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Opportunities and Challenges of Implementing Green and Smart Port Concepts in Indonesia

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ABSTRACT

The implementation of green and smart port principles in Indonesian ports is explored in research articles along with potential. Ports that are ”green” or ”smart” aim to minimize their negative environmental effects. These ideas can greatly increase port operations' sustainability and efficiency. The infrastructure and high logistics expenses in Indonesian ports are just two of the issues they encounter. The potential advantages of smart and environmentally friendly ports for Indonesia are examined in this study. Ports can serve as catalysts for the economy, lower logistics costs, environmental sustainability, improved global competitiveness, and climate change mitigation. Ports may support efforts around the world to lessen the effects of climate change by using sustainable practices and technologies. By looking at successful examples from other countries and analyzing the potential benefits of implementing green and smart ports for Indonesia's maritime industry, economy, and environment, this study aims to provide insightful analysis and recommendations for policymakers, port authorities, and other stakeholders in the country's maritime industry. In conclusion, effective and sustainable port operations can help a nation's economy and environment in the long run by spurring economic development, lowering logistical costs, improving global competitiveness, and aiding in environmental sustainability and climate change mitigation initiatives.

1. Introduction.

The maritime sector is essential for international trade and economic growth (Sepehri et al., 2022). Indonesia, the largest archipelagic nation in the world, largely relies on its ports to facilitate commerce and business activities (Adyasari et al., 2021; Pattipawaej, 2022). However, the demand for efficient and sustainable port operations is driving interest in green and smart port designs (Iris and Lam, 2021; Khan et al., 2022; Sinha and Roy Chowdhury, 2022).

With an emphasis on infrastructure modernization, technological adoption, environmental sustainability, and cooperation with international partners and experts, this research study examines prospects to apply green and smart port concepts at Indonesian ports.

The efficacy, security, and sustainability of port operations and services can be significantly improved by implementing new concepts (Hua et al., 2020; Wang et al., 2020). Green ports prioritize energy efficiency, carbon reduction, trash management, and biodiversity preservation in order to reduce the environmental impact of port operations. (Ge and Wen, 2021; Lin et al., 2022). Smart ports, on the other hand, employ cutting-edge technology, such as the Internet of Things (IoT), artificial intelligence, data analytics, and automation, to enhance port operations and overall performance (Yang et al., 2018; Clemente et al., 2023; Cunha et al., 2023).

What are the challenges and opportunities in implementing green and smart port concepts in Indonesian ports? Despite the potential advantages of implementing green and smart ports, Indonesian ports confront a number of difficulties, including out-

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of-date infrastructure, a lack of significant commercial ports, and expensive logistics. (Iman, Amanda and Angela, 2022).

This research report examines the chances for resolving these issues as well as the challenges of implementing green and smart ports in Indonesian ports. By examining successful examples from other countries and analyzing the potential benefits of implementing green and smart ports for Indonesia's maritime industry, economy, and environment, this study seeks to offer insightful insights and recommendations for policymakers, port authorities, and other stakeholders in the country's maritime industry.

2. Literature Review.

Focus is placed on sustainability, effectiveness, and overall port performance in green and smart ports (Chen et al., 2019; Costa et al., 2021). These ports' primary goals are to reduce their environmental impact, increase operational effectiveness, and foster economic competition (González-Cancelas, Molina Serrano and Soler-Flores, 2020).

Due to its potential to lessen the environmental impact of maritime operations, increase sustainable port activities, and boost overall efficiency, green and smart ports are essential to the worldwide marine industry. These ports prioritize applying cutting-edge techniques and technology to reduce pollution, save energy, and advance sustainable development (Chen et al., 2019).

The ports and maritime industry as a whole should invest in and promote environmentally friendly and sustainable operations. (Sislian and Jaegler, 2018). They substitute fossil fuels and power-hungry terminal equipment with green technology and low- or zero-carbon alternatives (Iris and Lam, 2019). Reduced emissions, waste management, biodiversity protection, and social responsibility are the main objectives (Yoo, Moon, and Kim, 2022).

On the other hand, smart ports use cutting-edge technologies like automation, big data, blockchain, IoT, artificial intelligence, and machine learning to enhance their operations and lessen their environmental effect (Clemente et al., 2023). They aspire to improve efficiency, effectiveness, and security by making ports more environmentally friendly, economically viable, and able to handle more port traffic (Han et al., 2022; Al-Fatlawi and Motlak, 2023; Safuan, 2023a).

The essential elements of green and smart ports can be divided into two categories: technology innovation and environmental sustainability, energy efficiency, carbon reduction, trash management, biodiversity protection, and social responsibility are crucial components of green ports (Sheu, Hu, and Lin, 2013; Sadri et al., 2022). Smart infrastructure, smart traffic patterns, smart logistics, port community systems (PCS), and smart safety and security are essential elements of smart ports. (El Imrani, 2021).

3. Methodology.

A technique based on case studies and qualitative methods is used in this study. Using diverse data sources and this study methodology, researchers can thoroughly examine complicated phenomena in particular contexts. (Priya, 2021). This methodology, which may involve the analysis of one or more cases, is particularly helpful for comprehending complex problems in practical contexts.

The following actions are taken by the researcher to conduct a qualitative case study: choose the case to study, decide on the research topic, specify the data collection techniques, gather the data, analyze the data, interpret the findings, validate the findings, and report the findings (Rashid et al., 2019).

4. Results & Discussion.

4.1. Major Indonesian Ports.

With over 1,700 tiny ports and harbors, Indonesia has a large number of ports. However, only 110 of these are container ports and only 110 are commercial ports big enough to take cargo ships. A sizable amount of Indonesia's shipping traffic is handled by these important ports. To strengthen the nation's maritime industry, however, issues including congestion, inefficiency, and antiquated infrastructure must be addressed (Ahmed, 2022).

4.2. Current infrastructure and capacity of Indonesian ports.

After Singapore, Malaysia, and Thailand, Indonesia's port infrastructure is ranked fourth in ASEAN for quality. The country's shipping industry has a lot of promise, but many of its ports have outdated infrastructure that can't handle the volume of maritime traffic. Due to some ports' overburdening, this has increased vessel turnaround times and logistics expenses (Duffield, Hui, and Wilson, 2019). The Indonesian government has been working to update and modernize some facilities' infrastructure, but there are still no significant commercial ports in the nation (Ahmed, 2022). Road, rail, and port infrastructure upgrades are required to lower logistics costs, which now consume a debilitating 24% of Indonesia's GDP. In order to reduce the logistics costs of container ships, the government has also announced intentions to create international hub ports as part of the Integrated Port Network (IPN) program (Duffield, Hui, and Wilson, 2019).

4.3. Government Initiatives for Green and Smart Ports in Indonesia.

The Indonesian government has launched a number of initiatives to make the nation's ports green and intelligent ports. These programs seek to cut carbon emissions, safeguard the marine habitat, and boost sustainability and overall effectiveness (Azhar et al., 2018). Among the major projects are: By 2024, 149 ports are to be transformed into green and intelligent ports, according to the Coordinating Ministry for Maritime Affairs and Investment. These ports comprise 112 ports handled by the government-owned port operator PT Pelindo Indonesia (Persero) and 37 ports managed by a number of institutions, including businesses and the Ministry of Transportation (Nasution, 2022). The government also plans to implement the National Logistics Ecosystem at 10 ports in Indone-

sia. This initiative aims to improve the efficiency and sustainability of port operations and services (Haris et al., 2022). The Green Port Awards were established by the Indonesian government to honor and promote the use of innovative, environmentally friendly port operations. The prizes seek to advance environmental responsibility, operational effectiveness, and port economies in Indonesia (Ritonga et al., 2022).

4.4. Challenges and Opportunities.

The adoption of green and smart ports in Indonesia presents a number of opportunities and problems, including those related to infrastructure, environmental concerns, and technological advancements. Infrastructure restrictions are just a few of the major difficulties. Many Indonesian ports struggle to satisfy maritime trade volumes due to problems like congestion, inefficiency, and aging infrastructure (Azhar et al., 2018); Despite having a significant number of ports, Indonesia lacks large-scale commercial ports that can handle rising shipping demands (Santoso et al., 2023); 24 percent of Indonesia's GDP is accounted for by high logistics expenses, which are caused by ineffective port infrastructure (Safuan, 2023b). Key opportunities include the following: Initiatives by the Indonesian government show its commitment to upgrading the nation's ports into environmentally friendly and cutting-edge facilities by setting a goal of developing 149 green and smart ports by 2024 (Nasution, 2022); The National Logistics Ecosystem (NLE) will be implemented in 10 ports in Indonesia by the government in order to improve the efficiency and sustainability of port operations and services (Santoso et al., 2023); Technology improvements and the use of smart port technologies like IoT, AI, and data analytics can improve port operations and services' efficiency, safety, security, and sustainability (Mariska, 2022; Safuan, 2023a); Collaboration with foreign partners and specialists as well as knowledge exchange about best practices for implementing green and smart ports will be beneficial for Indonesian ports (Senarak, 2020). Indonesia can successfully implement green and smart port concepts, creating a more sustainable and effective marine industry, by solving these issues and seizing the opportunities.

4.5. Case Studies of Green and Smart Port Implementation.

Implementation Case Studies for Green and Smart Ports: Wismar's seaport, the Port of Wismar, has effectively integrated digitization with environmentally friendly port operations, proving that both principles can be realized in real-world operations (Philipp et al., 2021); The VIDEL (Virtual Dashboard of Environmentally Logistics-Port-City) project is a conceptual framework for environmentally sound governance in Jakarta and Tanjung Priok Port. To make interactions between cities, ports, and industry simpler, it is designed as a smart platform with sustainability features (Santoso et al., 2023); An example of a smart port development plan in Indonesia is the Batu Ampar Port in the island of Batam. Batu Ampar Port is employing smart port technology and concepts in order to handle the high volume of ship arrivals and cargo handling that the free trade area and port experiences (Sari and Pamadi, 2019); This case study from Indonesia, Benoa Public and Fishing Terminals, focuses on the theoretical underpinnings of implementing green ports utilizing a circular economy strategy. In order to achieve sustainable port growth, the study emphasizes the significance of cleaner industrial techniques, waste management, and renewable energy sources (Gurning and Tangkau, 2022); The future ports discussed in Blue Seaports are intelligent, environmentally friendly, and electrified, with a focus on the role that automation, digitization, and renewable energy sources play in accomplishing green port goals (Clemente et al., 2023). The Green Flag Speed Reduction Program at the Port of Long Beach In order to lessen air pollution and greenhouse gas emissions, the Port of Long Beach developed the Green Flag Speed Reduction Program. The program works to lower airborne emissions and enhance local air quality by slowing down ships. (Inbound Logistics, 2016).

Lessons from the chosen case studies and their relevance to the ports in Indonesia in order to achieve environmental sustainability, this study emphasizes the significance of tackling environmental contamination issues in port operations by using green port methods in Saudi ports. By identifying key issues and implementing green port methods to minimize pollution and improve ecological sustainability, Indonesian ports can learn from Saudi ports (Alzahrani, 2022); The case study "Smart and Green Technologies in the Mediterranean Ports: The Genoa Port Case Study" highlights the value of implementing smart and green technologies to enhance innovation, knowledge transfer, flexibility, accessibility, and environmental safety. Indonesian ports can implement comparable technologies to increase their sustainability and competitiveness (Tommasetti A., Troisi O. and Tuccillo C., 2014); In order to assess how well ports make use of sustainable practices and cutting-edge technology, the research Designing Smart Ports by Integrating Sustainable Infrastructure and Economic Incentives proposes the implementation of a Smart Port Index (SPI). This indicator can be used by Indonesian ports to assess their development and pinpoint areas for improvement (Molavi, 2020). The purpose of this essay, "Constructing the Governance Framework of a Green and Smart Port," is to highlight the importance of having a governance framework to guide the development of green and smart ports. Creating a similar structure could assist Indonesian ports in implementing smart and eco-friendly port ideas (Chen et al., 2019). This study describes cutting-edge smart seaports in automation, real-time management, connection, and accessibility control in Blue Seaports: The Smart, Sustainable, and Electrified Ports of the Future. Indonesian ports might take inspiration from these instances and implement cutting-edge technology to improve productivity, dependability, and sustainability (Clemente et al., 2023).

4.6. Recommendations for Indonesian Ports.

In order to relieve congestion, inefficiencies, and antiquated facilities, recommendations for Indonesian ports in the areas of infrastructure, technology, and sustainability include modernizing, updating, and expanding current port infrastructure. To reduce logistical costs, this entails creating substantial commercial ports and enhancing infrastructure on the roads, rails,

and ports (Syafiq et al., 2022). Enhancing connectivity between ports and land infrastructure, such as roads and rail networks, will allow for more efficient cargo movement and lower transportation costs. (Syafiq et al., 2022). Make use of smart port technologies to enhance port operations' efficiency, security, and sustainability. These technologies include automation, data analytics, artificial intelligence, and the Internet of Things (Duffield, Hui, and Wilson, 2019; Safuan, 2023a). To reduce the environmental impact of port operations, promote environmental sustainability and adopt green port practices such energy efficiency, emissions reduction, trash management, and biodiversity protection (Duffield, Hui, and Wilson, 2019). Collaboration and knowledge exchange: Work with international partners and specialists to exchange information and best practices for implementing green and smart ports. This can assist Indonesian ports in adopting creative solutions and learning from successful models (Meyrick, 2012). Government policies and programs promoting green and smart port development, such as the National Logistics Ecosystem (NLE) implementation and the Green Port Awards, are encouraged by government funding (Duffield, Hui, and Wilson, 2019).

By putting these suggestions into practice, Indonesian ports may modernize their facilities, incorporate cutting-edge technology, and encourage environmental responsibility, creating a more productive and competitive maritime sector.

Conclusions.

Sustainable and effective port operations have major long-term advantages for a nation's economy and ecology. These advantages consist of Economic expansion; by enabling trade, luring investments, and bolstering supply chains, effective port management can accelerate economic growth (Alamoush, Ballini, and Ölçer, 2021). Ports can serve as economic development's catalysts, facilitating the expansion of the manufacturing and logistics industries, generating job possibilities, and raising income levels (Mlambo, 2021); By lowering operating expenses, eliminating delays, and streamlining operations, decreased logistics costs increase port efficiency and can result in cost savings. This could improve a nation's export and import competitiveness, fostering overall economic growth (Alamoush, Ballini, and Ölçer, 2021; Mlambo, 2021; Safuan, 2023b); The environmental effects of marine activities, such as air and water pollution, greenhouse gas emissions, and biodiversity loss, can be reduced through environmental sustainability and sustainable port operations. Ports may contribute to a more ecologically responsible global marine industry by embracing green port practices and technologies (Brown, 2019). Green port practices and technologies can help the global maritime industry become more environmentally responsible. A nation's competitiveness in the international maritime industry can be improved by effective and sustainable port operations, luring greater commerce and investment (Alamoush, Ballini and Ölçer, 2021); Social advantages, sustainable port development can result in jobs being created, local communities' quality of life being improved, and greater social responsibility (Mlambo, 2021); Ports may support worldwide efforts to minimize climate change and its effects by using sustainable practices and technologies (Brown, 2019).

In conclusion, effective and sustainable port operations can benefit a nation's economy and environment in the long run by fostering economic development, lowering logistical costs, improving global competitiveness, and assisting in environmental sustainability and climate change mitigation initiatives.

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