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Development of River Port (*Kelotok*) In Penajam Paser Utara and Balikpapan by using BOR, LF, AHP and Triangulation Analysis

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KEYWORDS
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ABSTRACT – The River Port in Penajam Paser Utara, East Kalimantan, serves as a vital transportation link connecting the coastal areas between Penajam Paser Utara and Balikpapan. Despite its strategic role, the port currently faces challenges, including limited berth capacity, insufficient supporting facilities, and low operational efficiency in River water transport services. This study, conducted in 2024, aims to analyze the operational characteristics of the River Port and transportation system, evaluate dock efficiency using the Berth Occupancy Ratio (BOR) and Load Factor (LF) methods, and determine infrastructure and service development priorities through the Analytic Hierarchy Process (AHP) approach. The research employs a quantitative, descriptive-analytical method that integrates primary and secondary data. The results show that the port's operational performance requires improvement in dock utilization efficiency and passenger load distribution. Development priorities emphasize increasing transport capacity, optimizing service schedules, enhancing accessibility, and providing essential facilities such as comfortable waiting areas and improved safety systems. The findings highlight that sustainable River transportation development is crucial to supporting urban mobility and regional economic growth in East Kalimantan. Strategic recommendations from this study are expected to strengthen the competitiveness and reliability of River Port services.

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INTRODUCTION

Ports play a crucial role in facilitating the movement of goods and passengers, particularly in regions with limited access to land-based transportation networks. Port infrastructure—including docks, accessibility routes, safety systems, and supporting facilities—must be continuously improved to ensure operational efficiency and maintain competitiveness in the maritime transport sector. Such improvements not only enhance port capacity but also contribute to regional economic development and intermodal connectivity [1].

Penajam Paser Utara (PPU) Regency holds a strategic position due to its proximity to Indonesia's new capital city, Ibu Kota Nusantara (IKN). Within this context, River Port functions as an essential hub for regional mobility and maritime connectivity. According to Law No. 17 of 2008 concerning Shipping, effective port management is fundamental for ensuring smooth logistics flows and improving public welfare [2]. Consequently, upgrading port infrastructure and services has become an urgent priority to support sustainable and efficient water-based transportation systems.

The official government website of PPU identifies River Port as a key transport node serving both passengers and cargo, especially for coastal and island communities [3]. As traditional river-based transport, River vessels play a vital role in connecting residents to economic, educational, and social centers. However, the port currently faces several challenges, including limited berth capacity, unregulated service schedules, and aging infrastructure [4]. The operation of *kelotok* river transport is constrained by inadequate port facilities, limited cargo-handling capacity, and aging infrastructure. These limitations reduce operational efficiency, increase vessel turnaround times, and hinder the ability of river transport services to accommodate growing passenger and freight demand. Similar challenges have been identified in developing inland waterway transport systems, where insufficient terminal facilities and obsolete infrastructure significantly affect service reliability and transport performance [4]. The growing economic and social activities in the region further strain the port's ability to accommodate increasing demand, underscoring the need for comprehensive evaluation and strategic development planning.

East Kalimantan, known as the "Island of a Thousand Rivers," relies heavily on inland waterways for mobility and logistics. In regions such as Balikpapan and Penajam Paser Utara, river transport remains indispensable for inter-regional connectivity. According to the Minister of Transportation Decree No. 73 of 2004 on River and Lake Transport Services, this transport mode encompasses the movement of passengers and goods across rivers, lakes, reservoirs, swamps, canals, and channels [5].

According to data published by the Balikpapan Statistics Agency (BPS), the number of registered *kelotok* vessels serving the Balikpapan–Penajam crossing route increased from 17 units in 2022 to 44 units in 2023. These figures refer specifically to river passenger transport vessels operating on the Balikpapan–Penajam route and do not represent the total number of water transport units in Balikpapan. The substantial increase in the vessel fleet indicates growing demand for cross-bay transportation services and reflects efforts by operators to enhance service capacity. This growth is particularly relevant to the present study, as the number of operating vessels directly influences berth occupancy, service frequency, load factor, and the overall performance assessment of the river transport terminal. Despite this growth, operational challenges persist—especially during peak seasons such as Eid holidays—where limited dock capacity often leads to congestion and long queues, thereby reducing service efficiency [6].

Considering these conditions, this study focuses on the Kelotok Port facilities and crossing services operating on the Penajam–Balikpapan route. The research aims to: (1) analyze the operational characteristics of the port and *kelotok* transportation services based on operational data collected during the survey period; (2) evaluate berth performance using the Berth Occupancy Ratio (BOR), represented by berth utilization and vessel service intensity, and assess transportation service performance using the Load Factor (LF), represented by passenger and motorcycle occupancy rates; and (3) determine priority strategies for port and service development using the Analytic Hierarchy Process (AHP). The AHP analysis incorporates judgments from key stakeholders, including port operators, vessel operators, local government agencies, transportation experts, and service users. The results are expected to provide a comprehensive basis for improving operational performance and supporting the sustainable development of the Penajam–Balikpapan *kelotok* crossing service. The remainder of this paper is organized as follows: Section 2 describes the materials and methods used in the study, Section 3 presents the results and discussion, and Section 4 provides conclusions and recommendations for port and transport development strategies.

