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Implementing green port strategies in Saudi ports to achieve environmental sustainability

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IMPLEMENTING GREEN PORT STRATEGIES IN SAUDI PORTS TO ACHIEVE ENVIRONMENTAL SUSTAINABILITY

By

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Declaration

I certify that all the material in this dissertation that is not my own work has been identified and that no material is included for which a degree has previously been conferred on me.

The contents of this dissertation reflect my own personal views and are not necessarily endorsed by the University.

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(Date): 20 September 2022
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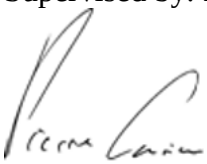
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Abstract

Title of Dissertation: **Implementing Green Port Strategies in Saudi Ports to Achieve Environmental Sustainability**

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More than 90 % of all goods traded worldwide pass-through maritime transit and ports, making them vital nodes in the network connecting economies worldwide. Seaports, however, are significant contributors to air and water pollution in coastal cities. Global issues, such as climate change and energy conservation, have raised worries about the environmental impact of port operations and expansion.

This research aims to address environmental contamination issues stemming from port operations by identifying the most significant challenges related to port operations by examining Saudi ports as case studies. The list of green port measures and strategies presently in developed countries was chosen as the foundation for semi-structured interviews conducted at two Saudi ports.

This paper presented three interviews in addition to the questionnaire, which included 26 participants from administrative and operational port sectors in Jeddah and 12 from King Fahad Industrial port. Based on the research findings, the Saudi ports are not nearly as advanced as other ports in implementing green port initiatives.

Finally, this report provides port decision-makers with recommendations for reducing environmental damage caused by port operations by implementing green ports. In addition, it provides the best international practices in port and green strategies and draws a roadmap for implementing the green port strategy.

KEYWORDS: Sustainability, Sustainability development, Environmental issues, Port operations issues, Environmental measure, green port, green port strategies.

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List of Abbreviations

EMAS	Eco-Management and Audit Scheme
EPA	Environmental Protection Agency
EMS	Environmental Management Systems
ESPO	European Sea Port Organization
IMO	International Maritime Organization
MOT	Ministry of Transport and Logistics serves
PERS	Port Environmental Reporting System
MAWANI	Saudi Ports Authority
SDM	Self-Diagnosis Method
SDGs	Sustainable Development Goals
TGA	Transport General Authority
TBL	Triple Bottom Line
TEUs	Twenty-Foot Equivalent Units
UNCTD	United Nations Conference on Trade and Development
WHO	World Health Organization

Chapter 1 Introduction

1.1 Background.

Environmental challenges have become increasingly significant worldwide, with organizations concerned about conducting business environmentally responsibly. While commitment to the natural environment has become critical today (Seroka-Stolka, 2014), the maritime transport and logistics business has received less attention from stakeholders than the sustainability concerns of aviation and overland freight industries. Although sea transport has fewer environmental impacts than other modes of transportation per kilometer driven, this is still a significant issue when considering the global nature of international trade. (Lim et al., 2019b).

Ships and port city interactions have been subjected to stricter International Maritime Organization (IMO) rules since 1997. Consequently, players in the industry have begun to pay more attention to sustainability problems, particularly in the supply chain (P. T. W. Lee et al., 2019). International trade and the global economy rely heavily on maritime transportation. Shipping by sea accounts for more than 80 % of global trade (UNCTAD, 2021). Ports are critical infrastructures that help drive economic development and growth with serve as gateways to international trade (Wright, 2013), and they are an essential component of the distribution network. Therefore, port administrations have increased the capacity of their port infrastructure to accept a wider variety of container vessel sizes and to address the rising demand for marine transport and logistics services. This is being achieved to the growing demand for these services (Lim et al., 2019b).

The environmental implications of ports have come more into the spotlight in recent years as a direct result of the high levels of energy consumption and pollution brought on by the expansion of port production and trade volumes. Environmental and climate change will be exacerbated by the release of pollutants from port operations (Hua et al., 2020). Moreover, ports perform more than just quayside cargo handling. As a result of their competition, their influence extends far into the country's hinterland. Management and operational strategies are intertwined with stakeholders across

multiple sectors, from local to global and corporate to government. Ports can significantly impact global transportation systems' social and environmental performance through their involvement in the supply chain. In some instances, ports have taken advantage of their capacity to address social and ecological externalities by complying with current environmental standards in their city, region, or country (Bergqvist & Monios, 2018).

1.2 Problem Statement.

These days, pollution in ports and ships has become a global concern, affecting the environment, health, and economy. The pollution has grown over the past three decades. This issue is compounded by the growth and expansion of global maritime trade. In terms of both volume and cost, maritime transport is among the most prominent and oldest types of transportation. However, due to the increase in sea freight, it has recently become highly polluting. World leaders established the 17 Sustainable Development Goals (SDGs) in 2015 as part of the 2030 Agenda for Sustainable Development. These targets, which seek to improve economic growth and address a wide variety of social requirements, including health and social protection and environmental protection by 2030, are part of an effort to create a better and more sustainable world for all people. These objectives must be long-term and sustainable in terms of the environment, society, and the economy (UN, n.d).

1.3 Aim of the study.

This research intends to tackle environmental pollution problems resulting from port operations by identifying the primary issues associated with port operations. This study discusses the results and suggestions for port decision-makers to decrease environmental harm caused by port operations by implementing green port logistics. It paves the way for future research of this nature.

1.4 Research Question and Objective.

A collection of research questions has been prepared to achieve the dissertation's aim and goal, as shown in Table 1.

Table 1

Research Questions and Objectives

#	Research Question	Research Objective
1	What are the pillars of green port?	To identify the pillars of the green port.
2	How can the environmental impact of ports be mitigated?	To identify the measures that can reduce the environmental effect on the ports.
3	What is the status of Jeddah's and King Fahad port in implementing green port?	To evaluate the level of the port of Jeddah and King Fahad in terms of implementing green ports.
4	How can ports implement green ports?	To determine ports, implement green ports.

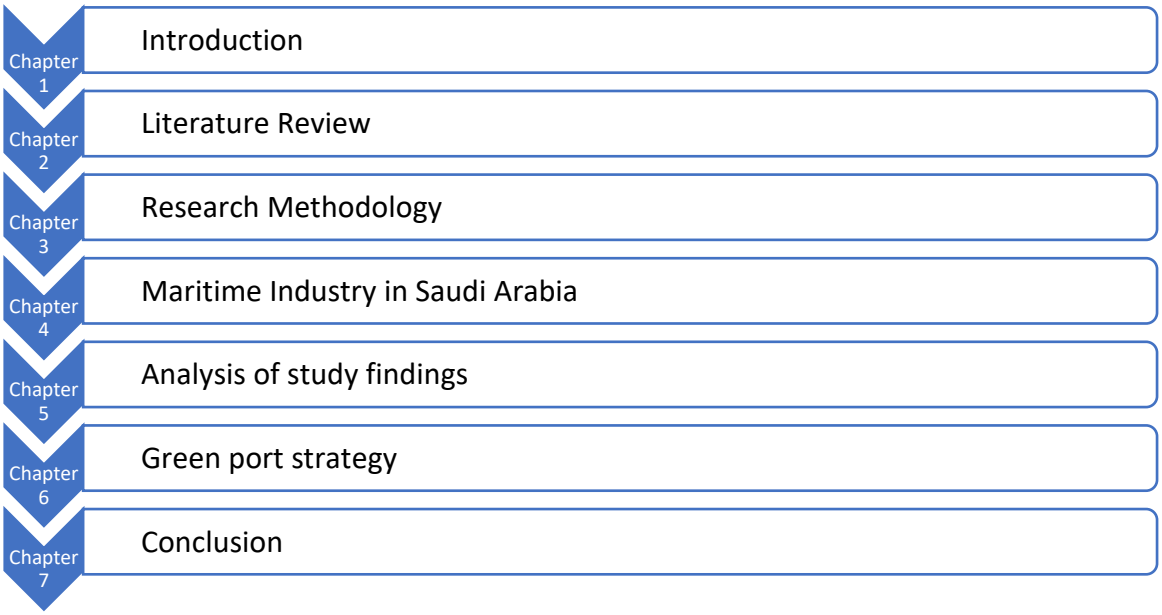
1.5 Dissertation Structure.

This research is structured into seven chapters. The first chapter contains an introduction, a problem statement, aims, research questions, and objectives, all of which contribute to the context of this research. The second chapter begins with a study of the relevant literature, during which the idea of sustainability is brought to the forefront. An overview of environmental concerns specific to ports is presented with the classification of environmental impacts in ports, which are port operations, pollution from ships, and Port hinterland intermodal emissions, then narrowed down to environmental issues arising from the port operation after that introduced, the measures that can reduce the environmental impact in the ports. The third chapter describes the methodology, which includes providing a complete approach to the design process and the framework for this study. It discusses the research ethics that were followed, how the data was acquired, and how reliable and valid the data is. The fourth chapter discusses the maritime transport industry in the Kingdom of Saudi Arabia. The fifth chapter analyzes and discusses the interviews and survey questionnaire results. The sixth chapter discusses solutions and suggestions for green

ports. Finally, the seventh chapter contains the limitation of the research, research implications, and the conclusion.

Figure 1

Structure of Dissertation.



Chapter 2: Port environmental issues and solutions to green pathways: a Literature Review

2.1 The concept of sustainability:

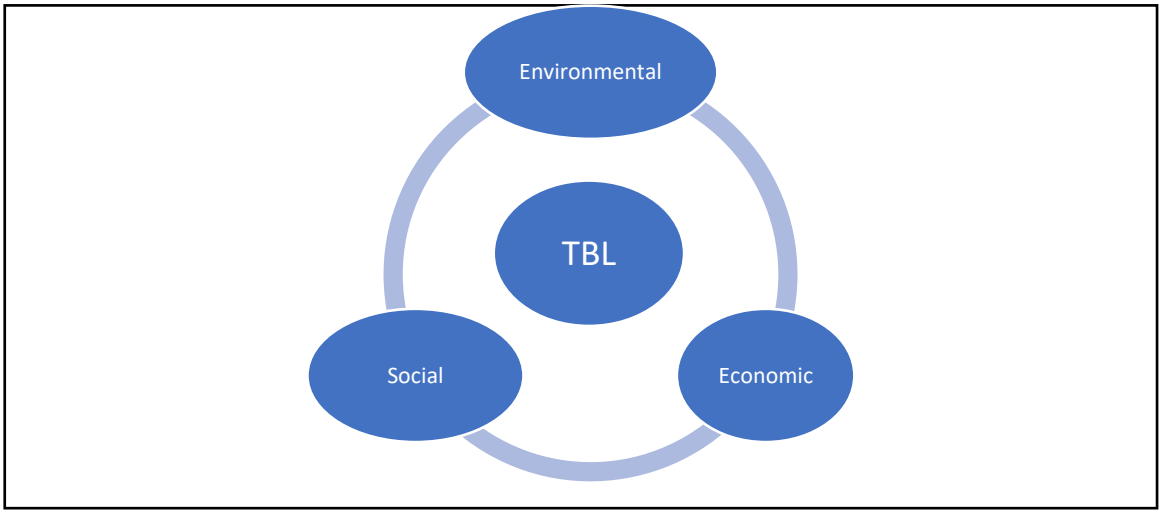
Sustainability is one of the most often used concepts in the scientific community and the environmental sciences yet analyzing the concept's history is challenging. This is since records of the systematic usage of a word, whose reference in the contemporary lexicon and political discourse is now so widespread, are dispersed worldwide. As a result, the term "sustainable" has typically meant "long-term," "durable," "sound," and "systematic," among other things (Leal Filho, 2000).

2.2 Sustainable development:

A triple bottom line (TBL) comprising environmental, economic, and social concerns may describe sustainable development (figure 2). The country has the most delicate balance of environmental quality, economic prosperity, and social equity. By adding social and environmental concerns, the TBL changes the emphasis of corporate success away from the economic perspective of shareholders and toward that of other stakeholders (Lam & Li, 2019a). Sustainable ports require balancing economic growth, environmental preservation, and social responsibility. Financial stability and corporate accountability concerns may cast new light on port operations in the maritime transportation as well and industries. The word "sustainability" has been given a more prominent role in the literature about port operations and growth due to the growing environmental and societal concerns over the potential for adverse environmental implications. Developing a port and the region around it in an efficient way, working with the ports as well as meeting their exact needs is the goal of strategies for developing ports without harming the environment, which "not only address problems in port areas like safe handling of goods or environmental management, but also include actual capacity development for ports and the establishment of related training capacity in the region" (Sislian et al., 2016).

Figure 2

Triple bottom line (TBL) of sustainability



Note. Developed by Author based on (Elkington, 1997).

2.3 Port environment Concern

International trade and the movement of goods rely heavily on shipping and ports. Ports are important hubs for commerce, industry, and logistics, but they are also significant sources of pollution in coastal cities (Sislian et al., 2016). Port facilities and services have grown out of control in response to rising maritime trade, resulting in significant pollution of the environment. Dredging spoil disposal and the release of effluent and other pollutants significantly influence the environment and the health and well-being of laborers. As a result of these issues, port sustainability is becoming increasingly important (Lim et al., 2019b).

Globally, a growing movement to reach net-zero emissions from port operations, as governments and consumers are becoming increasingly aware of the consequences of global climate change and ongoing concerns regarding environmental protection (Densberger & Bachkar, 2022).

Growing numbers of people are becoming concerned about the adverse effects of port operations and expansion on the surrounding ecosystem. Ports that can maintain their sustainability strike a balance between economic success, social well-being, and environmental quality. A key factor in promoting critical sustainability is attracting and retaining clients who respect sustainability (Lam & Li, 2019a).

Jim et al. (2.13) researched Asia's green ports with two surveys on green seaport performance based on 17 green performance indicators grouped into five categories and ranked by AHP. The least or most important green port performance metrics are air pollution avoidance, electric equipment utilization, and low-sulfur fuel promotion. Sediment and coastal erosion, ecotourism, and wetland habitat are less critical. The AHP-round survey replies differed from the initial Likert scale survey. Noise, dust, air quality, and bilge are four of European port management's top ten environmental challenges. Air quality is the sixth most-discussed environmental concern, according to ESPO (2005), and clean energy is needed for ships and port equipment.

2.4 Cause of Environment issues in ports:

Ports throughout the globe are struggling with environmental issues while still supporting the maritime industry. Ports' negative environmental consequences are rising as cargo quantities continue to grow. There is a rising demand from communities for ports to reduce or eliminate the environmental damage caused by their activities. Some ports sometimes aim to become "green ports" (Wayne K. Talley, 2009).

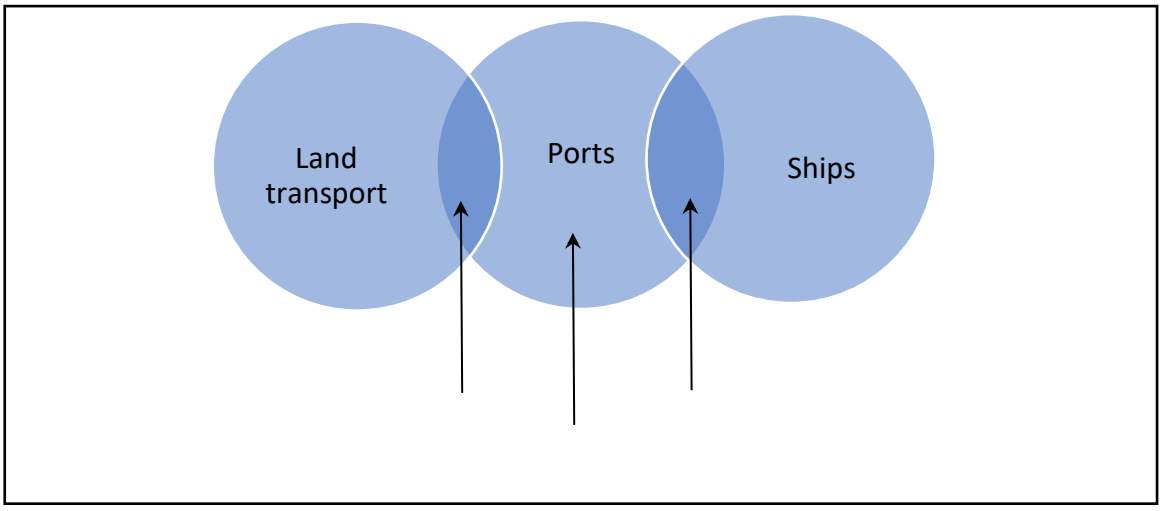
Ports create externalities; hence, environmental concerns are on the rise. Environmental issues are of utmost importance for ship and cargo handling, port industrial operations, port planning and extension, and hinterland access. Port operations and development are important polluters. These include ship emissions, terminal handling equipment (cranes, yard equipment), as well as the port's logistics and industrial activity. Also problematic are port-related noise, environmental issues, and congestion caused by barges, rail, and trucks (Theo Notteboom, 2022).

To accurately assess and explain environmental consequences, it is essential to define port operations and their related environmental factors. Activities, goods, or services that have the potential to interact with the environment are considered to have environmental elements under ISO 14001 standards (Široka et al., 2021).

Economic expansion has environmental implications because of the many services that ports provide, such as logistics, connecting to land and maritime transportation networks, commercial and semi-industrial operations, logistics and distribution operations, and the generation and distribution of energy. The environmental impacts of port development, operations, and shipping/land transportation activities are exacerbated by these challenges (externalities) (Alamoush et al., 2021). The effect on the environment of ports may thus be classified into three categories: port operations, pollution from ships, and Port hinterland intermodal emissions (OECD, 2017).

Figure 3

Classification of environmental impacts in ports



Note. Developed by the author based on Notteboom (2022) and OECD (2017).

2.4.1 Ships aspect:

As worldwide trade and port traffic increase, more people are becoming aware of the shipping industry's significant contribution to air pollution, although shipping is commonly considered a greener mode of transport (H. Lee et al., 2020). Pollutants such as greenhouse gases and carbon monoxide are frequently referred to as the principal pollutants from the combustion of ship engines. These pollutants are NOx, SOx, and PM10 (particulates smaller than 2.5 microns). Experts predict that over the coming 10-40 years, due to the expansion of the e-commerce industry and international trade, there will be a dramatic rise in the emissions produced by ships (Eyring et al., 2005). In 2010, the percentage of NOx pollutants emitted was estimated to be 15 % anthropogenic emissions globally. In contrast, reports put the quantity of sulfur dioxide (SO2, which made up 98% of released SOx) from ships between 4% and 9% (Tzannatos, 2010).

Over 70% of global routes' exhaust emissions are thought to occur within 400 kilometers of shore, with 60-90% of those emissions stem from using auxiliary engines during berthing (Ballini & Bozzo, 2015). Pollutants released into the atmosphere can then migrate to the mainland, interacting with and impacting the local climate (Endresen et al., 2003). Thus, in the past few decades, ship emissions, particularly in-port emissions, have garnered growing attention from the public and research sectors (Eyring et al., 2010). Climate change, coastal air quality, and community health have all been impacted by emissions (GHGs cause the radiative imbalance of the atmosphere; NOx boosts surface ozone production, and NOx contributes to acidification)(H. Lee et al., 2020).

2.4.2 Landside aspect:

Port operations have become more complicated and complex, and their impact on supply chains is becoming more significant. A rising number of investigations have examined the competitiveness of supply chains about ports as a consequence of this well-known phenomenon. In addition to being an essential part of the supply chain,

hinterland connectivity and port performance are strongly linked (Lam & Gu, 2013). According to some research, these two aspects appear to have a good link (Bichou & Gray, 2004; Paixão & Marlow, 2003; Rodrigue & Notteboom, 2009).

2.4.3 ports operations aspect:

The world has become more integrated, maritime movements and maritime activities at ports have grown, as have worldwide worries about the environmental consequences (Dinwoodie, Tuck, & Knowles, 2012). The ports' operations may harm the environment and human health. These activities involve the use of a variety of (mainly diesel-powered). In addition, port activities contribute to noise, odor emission, rubbish accumulation, water and air pollution (Široka et al., 2021). Maritime operations include a variety of standard procedures, such as marine fuel bunkering, exchanging ballast water, and anchoring, that a ship must accomplish when it is docked to conduct maritime operations properly. The operations of a corporation have the potential to have an impact on a wide range of environmental parameters, including emissions into the atmosphere, soil and sediments, water discharges, noise levels, and the production of garbage. (Dinwoodie, Tuck, & Knowles, 2012).

2.5 Environment issues caused by ports operations and solutions (measures)

In the twenty-first century's second decade, ports face several challenges. Environmental management is increasingly incorporated into any organization that claims to be sustainable, efficient, and law compliant. The European Sea Ports Organization (ESPO) identified sustainable port operations development as a key issue. The port may influence the environment in the area around it (inside and outside). In addition to acting as a receiver and a transmitter, it also serves as both. For European ports, environmental concerns are of strategic importance. Priorities for top ten environmental issues in European ports include air quality, noise pollution, energy consumption, water quality, port waste, port development, relations with the local community, climate change and ship waste (Oniszczuk-Jastrząbek et al., 2018). As a

result of these problems, the port industry now needs to carefully consider about implementing a sustainability approach (Lim et al., 2019a).

A recent review (Alamoush et al., 2021) that revisited the port sustainability based on 112 peer reviewed articles and technical reports classified the issues in ports from the environmental perspectives (toward greening the port as a pillar of the sustainability triple bottom lines 3BLs) into: air pollution issues, noise pollution, water pollution and waste issues, freshwater consumptions, hazardous cargo, visual pollution, climate change, and marine biology.

2.5.1 Air pollution

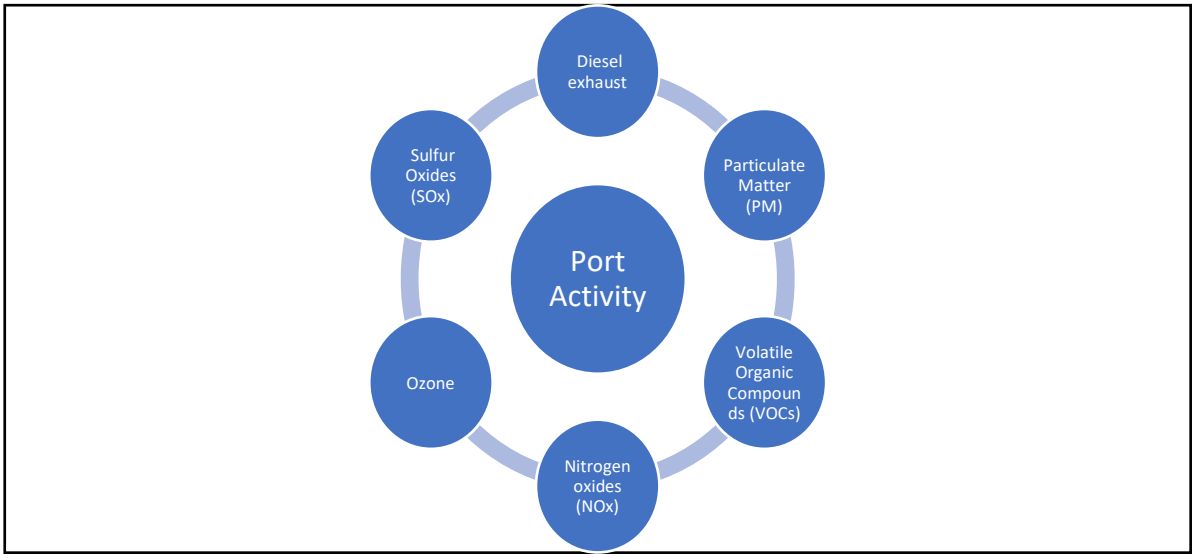
As large sources of air pollutants, ports have a considerable impact on the health of individuals living in close populations, and on regional air pollution. In addition to diesel exhaust, PM, VOCs, NOx, ozone, and sulfur oxides, there are several other air pollutants that may harm human health when they're released into the atmosphere during port operations (SOx). Air pollution from ports may also include harmful chemicals like carbon monoxide (CO), formaldehyde, heavy metals, dioxins, and pesticides used to fumigate produce (Bailey & Solomon, 2004). Globally, billions of people are affected by the dangerous effects of air pollution. For instance, in 2017, 111 million Americans (about 35% of the U.S. population) were estimated to reside in counties with bad air quality, as reported by the Environmental Protection Agency (EPA) (Lu, 2020).

Boats in the marine industry are responsible for 14% of the NOx and 5% of the SOx from all fossil fuels. A total of 7% of the United States' NOx and 6% of its PM emissions in the year 2000 came from commercial marine boats. (Diane Bailey & Solomon, 2004). Pollutants in the air that ports produce have consequences for both the environment and society (Dinwoodie, Tuck, Knowles, et al., 2012). Among the environmental repercussions are the acidifications of the oceans, which is caused by two distinct factors. The ocean's absorption of CO2 from the atmosphere is the primary cause, although evidence is mounting that additional contaminants in coastal areas

may be contributing to the acidification caused by CO2 (Billé et al., 2013). While, socially, they have a negative influence on the health of local populations and employees, including respiratory disorders (asthma), lung cancer, cardiovascular disease, early death, and birth defects (Diane Bailey & Solomon, 2004). According to the World Health Organization (WHO), the air quality standards are intended to provide direction in minimizing the health implications of air pollution. However, research shows that nine out of ten people breathe air that is higher in quality than the WHO guideline. It is estimated that air pollution causes the deaths of at least 7 million people around the world every single year. (WHO, n.d). Approximately 60,000 premature deaths per year were attributed to air pollution, primarily along the coasts of East Asia, South Asia, and Europe. The exposure to fine particulate matter reduces life expectancy. Lower life expectancy is associated with exposure to fine particulate matter. Numerous adverse effects on human health have been linked to exposure to tiny particles, including an increased risk of death (Wang et al., 2021).

Figure 4

Sources of air pollution from ships in ports

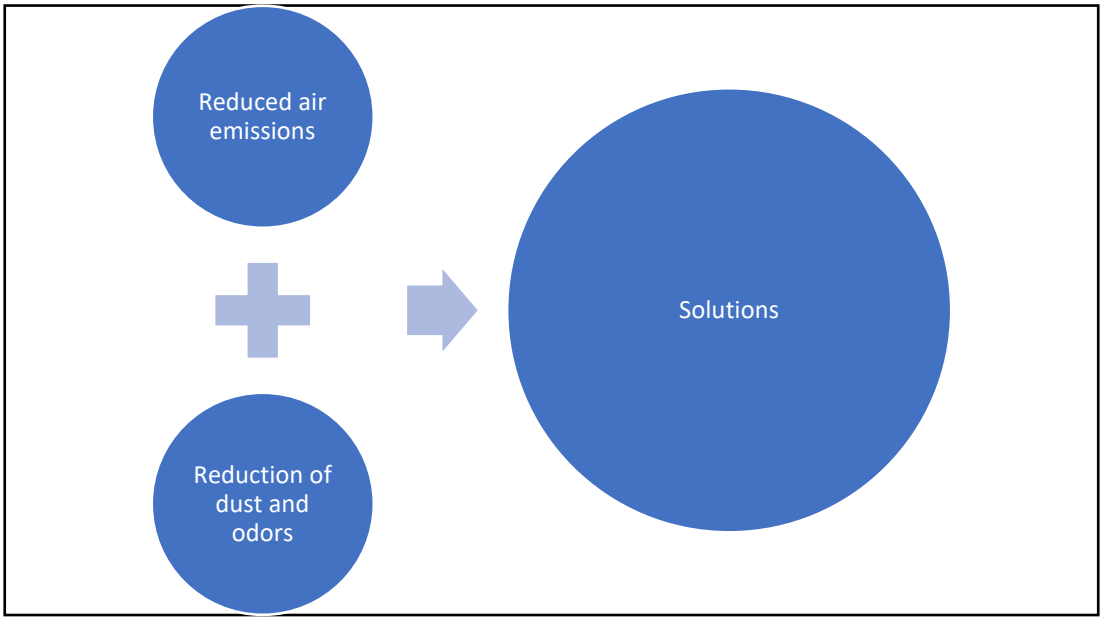


Note. Developed by Author based on (Diane Bailey & Solomon, 2004).

Port operations may minimize air pollution and dust and odor by implementing a variety of strategies. Co-benefits of air pollution reductions and GHG emission reductions should be taken into consideration figure 2 (Alamoush et al., 2021). Table 2 presents a synthesis of actions and measures that can be implemented.

Figure 5

Solutions and actions to reduce air pollution



Note. Developed by author based on Alamoush et al., 2021.

Table 2

Management of air pollution actions and measures

Actions and solutions	Measures
Reduced air emissions	- Inventories of emissions and energy consumption. - Emission control inside the ports. - Replacing polluted equipment or replacing the engine with clean engine.

	- Use low-sulfur fuel and alternative fuels that can be made from renewable sources (such as LNG, hydrogen, ammonia, renewable diesel, and methane). - Onshore power supply (OPS) for ships. - Supply of alternative fuel bunkering for vessels. - Economic Operator System's automatic clearance, extended gate hours, off-dock staging yards, and chassis eliminate port truck traffic congestion.
Reduction of dust and odors	- using of dust and smoke recycling methods for dry bulk ships. - Reduce emissions of volatile organic compounds (VOCs) from liquid bulk ships operations.

Note. (Alamoush et al., 2021; Darbra et al., 2009; Dinwoodie, Tuck, Knowles, et al., 2012; Jim et al., 2013; Oh et al., 2018; Peris-Mora et al., 2005).

2.5.2 Noise pollution

Human and environmental health are negatively impacted by noise pollution, which is caused by human activity such as industry and transportation. Port areas have the most industrial and traffic noise and are becoming complex infrastructure with similar environmental impacts as industrial and manufacturing sites. Port activities include resource extraction, coastal zone industry, inshore fishing, and mariculture. Ports are frequently near urban areas, therefore any environmental issues from the port activity will affect nearby areas (Piličić et al., 2020)**.** The port authorities and port stakeholders must manage noise levels from the port and logistic operations, industrial activity, and port development projects. Noise management is a key goal for ports in their relationship with the cities they're in, and it's the fourth environmental priority of European ports (ESPO, 2021).

There are much more complicated activities at ports and harbors than at other logistical sites and analyzing noise pollution is difficult since there are so many distinct kinds of sound sources in one region. Industrial and shipyard activity, as well as ancillary

services, contribute to the port area's aural pollution. Noise pollution may have a harmful impact on both the natural environment and the human population (Schenone et al., 2014). There are many activities directly associated to the port's tasks, such as cargo transports, commercial ship powering, sludge and sewage, and products handling. Other activities are indirectly related, such as heavy or light railway and vehicle traffic, power plant waste, production, and others (Schenone et al., 2016). One of the primary sources of noise in ports is machinery, in ports, cargo handling machinery is a substantial source of noise, Two-way trucks, automobile traffic, railways, Ramps at the vessel-quay contact, Container, and bulk cargo handling, and ships (D Bailey et al., 2004).

Therefore, it is imperative that ports need measures to monitor and control noise above a certain level, which is possible to implement the following measures such as (Alamoush et al., 2021; Chen & Pak, 2017; Schenone et al., 2016) A noise level monitoring system,

- Noise control laws and regulations,
- Decreasing the amount of noise as well as vibration generated by equipment from cargo-handling and ships, and
- Minimizing the noise impact on the locals and communities during the development and expansion of infrastructure.

2.5.3 Water pollution and waste

For many years, the world's oceans and seas have experienced environmental deterioration, and there is a need to avoid additional damage. Pollution is a key contributor to environmental deterioration, with the world's seas collecting contaminants from both land and sea, including trash. Waste is described as everything that is no longer valuable, such as white goods that have passed their expiration date, food waste, garbage from packaging, sewage, and hazardous by-products of manufacture. Waste is a problem that affects people across the world and appears to be becoming worse as we move into the twenty-first century (Butt, 2007). Port and

supply chain operations have several consequences. Certain activities and operations including as sewage, bilge wastes, waste oil discharges, dredging, and leakages, degrade the water quality of the sea (Darbra et al., 2009; Peris-Mora et al., 2005). Therefore, one of the most significant environmental issues is the worldwide poisoning of freshwater systems by industrial and natural chemical substances. Thus, nearly 20% of the world's population lives in unsanitary conditions, and 15% do not have access to clean water (Bhatnagar et al., 2014).

Port garbage pollutes the land and groundwater, causing environmental health (PIANC, 2014). In addition, water pollution results from several sources, most notably oil leakage in ships, cargo residues, ballast water and garbage waste. Moreover, to causing damage to the environment, these pollutants pose a threat to maritime habitats and species. Marine ecosystem health is significantly impacted by the introduction of alien species into national waters through shipping ballast water, which can also decimate natural species and create an ecological imbalance (Jim et al., 2013). It's indeed possible to have skin ailments and harm the marine ecosystem and habitats if sewage from ships is disposed of in the sea in port regions. To prevent and minimize the discharge of waste matter, as well as water pollution, ports can provide standard water quality by implementing appropriate pollution controls (Alamoush et al., 2021).

Control, prevention, and monitoring of cargo as well as oil spills through operations and disconnection of pipes liquid bulk ships, as well as from engine oil and lubricants, can be achieved by a variety of methods. Another waste issues can be improved by the circular economy (PIANC, 2014). Although, port operations and economic activities create significant amounts of material at sea and on land, which generates negative pollution. However, ports can implement circular economy practices to reduce, recycle, and reuse garbage, changing the supply chain from continuous to circular (Alamoush et al., 2021).

2.5.4 Freshwater consumptions

The activities, cleaning, and washing carried out on bulk ships and yards, in addition to the provisioning of water for highly demanding cruise ships, all contribute to the

high-water consumption that is seen at ports. It is possible to put into place safeguards for the protection of freshwater resources and measures to preserve water. For instance, ports might establish targets to cut down on the amount of drinking water that is wasted, keep track of how much water is used and any leaks that may occur, treat, and reuse wastewater recycle (on-site) cleansing water for irrigation and cleaning, and collect precipitation (Alamoush et al., 2021; Jim et al., 2013).

2.5.5 Hazardous cargo

Concerns have been raised about the effective management of hazardous cargo carriers in a port environment due to the loss of life and environmental degradation affected by way of accidents in the transport of hazardous products (Khan et al., 2021).

When a substance may cause damage to human health, property, or the natural environment it is considered hazardous and is thus considered a hazardous good. Some of the most common dangerous goods are petroleum fuels like natural gas and refined crude oil. When it comes to port logistics, there are a lot of variables to consider. Hazardous commodities transit, storage, packaging, loading, and discharging, as well as information on the physical distribution of the items, are all part of the port operations involved in minimizing risk. The storage and movement of hazardous products at ports and between ports are subject to dangers. Personal injury, property damage, and environmental degradation are all possible outcomes of mishaps involving hazardous products at ports (Liu et al., 2019).

For example, those incidents involving hazardous cargo, such as those that occurred in the ports of Tianjin and, Beirut have aroused significant concerns regarding the proper handling of high-risk cargo. Although the significance of human error in such catastrophes is well-known, less is known about how the linked elements interact. Therefore, the ports can take measures related to direct and indirect safety (Khan et al., 2021). Table 3 presents some actions and measures that can be implemented to reduce the negative impact from hazardous cargoes.

Table 3

Management of hazardous cargo actions and measures

#	safety procedures		
1	Direct safety measures.	1.1 Training: 1.2 Supervision: 1.3 Incentives and disincentives	- Training of personnel who handle dangerous goods. - Using previous incidents and benefiting from them in employee training. - Employees should receive hands-on training in how to respond mentally and psychologically, as well as how to assess the situation and act in the event of an emergency. - Extensive supervision of the storage of dangerous goods. - Supervising the periodic inspection repairs and maintenance of equipment machinery and IT tools. - Providing Incentives and disincentives for good and bad performance.
2	Direct safety measures.	Policies and legislation	- Develop and enact policies related to an effective safety system.

			- quantify the safety environment, culture, and performance of diverse safety companies using a variety of programs.

Note. Created by author based on (Khan et al., 2022).

2.5.6 Climate change

Ports play a critical role in the expansion of the global economy. Carbon dioxide emissions from port activities are among the most major environmental factors that contribute to climate change (Azarkamand et al., 2020). Global economic growth and human well-being will be harmed if climate change has an influence on ports such as seaports, dry ports, logistics and distribution centers, etc.). There are numerous unknowns, however, because the effects of climate change can vary widely from country to country and area to region (Ng et al., 2015). An adaptation strategy is needed for the global economy's backbone, which is maritime trade and coastal infrastructure through adaptation and mitigation (Becker et al., 2012).

Table 4

Climate change adaptation measures and actions

Climate change affects the environment.	Potential threat	Measures
	(A) The Port's facilities might be destroyed by high waves.	(A) Increase breakwater size.
		(A) Raise the height of the port.

Sea level rise (SLR)	(B) Port infrastructure and superstructures flood.	(B) Improve the flood-resilience of transportation infrastructure.
	(C) Port-area erosion.	(A) Increase beach nourishment and coastal protection.
	(D) Channel deposition and sedimentation.	(A) Dredging should be increased or expanded.
	(E) Flooding limits road/rail access to port/terminal.	(A) Improve port/terminal access.

Note: (Yang et al., 2018).

Table 5

Climate change mitigation measures and actions

Actions and solutions	Measures
Reducing greenhouse gas emissions and increasing energy efficiency.	- creation of an inventory of energy use and a carbon footprint that considers shipping as well as land transportation. - Utilization of renewable energy systems such as solar, wind, ocean, geothermal. - Reducing energy usage by insulating, coating, and painting facilities, stores, and warehouses, and utilizing refrigerated sheds. - LED lighting with sensors that turn on and off automatically. - Utilization of energy-efficient technologies such as intelligent grids, microgrids, intelligent load management, regenerative energy reclamation, virtual power plants,

	energy-storage systems, and energy-saving tires. - management of the heating, ventilating, and air-conditioning systems (HVAC). - Effectiveness planning for example cranes and yard planning. - Carbon capture and storage projects.

Note. (Alamoush et al., 2021; Lim et al., 2019a; PIANC, 2014; Villalba & Gemechu, 2011).

2.5.7 Marine biology

Shipping and port operations can, in several different ways, have a negative impact on both the terrestrial habitat and the marine ecology. The activities and operations of the port, in addition to the expansion project of the port, could result in the loss of habitat (Walker et al., 2018). Two main causes lead to pollution accumulation in harbors sediments which are ports and channels are a focus of industrial (shipping, cargo handlining, accidental spills) and urban (waste-water emissions) operations, as well as they are constructed to reduce hydrodynamic energy inside (Casado-Martínez et al., 2009).

Ports can take steps to reduce the impact of sediments, prevent the destruction caused by dredging, safeguard the quality of habitat both in and above water, and exert more control over the foods that are sold there (PIANC, 2014; Shiau & Chuang, 2015). Dredging initiatives, such as deepening of channels and berths to accommodate larger ships, necessitate resource conservation and novel mitigating measures for example sediment management plans (Alamoush et al., 2021).

Table 6

Actions and measurements in marine biology

Actions and solutions	Measures
Reduce and treat sedimentation.	- Reusing dredged sediments. - Control of silt entering the port and erosion of the coastline. - Putting the sediment in a different place.
Prevent destructive dredging.	- Observe dredging activities (pre and after dredging sampling). - Use environmentally friendly dredgers whether renting, leasing, or approving them. - Turbidity reduction and remediation of contaminated places.
Protect the quality of the habitat (above and below water areas).	- Port-area ecological monitoring and mitigation for habitat quality, protection, and restoration of wetlands. - Restoration of habitat by expanding tidal areas. - Establishing wildlife refuges in and around port areas to protect birds and fish. - Monitoring of soil pollution. - Antifouling and wastewater discharge monitoring and control. - Buying, manufacturing, selling, and banking ecological service credits to mitigate wetlands development consequences. - Buffer zones for endangered coral. - Along harbor entrances, fish bubble curtains prevent fish from entering the dredging area. - Monitoring of soil pollution.

	- Antifouling and wastewater discharge monitoring and control. - Buying, manufacturing, selling, and banking ecological service credits to mitigate wetlands development consequences. - Buffer zones for endangered coral. - Along harbor entrances, fish bubble curtains prevent fish from entering the dredging area.
Controlling floods.	- Food safety training and innovative technology.

Note. (Alamoush et al., 2021; Jim et al., 2013; PIANC, 2014).

2.5.8 Visual pollution

Visual pollution is the observable deterioration of the landscape as well as a decrease in the landscape's aesthetic quality. The coastal beauty is being degraded and there is an increase in the amount of visual pollution as a result of factors such as erosion, marine wrack, litter, sewage overflow, and beach driving. Despite its importance and negative impacts on the environment, visual pollution is perhaps the least addressed sort of coastal pollution (Alharbi & Rangel-Buitrago, 2022). The complexity of assessing aesthetic pollution stems from the fact that this type of pollution cannot be characterized ambiguously. Moreover, the same object may be viewed as contributing to beauty by some, while it may cause discomfort in others (Batzias & Kopsidas, 2020).

This type of pollution has an obviously negative visual impact. The term "visual pollution" is used to describe the individual or combined effects of various forms of pollution on the aesthetic value of the coastal landscape. (Alharbi & Rangel-Buitrago, 2022). Landscape is defined as a place whose character is determined by the interaction and action of natural and human forces, and it is an important factor in an individual's social well-being and people's quality of life. Many facilities that can cause visual pollution, such as cranes and large cargo handling equipment, are

increasing and expanding, and the port area is illuminated at night. (PIANC, 2014). It is necessary for ports to evaluate the visual influence that existing landscapes have on their operations in order to reduce this (Alamoush et al., 2021).

Measures that reduce visual pollution can be taken for example consider the visual impact of noise barriers when designing them. Sky and nearby perspectives should have minimal illumination to retain a nighttime setting. Flares used to discharge gas byproducts or other industrial processes should be aesthetically pleasing (PIANC, 2014). In addition, utilize illumination that mimics the biological spectrum contributes to reducing visual pollution (Chiu et al., 2014).

2.6 Environmental Measures

Based on the literature review above, the port environmental issues and solutions are summarized in the following table, that is to be used for the case study investigation.

Table 7

Measures related to environmental impact in ports

#	Measures	Detailed measures
1	**Air pollution (AP)**	- AP1. Inventories of emissions and energy consumption. - AP2. Emission control inside the ports. - AP3. