increasingly required to improve operational efficiency and strategic responsiveness.

PT Cahaya Amanah Nusantara (PT CAN) is an Indonesian SME specializing in repair and maintenance services for ice cream refrigeration units. The company serves several major domestic and multinational fast-moving consumer goods (FMCG) clients and has expanded its service coverage beyond its initial workshop in Bekasi to additional locations in Tangerang and Pontianak. This expansion reflects growing demand for geographically proximate technical services that can meet strict service-level expectations and minimize equipment downtime.

Demand for refrigeration services has increased in parallel with the rapid growth of Indonesia's ice cream and cold-chain industries. According to IMARC Group (2024), Indonesia's ice cream market was valued at USD 1,015.0 million in 2024 and is projected to reach USD 1,628.0 million by 2033, with a compound annual growth rate of 5.39%. This growth intensifies the need for timely repair and maintenance services to ensure operational continuity. For service-oriented SMEs such as PT CAN, the ability to respond quickly to client requests has become a key determinant of competitiveness.

In 2025, PT CAN was presented with a strategic opportunity to serve a new corporate client in East Java. However, the client required the establishment of a local workshop facility to ensure rapid response times and reduced logistical inefficiencies. Relying on existing workshops in Bekasi and Tangerang to serve East Java resulted in long travel distances, higher operational costs, and extended service lead times. This situation created an urgent need for PT CAN to identify a suitable workshop location in East Java that could meet service-level expectations while remaining operationally and strategically viable.

Such circumstances reflect a common challenge faced by SMEs, where strategic expansion decisions must be made under time pressure and with limited access to analytical decision-support tools. In practice, facility location decisions in SMEs often rely on managerial intuition, personal experience, or client recommendations. While such approaches enable rapid decision-making, they also increase the risk of suboptimal location choices, leading to inefficiencies, elevated costs, and exposure to environmental hazards such as flooding. Prior studies highlight that limited access to structured decision-support systems frequently leads SMEs to ad hoc expansion decisions with insufficient long-term

evaluation (Conlan et al., 2022; Johanson & Oliveira, 2024).

The geographic complexity of East Java, characterized by dispersed industrial centers, heterogeneous infrastructure quality, and varying environmental risks, further complicates location selection. Accessibility alone is insufficient to determine suitability, as environmental exposure and strategic alignment with industrial activity also affect operational sustainability. Workshop facilities located in flood-prone areas face heightened risks of service disruption, asset damage, and increased maintenance costs, underscoring the importance of integrating environmental considerations into location planning.

Given these challenges, selecting a workshop location based solely on intuition poses a significant risk to PT CAN's operational performance and service reliability. This study therefore proposes a structured, spatially informed decision-support approach to evaluate candidate workshop locations in East Java. By integrating network-based accessibility analysis, industrial activity assessment, and flood-risk evaluation, the study aims to support evidence-based facility location decisions that balance service efficiency, strategic alignment, and environmental risk mitigation.

RESEARCH METHODS

This study employs a quantitative, sequential spatial decision-support design to evaluate the optimal workshop location for PT Cahaya Amanah Nusantara (PT CAN) in East Java. The analysis integrates company operational data with geospatial datasets and applies a three-stage analytical framework consisting of network-based accessibility screening, spatial strategic–environmental assessment, and multi-criteria decision synthesis. Primary data include the distribution of PT CAN's client cities in East Java and historical monthly service project records, which are aggregated and normalized to represent demand weights. Secondary data consist of road network data from OpenStreetMap, administrative boundary data, industrial activity information, and flood hazard exposure data obtained from official government sources.

Accessibility analysis is conducted using road-network travel-time modelling under a predefined Service-Level Agreement (SLA) threshold of 240 minutes. Shortest-path travel times between candidate hub locations and client cities are computed and evaluated using demand-weighted coverage analysis. Candidate hubs are ranked using the Maximal Covering Location Problem (MCLP) with a single-facility objective to identify operationally feasible locations. Shortlisted hubs are subsequently assessed based on strategic suitability and environmental risk, represented by industrial activity intensity and flood hazard exposure at the administrative-area level.

The final location decision is determined through Multi-Criteria Decision Analysis (MCDA) using the Weighted Linear Combination (WLC) method. Accessibility performance, strategic suitability, and environmental risk are normalized and aggregated using managerial preference weights to produce a composite suitability score for each candidate location. All analyses are implemented using Python-based geospatial and computational tools, ensuring transparency and replicability of the decision-support framework.