METHOD

This study employs a mixed-methods approach combining quantitative and qualitative analyses with a descriptive-analytical framework to evaluate the performance of the Kelotok Port facilities and crossing services on the Penajam–Balikpapan route. Quantitative data were collected through field observations, traffic surveys, and operational records obtained from port operators during the observation period. The survey recorded vessel arrivals and departures, berth occupancy time, passenger volumes, motorcycle volumes, vessel capacities, and service frequencies. These data were used to calculate the Berth Occupancy Ratio (BOR) and Load Factor (LF) as indicators of port and transportation service performance.

The qualitative component was conducted through semi-structured interviews and document reviews. Interview participants consisted of representatives from the port management authority, kelotok vessel operators, local transportation agencies, and service users. The interviews were intended to identify operational constraints, infrastructure deficiencies, safety issues, and future development needs. Secondary data were obtained from the Balikpapan Statistics Agency (BPS), relevant government reports, port operational documents, and previous studies related to river transportation and port development.

The variables analyzed in this study include: (1) berth performance, represented by the number of vessels served, berth service time, number of available berths, and effective operating days; (2) vessel utilization, represented by passenger and motorcycle occupancy rates compared with available vessel capacity; and (3) port development indicators, including terminal infrastructure, floating dock facilities, ticketing facilities, vessel modernization (e.g., catamaran and double-deck vessels), accessibility, and safety facilities. Quantitative data were analyzed using BOR and LF calculations, while qualitative findings were synthesized to identify development priorities. The Analytic Hierarchy Process (AHP) was subsequently applied using expert judgments from key stakeholders to determine priority strategies for improving port facilities and transportation services on the Penajam–Balikpapan crossing route [10].

Data Collection Methods

Primary Data: Obtained from field observations and AHP-based interviews/questionnaires. Secondary Data: Collected from transport agencies and literature, including operational statistics and official reports.

Berth Occupancy Ratio (BOR)

The Berth Occupancy Ratio (BOR) is used to evaluate berth utilization and determine whether existing docking facilities can adequately accommodate vessel traffic. BOR is calculated as the percentage of berth occupancy time relative to the total berth time available during the observation period [11].
Used to evaluate berth utilization:

$$BOR = \frac{Vs \times St}{E\,Time \times n} x100\% \tag{1}$$

Where:
Vs = Number of ships served (unit/year)
St = Service time (hours/day)
n = Number of berths
E Time = Number of operational days/year

According to UNCTAD, the recommended BOR threshold varies with the number of berths, as shown in Table 1.

Table 1. Recommended BOR Threshold by UNCTAD [7].

Number of berths	Recommended BOR
1	40%
2	50%
3	55%
4	60%
5	65%
06-10	70%

Load Factor (LF)

The Load Factor (LF) method is used to assess the utilization level of vessel capacity by comparing actual passenger or motorcycle loads with the available carrying capacity [12].
Used to assess vessel utilization efficiency:

$$\text{LF} = \frac{Kp}{Kt} x100\% \quad (1)$$

Where:
Kp = Utilized capacity (vehicles/passengers)
Kt = Total vessel capacity

The recommended load factor is 70% to 80% for safe and efficient operations [8].

Analytic Hierarchy Process (AHP)

The Analytic Hierarchy Process (AHP), developed by Saaty [13], is used to determine development priorities based on stakeholder judgments. The method structures decision-making problems into hierarchical levels consisting of goals, criteria, sub-criteria, and alternatives. Pairwise comparison matrices are developed using Saaty's 1–9 preference scale to evaluate the relative importance of each criterion. It used to determine development priorities based on multi-criteria decision-making. Stages include hierarchy structuring, pairwise comparison, priority weighting, and consistency analysis [9].

Triangulation Analysis

Triangulation is applied to improve the validity and reliability of the research findings by integrating multiple sources of evidence [14]. In this study, triangulation combines:

1. Field observation data,
2. Operational records and secondary statistics,
3. Stakeholder interview results, and
4. Quantitative performance indicators (BOR and LF).

The triangulation process enables cross-verification among different data sources, ensuring that development recommendations are supported by both quantitative evidence and stakeholder perspectives [14].

Triangulation integrates:

1. BOR results (berth efficiency) → The Berth Occupancy Ratio (BOR) analysis is used to evaluate berth efficiency, indicating how effectively the existing port facilities are utilized.
2. LF results (vessel efficiency) → The Load Factor (LF) analysis aims to assess vessel efficiency, showing the level of passenger capacity utilization on river transport.

3. AHP outcomes (development priorities) → The Analytical Hierarchy Process (AHP) is applied to determine development priorities, integrating the findings of BOR and LF into structured decision-making criteria and alternatives.

Research Stages

The research approach depicted in Figure 1 includes six consecutive stages, starting with the identification of the problem and the establishment of research objectives. This is followed by an extensive review of existing literature to set the theoretical groundwork for the study. Data collection is then carried out through surveys and field observations, after which it is analyzed using three complementary methods: the Berth Occupancy Ratio (BOR), Load Factor (LF), and Analytic Hierarchy Process (AHP).

