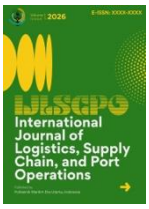
**International Journal of Logistics, Supply Chain, and Port Operations**
Vol 1, No. 1, 2026, pp. 13-20

Available *Online* di https://journals.polimaritimekautama.ac.id/index.php/ijlscpo
ISSN xxxx-xxxx




# Green Port Development and Maritime Decarbonization: Insights from Sustainability Initiatives at the Port of Rotterdam

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*Received: 03-12-2025* *Revised: 05-01-2026* *Accepted: 07-02-2026*

**Abstract:** Sustainability has become a central concern in the maritime logistics industry as ports face increasing pressure to reduce environmental impacts while maintaining efficient supply chain operations. Green port strategies have emerged as an important approach for promoting environmentally sustainable port management and supporting the transition toward low-carbon maritime logistics systems. This study aims to explore the implementation of green port strategies and their role in supporting sustainable maritime supply chains at the Port of Rotterdam. A qualitative research approach was employed using a case study design to examine sustainability initiatives implemented at the port. Data were collected through semi-structured interviews with key stakeholders in port logistics operations, supported by document analysis of sustainability reports and policy documents related to port environmental programs. The findings indicate that renewable energy adoption, digital logistics systems, and collaborative stakeholder initiatives play a crucial role in advancing sustainable port operations. The study also identifies several challenges associated with green port implementation, including high infrastructure investment costs, technological transition barriers, and the need for coordination among multiple maritime stakeholders. The results highlight the importance of integrated sustainability strategies that combine technological innovation, policy support, and stakeholder collaboration to achieve effective maritime decarbonization. This research contributes to the growing literature on green port development and provides practical insights for port authorities and logistics managers seeking to implement sustainable maritime supply chain strategies.

**Keywords**: Green Port, Sustainable Maritime Logistics, Port Sustainability, Maritime Decarbonization, Port Operation

**How to cite:** Rachma Waty Fazry(2026). Article tittle. *International Journal of Logistics, Supply Chain, and Port Operations, 1(1): 13-20*

## INTRODUCTION

Global trade has expanded rapidly over the past few decades, increasing the strategic importance of ports as critical nodes in international supply chains. Ports facilitate the movement of goods between countries and support economic growth by enabling efficient maritime transportation and logistics operations. However, the growing scale of maritime trade has also raised significant environmental concerns, particularly related to greenhouse gas emissions, air pollution, and energy consumption generated by port activities and shipping operations (Notteboom, Pallis, & Rodrigue, 2021).

The maritime transport sector plays a major role in global logistics networks but is also responsible for a considerable share of global carbon emissions. According to international environmental reports, emissions from shipping and port operations continue to rise as global trade increases. These environmental challenges have placed increasing pressure on port authorities and maritime stakeholders to adopt more sustainable operational practices and reduce the environmental impact of port logistics systems (UNCTAD, 2022).

In response to these challenges, the concept of green ports has emerged as an important strategy for promoting sustainability in maritime logistics. Green port strategies focus on reducing environmental impacts through the adoption of cleaner technologies, improved energy efficiency, and environmentally responsible port management practices. These strategies include the use of renewable energy sources, electrification of port equipment, shore power systems for vessels, and the development of environmentally sustainable logistics infrastructure (OECD, 2021).

The implementation of green port strategies is also closely related to the development of sustainable maritime supply chains. Modern supply chains require efficient logistics systems that not only support economic competitiveness but also address environmental sustainability. As a result, port authorities and logistics operators are increasingly integrating environmental considerations into supply chain management practices. Sustainable maritime logistics emphasizes the reduction of emissions, efficient resource utilization, and environmentally responsible transportation practices throughout the logistics network.

Among global ports, the Port of Rotterdam has become one of the leading examples of green port development and sustainable maritime logistics. As one of the largest ports in Europe, the Port of Rotterdam has implemented a wide range of environmental initiatives aimed at reducing carbon emissions and promoting sustainable port operations. These initiatives include investments in renewable energy infrastructure, development of hydrogen energy systems, and the implementation of smart technologies that support more efficient cargo handling and logistics operations.

Despite the growing adoption of green port strategies worldwide, the transition toward sustainable maritime logistics remains complex. Implementing environmental initiatives in port operations requires significant investments, technological innovation, and strong coordination among multiple stakeholders within the maritime supply chain. Port authorities must also balance environmental sustainability with operational efficiency and economic competitiveness.

Previous studies have primarily examined port sustainability from technological and economic perspectives. However, there is still limited research exploring how stakeholders within port logistics systems perceive and implement sustainability initiatives in practice. Understanding the perspectives and experiences of port stakeholders is important for identifying the opportunities and challenges associated with the development of green ports and sustainable maritime supply chains.

Therefore, this study aims to explore the implementation of green port strategies and their role in supporting sustainable maritime supply chains through a case study of the Port of Rotterdam. By examining sustainability initiatives implemented at the port and analyzing the perspectives of stakeholders involved in port logistics operations, this research seeks to provide deeper insights into how green port strategies contribute to the development of more sustainable maritime logistics systems.

## METHOD

This study employs a qualitative research approach to explore the implementation of green port strategies and their role in supporting sustainable maritime supply chains at the Port of Rotterdam. A qualitative approach was chosen because it allows for a deeper understanding of how sustainability initiatives are implemented in port logistics operations and how stakeholders perceive the transition toward environmentally sustainable port management practices.

The research adopts a case study design focusing on the Port of Rotterdam as one of the leading examples of green port development in the global maritime industry. The case study approach is appropriate for this research because it enables an in-depth examination of complex operational, technological, and organizational processes within real-world port logistics environments. The Port of Rotterdam was selected due to its strong commitment to sustainability initiatives, including investments in renewable energy infrastructure, decarbonization programs, and the implementation of environmentally responsible logistics strategies.

Data were collected using multiple qualitative data collection techniques. First, semi-structured interviews were conducted with key stakeholders involved in port operations and sustainability initiatives. These informants included port authority officials, logistics managers, shipping company representatives, environmental policy specialists, and technology experts working within the port ecosystem. Purposive sampling was applied to select participants who possess relevant knowledge and experience related to green port strategies and sustainable maritime logistics practices.

Second, document analysis was conducted to examine policy documents, sustainability reports, and official publications related to environmental initiatives at the Port of Rotterdam. These documents provided valuable insights into the strategic planning, regulatory frameworks, and operational programs supporting port sustainability initiatives. In addition, industry reports and maritime logistics studies were reviewed to provide contextual understanding of sustainability trends in global port operations.

The collected data were analyzed using thematic analysis. This analytical process involved several stages, including data organization, coding of interview transcripts and documents, identification of recurring themes, and interpretation of patterns related to the implementation of green port strategies. Through thematic analysis, the study identified key factors influencing the success of sustainability initiatives as well as the challenges faced by port stakeholders during the transition toward environmentally sustainable port logistics systems.

To enhance the credibility and reliability of the research findings, this study applied data triangulation by comparing information obtained from interviews, policy documents, and secondary sources. This triangulation process ensured that the research results were supported by multiple sources of evidence and provided a comprehensive understanding of how green port strategies contribute to sustainable maritime supply chain development.

## RESULTS AND DISCUSSION

The findings of this study reveal several key insights regarding the implementation of green port strategies and their contribution to the development of sustainable maritime supply chains at the Port of Rotterdam. Based on interview data, document analysis, and sustainability reports, several major themes emerged that illustrate how environmental initiatives are integrated into port operations and logistics management.

### Integration of Environmental Sustainability into Port Operations

One of the most significant findings of this study is the strong integration of environmental sustainability principles into port management strategies. In recent years, sustainability has become a major priority for port authorities around the world as maritime logistics activities contribute significantly to global greenhouse gas emissions. Modern port management therefore increasingly integrates environmental policies into operational strategies in order to reduce environmental impacts while maintaining efficient logistics performance (Notteboom & Rodrigue, 2020).

The Port of Rotterdam has implemented various environmental initiatives aimed at reducing carbon emissions and improving energy efficiency across port operations. These initiatives include the adoption of renewable energy sources, electrification of port equipment, and the implementation of shore power systems that allow vessels to use electricity while docked rather than relying on fossil fuel-powered engines. The implementation of these technologies reflects the port's commitment to developing sustainable maritime logistics systems and supporting global decarbonization efforts in the shipping industry (Acciaro, Vanelslander, Sys, Ferrari, Roumboutsos, Giuliano, & Kapros, 2014).

In addition, environmental sustainability initiatives in port operations often involve the development of green port strategies that focus on reducing air pollution, improving energy efficiency, and promoting environmentally friendly logistics practices. According to research on sustainable port management, green port initiatives such as renewable energy integration, low-emission cargo handling equipment, and environmentally responsible infrastructure development can significantly reduce the environmental footprint of maritime logistics operations (Lam & Notteboom, 2014).

These measures significantly reduce greenhouse gas emissions generated by port activities and contribute to cleaner maritime logistics operations. Shore power systems, for example, allow ships to turn off auxiliary engines while docked and connect directly to the port's electrical grid, thereby reducing fuel consumption and lowering emissions of carbon dioxide, nitrogen oxides, and particulate matter. Such systems are increasingly adopted in major international ports as part of broader strategies to support sustainable shipping and environmentally responsible port operations (Merk, 2018).

From the perspective of port management, integrating sustainability goals into operational strategies also supports long-term competitiveness. Environmentally sustainable ports are more attractive to global shipping companies and logistics providers that prioritize environmentally responsible supply chain practices. Studies on maritime logistics management in Indonesia also indicate that the adoption of green port strategies can improve port performance while simultaneously reducing environmental impacts of port activities (Hidayat & Santoso, 2023).

Overall, by integrating sustainability goals into operational management, port authorities demonstrate how environmental considerations can be incorporated into daily logistics activities without compromising operational efficiency. Sustainable port management practices not only reduce environmental impacts but also

support long-term economic growth and strengthen the resilience of maritime logistics systems in the face of increasing environmental regulations and global climate commitments (Arifai, Nugroho, & Pratama, 2022).

**Renewable Energy and Clean Fuel Development**

Another important finding of this study is the increasing role of renewable energy and alternative fuels in supporting green port initiatives. In recent years, ports around the world have increasingly adopted renewable energy technologies and low-carbon fuel systems as part of their strategies to reduce environmental impacts and support sustainable maritime transport. Renewable energy sources such as wind power, solar energy, and alternative fuels are being integrated into port infrastructure to improve energy efficiency and reduce greenhouse gas emissions generated by port operations (Notteboom & Rodrigue, 2020).

The Port of Rotterdam has invested heavily in renewable energy infrastructure and the development of clean fuel technologies, including hydrogen energy systems and biofuel initiatives. Hydrogen energy is considered one of the most promising alternatives for decarbonizing maritime transport because it can significantly reduce carbon emissions when used as a fuel source for ships, port equipment, and logistics vehicles. The development of hydrogen infrastructure in ports is therefore becoming an important step toward achieving sustainable maritime logistics systems (Merk, 2018).

These efforts are part of a broader strategy aimed at supporting the decarbonization of maritime transport. The transition toward cleaner energy systems within port environments requires the development of new energy infrastructures that can support alternative fuel distribution and storage. According to research on green port development, the integration of renewable energy and alternative fuels into port operations can significantly reduce emissions while simultaneously improving the long-term sustainability of maritime logistics systems (Acciaro et al., 2014).

In addition to infrastructure development, the port authority has established strategic partnerships with energy companies and technology providers to accelerate the adoption of sustainable energy solutions in port logistics systems. Collaboration between port authorities, private sector companies, and technology developers is essential for advancing innovation in clean energy technologies and supporting the large-scale implementation of environmentally friendly logistics systems (Lam & Notteboom, 2014).

These collaborations enable the development of new energy infrastructures that support cleaner shipping operations and reduce the environmental footprint of maritime logistics activities. By working with energy providers, shipping companies, and research institutions, port authorities can develop integrated energy ecosystems that support sustainable maritime transport and promote innovation in green logistics technologies. Research on maritime logistics development in Indonesia also highlights the importance of collaboration between stakeholders in implementing sustainable logistics practices and improving environmental performance within port operations (Hidayat & Santoso, 2023).

Overall, the increasing adoption of renewable energy and alternative fuels demonstrates the growing commitment of port authorities to achieving environmentally sustainable logistics operations. By integrating renewable energy systems, promoting clean fuel technologies, and strengthening collaboration with energy and technology partners, modern ports are able to support the transition toward low-carbon maritime transport while maintaining efficient and competitive logistics systems (Arifai, Nugroho, & Pratama, 2022).

**Digital Technologies Supporting Green Port Operations**

Digital technologies play an important role in enabling environmentally sustainable port operations. In modern maritime logistics systems, digital transformation has become a key factor in improving operational efficiency while simultaneously supporting environmental sustainability goals. Technologies such as big data analytics, Internet of Things (IoT), and advanced digital monitoring systems enable port authorities to manage logistics activities more efficiently and reduce environmental impacts associated with port operations (Ivanov, Dolgui, & Sokolov, 2019).

The Port of Rotterdam utilizes advanced digital systems to monitor cargo flows, track vessel movements, and optimize logistics processes. Digital platforms such as port community systems and integrated logistics management platforms provide real-time operational data that can be used to improve coordination among port stakeholders, including shipping companies, terminal operators, and logistics service providers. These systems allow port managers to monitor operational performance more accurately and ensure that logistics activities are conducted efficiently and sustainably (Notteboom & Rodrigue, 2020).

Furthermore, the integration of digital technologies in port logistics systems enhances supply chain visibility and improves decision-making processes. By providing real-time information on cargo movements

and port activities, digital platforms help reduce operational uncertainties and enable faster responses to logistical challenges. This capability improves coordination among supply chain stakeholders and supports the development of more efficient maritime logistics networks (Gunasekaran, Subramanian, & Ngai, 2019).

By using data analytics and digital monitoring systems, port authorities can identify operational inefficiencies and optimize cargo handling processes. Data-driven decision-making enables managers to analyze energy consumption patterns, equipment utilization, and vessel turnaround times, allowing them to implement operational improvements that reduce fuel consumption and minimize environmental impacts. According to research on sustainable port management, digital technologies are essential tools for supporting green port initiatives and enhancing environmental performance within maritime logistics systems (Acciaro et al., 2014).

This technological integration contributes to more efficient resource utilization and supports sustainability objectives by reducing fuel consumption and operational waste within port logistics systems. The adoption of digital logistics technologies also enables ports to develop more environmentally responsible operational strategies while maintaining high levels of service efficiency. Research on maritime logistics development in Indonesia indicates that digitalization in port management can improve operational transparency, enhance logistics efficiency, and support sustainable logistics practices within national port systems (Hidayat & Santoso, 2023).

Overall, digital technologies serve as critical enablers for sustainable port management. By integrating digital monitoring systems, data analytics, and real-time logistics platforms into port operations, port authorities can achieve higher operational efficiency while simultaneously reducing the environmental footprint of maritime logistics activities (Arifai, Nugroho, & Pratama, 2022).

**Stakeholder Collaboration in Sustainable Maritime Supply Chains**

The study also highlights the importance of collaboration among stakeholders in achieving sustainable maritime logistics systems. In modern maritime logistics networks, sustainability initiatives cannot be implemented effectively by a single organization alone. Instead, they require strong collaboration among multiple stakeholders within the maritime supply chain, including port authorities, shipping companies, logistics providers, energy companies, and government agencies. Collaborative governance enables stakeholders to coordinate sustainability strategies, share technological innovations, and develop integrated environmental management practices within port operations (Notteboom & Rodrigue, 2020).

The Port of Rotterdam has established various collaborative platforms that allow stakeholders to coordinate sustainability initiatives and share knowledge related to environmentally responsible logistics practices. These platforms facilitate communication and cooperation between public and private sector actors involved in port logistics activities. Through these partnerships, stakeholders can jointly develop sustainable solutions such as clean energy infrastructure, emission reduction programs, and environmentally friendly cargo handling technologies (Acciaro et al., 2014).

Collaboration among maritime stakeholders is particularly important in implementing large-scale environmental programs that require significant technological investment and policy coordination. For example, initiatives such as the development of alternative fuel infrastructure, electrification of port equipment, and implementation of green shipping corridors often require coordinated actions between port authorities, shipping companies, and energy providers. According to research on sustainable port development, stakeholder collaboration significantly enhances the effectiveness of environmental management strategies within port systems (Lam & Notteboom, 2014).

Furthermore, collaborative partnerships also support knowledge sharing and innovation in sustainable maritime logistics. By working together, stakeholders can exchange best practices, share operational experiences, and jointly develop new technologies aimed at reducing environmental impacts in port logistics operations. Such collaboration accelerates the diffusion of sustainable technologies and improves the overall environmental performance of maritime logistics networks (Merk, 2018).

In the context of maritime logistics development in Indonesia, collaboration between government institutions, port authorities, and private logistics companies has also been identified as a critical factor in supporting sustainable port management practices. Studies on maritime logistics governance in Indonesia indicate that integrated stakeholder cooperation can improve operational coordination and support the implementation of environmentally sustainable logistics strategies (Hidayat & Santoso, 2023).

Overall, these collaborative efforts help align sustainability goals across the maritime supply chain and facilitate the implementation of large-scale environmental programs. By strengthening cooperation among stakeholders, port authorities can develop more effective sustainability strategies that support both environmental protection and long-term economic growth in maritime logistics systems (Arifai, Nugroho, & Pratama, 2022).

**Challenges in Implementing Green Port Strategies**

Despite the significant progress achieved in green port development, several challenges remain in implementing sustainability initiatives within port logistics systems. Although many ports around the world have adopted environmentally sustainable strategies, the transition toward green port systems often requires major structural, technological, and organizational changes. These changes involve not only infrastructure development but also policy adjustments, financial investment, and stakeholder collaboration. As a result, implementing sustainability initiatives in port logistics systems can be complex and time-consuming (Notteboom & Rodrigue, 2020).

One major challenge identified in this study is the high investment cost required for developing renewable energy infrastructure and sustainable port technologies. The implementation of renewable energy systems, electrified port equipment, alternative fuel infrastructure, and digital monitoring technologies often requires substantial capital investment. For many port authorities, particularly in developing economies, securing financial resources for large-scale sustainability projects can be difficult. In addition, such projects typically require long-term planning and coordination with private sector partners, which may slow down the implementation process (Acciaro et al., 2014).

Another challenge involves the complexity of coordinating environmental initiatives across multiple stakeholders within the maritime supply chain. Green port development requires cooperation between port authorities, shipping companies, logistics operators, government agencies, and energy providers. However, achieving effective coordination among these stakeholders can be difficult due to differences in operational priorities, regulatory responsibilities, and economic interests. Studies on sustainable port governance emphasize that stakeholder misalignment may limit the effectiveness of environmental programs and delay the implementation of sustainability initiatives (Lam & Notteboom, 2014).

Achieving meaningful emissions reductions also requires collective action from shipping companies and logistics operators that operate within port environments. Even when port authorities introduce sustainability policies, the success of these initiatives often depends on the willingness of private sector stakeholders to adopt environmentally responsible practices. For example, shipping companies must invest in cleaner vessels and alternative fuels, while logistics providers must adopt energy-efficient transportation systems. Without strong collaboration across the maritime supply chain, sustainability goals may be difficult to achieve (Merk, 2018).

Additionally, technological transition presents operational challenges for port organizations. Implementing new technologies such as automated cargo handling systems, digital monitoring platforms, and renewable energy infrastructures requires significant organizational adaptation. Port authorities must invest in workforce training, update operational procedures, and develop new management capabilities in order to successfully integrate these technologies into daily logistics operations. Without adequate organizational readiness and capacity development, the potential benefits of sustainability initiatives may not be fully realized (Ivanov, Dolgui, & Sokolov, 2019).

In the Indonesian context, similar challenges have been identified in efforts to promote sustainable port development and maritime logistics transformation. Research on port governance and digital logistics transformation in Indonesia highlights that financial limitations, technological readiness, and institutional coordination remain key barriers to implementing large-scale sustainability initiatives within port systems (Hidayat & Santoso, 2023).

Overall, although sustainability initiatives offer significant environmental and operational benefits, their implementation requires careful planning, long-term investment, and strong collaboration among maritime stakeholders. Addressing these challenges is essential for ensuring that green port strategies can be implemented effectively and contribute to the long-term sustainability of maritime logistics systems (Arifai, Nugroho, & Pratama, 2022)

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**Implications for Sustainable Port Development**

The findings of this study demonstrate that green port strategies play a critical role in promoting sustainable maritime supply chains. As global trade continues to expand, ports are increasingly expected to balance economic growth with environmental responsibility. Green port initiatives provide a strategic framework for reducing the environmental impacts of maritime logistics while maintaining efficient port operations. By integrating environmental management practices into port development strategies, port authorities can improve both environmental performance and operational efficiency within maritime supply chains (Notteboom & Rodrigue, 2020).

The successful implementation of sustainability initiatives at the Port of Rotterdam demonstrates how ports can significantly reduce environmental impacts while maintaining high levels of logistics efficiency. Through the adoption of renewable energy systems, electrified port equipment, digital monitoring technologies, and collaborative environmental programs, the port has successfully integrated sustainability principles into its operational management. These initiatives illustrate how modern port governance can support the transition toward low-carbon maritime logistics systems while maintaining competitiveness in global trade networks (Acciaro et al., 2014).

For port authorities and policymakers, these findings highlight the importance of adopting integrated sustainability strategies that combine technological innovation, renewable energy development, and stakeholder collaboration. Sustainable port development requires coordinated efforts between public institutions, private sector stakeholders, and logistics service providers in order to ensure that environmental policies can be effectively implemented across maritime supply chains. Studies on sustainable port governance emphasize that integrated policy frameworks and collaborative partnerships are essential for achieving long-term environmental and economic benefits in maritime logistics systems (Lam & Notteboom, 2014).

By investing in green technologies and strengthening coordination among supply chain actors, ports can contribute significantly to global decarbonization efforts while enhancing the competitiveness of maritime logistics systems. Technological innovations such as digital logistics platforms, renewable energy infrastructures, and environmentally friendly cargo handling technologies enable ports to reduce emissions, improve energy efficiency, and enhance operational performance simultaneously (Ivanov, Dolgui, & Sokolov, 2019).

In the Indonesian context, similar approaches can be adopted to support the development of environmentally sustainable maritime logistics systems. Research on port development and maritime logistics governance in Indonesia highlights the importance of integrating environmental policies, technological innovation, and stakeholder collaboration in order to improve port sustainability and operational efficiency (Hidayat & Santoso, 2023).

Overall, the transition toward sustainable port operations represents a crucial step in addressing environmental challenges in global trade. Green port initiatives not only improve environmental performance but also support the long-term sustainability and resilience of maritime supply chains. By adopting integrated sustainability strategies and investing in green technologies, ports can strengthen their role as key facilitators of environmentally responsible global logistics systems (Arifai, Nugroho, & Pratama, 2022).

## CONCLUSIONS

This study explored the implementation of green port strategies and their role in supporting sustainable maritime supply chains at the Port of Rotterdam. The findings indicate that environmental sustainability has become a central component of modern port management strategies. Through the integration of renewable energy technologies, environmentally friendly operational practices, and digital logistics systems, the Port of Rotterdam has demonstrated how ports can reduce environmental impacts while maintaining efficient logistics operations.

The study highlights that the successful implementation of green port initiatives depends on several key factors. First, strong environmental commitment from port authorities is essential to drive sustainability programs and integrate environmental objectives into operational strategies. Second, the adoption of clean energy technologies, such as renewable energy systems and alternative fuels, plays a crucial role in reducing carbon emissions generated by port activities and maritime transport. Third, the use of digital technologies

enables port operators to optimize logistics processes, improve operational efficiency, and support environmentally sustainable resource management.

Another important finding of this research is the significance of collaboration among maritime supply chain stakeholders. Sustainable maritime logistics requires coordinated efforts among port authorities, shipping companies, logistics providers, energy companies, and government institutions. Through collaborative partnerships, stakeholders can develop joint initiatives that support environmental sustainability and accelerate the transition toward greener port operations.

Despite the significant progress achieved in green port development, several challenges remain in implementing sustainability initiatives within port logistics systems. High investment costs, technological transition challenges, and the need for coordination among multiple stakeholders represent major barriers that ports must address when implementing environmentally sustainable strategies. These challenges highlight the importance of long-term strategic planning and policy support to ensure the successful adoption of green port initiatives.

Overall, the findings of this study demonstrate that green port strategies play a vital role in advancing sustainable maritime supply chains. By integrating environmental sustainability into port operations, ports can contribute to global efforts to reduce carbon emissions while maintaining competitiveness in international trade. The insights provided by this research offer valuable implications for port authorities, logistics operators, and policymakers seeking to develop sustainable port management strategies and strengthen the environmental performance of maritime logistics systems.

## REFERENCES

Acciaro, M., Vanelslander, T., Sys, C., Ferrari, C., Roumboutsos, A., Giuliano, G., & Kapros, S. (2014). Environmental sustainability in seaports: A framework for successful innovation. *Maritime Policy & Management, 41*(5), 480–500. https://doi.org/10.1080/03088839.2014.932926

Arifai, M., Nugroho, A., & Pratama, R. (2022). Digital transformation and sustainable logistics development in Indonesia. *Journal of Logistics and Supply Chain Management, 6*(2), 85–97.

Christopher, M. (2016). *Logistics and Supply Chain Management* (5th ed.). Pearson Education.

Heilig, L., Schwarze, S., & Voß, S. (2017). An analysis of digital transformation in the history and future of modern ports. *Computers in Industry, 89*, 96–114. https://doi.org/10.1016/j.compind.2017.03.011

Hidayat, R., & Santoso, B. (2023). Sustainable port management and maritime logistics development in Indonesia. *Journal of Maritime Logistics and Management, 5*(1), 45–56.

Ivanov, D., & Dolgui, A. (2021). A digital supply chain twin for managing disruption risks and resilience. *International Journal of Production Research, 59*(9), 1–20. https://doi.org/10.1080/00207543.2020.1840370

Ivanov, D., Dolgui, A., & Sokolov, B. (2019). The impact of digital technology and Industry 4.0 on supply chain resilience. *International Journal of Production Research, 57*(3), 829–846. https://doi.org/10.1080/00207543.2018.1488086

Lam, J. S. L., & Notteboom, T. (2014). The greening of ports: A comparison of port management tools used by leading ports. *Transport Reviews, 34*(2), 169–189. https://doi.org/10.1080/01441647.2014.891162

Merk, O. (2018). *The environmental impact of ports and port-cities*. Paris: OECD Publishing.

Notteboom, T., & Rodrigue, J. P. (2020). Port regionalization and environmental sustainability in maritime logistics. *Maritime Economics & Logistics, 22*(1), 1–18

Notteboom, T., Pallis, T., & Rodrigue, J. P. (2021). Disruptions and resilience in global container shipping and ports: The COVID-19 pandemic versus the 2008–2009 financial crisis. *Maritime Economics & Logistics, 23*(2), 179–210.

OECD. (2021). *Green Ports and Environmental Sustainability in Maritime Logistics*. OECD Publishing.

UNCTAD. (2022). *Review of Maritime Transport 2022*. United Nations Conference on Trade and Development.

World Bank. (2021). *Port Reform Toolkit: Sustainable Port Development*. World Bank Publications.