RESULTS AND DISCUSSIONS

Network-Bases Accesbility Reuslt (Operational Implication)

The establishment of a service workshop in East Java has substantial operational implications for PT Cahaya Amanah Nusantara (PT CAN), particularly with respect to service responsiveness, technician mobility, and compliance with Service-Level Agreement (SLA) requirements. Network-based analysis confirms that workshop location directly determines the proportion of client demand that can be served within acceptable response-time limits. This finding demonstrates that spatial expansion into East Java is not merely an administrative or logistical adjustment, but a structural operational decision that reshapes the firm's service delivery system.

The road-network analysis indicates full routability across the East Java transportation network, with all candidate hub–demand city pairs producing finite travel times. This result confirms that the observed variation in accessibility performance reflects real spatial and infrastructural constraints rather than artifacts of incomplete data or disconnected network segments. The completeness of the origin–destination matrix provides a robust foundation for interpreting subsequent SLA-based accessibility outcomes.

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Finite ratio: 1.0
Median OD (min): 245.89762040023908
Max OD (min): 646.1268156409293
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Figure 1. OD Matrix Computation Using Python

Despite full routability, the distribution of travel times varies substantially across candidate hubs. Some locations exhibit consistently shorter travel times to a wide range of client cities, while others show uneven accessibility patterns characterized by strong access to a limited subset of cities and prolonged travel times to the remainder. These spatial disparities illustrate why intuitive or distance-based location selection is insufficient in East Java, where heterogeneous road quality and demand dispersion strongly influence service efficiency.

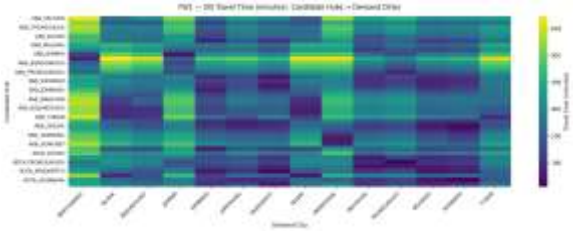

Figure 2. SLA Result Heatmap Visualization.

To reflect actual service workload, accessibility performance is evaluated using demand-weighted SLA coverage rather than unweighted reachability. The results demonstrate that when service demand intensity is incorporated, accessibility rankings change significantly. Candidate hubs that appear geographically central do not necessarily achieve high demand-weighted coverage if they are poorly aligned with high-demand cities. This confirms that operational efficiency is shaped by the interaction between spatial location and demand concentration, rather than proximity alone.

From an operational standpoint, high demand-weighted SLA coverage implies a greater ability to meet response-time commitments for the majority of service workload. This translates into reduced cumulative technician travel time, improved scheduling stability, and higher effective service capacity. Conversely, hubs with lower coverage scores would impose higher travel burdens on technicians, increasing fatigue, response variability, and operational costs. These findings show that workshop placement has direct implications for labor productivity and service reliability.

Environmental conditions introduce additional implications that are not captured by accessibility metrics alone. Flood hazard assessment reveals

considerable variation in environmental exposure across East Java. Certain candidate hub locations are situated within administrative areas characterized by extensive flood-prone spatial coverage and higher hazard severity, while others exhibit relatively limited exposure. These differences imply that workshop location affects not only routine service efficiency but also vulnerability to disruption during extreme weather events.

Flood exposure influences operational performance through multiple channels. High-risk areas are more likely to experience road closures, traffic congestion, and infrastructure degradation during heavy rainfall, undermining the reliability of otherwise efficient service routes. In addition, environmental disruption can affect technician availability, workshop operability, and asset protection. As a result, environmental vulnerability may erode operational gains achieved through optimal accessibility under normal conditions.

Importantly, the results indicate that strong accessibility performance does not automatically correspond to low environmental risk. Some candidate hubs that perform well in SLA-based coverage are associated with moderate to high flood exposure, while environmentally safer locations may exhibit weaker accessibility to high-demand cities. This divergence highlights a fundamental trade-off between service efficiency and operational resilience that must be addressed explicitly in location planning.

The interaction between accessibility and environmental risk demonstrates the limitations of single-criterion decision-making. Selecting a workshop location based solely on minimizing travel time may increase exposure to environmental disruption, while prioritizing environmental safety alone may compromise SLA compliance. The findings therefore justify the use of a sequential evaluation approach in which operational feasibility is established first, followed by environmental assessment as a moderating constraint rather than an exclusionary filter.