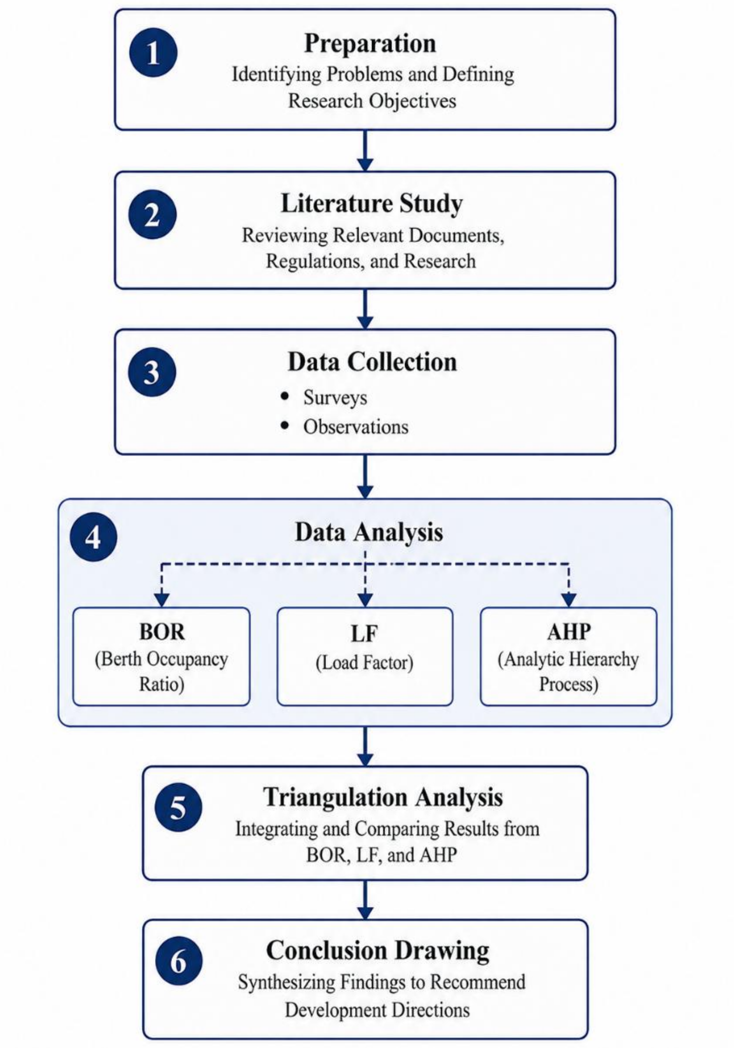


Figure 1. Research Stage

The findings derived from these analyses are combined through triangulation to enhance the dependability and thoroughness of the results. Ultimately, the study concludes with the development of recommendations and future directions based on the integrated results of the analysis.

RESULTS AND DISCUSSION

Overview of The Study Area

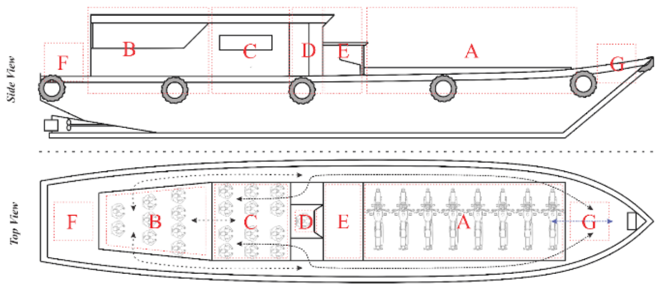
Kampung Baru River Port, Balikpapan

Located at coordinates 1°15'24.0"S 116°49'48.0" E, this port facilitates crossings to Penajam Paser Utara. The terminal spans 0.884 ha and is privately managed under supervision from the Balikpapan Department of Transportation and Port Authority. The deck-on-pile wharf-style pier accommodates up to 10 vessels concurrently.

Penajam River Port, Penajam Paser Utara

This port is situated at 1°14'34.2"S 116°46'39.8"E and spans 0.624 ha. It is similarly managed under private operation with oversight from the local transportation authority. The pier can support 10 berths, matching Kampung Baru's capacity.

Vessel Operations



Code	Area Description
A	Vehicle Area
B	Outer Passenger Area
C	Inner Passenger Area
D	Helmsman Area
E	Cargo Area
F	Anchor Deck Area
G	Embarkation–Disembarkation Deck Area for Passengers and Vehicles

Vehicle Lane
Passenger Lane

Figure 2. General Arrangement of a Klotok Ship with its Dimensions

Based on field observations and operational records obtained from the local river transport operator and port authority, a total of 44 river vessels are registered to serve the crossing route. The operational survey was conducted over a 14-day observation period, covering both weekdays and weekends. During the observation period, an average of 22 vessels were actively operating each day, where *active vessels* are defined as vessels that performed at least one round-trip crossing service within the day. The number of active vessels may vary depending on passenger demand, weather conditions, and vessel maintenance schedules.

As shown in Figure 2, each vessel has a normal operational capacity of 6–8 motorcycles and approximately 25 passengers per trip. During peak-demand periods, such as morning and evening commuting hours or holiday seasons, operators may optimize deck utilization, increasing the carrying capacity to approximately 15 motorcycles and 30 passengers, while still complying with applicable safety regulations. The average daily operation of 22 active vessels was used as the basis for the Load Factor calculation, berth performance evaluation, and the assessment of operational efficiency presented in this study.

