



Enhancing Collaboration and Information Sharing in Smart Eco-Ports

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ABSTRACT

This study examines stakeholder collaboration and information sharing practices at Tanjung Priok, Indonesia's primary container port. Through semi-structured interviews with eight maritime professionals conducted between January-June 2024, we identified critical coordination gaps and data exchange barriers. Participants represented port authority operations, shipping management, terminal services, and logistics providers all graduate students in STIP Jakarta's Master of Arts in Maritime Studies program. Findings reveal fragmented communication systems, limited data accessibility, and absence of standardized protocols. These barriers impede Tanjung Priok's advancement toward smart eco-port operations aligned with Indonesia's maritime modernization goals and IMO 2050 environmental targets. —

1. Introduction.

Indonesia's archipelagic geography positions maritime infrastructure as critical for economic development. Tanjung Priok handles approximately 6.5 million TEUs annually, representing 65% of Indonesia's containerized trade (Ministry of Transportation, 2023). However, operational efficiency and environmental performance face persistent challenges requiring coordinated stakeholder action and transparent information flows.

Smart eco-port development integrates digital technologies with environmental sustainability principles. While ports globally adopt IoT monitoring, predictive analytics, and automated cargo handling (Plaza-Hernández et al., 2021), organizational readiness often lags technological capability. Successful implementation depends not merely on technology deployment but on stakeholder willingness to collaborate and share operational data (Berg, 2013; Pantouvakis & Vlachos, 2020).

Research examining collaboration dynamics within Indonesian port contexts remains sparse. Most studies focus on technological infrastructure rather than organizational coordination

mechanisms. This gap is particularly evident in practitioner-oriented research capturing operational perspectives from front-line maritime professionals. Our study addresses this limitation by investigating how Tanjung Priok stakeholders currently coordinate activities and exchange information.

Research Objectives:

1. Document collaboration patterns among port stakeholders
2. Identify information sharing barriers and gaps
3. Assess stakeholder perceptions of coordination effectiveness
4. Propose evidence-based recommendations for improved collaboration

2. Methodology.

2.1. Research Design.

We employed qualitative methodology using semi - structured interviews. This approach captures stakeholder experiences and contextual nuances often missed by survey instruments (Padgett, 2016; Willig, 2014). Given the exploratory nature of investigating collaboration dynamics, qualitative methods provide appropriate depth for understanding complex organizational phenomena.

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2.2. Participant Selection.

Eight participants were recruited through purposive sampling based on operational roles at Tanjung Priok:

- Port Authority Staff** (n=2): Operations management and regulatory compliance.
- Shipping Company Managers** (n=2): Vessel scheduling and cargo coordination.
- Terminal Operators** (n=2): Container handling and yard management.
- Logistics Providers** (n=2): Freight forwarding and supply chain coordination.

All participants were enrolled in the Master of Arts in Maritime Studies program at Sekolah Tinggi Ilmu Pelayaran Jakarta, bringing both practical experience and theoretical understanding to research discussions. This combination of operational knowledge and academic perspective enriched data quality.

2.3. Data Collection.

Interviews occurred between January-June 2024, each lasting 45-65 minutes. The interview protocol covered:

- Current collaboration practices and coordination mechanisms
- Information sharing systems and data accessibility challenges
- Technology utilization in daily operations
- Perceived barriers to effective stakeholder coordination
- Recommendations for operational improvements

Sessions were audio-recorded with informed consent and transcribed verbatim. Participant confidentiality was maintained through anonymization in all reporting.

2.4. Data Analysis.

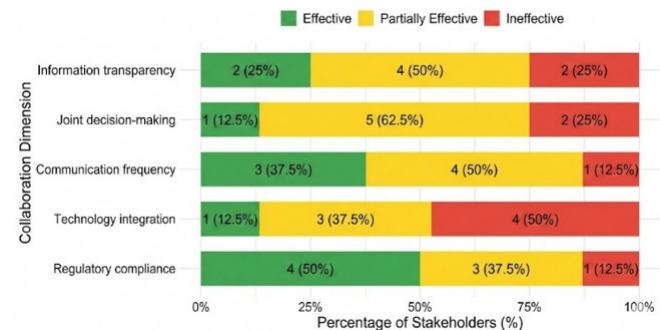
Thematic analysis followed systematic procedures (Kim, Sevcik & Bradway, 2017). Initial open coding identified recurring themes across transcripts. Axial coding established relationships between categories. Three researchers independently coded data to enhance reliability through analytical triangulation. Interpretive differences were resolved through consensus discussions.