Environmental risk functions as a conditional factor that shapes the robustness of operational performance rather than negating feasibility outright. Locations with moderate environmental exposure may remain viable provided that accessibility performance is sufficiently strong, whereas environmentally favorable locations with weak accessibility may struggle to support service demand efficiently. This reinforces the need to evaluate operational and environmental dimensions jointly rather than independently.

Beyond immediate service implications, the results suggest broader structural consequences for PT CAN's expansion strategy. Establishing a workshop in East Java fundamentally reconfigures service catchment areas and redistributes travel burdens that were previously concentrated on facilities in western Indonesia. The analysis indicates that without a regional workshop, a substantial portion of East Java demand lies beyond efficient service reach, confirming that prior operational inefficiencies were structural rather than incidental.

From a methodological perspective, the findings demonstrate the analytical value of combining network-based accessibility analysis with environmental risk assessment in service facility planning. The ability to trace operational outcomes to spatial characteristics enhances interpretability

and supports evidence-based decision-making under geographic uncertainty.

Overall, the results show that establishing a workshop in East Java entails intertwined operational and environmental implications for PT CAN. Accessibility determines service efficiency and SLA compliance, while environmental exposure shapes operational resilience and reliability. These dimensions interact rather than operate independently, and their combined effect defines the practical feasibility of regional expansion. This integrated understanding provides the analytical foundation for evaluating and comparing suitable candidate hub locations, which is addressed in the subsequent research question.

Suitable Candidate Hubs in East Java Based on Strategic Suitability and Environmental Risk

The identification of suitable workshop hub locations in East Java is conducted through a structured comparison of candidate hubs that have passed the operational feasibility screening. Based on demand-weighted Service-Level Agreement (SLA) coverage, four locations which are Kota Surabaya, Kabupaten Gresik, Kota Mojokerto, and Kabupaten Lamongan were shortlisted as operationally viable alternatives. These hubs demonstrate comparable abilities to serve PT Cahaya Amanah Nusantara's (PT CAN) client demand within the defined SLA threshold, indicating that each location satisfies the minimum operational requirements for regional service deployment.

	hub_name	covered_weight
0	KOTA_SURABAYA	0.915416
1	KAB_GRESIK	0.915416
2	KOTA_MOJOKERTO	0.904098
3	KAB_LAMONGAN	0.904098
4	KOTA_KEDIRI	0.904098
5	KAB_BOJONEGORO	0.789135
6	KOTA_MADIUN	0.789135
7	KAB_BOJONEGORO	0.789135
8	KAB_NGANJUK	0.734453
9	KAB_NGANJUK	0.734453

Figure 3. MCLP Result Covered Weight.

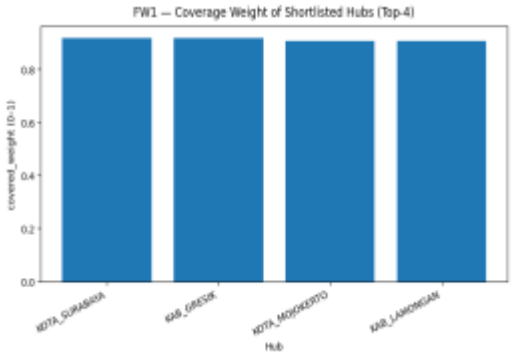

Figure 4. Shortlisted Candidate Hubs Bar Chart.

Although the accessibility-based screening confirms that multiple locations are operationally feasible, the demand-weighted SLA results alone do not provide sufficient differentiation for final decision-making. The coverage scores among the shortlisted hubs show relatively narrow separation, suggesting that accessibility performance by itself may conceal longer-term spatial and contextual limitations. This finding reinforces the necessity of incorporating additional evaluation dimensions that reflect PT CAN's service context, particularly strategic alignment with industrial activity and exposure to environmental risk.

Strategic suitability assessment based on industrial intensity and spatial extent reveals pronounced differences among the shortlisted hubs. Kabupaten Gresik exhibits the strongest strategic profile, characterized by the largest

industrial land area and the highest concentration of industrial estates in East Java. This spatial configuration places Gresik within a dense industrial corridor that aligns directly with PT CAN's core business of industrial refrigeration repair and maintenance. The industrial dominance of Gresik is clearly illustrated in Figure 5. Industrial Area Visualization and further quantified in Figure 6. Industrial Area Size Visualization, which show that Gresik substantially exceeds other shortlisted hubs in terms of industrial land availability.