Berth Occupancy Ratio (BOR) Analysis

Kampung Baru, Balikpapan Port BOR Analysis

As shown in Figure 3, a survey on May 15, 2025, recorded the average service time (St) for 11 sampled River vessels at 27.091 minutes, or 0.452 hours. With 33,952 vessels (Vs) served in 2024, and assuming 10 berths (n) operating every day of the year (365 days), with the calculation results of the BOR value being 42,04%

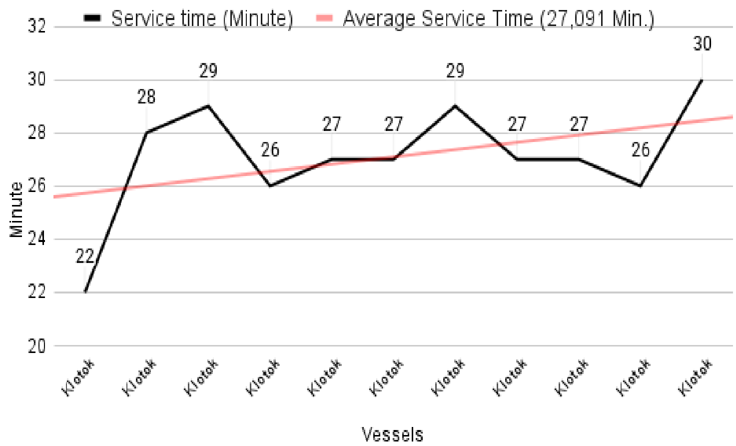


Figure 3. Berth Service Time at Kampung Baru, Balikpapan Port

The resulting BOR of 42.04% is significantly below the UNCTAD-recommended standard of 70% for ports with 6–10 berths, indicating underutilization. Field observations confirmed that, despite having 10 berthing slots, only 3–4 vessels are typically operational, while the others remain docked and inactive.

While wharf congestion was not observed, queuing issues occurred within the terminal area. Vehicle lines extended up to 13 meters, causing delays of 5–8 minutes for ticketing. Contributing factors include narrow vehicle entry lanes and shared ingress/egress routes. Recommended improvements include: Land reclamation to expand terminal staging areas and separate entrance and exit lanes to reduce traffic conflicts.

Penajam Port BOR Analysis

As shown in Figure 4, the same service time survey at Penajam Port revealed an average of 20.818 minutes, or 0.347 hours. The number of vessels served was the same as Kampung Baru's at 33,952 in 2024. the calculation results of the BOR value being 32,27%

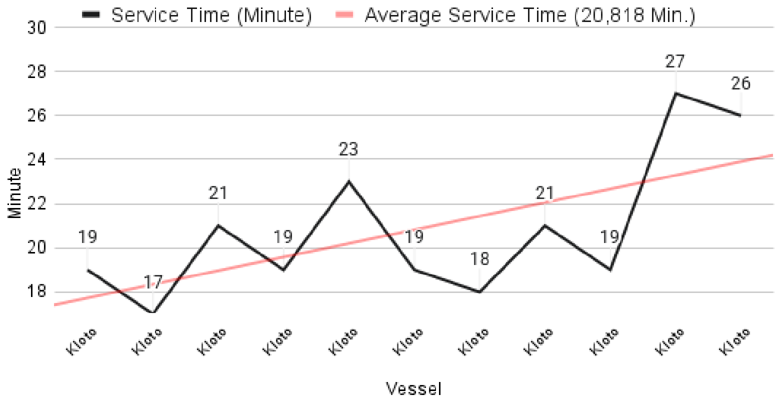


Figure 4. Berth service time at Penajam Port

A BOR of 32.27% is even lower than Kampung Baru's, again falling well short of the 70% benchmark. Observations suggest similar conditions in which only 3–4 berths are actively used. Additionally, vehicle queues reached 15 meters, with similar delays (5–8 minutes), primarily due to limited access and poor traffic flow design. To alleviate congestion, recommended actions include: reclaiming land to enlarge waiting areas and designing dedicated entry and exit paths

BOR Discussion

The BOR analysis for both Kampung Baru and Penajam ports reveals systemic inefficiencies in berth utilization. Despite sufficient physical capacity (10 berths each), the operational deployment of vessels is limited, resulting in BOR values of 42.04% and 32.27%, respectively. These results indicate that corresponding vessel operations do not match physical infrastructure. The mismatch highlights a need for improved scheduling and fleet rotation management. On the landside, both ports suffer from terminal congestion. Although the berths are underused, vehicle bottlenecks emerge due to spatial limitations and inadequate traffic flow design. Such issues hamper overall service quality and user satisfaction.

To address both sea- and landside challenges, an integrated approach is necessary. Key recommendations include:

1. Operational Optimization: Improve scheduling to ensure higher berth rotation rates and reduce idle vessels.
2. Terminal Layout Improvement: Reconfigure traffic circulation within terminals to segregate entry and exit flows.
3. Infrastructure Expansion: Implement targeted reclamation or spatial expansion to improve queuing zones and accessibility.
4. By aligning vessel operations with available infrastructure and enhancing terminal logistics, both ports can better support urban mobility between Balikpapan and Penajam Paser Utara and reduce systemic inefficiencies.

Load Factor (LF) Analysis

Load Factor analysis refers to the percentage of capacity utilization of transport modes, in this case, for both vehicle and passenger River boats. According to the Decree of the Minister of Transportation No. 32 of 2001, Article 24 paragraph (2), an average Load Factor of 70% is recommended before increasing operational capacity on any ferry crossing.

Vehicle Load Factor

As shown in Figure 5, the annual average Load Factor for River motorcycles reached 82.08%. The Load Factor fluctuated monthly, with peaks in November (99.03%) and lows in October (41.96%). However, it is essential to note that there was a data gap or unrecorded entries in the vehicle arrival data during April and October, which may have influenced the calculated Load Factor values for those months. For example, the significant dip in October may not solely indicate a drop in demand or operational disruption but could partially result from incomplete data. Similarly, April's spike to 92.11%—from 44.58% in March—may be attributed to both holiday-related surges and inconsistencies in data recording.

