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Green Logistics in Practice, A Qualitative Study of Port Sustainability in Eastern Indonesia

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ABSTRACT: This study examines the implementation of green logistics strategies in freight transportation at Soekarno Hatta Port, Makassar. Data were collected over three months (July–September 2024) through in-depth interviews with 15 informants, participatory observation, and document analysis. Informants represented port authorities, logistics operators, truck drivers, government officials, and academics. Findings show that 9 of 15 informants at managerial level demonstrated high awareness of green logistics, while most operational staff (6 drivers and dock operators) had limited knowledge. Existing initiatives include optimized truck scheduling to reduce idle time and partial electrification of cargo handling equipment. However, barriers such as the lack of electric vehicle infrastructure, absence of regional regulations, and limited sustainability training hinder broader adoption. The study recommends integrating digital emission monitoring, introducing regional fiscal incentives, and developing targeted training programs. By addressing these gaps, Soekarno Hatta Port could become a pioneering model for sustainable logistics in Eastern Indonesia. This research contributes empirically to the discourse on port sustainability by providing localized insights applicable to other regional ports.

Keywords: Green Logistics, Sustainable Port Operations, Stakeholder Awareness, Emission Monitoring, Infrastructure Barriers.

INTRODUCTION

Logistics operations are vital to regional connectivity and trade, but their rapid growth has created challenges in balancing efficiency and environmental sustainability. In Indonesia, freight transport contributes about 27% of national carbon emissions (KLHK RI, 2023), with motorized vehicles as the main source. These environmental pressures are particularly evident in port areas where cargo activities are concentrated, (KLHK RI, 2023).

Soekarno Hatta Port in Makassar, Eastern Indonesia, handled over 8 million tons of cargo in 2023 (Pelindo Regional 4, 2024), As a key hub for inter-island and international trade, it faces externalities such as congestion, greenhouse gas emissions, and pollution. These conditions highlight the urgent need to adopt environmentally conscious logistics practices at the port level.

One solution widely recognized is green logistics, which integrates environmental principles such as fuel efficiency, renewable energy use, and waste reduction into logistics operations. While international examples show significant benefits, the Indonesian context especially outside Java faces distinct challenges such as limited infrastructure, weak incentives for clean transport, and low stakeholder awareness (Elnabawi & Elsalam, 2023; Notteboom et al., 2020).

In Indonesia, however, the green logistics paradigm remains nascent. The transition toward sustainability is hindered by structural barriers such as inadequate multimodal transport infrastructure, a lack of incentives for low emission vehicle adoption, and limited awareness among logistics stakeholders. This reflects broader institutional and behavioral challenges in aligning local logistics practices with national and global sustainability commitments. The gap is even more pronounced outside Java, where regional ports face resource limitations and receive less policy attention.

Notably, the Soekarno Hatta Port has high potential to become a pioneer in Indonesia's transition toward sustainable logistics. This is due not only to the scale and intensity of its operations but also to the technological and infrastructural capacities it possesses. Key strategies to green the logistics system in such port environments may include vehicle electrification, emission monitoring systems, optimized delivery scheduling, and renewable energy integration at cargo handling terminals. These approaches resonate with best practices documented in global ports where automated cargo systems and clean energy adoption have led to measurable reductions in emissions and enhanced operational efficiency (Notteboom et al., 2020).

In the national context, this shift is in line with Indonesia's commitment to reduce greenhouse gas emissions by 31.89% unconditionally or up to 43.20% with international support by 2030, as outlined in its Enhanced Nationally Determined Contribution (ENDC). Given the anticipated growth in industrial activity and regional trade across Eastern Indonesia, transport and logistics are seen as crucial sectors for achieving these environmental targets. Regional ports, therefore, hold a strategic position in both facilitating economic development and serving as catalysts for low carbon transition pathways.

Despite the urgency and potential, academic literature on green logistics implementation in Indonesia's port sector remains heavily skewed toward major ports on Java Island, such as Tanjung Priok. These studies, while valuable, do not account for the unique socio economic, institutional, and environmental dynamics of regional ports like Soekarno Hatta. For instance, challenges related to stakeholder coordination, infrastructure readiness, and regulatory support differ markedly in Eastern Indonesia. Consequently, localized research is essential for designing context specific solutions and informing policy that is both scalable and grounded in empirical realities.

This study, therefore, seeks to fill this gap by providing an in depth analysis of green logistics strategies in freight transportation at Soekarno Hatta Port in Makassar. The primary focus includes identifying existing environmentally friendly practices, examining the barriers to broader implementation, and proposing strategic recommendations to foster an efficient and sustainable logistics system. In doing so, this research aims to contribute both theoretically and practically: by enriching the discourse on green logistics in regional port contexts, and by offering actionable insights for policymakers, industry players, and academic researchers.

In summary, Soekarno Hatta Port provides an important case for examining the opportunities and challenges of green logistics in Indonesia's regional ports. The study emphasizes the need for investments, regulatory innovation, and collaborative governance to advance sustainability in logistics.

METHOD

This study applied a descriptive qualitative design to analyze the implementation of green logistics strategies in freight operations at Soekarno Hatta Port, Makassar. This approach was chosen to capture the complex interactions among policies, practices, and stakeholder perceptions in port logistics systems, and to identify both barriers and enabling factors for sustainability (Brusselaers et al., 2021).

The study was conducted at Soekarno Hatta Port, Makassar, which serves as the primary logistics hub in Eastern Indonesia. Data collection took place over three months (July–September 2024), allowing engagement with diverse stakeholders and sufficient observation of port operations.

Multiple qualitative data collection techniques were employed to ensure data richness and triangulation. The primary methods included in depth interviews, participatory observation, and document analysis:

In depth interviews were conducted with a diverse range of key informants, selected for their direct involvement or expertise in port logistics. The informants included:

- Representatives from Pelindo Regional 4 (port authority)
- Terminal cargo managers and logistics operators
- Truck drivers and freight service users
- Officials from Makassar's Transportation Agency
- Academics and sustainability experts

These interviews sought to uncover stakeholder perspectives on green logistics, including knowledge levels, perceived barriers, ongoing initiatives, and future opportunities.

Participatory observation was used to document the real time operational context of freight transport at the port. This included observing vehicle types, cargo handling practices, scheduling systems, and the presence (or absence) of emission mitigation technologies. Observations helped

verify claims made in interviews and revealed practical challenges not always captured through dialogue.

Document analysis involved reviewing institutional and policy documents such as annual reports from Pelindo, municipal transport planning frameworks, and green logistics guidelines from regulatory agencies. This approach provided background on the formal structures supporting or constraining environmental innovation at the port.

These varied techniques allowed for a layered understanding of the systemic, behavioral, and technical dimensions of green logistics implementation.

Informants were selected using purposive sampling, with inclusion criteria: (i) direct involvement in port logistics operations or regulation, and (ii) minimum three years of experience in the sector. Exclusion criteria were stakeholders without operational relevance or temporary/short-term contractors. Data saturation was reached after 15 interviews, when no new themes emerged (Rutaba, 2023).

The qualitative data were analyzed using thematic analysis, a method particularly suitable for studies involving multiple stakeholder perspectives and evolving sustainability practices (Kusters et al., 2020). The process included the following stages:

- Transcription of all interview recordings
- Initial coding to identify recurring concepts or patterns
- Categorization of codes into thematic clusters such as "stakeholder awareness," "institutional barriers," or "technology adoption"
- Interpretation of themes in relation to the study's objectives
- Synthesis of findings into a coherent analytical narrative

The thematic analysis approach allows for flexible coding that can adapt to emergent issues raised by informants while maintaining a consistent structure for interpretation. This flexibility is particularly valuable in the context of green logistics, where technological, regulatory, and cultural dimensions intersect (Rutaba, 2023).

Additionally, the analysis was informed by theoretical perspectives on multi stakeholder governance and sustainable supply chains, enabling findings to be situated within broader academic and policy discourses (Clarke & MacDonald, 2016).

To enhance the validity and reliability of the study, triangulation was applied at multiple levels. First, data from interviews were cross verified with observational insights and documentary evidence. Second, triangulation of informant types ensured that perspectives from both public and private sectors, as well as from strategic and operational levels, were included. This strategy helped reduce the risk of bias and provided a more holistic understanding of the phenomena under investigation.

Moreover, the member checking technique was used to validate findings. This involved presenting preliminary interpretations back to selected informants for feedback and confirmation. Member checking not only improved the accuracy of the analysis but also increased the credibility of the results in the eyes of practitioners, aligning with best practices in participatory and applied research methodologies (Sun et al., 2020).

In conclusion, the methodological framework adopted in this study was carefully structured to ensure depth, rigor, and contextual sensitivity. By combining purposive sampling with multi method data collection, and applying systematic yet adaptable analysis techniques, the research was well positioned to capture the complexities of green logistics implementation at a regional Indonesian port. This methodological rigor enhances the utility of the findings for informing both academic discourse and practical policy formulation.

RESULT AND DISCUSSION

The analysis of field data highlights variations in awareness, practices, and readiness among stakeholders at Soekarno Hatta Port. While managerial staff show stronger understanding of green logistics principles, operational workers remain less informed. Existing initiatives are present but fragmented, and structural barriers such as the absence of EV infrastructure persist. To provide a clearer overview of these patterns, Table 1 summarizes the distribution of stakeholder responses and key findings.

Table 1. Summary of Stakeholder Responses (n=15)

Tema	Jumlah Informan	Persentase	Temuan Utama
Awareness of Green Logistics	9 (managers, officials, academics)	60%	Memahami konsep dasar efisiensi energi & emisi.
	6 (drivers, dock workers)	40%	Minim pemahaman, belum pernah ikut pelatihan.
Ongoing Practices	3 operators	-	Optimasi jadwal truk.
	2 firms	-	Elektrifikasi alat bongkar muat.
	2 firms	-	Program eco-driving terbatas.
Barriers	15 (semua)	100%	Tidak ada infrastruktur EV.
	9	60%	Tidak ada regulasi/fiskal insentif.
HR Readiness	4 companies	-	Memulai eco-driving training.
	7 workers	-	Masih menolak perubahan perilaku.
Opportunities	2 projects	-	Pilot monitoring digital emisi.

Stakeholder Awareness of Green Logistics

Interviews showed a clear gap in awareness. Out of 15 informants, 9 managers and logistics coordinators (60%) demonstrated good understanding of green logistics concepts (e.g., energy

efficiency, emission reduction). Meanwhile, 6 operational workers (drivers and dock operators, 40%) admitted to limited or no knowledge of sustainable practices. This confirms the need for inclusive training across all workforce levels (Elnabawi & Elsalam, 2023; Kusters et al., 2020).

Ongoing Green Logistics Practices

Despite infrastructural and regulatory limitations, several environmentally conscious initiatives have been implemented. These include the adoption of more efficient truck scheduling systems to reduce queue times, minimizing idling emissions, and the transition of some heavy machinery at docking terminals to electric power. Additionally, HR departments in some logistics firms have begun advocating fuel efficient driving practices among drivers.

These practices reflect broader regional trends in energy efficient logistics as observed in Asian ports (Notteboom et al., 2020). Scheduling optimization, in particular, has proven effective in reducing idle time, while the electrification of cargo handling equipment contributes to long term emission reduction. However, these initiatives remain fragmented, lacking integration into a cohesive strategy or monitoring system, which limits their broader environmental impact.

Structural Barriers to Implementation

Several key structural impediments hinder the full adoption of green logistics. Among the most pressing is the absence of electric vehicle (EV) infrastructure, such as charging stations and designated lanes for electric freight transport. Logistics firms reported interest in electric vehicle adoption but cited a lack of regional support systems.

Moreover, the policy environment remains underdeveloped. There are currently no regional regulations or incentives that explicitly encourage low emission transport modes. Without clear mandates or fiscal support, green investments are often deemed high risk by logistics companies. This situation reflects the broader regional trend in Southeast Asia, where regulatory clarity and infrastructure investment are critical to accelerating sustainability transitions (Lee, 2019).

Human Resource Readiness

Stakeholder interviews highlighted mixed levels of readiness among human resources. While larger logistics companies have begun offering eco driving training and raising environmental awareness, such efforts are neither uniform nor sustained. Many workers continue to prioritize speed and volume over energy efficiency, influenced by performance metrics and longstanding habits.

Resistance to behavioral change, especially among senior drivers and field staff, has been identified as a barrier to effective green logistics implementation. Literature on organizational transformation confirms that altering work culture requires continuous training, feedback mechanisms, and incentive structures aligned with sustainability goals (Moreno-Serna et al., 2021). The study findings underscore the importance of incorporating sustainability training into routine operational practices.

Strategic Opportunities and Recommendations

Opportunities are emerging. Pelindo Regional 4 and local universities are piloting a digital emissions monitoring system, involving 2 logistics firms in trial phases. Informants also suggested fiscal incentives and sustainability-linked training as key enablers. These opportunities underline

the potential of collaborative governance in transforming Soekarno Hatta Port into a regional sustainability model.

These developments point to the value of multi stakeholder partnerships in fostering innovation (Brusselaers et al., 2021). University industry collaboration not only enhances knowledge transfer but also builds institutional capacity for sustainable logistics practices. To scale these initiatives, the study recommends:

- Developing a localized roadmap for electric vehicle infrastructure at ports
- Introducing regional fiscal incentives for companies adopting green technologies
- Institutionalizing sustainability training for logistics personnel
- Establishing performance based green logistics indicators

Such steps can catalyze the transformation of Soekarno Hatta Port into a regional model for sustainable logistics, aligning local practices with Indonesia's national and international environmental commitments.

The implementation of green logistics at Soekarno Hatta Port in Makassar reflects a dynamic interplay of awareness, operational innovation, institutional challenges, and strategic opportunities. The following discussion synthesizes field findings with theoretical insights to unpack the complexities and pathways for sustainable transformation in port based logistics systems.

Stakeholder Awareness of Green Logistics

Differences in awareness between management (60%) and operational workers (40%) confirm that green logistics remains an elite-driven agenda. This finding is consistent with previous research on Indonesian ports where sustainability initiatives were often top-down and not fully absorbed by the workforce (e.g., Tanjung Priok studies, KLHK, 2023). To address this, Soekarno Hatta Port should develop modular training tailored to truck drivers and dock operators, using local dialects and practical demonstrations to enhance accessibility. (Kusters et al., 2020; Sun et al., 2020).

Ongoing Green Logistics Practices

Initial efforts at Soekarno Hatta such as scheduling optimization and electrification of cargo handling equipment demonstrate a practical awareness of eco efficiency, aligning with global best practices (Notteboom et al., 2020). These measures embody the principle of reducing environmental impact while enhancing operational efficiency.

However, the absence of systematic monitoring frameworks constrains the full realization of these benefits. The integration of real time emissions monitoring technologies, potentially powered by Internet of Things (IoT) systems, can offer granular data on logistics performance. Such tools not only enable transparency and traceability but also empower managers to make informed decisions aligned with green KPIs (Elnabawi & Elsalam, 2023). Institutionalizing these systems would mark a shift from fragmented initiatives to a cohesive environmental strategy.

Structural Barriers to Implementation

Structural impediments most notably inadequate EV infrastructure and the lack of enabling regulations underscore the broader systemic inertia impeding green logistics adoption. These challenges mirror what policy scholars refer to as a "policy implementation gap," wherein national goals are not sufficiently translated into local operational guidelines (Howlett, 2019).

Bridging this gap necessitates regulatory alignment and infrastructural investment. Local governments can play a catalytic role by piloting green port initiatives, including the construction of charging stations and the establishment of dedicated low emission zones. Fiscal incentives such as tax rebates for logistics firms investing in clean technologies could further enhance participation. Tailored regional policies are crucial to ensure that national sustainability agendas resonate with local operational realities (Lee, 2019).

Human Resource Readiness

Behavioral inertia within the workforce remains a key barrier. While some companies have introduced eco driving programs, these are not yet institutionalized or linked to performance evaluation systems. Literature on organizational change underscores the importance of aligning incentive structures with desired behaviors to foster cultural transformation (Sun et al., 2020).

A holistic HR strategy for green logistics should therefore integrate sustainability criteria into recruitment, training, performance appraisal, and recognition systems. Community based training initiatives, involving peer learning and local champions, could be particularly effective in contexts like Makassar where cultural dynamics significantly influence work practices. Such an approach not only builds individual competencies but also nurtures a collective sense of responsibility.

Strategic Opportunities and Recommendations

Opportunities exist for Soekarno Hatta Port to become a green logistics model in Eastern Indonesia. The ongoing pilot project with local universities on digital emission monitoring is a significant step. To strengthen impact, the port authority could (i) integrate emission data into annual performance reports, (ii) allocate a sustainability budget line, and (iii) co-develop training curricula with universities and vocational schools. These actions would embed sustainability into the port's institutional framework, moving beyond ad-hoc initiatives (Clarke & MacDonald, 2016).

CONCLUSION

This study investigated the implementation of green logistics at Soekarno Hatta Port, Makassar, through qualitative inquiry with 15 stakeholders. The findings reveal disparities in awareness between management and operational workers, fragmented adoption of eco-friendly practices, and major barriers including limited EV infrastructure, underdeveloped regulations, and uneven workforce readiness. Despite these obstacles, promising initiatives such as optimized truck scheduling, partial electrification of equipment, and university industry collaborations on emission monitoring show that the port holds significant potential to pioneer sustainable logistics in Eastern Indonesia. The main contribution of this research lies in providing empirical evidence from a regional port that has been underrepresented in Indonesian logistics literature.

However, the study has limitations, including a relatively small sample size, potential response bias, and a short observation period that did not capture seasonal variations. Future research should expand to larger samples, apply mixed methods, and include comparative studies with other regional ports. Practically, Soekarno Hatta Port can strengthen its role in sustainable transformation by institutionalizing green KPIs, piloting EV infrastructure, and integrating sustainability training into performance systems. Through coordinated multi-stakeholder efforts, the port can transition from fragmented initiatives to a replicable model of green logistics for Indonesia's regional port system.

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