The concentration of industrial estates within a relatively contiguous geographic corridor reduces fragmentation of service demand and facilitates more efficient technician routing and parts logistics. In contrast, the industrial activity observed in Kota Mojokerto, Kota Surabaya, and Kabupaten Lamongan is more spatially dispersed and limited in extent, which may constrain economies of scale and reduce the long-term efficiency of a centralized service workshop.

Figure 5. Industrial Area Visualization

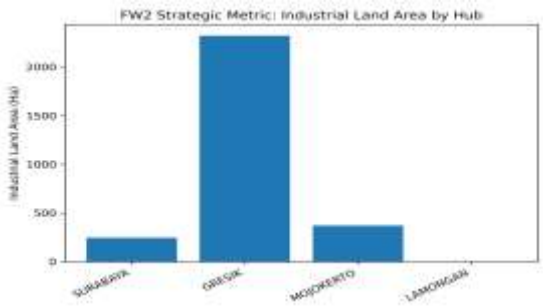

Figure 6. Industrial Area Size Visualization

As it can be seen, Kota Mojokerto demonstrates a moderate level of industrial activity, suggesting balanced but limited strategic suitability. While Mojokerto benefits from compact spatial structure and proximity to certain demand centers, its industrial base is smaller in scale, potentially constraining long-term demand growth for industrial service operations. Kota Surabaya and Kabupaten Lamongan display comparatively weaker strategic alignment within the context of industrial spatial indicators applied in this study. Despite Surabaya's metropolitan status, the spatial distribution of industrial land relevant to PT CAN's service operations is limited, while Lamongan exhibits minimal industrial concentration. These contrasts indicate that urban scale alone does not guarantee strategic suitability for industrial service facilities.

Environmental risk assessment further differentiates the shortlisted hubs by revealing substantial variation in flood exposure across administrative areas. Kota Mojokerto emerges as the most environmentally favorable location, exhibiting minimal flood-affected area and low hazard severity. In contrast, Kabupaten Lamongan shows relatively high flood exposure, reflecting broader flood-prone spatial extent and higher historical hazard records. Kabupaten Gresik and Kota Surabaya occupy intermediate positions, indicating moderate but manageable environmental risk. These patterns are clearly depicted in Figure 7. Flood Hazard Index Visualization and Figure 8. Flood Hazard Area Visualization.

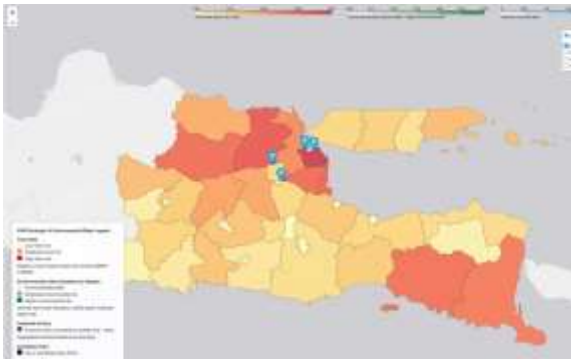

Figure 7. Flood Hazard Index Visualization.

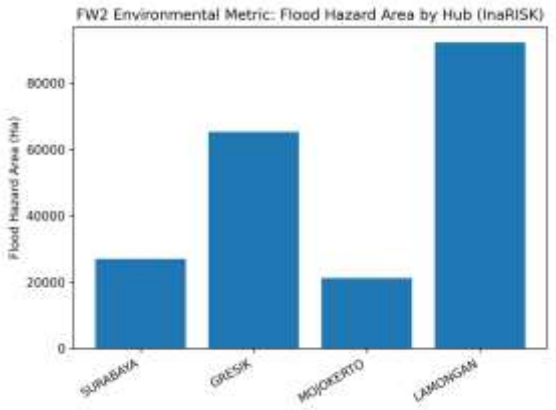

Figure 8. Flood Hazard Area Visualization.

The environmental assessment highlights an important trade-off between strategic suitability and environmental safety. Locations with strong industrial profiles may face higher environmental exposure, while environmentally safer locations may lack sufficient industrial depth to support long-term service expansion. This divergence confirms that environmental risk should be treated as a moderating constraint rather than a single exclusionary criterion in facility location decisions, particularly for small and medium enterprises (SMEs) operating under resource constraints.