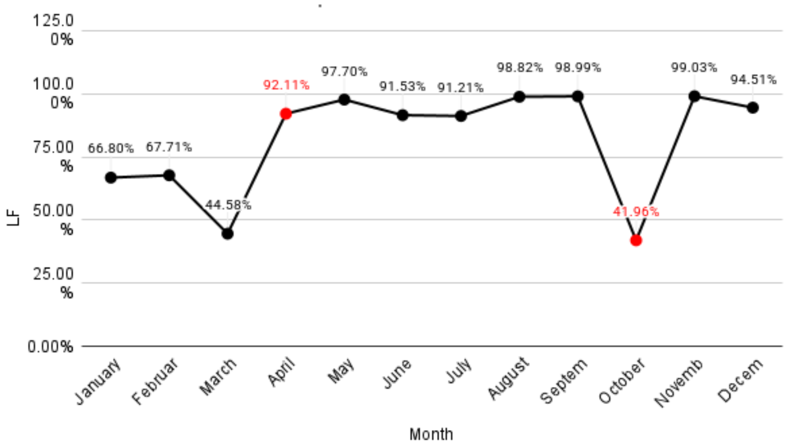


Figure 5. Vehicle Load Factor

These fluctuations highlight the need for better demand forecasting, consistent data monitoring, and adaptive fleet management. Although the annual average exceeded the recommended 70%, the anomalies in April and October indicate inefficiencies and potential safety concerns.

Thus, the following actions are recommended:

1. Adjust fleet allocation during peak/low seasons
2. Monitor vehicle volume trends more closely
3. Evaluate potential addition of vessels during high-demand months

Passenger Load Factor

As shown in Figure 6, it can be observed. That passenger data reveals an even higher average Load Factor of 86.86%. However, values exceeded 100% from January to April—indicating overloading—peaking at 118.74% in March. Such conditions are unsafe and may violate maritime safety regulations.

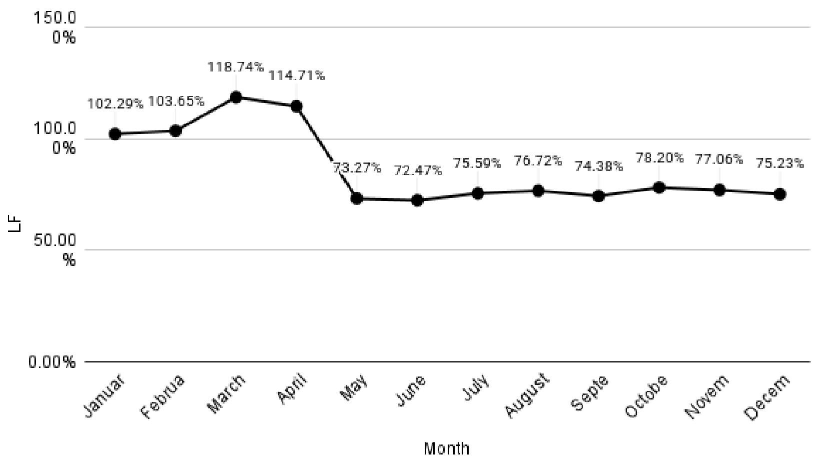


Figure 6. Passenger Load Factor

The second half of the year shows stabilization, with Load Factor between 72% and 78%, still above the 70% benchmark. Despite this, the early-year overloads require urgent corrective measures:

1. Enforce strict passenger capacity limits
2. Increase the number of active vessels during early-year peak months
3. Enhance ticketing and boarding controls

Overall, while Load Factor metrics suggest efficient use of capacity, the safety and operational integrity of the system must not be compromised. Fleet management should respond dynamically to demand trends to maintain a balance between efficiency, safety, and service quality.

LF Discussion

The BOR and Load Factor analyses across both ports indicate significant insights. While berth usage is low (BOR < 50%), vessel capacity utilization (Load Factor > 80%) is relatively high, suggesting that limited vessel deployment—not infrastructure—restricts optimal operations. Moreover, the analysis underscores the mismatch between water-side efficiency (ample berth space) and land-side constraints (vehicle queuing, circulation issues). Similarly, vessel overloading in early-year months—especially for passengers—demands attention to safety compliance.

Thus, integrated strategies must include:

1. Optimizing berth scheduling and vessel rotation
2. Redesigning terminal access and traffic flows
3. Dynamic adjustment of active vessels based on seasonal demand
4. Enforcing load limits and safety protocols
5. Such multi-aspect improvements would better align infrastructure capacity with operational realities, ensuring that service delivery is both efficient and safe.

Analytic Hierarchy Process (AHP)

This analysis uses the Analytical Hierarchy Process (AHP) method. It targets key stakeholders, including the Port Manager of River Kampung Baru in Balikpapan and the Head of the Department of Transportation in Penajam Paser Utara. The aim is to identify and prioritize the most relevant and effective development strategies for the River Port and waterway transportation system connecting Penajam Paser Utara and Balikpapan. The primary focus is to improve service quality, operational capacity, and long-term sustainability, while addressing congestion and queuing issues.

