The Drivers and Barriers of Green Ports

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Ports play an increasingly significant role in fostering regional economic growth and international trade as a key hub of the transportation network. Ports now provide cities, regions, and nations with a vital strategic resource for taking part in global economic cooperation and competitiveness, in addition to providing space for transportation, logistics, and a way to connect with the outside world. Green ports are presented as an achievable solution to the energy issue and environmental degradation. A green port is a port that not only satisfies environmental criteria but also provides economic benefits. Green ports are an excellent strategy to reduce environmental pollution and ecological harm, as well as to maintain the ports' water resources and natural environment.

Keywords: green port ; environmental regulations ; foreign capital ; criteria ; initial capital

1. Introduction

The production of air, oil, and noise pollution, as well as health and ecological dangers, by ports, has a substantial and often fatal influence on port stakeholders and a long-term and green port growth plan [1]. The key issue in ecological ports is striking a balance between the impact on the environment and business interests. As a result, various studies propose that a sustainable port or green port may be used to address this problem [2][3][4][5]. According to [5], a sustainable port (also known as a green port) is one that the port authority, in collaboration with port users, proactively designs and conducts, relying on an economically sustainable strategic plan, collaborating with natural philosophy, and engaging stakeholders. Starting from a long-term goal on the location in which it is positioned and from its position of privilege within the supply chain, it ensures development that anticipates the needs of the community. Ref. [4] favored the idea of a green port that produced all of its renewable energy sources (RES), such as wind turbines or a small solar park, to balance off any energy consumed in operating the port's operations. Ref. [2] proposed that a green port is one that has either made an investment in new machinery with improved environmental performance or has developed a strategy to reduce emissions, energy consumption in operations, and water pollution. The three bottom lines of economic growth, social well-being, and environmental preservation should be controlled and balanced through the active integration of climate change mitigation and adaptation measures into the green port's policies and objectives [3]. A green port is one that aims for environmental preservation, energy savings, safety, and human health in port operations. A green port is one that has a specific plan or action to prevent negative environmental consequences and guide people in environmental protection. For example, the port replaces fossil fuel-powered equipment with electrical equipment to decrease air pollution, and it uses shore power as an alternative to generators inside ships to reduce air pollution and noise, using a green prize to motivate people to adhere to the rules. Previous research has indicated that a green port must meet needs such as air pollution management, noise pollution management, solid waste pollution management, water pollution management, human resource training, information technology application, and hazard response [6][7]. Based on the findings of these studies, the Vietnamese government released the "Green Port Development Program" in 2020, requiring seaports to comply with the requirements voluntarily by 2025, and mandatorily by 2030.

2. Environmental Regulations

To safeguard the port environment and lower the danger of pollution, environmental regulations comprise both international conventions and national policies [8][9][10][11][12][13][14]. The International Maritime Organization (IMO) was founded by the United Nations in 1948 to develop and enforce a comprehensive regulatory framework for shipping. It is now in charge of issues with security at sea, the environment, legislation, technological collaboration, shipping efficiency, and more. The majority of states, including Vietnam, have ratified the IMO conventions. At the same time, the European Union has established a number of environmental rules that primarily focus on air pollution, wildlife and biodiversity, water and marine ecosystems, soil, waste, and other aspects that would reduce environmental threats. The European directives must be followed by all EU members. Each country must ratify the European regulation and implement it into its legal system within a reasonable time limit. According to its needs and obligations, each nation builds its environmental policy.

The nation's environmental policy combines its obligations and goals [15]. For instance, by the year 2030, the Vietnamese government wants all ports to operate in accordance with green port standards.

3. Foreign Capital

Foreign direct investment, loans from multilateral organizations like the World Bank, or loans from foreign governments are all examples of ways that money from abroad enters the home nation and is referred to as "foreign capital". Direct and indirect foreign investments fall into two different groups [16]. Foreign direct investment (FDI) has driven remarkable economic progress in a number of emerging countries [16]. In general, FDI increases the availability of money and, with the proper host-country rules, may also hasten the transfer of technology. The development of human capital is aided by technology transfer, which can increase the likelihood of economic growth. In other words, FDI might both directly and indirectly assist economic growth.

For more than 30 years and even today, capital from foreign direct investment (FDI) has significantly aided Vietnam's socioeconomic development. FDI into Vietnam increased by 9.2% from 2020 to 31.15 billion USD in 2021, notwithstanding the COVID-19 pandemic's challenging course of development. This indicates how confident international investors are about the business climate in Vietnam. The construction of seaport infrastructure has benefited significantly in recent years from FDI funding. The presence of international firms in the transport and port sectors, such as Hutchison, PSA, DP World, SSA, Maersk A/S, and CMA-CGM, has greatly increased FDI in Vietnam [17].

Additionally, indirect investment resources, namely, official development assistance, are used to upgrade the seaport infrastructure in Vietnam (ODA). Three significant ports—including Cai Lan, Tien Sa, and Cai Mep–Thi Vai—have had investments completed by the maritime industry using ODA assistance. Basically, the seaport system has made it possible for goods to be imported and exported and for linkages to be formed between different areas of the country by water, favorably impacting economic growth and initially meeting the demands of the socio-economic development of the country [17].

Vietnam is working to develop a circular economy in which seaports are headed on the right path for sustainability. Many people are interested in the green port's building. The creation of a green port, however, will be quite expensive. In order to implement the port greening strategy, foreign capital will be a crucial resource.

4. Cooperation of Involved Parties (Shipping Firms, Transportation Companies)

The challenge of changing ports toward sustainability and the necessity to include a wide variety of stakeholders are acknowledged in several publications, both inside and beyond the scope of this study (e.g., [18][19][20]). Three kinds of green port environmental issues may be distinguished, according to the OECD (2011): (1) ship emissions, (2) port operations, and (3) traffic in the hinterland. Key causes of air pollution brought on by shipping include sulfur oxides (SOx), nitrogen oxides (NOx), and particulate matter, all of which have an impact on local and regional air pollution. Additionally, the physical and emotional health of dockworkers as well as residents in coastal regions might be negatively impacted by noise from ship auxiliary engines during laytime. Due to the enormous number of cars that go to and from ports, pollution and traffic are the key challenges from an inland perspective [21]. The Association of Southeast Asian Nations highlighted one of the major barriers to the sustainable growth of ports in Asia as poor coordination with shipping companies and other supply chain partners [22][23].

Numerous earlier studies have demonstrated that the concerted effort by multiple stakeholders to alleviate the burden on the port authority will make the development of the green port plan more successful [24][25][26][27][28][29][30]. First, by deploying more environmentally friendly ships, such as propulsion improvements and auxiliary engine retrofits [26][28][31], or slowing down their speed in the port area [24], shipping firms may promote a more environmentally friendly port strategy. Second, some significant solutions for the inland transportation system are provided to reduce air pollution, noise, traffic accidents, and congestion by developing an intermodal rail and road infrastructure and encouraging shippers to transfer their goods by rail to and from ports [25]. With the assistance of all parties concerned, the development of green ports will be more successful.

5. Inconsistent Criteria

The absence of uniformity in green port criteria presents another challenge to development. Research on the green port criterion is expanding [7][32][33][34][35][36][37][38][39][40]. However, ports will find it challenging to determine their development direction due to the abundance of green port requirements. For instance, ref. [41] suggested that adopting an onshore power supply system (cold ironing) and lowering the ship's speed while enhancing its landfall are two of the best ways to a port's greenness performance.

Ref. [7] proposed sustainable criteria for green ports—such as liquid pollution management, air pollution management, noise control, marine ecological protection, biological system preservation, low-carbon and energy-saving management, and establishment of green port organizational management. On the other hand, six green port performance indicators have been developed by the majority of port authorities (Shanghai, Hong Kong, Singapore, Port of L.A. and L.B., and Kaohsiung, 2012) and international organizations (PPCAC, IAPH): speed reduction after landfall, cold ironing, using electrically powered equipment, encouraging the use of low-sulfur fuel, a willingness to reuse recyclable resources, and encouraging the development of public transport modes [6].

It appears that there are several varied criteria in the research. This makes it difficult for ports to decide which factors are crucial for the growth of their green ports. The development of green ports at ports in underdeveloped countries with limited resources may be hampered by the requirement to invest significant time and money in determining which criteria are appropriate for them.