Suitable Candidate Hubs in East Java Based on Weighted Linear Combination (WLC)

To reconcile the competing dimensions of accessibility, strategic suitability, and environmental risk, this study applies a Multi-Criteria Decision Analysis (MCDA) using the Weighted Linear Combination (WLC) method. The relative importance of each criterion is defined through a predefined weighting structure that reflects PT Cahaya Amanah Nusantara's operational priorities. Accessibility performance is assigned the greatest importance, as travel-time efficiency and Service-Level Agreement (SLA) compliance directly affect service reliability and customer satisfaction. Strategic industrial suitability is given the second-highest emphasis to ensure alignment with industrial activity and long-term service demand, while environmental suitability is incorporated as a moderating factor to account for operational risk without dominating the decision outcome.

The composite WLC results reveal clear differentiation among the shortlisted hubs. Kabupaten Gresik achieves the highest overall suitability score of 0.937016, as shown in Figure 9. WLC Result of Each Shortlisted Candidate Hub.

	rank	hub_name	kabkota_name_clean	w_sla	w_env	w_str	score_wlc
0	1	KAB_GRESIK	GRESIK	0.450000	0.137016	0.350000	0.937016
1	2	KOTA_MOJOKERTO	MOJOKERTO	0.444436	0.186058	0.120853	0.751548
2	3	KOTA_SURABAYA	SURABAYA	0.450000	0.091881	0.080899	0.622720
3	4	KAB_LAMONGAN	LAMONGAN	0.444436	0.100000	0.000000	0.544436

Figure 9. WLC Result of Each Shortlisted Candidate Hub

This outcome reflects Gresik's strong balance between high accessibility performance and dominant strategic industrial attractiveness, despite a comparatively lower environmental contribution relative to Mojokerto. Kota Mojokerto ranks second, benefiting from superior environmental conditions but constrained by weaker strategic alignment. Kota Surabaya and Kabupaten Lamongan rank third and fourth, respectively, primarily due to limited strategic contributions, even

though their accessibility scores are comparable to other candidates. The final ranking is summarized visually in Figure 10. WLC Result Ranking of Each Shortlisted Candidate Hub.

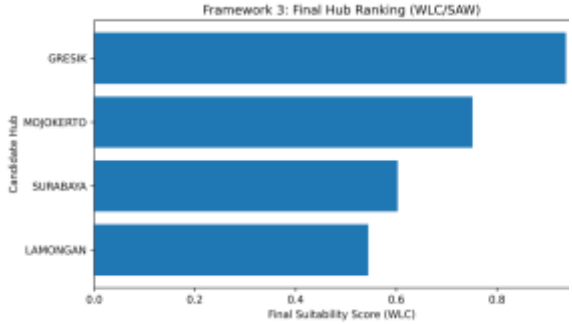

Figure 10. WLC Result Ranking of Each Shortlisted Candidate Hub.

Further insight into the decision outcome is provided by contribution analysis, which decomposes the weighted influence of each criterion on the final composite score. Figure 11. WLC Weighted Contribution by Criterion of Each Shortlisted Candidate Hub illustrates that Kabupaten Gresik derives a substantial portion of its final score from strategic suitability, complemented by strong accessibility performance.

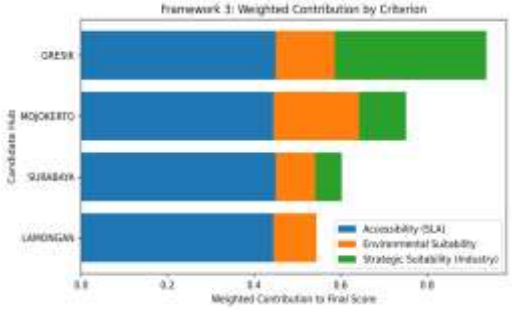

Figure 11. WLC Weighted Contribution by Criterion of Each Shortlisted Candidate Hub.

In contrast, Mojokerto's score is driven primarily by environmental advantage, while Surabaya and Lamongan rely heavily on accessibility with minimal strategic contribution. This decomposition confirms that the final selection is not driven by a single dominant factor, but by an integrated performance profile across multiple criteria.

From a business solution perspective, the results provide a clear and defensible basis for selecting Kabupaten Gresik as the most suitable workshop hub location for PT CAN's expansion into East Java. The decision is grounded in empirical evidence rather than intuition, demonstrating how integrated spatial analysis can support strategic expansion planning for SMEs. The selection of Gresik enables PT CAN to position its service operations within a dense industrial ecosystem while maintaining acceptable environmental risk and strong service accessibility.