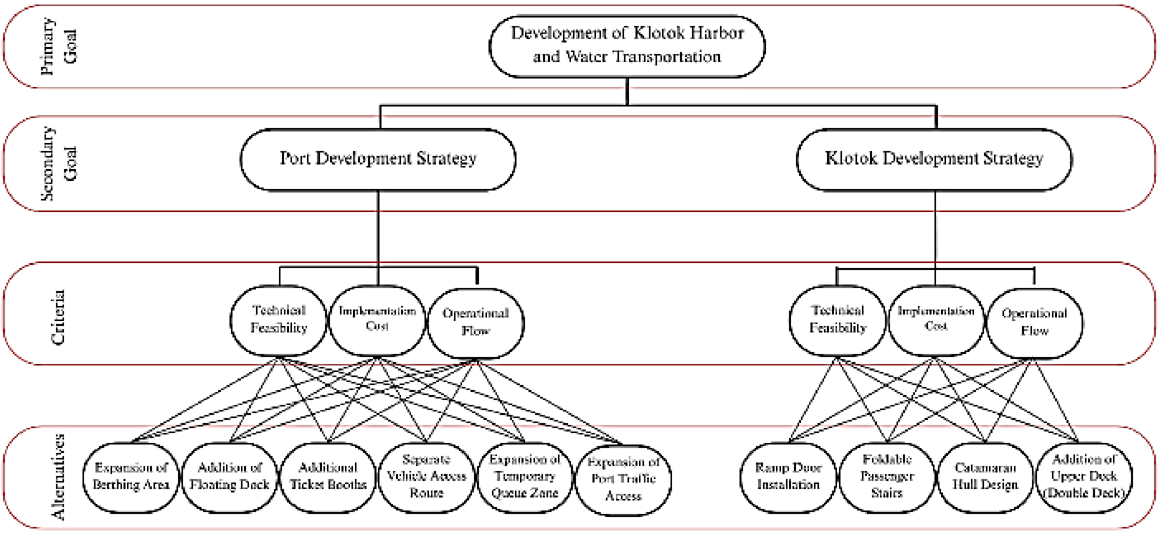


Figure7. AHP Hierarchical Structure

As shown in Figure 7, it can be observed that the AHP hierarchy for this study is structured as follows:
Main Goal: Prioritize development strategies for River Port and water transportation.

Priority Results for Port Development in Penajam Paser Utara

The pairwise comparison matrix produced the following weights for key criteria:
Technical Feasibility: 63%, Operational Flow: 26%, and Implementation Cost: 11%, Consistency Ratio (CR) = 0.048, which is less than 0.1, indicating a consistent result.

These results demonstrate a strong preference for technically feasible solutions that can immediately improve passenger flow and reduce operational issues. Although implementation costs are acknowledged, they are not the dominant concern in the Penajam context.

Table 2. Priority Results for River Port Development in Penajam Paser Utara

Alternative	Weight	Rank
Expansion of Temporary Queue Zone	38%	1
Additional Ticket Booths	27%	2
Addition of Floating Dock	15%	3
Separate Vehicle Access Route	9%	4
Expansion of Port Traffic Access	8%	5
Expansion of Berthing Area	3%	6

As shown in Table 2, the highest-ranking alternative—the expansion of the temporary queue zone—addresses the chronic problem of congestion during peak hours. Additional ticket booths also score highly, suggesting that streamlining ticketing processes is a major operational priority.

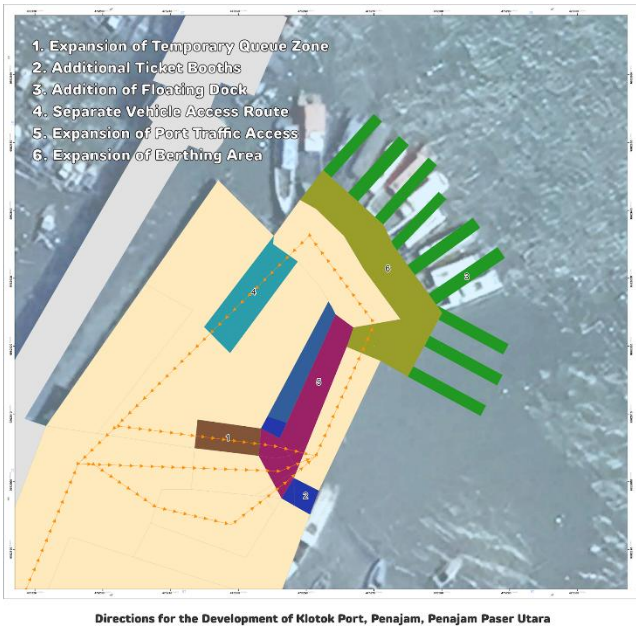


Figure 8. Priority development for River Transportation in Penajam Paser Utara

Priority Results for River Transportation in Penajam Paser Utara

As shown in Figure 8, it can be observed that the Weights for key criteria:Technical Feasibility: 63%, Operational Flow: 26%, Implementation Cost: 11%, and CR = 0.048 < 0.1 (consistent)

This priority structure emphasizes solutions that are not only implementable but also significantly improve boarding and disembarkation efficiency.

Table 3. Priority Results for River Transportation Development in Penajam Paser Utara

Alternative	Weight	Rank
Ramp Door Installation	55%	1
Foldable Passenger Stairs	27%	2
Catamaran	12%	3
Double Deck	6%	4

As shown in Table 3, the ramp door installation was overwhelmingly preferred, suggesting it is seen as the most critical and feasible intervention to enhance turnaround times and improve safety. Foldable stairs are also favored for improving passenger convenience and accessibility.

Priority Results for Port Development in Balikpapan

Weights for key criteria:Implementation Cost: 64%, Technical Feasibility: 28%, Operational Flow: 7%, and CR = 0.083 < 0.1 (consistent)

In Balikpapan, the analysis shows a much greater emphasis on implementation cost, reflecting budget constraints or capital investment sensitivity. Technical feasibility still plays a role, but less so than in Penajam.

Table 4. Priority Results for Port Development in Kampung Baru, Balikpapan

Alternative	Weight	Rank
Expansion of Temporary Queue Zone	37%	1
Expansion of Port Traffic Access	30%	2
Separate Vehicle Access Route	17%	3
Additional Ticket Booths	9%	4

As shown in Table 4, the prioritization highlights the need for efficient flow management and minimal-cost expansion strategies, with queue zone and access improvements leading the list of preferred improvements.

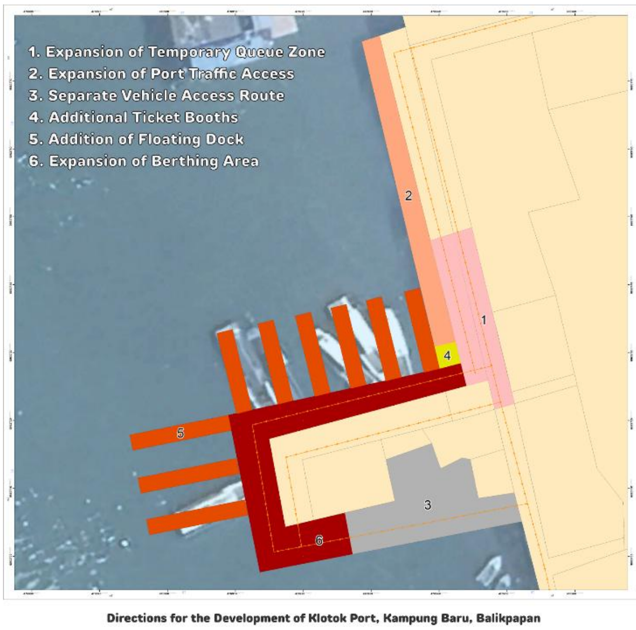


Figure 9. Priority development for River Transportation in Balikpapan

Priority Results for River Transportation in Balikpapan

As shown in Figure 9, it can be observed that the Weights for key criteria: Implementation Cost: 64%, Technical Feasibility: 28%, Operational Flow: 7%, and CR = 0.083 < 0.1 (consistent)

This reinforces the finding that cost remains the most crucial consideration in Balikpapan, especially for vessel upgrades and user experience enhancements.

Table 5. Priority Results for River Transportation in Kampung Baru, Balikpapan

Alternative	Weight	Rank
Ramp Door Installation	58%	1
Foldable Passenger Stairs	30%	2
Double Deck	7%	3
Catamaran	5%	4

As shown in Table 5, Ramp doors again emerge as the top priority due to their relatively low cost and significant impact on loading/unloading efficiency. Foldable stairs are also cost-effective and enhance user comfort, contributing to their high ranking.

Discussion of AHP Analysis

The AHP results indicate that both port and water transportation development strategies favor infrastructure improvements with high technical feasibility and significant impact on operational efficiency. However, priority considerations differ between regions. In Penajam, technical feasibility and operational flow dominate decision-making, leading to recommendations such as expanding the queue zone and installing ramps. In Balikpapan, cost considerations are more influential, resulting in priorities that optimize efficiency within budgetary constraints. Key recommendations include the development of temporary queuing areas and the implementation of ramp doors as strategic, cost-effective interventions for short- to medium-term implementation.

Triangulation Analysis

The triangulation analysis integrates the results of the Berth Occupancy Ratio (BOR), Load Factor (LF), and Analytic Hierarchy Process (AHP) methods to formulate comprehensive recommendations for the development of River Port and its water transportation system. The BOR analysis indicates that the 2024 berth occupancy values at Kampung Baru Pier (42.04%) and Penajam Pier (32.27%) remain well below the 70% threshold recommended by UNCTAD, suggesting that berth capacity is still adequate. Nevertheless, field observations revealed persistent vehicle queues reaching approximately 15 meters near the port entrances. This finding indicates that congestion is primarily caused by limitations in traffic circulation, access roads, and queue management rather than insufficient berth capacity. The AHP analysis supports this conclusion, identifying queue zone expansion, traffic access improvement, and separate vehicle access routes as the highest priorities for Balikpapan, while queue zone expansion, additional ticket booths, and floating dock installation were prioritized for Penajam. These recommendations are consistent with successful implementations reported in other ports, where improvements in queuing areas, ticketing systems, and traffic circulation significantly reduced congestion and improved operational efficiency.

In contrast, the Load Factor analysis reveals a different challenge in the water transportation system. The average LF values for vehicle ferries (82.08%) and passenger ferries (86.86%) exceed the 70% standard specified by the Indonesian Ministry of Transportation, with peak values reaching 99.03% and 118.74%, respectively. These results indicate that the vessels are operating close to or beyond their optimal capacities, potentially affecting safety, comfort, and service reliability. To address this issue, the AHP analysis identified ramp door installation and foldable passenger stairs as the most urgent priorities for both Balikpapan and Penajam due to their ability to accelerate boarding and disembarkation processes. Medium-term development strategies include the addition of double-deck arrangements and the adoption of catamaran hull configurations, which offer larger deck areas, improved stability, and better separation between passenger and vehicle spaces. Evidence from previous studies and practical implementations demonstrates that these solutions can effectively enhance operational efficiency and vessel capacity. Therefore, the integrated findings suggest that port development should prioritize improvements in queue management and traffic flow infrastructure, while water transportation development should focus on enhancing vessel accessibility and capacity. The implementation of these measures is expected to reduce congestion, improve service quality, increase operational safety, and support the long-term sustainability of the Balikpapan–Penajam river transportation network.`

CONCLUSIONS

This study evaluated the operational and infrastructure performance of the River Port and water transportation system connecting Kampung Baru, Balikpapan, and Penajam using an integrated approach based on Berth Occupancy Ratio (BOR), Load Factor (LF), and Analytic Hierarchy Process (AHP). The BOR analysis indicated that berth utilization at both ports remains below the UNCTAD recommended threshold of 70%, with values of 42.04% at Kampung Baru and 32.27% at Penajam, suggesting that existing berthing facilities are still adequate. However, field observations revealed significant congestion in vehicle queuing and traffic circulation areas, indicating that operational bottlenecks are primarily caused by limited terminal space and inadequate landside infrastructure rather than berth capacity constraints. In contrast, the LF analysis showed that both vehicle and passenger vessels operate above the recommended capacity limit, with average load factors of 82.08% and 86.86%, respectively, highlighting concerns related to safety, service quality, and operational efficiency. The AHP results identified queue zone expansion, improved traffic access, additional ticketing facilities, ramp door installation, and foldable passenger stairs as the most effective short-term development priorities, while floating docks, double-deck vessels, and catamaran configurations were recommended as medium-term solutions. These findings are supported by successful implementations in several Indonesian ports and demonstrate the importance of adopting an integrated development strategy that simultaneously addresses port infrastructure and vessel operations. Such an approach is expected to reduce congestion, improve service quality and safety, increase operational efficiency, and support the long-term sustainability of the Balikpapan–Penajam river transportation system.

REFERENCES

[1] B. Triatmodjo, *Pelabuhan dan Fasilitasnya* [Ports and Facilities]. Yogyakarta, Indonesia: Beta Offset, 2010.

[2] Pemerintah Republik Indonesia, *Undang-Undang Republik Indonesia Nomor 17 Tahun 2008 tentang Pelayaran*. Jakarta, Indonesia: Pemerintah Republik Indonesia, 2008.

[3] Pemerintah Kabupaten Penajam Paser Utara, "Penjabat Bupati ajak pemilik lahan Pelabuhan River diskusi renovasi, [Acting Regent invites River Port land owners to discuss renovations]" *Website Resmi Pemerintah Kabupaten Penajam Paser Utara*, Penajam Paser Utara, Indonesia, 2024. [Online]. Available: https://penajamkab.go.id. [Accessed: Jun. 22, 2026].

[4] A. A. Fisu, "Analisis dan Konsep Perencanaan Kawasan Pelabuhan Kota Penajam sebagai Pintu Gerbang Kab. Penajam Paser Utara Kalimantan Timur [Analysis and Planning Concept of Penajam City Port Area as the Gateway to Penajam Paser Utara Regency, East Kalimantan]," *PENA TEKNIK: Jurnal Ilmiah Ilmu-Ilmu Teknik*, vol. 1, no. 2, pp. 125–136, Sep. 2016, doi: 10.51557/PT_JIIT.V1I2.62.

[5] Kementerian Perhubungan Republik Indonesia, *Keputusan Menteri Perhubungan Nomor 73 Tahun 2004 tentang Penyelenggaraan Angkutan Sungai dan Danau* [Decree of the Minister of Transportation Number 73 of 2004 concerning the Implementation of River and Lake Transportation]. Jakarta, Indonesia: Kementerian Perhubungan Republik Indonesia, 2004.

[6] Badan Pusat Statistik Kota Balikpapan, "*Banyaknya angkutan umum menurut jenisnya di Kota Balikpapan tahun 2022* [Number of public transportation by type in Balikpapan City in 2022]," BPS Kota Balikpapan, Balikpapan, Indonesia, 2023.

[7] United Nations Conference on Trade and Development (UNCTAD), *Port Performance Indicators*. Geneva, Switzerland: UNCTAD, n.d.

[8] World Shipping Council, "Understanding load factor in maritime transportation," World Shipping Council, Washington, DC, USA, 2020.

[9] BINUS University, "Konsep AHP (Analytical Hierarchy Process)," BINUS University, 2021. [Online]. Available: https://binus.ac.id. [Accessed: Jun. 22, 2026].

[10] S. Suardi et al., "Design of Motorcycle-Passenger Ship (River) Catamaran Type for Kampung Baru Balikpapan–Penajam Paser Utara," *International Journal of Marine Engineering Innovation and Research*, vol. 8, no. 1, pp. 1–12, 2023. Doi. https://doi.org/10.12962/j25481479.v8i3

[11] Directorate General of Sea Transportation, *Technical Guidelines for Port Planning and Operations*. Jakarta, Indonesia: Ministry of Transportation, 2022.

[12] J. Jinca, *Transportation System Planning*. Jakarta, Indonesia: Erlangga, 2018.

[13] T. L. Saaty, *The Analytic Hierarchy Process*. New York, NY, USA: McGraw-Hill, 1980.

[14] N. K. Denzin, *The Research Act: A Theoretical Introduction to Sociological Methods*, 3rd ed. Englewood Cliffs, NJ, USA: Prentice-Hall, 1989.