6. Lack of Technical Advancement

The application of cutting-edge technology in the environmentally friendly ship and port infrastructure is referred to as technical development. A number of cutting-edge technologies—including cold ironing technology, seawater filters, alternative energy sources, and monitoring systems—have been suggested for use at green ports in [9]. First, cold ironing is the practice of providing a ship with electricity from the land while it is berthed rather than using its auxiliary engines. This corresponds to being able to shut off every engine. The use of cold iron can lower greenhouse gas emissions but only if the onshore electricity is generated from renewable energy sources [42]. It has been shown that cold ironing reduces overall greenhouse gas emissions from transportation by less than 0.5% [43]. Ref. [14] explores the effectiveness of cold ironing as an emissions reduction alternative and develops a mathematical methodology for assessing the technology's economic viability. Cold ironing, according to ref. [14], can result in local emissions reductions ranging from 48% to 70% for CO_2, 3% to 60% for SOx, 40% to 60% for NOx, and 57% to 70% for BC of a container terminal's ship emissions inventory. Additionally, seawater is pumped, for instance, in the cramped scrubber of a ship. The scrubber receives ship exhaust gas, which interacts with saltwater there. A rapid and efficient reaction takes place when SO_2 comes into contact with seawater, turning the SO_2 and calcium carbonate ($CaCO_3$) in the saltwater into CO_2 and calcium sulphate (gypsum), an essential component of regular seawater [44]. Furthermore, the development of advanced monitoring systems has made it feasible to locate potential pollution sources and provide timely pollution control actions [8]. In yard operations, the biggest environmental advantages will come from the deployment of more efficient ship-to-shore cranes, which will improve the number of transfers per hour and hence shorten the entire turnaround time of large polluting vessels. On the hinterland side, ITS may be utilized to decrease line formation at the gates. Furthermore, the ongoing replacement of truck fleets, together with efforts to cut driver idling periods, will result in significant reductions in emissions at the gate. Last but not least, employing complementary or alternative energy sources—including wind, solar, and biofuels—can reduce emissions into the environment and assist in achieving environmental goals [9]. Refs. [9][41][45][46][47][48] have demonstrated the importance of advanced technology in achieving the port's sustainable goals.

However, the technology employed in green ports poses a big problem for ports today. Most ports in underdeveloped countries have outdated equipment, which is bad for the environment. Access to new technologies will be challenging in the near future. Equipment that requires electricity, onshore power sources, and systems for creating alternative energy all need considerable capital investments over protracted periods of time. Due to the absence of current technology, adopting a green port plan in poor countries will be quite difficult.

7. Lack of Initial Capital

All costs related to the facility before, during, and after the green port's development are included in the list of financial barriers. In order to satisfy the criteria of decreasing emissions at the port, modern technology, such as cold ironing systems, must be installed. Diesel-powered equipment must also be replaced with equipment that runs on electricity. Numerous studies have shown that the cost of implementing a cold ironing system might be high [49][50]. For instance, it was anticipated that investment expenses at the ports of Aberdeen and Copenhagen would total £6.6 million and €37 million, respectively. According to the World Ports Climate Initiative (WPCI), annual operating and maintenance expenditures represent 5% of the project's total investment costs [51]. The cost of powering the berthed ships varies greatly depending on the electricity policies of the various nations. The shortage of electricity in some cities or areas may also be a barrier. Local grids frequently cannot handle high-voltage cold ironing systems. This is especially true in smaller cities. In order to support cold ironing system investments in such areas, further multimillion-dollar expenditures in new electrical networks and transformation substations are required [52]. Additionally, employing electric equipment comes with a high initial cost. The majority of the machinery at the port is driven by diesel, which produces a lot of emissions and noise pollution. Furthermore, resources are needed for the training of human resources for the management and upkeep of green ports. Port authorities will thus be under pressure to raise a significant initial capital source for building a green port (**Figure 1**).

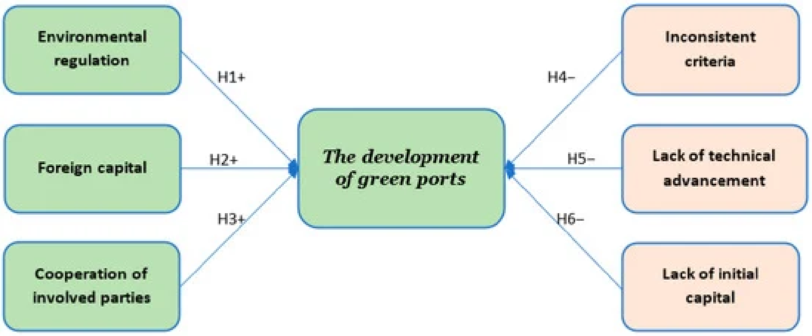

Figure 1. The research model.

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