The implementation implications of this selection are analytically derived from the spatial results. Establishing a workshop in Kabupaten Gresik allows PT CAN to optimize technician deployment and reduce travel uncertainty when serving high-demand industrial clients, as supported by the accessibility patterns observed in Figure 12. Recommended Hub Road Network Visualization. Strategic alignment with industrial activity further supports phased implementation and scalability, enabling PT CAN to expand service capacity incrementally without requiring immediate large-scale infrastructure investment.

Figure 12. Recommended Hub Road Network Visualization.

Overall, the integrated evaluation confirms that Kabupaten Gresik represents the most balanced workshop location for PT Cahaya Amanah Nusantara's expansion in East Java. Rather than excelling in a single dimension, Gresik achieves a robust overall performance through the combined strength of network-based accessibility, strategic industrial alignment, and manageable environmental risk.

By explicitly synthesizing these dimensions within a Weighted Linear Combination framework, the study demonstrates how complex spatial trade-offs can be translated into a transparent and defensible business decision. This final synthesis positions Kabupaten Gresik not only as the optimal location from an analytical standpoint, but also as a practically feasible hub that aligns operational efficiency, strategic scalability, and risk-aware implementation. As such, the WLC-based evaluation functions as the conclusive decision layer of the analysis, reinforcing the value of integrated spatial decision-support systems for facility location planning in SME contexts.

CONCLUSION AND SUGGESTION

This study demonstrates that an integrated spatial decision-support framework combining network-based accessibility analysis, strategic spatial assessment, and environmental risk evaluation can effectively support facility location decisions for service-oriented small and medium-sized enterprises (SMEs). By applying this framework to the case of PT Cahaya Amanah Nusantara (PT CAN), the research addresses the practical challenge of selecting a workshop location in East Java under conditions of spatial complexity, heterogeneous infrastructure, and environmental uncertainty.

The results indicate that Kabupaten Gresik emerges as the most suitable workshop location among the shortlisted alternatives. This outcome is not driven by a single dominant factor, but rather by a balanced performance across operational accessibility, strategic industrial suitability, and environmental feasibility. Network-based analysis confirms that Gresik provides strong Service-Level Agreement (SLA) coverage for major demand cities, while spatial assessment shows that its proximity to concentrated industrial activity aligns closely with PT CAN's service-oriented business model. Although Gresik does not exhibit the lowest environmental risk among candidate locations, its flood exposure remains manageable and does not outweigh its operational and strategic advantages. These findings highlight the importance of evaluating trade-offs explicitly rather than relying on intuition or single-criterion optimization in facility location planning.

From a managerial perspective, the study confirms that data-driven spatial analysis can provide meaningful and actionable decision support for SMEs operating in geographically dispersed service markets. The application of an integrated framework allows PT CAN to justify its expansion strategy transparently, reduce uncertainty in strategic decision-making, and improve alignment between operational performance and long-term business objectives. The results also suggest that environmental risk should be treated as a moderating consideration that informs adaptive implementation strategies, rather than as an absolute exclusion criterion, particularly in resource-constrained SME contexts.

Based on these conclusions, it is recommended that PT Cahaya Amanah Nusantara proceed with the establishment of a workshop facility in Kabupaten Gresik as the primary operational hub for East Java. Implementation should be conducted in a phased and adaptive manner, supported by continuous monitoring of service response times, SLA compliance, and operational reliability. Strategic engagement with industrial clients located within key industrial corridors surrounding Gresik is also advised to maximize the benefits of spatial proximity and to support scalable service growth. In addition, ongoing awareness of localized environmental risks and the incorporation of flexible routing and contingency planning are essential to maintain service continuity.

From an academic perspective, this study contributes a structured and replicable framework for facility location decision-making that integrates network analysis, spatial risk assessment, and multi-criteria synthesis using open-source data and tools. Future research may extend this framework by incorporating additional criteria such as cost structures, labor availability, or regulatory constraints, as well as by applying it to different regions or service industries to test its generalizability. Longitudinal studies examining post-implementation performance would further strengthen understanding of how analytically derived location decisions translate into real-world operational outcomes. Overall, the findings affirm that spatially informed and analytically grounded decision-making can enhance both managerial effectiveness and strategic resilience in SME facility planning.

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