3. Findings.

3.1. Collaboration Effectiveness Assessment.

Participants evaluated current collaboration across five dimensions. Figure 1 presents assessment distributions:

Figure 1: Stakeholder Collaboration Assessment (n=8).



Source: Authors.

Regulatory compliance received highest effectiveness ratings, likely reflecting Ministry of Transportation oversight and STCW Convention adherence requirements (Christodoulou - Varotsi & Pentsov, 2008). Technology integration showed poorest performance only one participant rated it effective while half considered it ineffective.

Communication frequency received moderate ratings, though one shipping manager noted: "We communicate regularly but often reactively when problems arise rather than proactively planning together."

3.2. Information Sharing Barriers.

Analysis identified five primary obstacles preventing effective data exchange:

Table 1: Information Sharing Barriers by Stakeholder Group.

Barrier Category	Port Authority	Shipping	Terminals	Logistics	Prevalence
System incompatibility	✓✓	✓	✓✓	✓	75%
Data access delays	✓	✓✓	✓	✓✓	75%
Format inconsistency	✓	✓	✓✓	✓	62.5%
Security concerns	✓✓	✓	✓	✓	62.5%
Absence of standards	✓	✓✓	✓	✓✓	75%

Note: ✓✓ indicates both group participants mentioned; ✓ indicates one participant mentioned

Source: Authors.

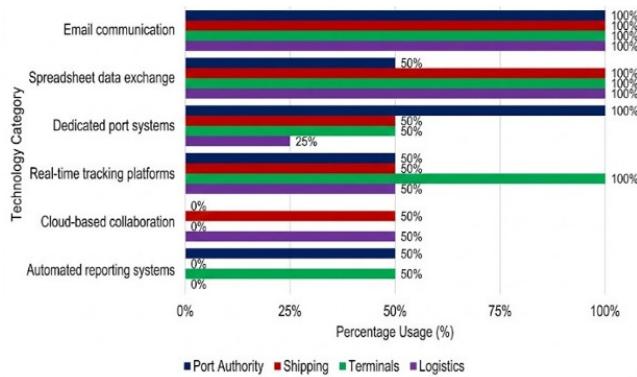
System incompatibility, data access delays, and standards absence emerged as most widespread concerns. One terminal operator explained: "Each shipping line uses different systems and formats for vessel manifests. We spend considerable time manually consolidating information before yard planning."

A logistics provider added: "Getting real-time container status requires checking multiple platforms. No single source provides complete visibility."

3.3. Technology Adoption Patterns.

Current technology utilization varies substantially across stakeholder categories:

Figure 2: Digital Technology Usage in Daily Operations.



Source: Authors.

Email remains universal, though participants acknowledged its limitations for structured data exchange. One port authority staff member observed: "Email works for general communication but becomes chaotic for tracking multiple vessel movements and container statuses simultaneously."

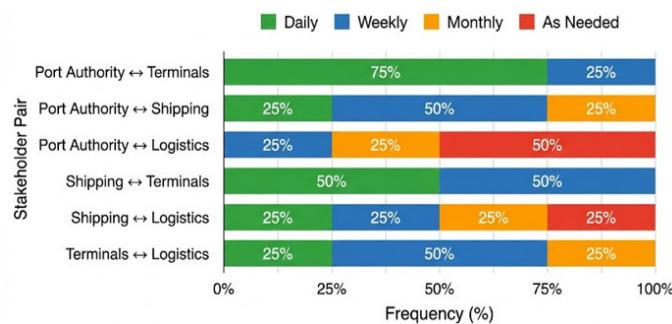
Spreadsheet usage was nearly universal except among port authority personnel, who rely more on dedicated port management systems. However, these systems often lack integration with external stakeholder platforms, creating information silos.

Real-time tracking adoption was highest among terminal operators (100%) but inconsistent across other groups. Cloud-based collaboration tools showed low penetration, with security concerns cited as primary barriers.

3.4. Stakeholder Collaboration Patterns.

We mapped interaction frequencies between stakeholder groups:

Figure 3: Inter-Stakeholder Collaboration Frequency.



Source: Authors.

Port authority-terminal interactions occur most frequently (75% daily), reflecting operational interdependence for berth allocation and cargo clearance. Port authority-logistics collaboration shows weakest integration, occurring mostly on as-needed basis rather than systematic coordination.

One logistics provider noted: "We coordinate directly with shipping lines and terminals but rarely interact with port authority unless regulatory issues arise. Better integration could streamline customs clearance."

3.5. Perceived Collaboration Value.

Participants rated the importance of enhanced collaboration across operational dimensions:

Table 2: Perceived Importance of Collaboration Improvements.

Operational Dimension	Critical	Important	Moderate	Low
Vessel turnaround time	7 (87.5%)	1 (12.5%)	0 (0%)	0 (0%)
Cargo tracking accuracy	6 (75%)	2 (25%)	0 (0%)	0 (0%)
Environmental compliance	5 (62.5%)	2 (25%)	1 (12.5%)	0 (0%)
Cost reduction	4 (50%)	3 (37.5%)	1 (12.5%)	0 (0%)
Emergency response	6 (75%)	2 (25%)	0 (0%)	0 (0%)

Source: Authors.

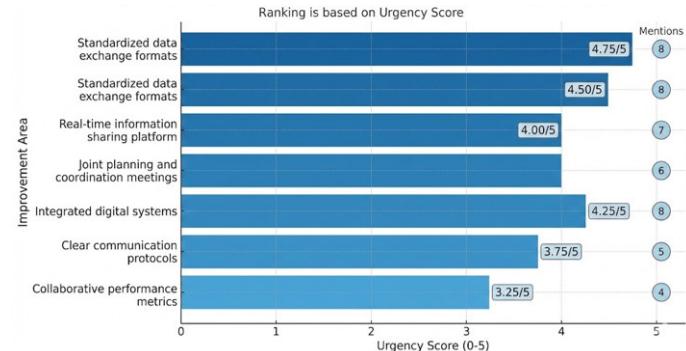
Vessel turnaround time improvement received highest criticality ratings (87.5%), reflecting competitive pressure and customer service demands. One shipping manager stated: "Every hour of port delay costs us money and affects schedule reliability across our entire network."

Environmental compliance importance recognition (62.5% critical) aligns with Indonesia's commitment to IMO 2050 decarbonization targets and Ministry of Transportation sustainability mandates.

3.6. Proposed Improvement Priorities.

Participants identified priority areas for collaboration enhancement:

Figure 4: Stakeholder Improvement Priorities (Ranked by Urgency).



Source: Authors.

Standardized data formats received universal support with highest urgency ratings. One terminal operator emphasized: "If we all used common standards for vessel notifications, container manifests, and gate documentation, efficiency would improve dramatically."

Integrated digital systems also garnered universal mention, though one port authority staff member cautioned: "System integration requires significant investment and organizational change management beyond just technology procurement."

4. Discussion.

4.1. Fragmented Coordination Ecosystem.

Findings reveal Tanjung Priok operates with fragmented coordination mechanisms despite stakeholder recognition of collaboration's importance. This paradox -acknowledged value but inconsistent practice- suggests organizational and systemic barriers rather than attitudinal resistance.

The strong performance in regulatory compliance compared to weak technology integration indicates stakeholders respond effectively to mandated requirements but struggle with voluntary coordination improvements. This pattern suggests structured frameworks and clear governance may be necessary to drive collaboration enhancement beyond regulatory minimums (Gavalas, Syriopoulos & Roumpis, 2022).

4.2. Information Asymmetry and Access Barriers.

Data access delays and format inconsistencies create information asymmetries affecting operational decision-making. When stakeholders operate with incomplete or delayed information, they make suboptimal decisions that cascade through the supply chain. A terminal operator's delayed vessel arrival notification forces logistics providers to adjust trucking schedules reactively rather than proactively, increasing costs and congestion.

The absence of standardized data formats particularly affects Indonesia's context where multiple international shipping lines, diverse terminal operators, and numerous logistics providers interact within regulatory frameworks shaped by both national requirements and international conventions (House & Saeed, 2016). Standards adoption would require coordination across organizations with varying technological capabilities and commercial interests.

4.3. Technology Adoption Disparities.

Technology utilization patterns reveal significant disparities across stakeholder groups. While terminals demonstrate high real-time tracking adoption, logistics providers and shipping companies show inconsistent usage. This fragmentation prevents emergence of integrated visibility across the supply chain.

The low cloud - based collaboration adoption (0-50% across groups) despite proven benefits in other industries (Roesler, Barrière & Willrich, 2020) suggests both technical barriers (infrastructure, security) and organizational reluctance to shift from established practices. Security concerns mentioned by 62.5% of participants reflect legitimate data privacy considerations but may also indicate risk-averse cultures resistant to technological change.

4.4. Implications for Smart Eco-Port Development.

Tanjung Priok's smart eco-port advancement faces organizational readiness gaps alongside technical requirements. While Indonesia's Ministry of Transportation has invested in port infrastructure modernization, our findings suggest parallel investment in organizational capacity building and inter-stakeholder coordination mechanisms is equally critical.

The environmental compliance importance recognition (62.5% rated critical) provides foundation for sustainability-oriented collaboration. Linking collaboration improvements to environmental performance monitoring -such as reduced vessel waiting time decreasing emissions- could strengthen business cases for coordination investments (Fang et al., 2019; Tseng et al., 2021).

4.5. Practitioner Perspectives on Solutions.

The high urgency assigned to standardized data formats (4.75 / 5) and integrated systems (4.25 / 5) indicates stakeholders have clear views on needed improvements. These priorities align with smart port literature emphasizing interoperability and data standards (Bibri & Krogstie, 2017; Kourtit, Nijkamp & Steenbruggen, 2017).

However, implementation requires addressing power dynamics and commercial sensitivities. Some stakeholders may resist transparency fearing competitive disadvantage or regulatory scrutiny. Port authorities must balance facilitation roles with regulatory enforcement, potentially creating tension in collaborative initiatives.

5. Recommendations.

Based on empirical findings, we propose five evidence-based recommendations:

5.1. Establish Data Standardization Working Group.

Form a multi-stakeholder committee to develop and implement common data exchange standards for vessel notifications, container manifests, and gate documentation. This group should include representatives from each stakeholder category plus Ministry of Transportation observers to ensure regulatory alignment.

Implementation Timeline: 6-12 months for standard development; 12-18 months for phased adoption.

5.2. Deploy Integrated Information Platform.

Develop centralized digital platform providing real-time visibility across stakeholder operations while maintaining appropriate security controls. Platform should enable authenticated access based on organizational roles and commercial relationships.

Critical Features:

- Vessel schedule visibility and berth planning
- Container tracking and status updates
- Automated notifications for exceptions and delays
- Performance analytics dashboard

5.3. Formalize Coordination Mechanisms.

Institute regular multi-stakeholder coordination meetings (weekly operational, monthly strategic) to address ongoing challenges and plan collaborative improvements. Structure meetings with clear agendas, decision-making protocols, and accountability for action items.

5.4. Align Environmental Performance Metrics.

Develop shared environmental performance indicators linking collaboration effectiveness to sustainability outcomes. Metrics should track vessel turnaround time reduction, cargo dwell time, truck queuing duration, and estimated emissions reductions from efficiency improvements.

5.5. Invest in Digital Literacy and Change Management.

Provide training programs for maritime professionals on collaborative technologies and data-driven decision-making. Address not only technical skills but also organizational culture change required for transparent information sharing.

6. Limitations and Future Research.

This study's modest sample size ($n=8$) limits generalizability, though theoretical saturation was achieved for major themes. All participants belonged to STIP Jakarta's graduate program, potentially creating selection bias toward stakeholders already engaged in professional development and reflective practice.

Future research should:

- a. Expand sample across multiple Indonesian ports to identify context-specific versus universal challenges.
- b. Employ quantitative methods to measure collaboration impact on operational performance metrics.
- c. Conduct longitudinal studies tracking collaboration improvements over time.
- d. Compare Indonesian experiences with regional ports (Singapore, Malaysia, Thailand) to identify transferable practices.

Conclusions.

Tanjung Priok faces significant collaboration and information sharing challenges impeding smart eco - port development. While stakeholders recognize coordination's importance and demonstrate compliance with regulatory requirements, voluntary collaboration mechanisms remain underdeveloped. System incompatibilities, data access delays, and standards absence create persistent operational inefficiencies. However, findings also reveal strong stakeholder interest in improvement and clear priorities for intervention. The high urgency assigned to data standardization and integrated systems indicates readiness for coordinated action if appropriate governance structures and technological infrastructure are established. Advancing Tanjung Priok toward smart eco-port operations requires parallel attention to organizational capacity and technological capability. Indonesia's maritime sector cannot achieve sustainability and efficiency goals through infrastructure investment alone. Enhanced collaboration mechanisms, standardized information exchange protocols, and integrated digital platforms are equally essential. Port authorities must assume leadership roles in facilitating multi-stakeholder coordination while balancing regulatory oversight responsibilities. Success depends on building trust,

demonstrating tangible benefits from collaboration, and creating governance frameworks that align diverse organizational interests toward shared sustainability and efficiency objectives.

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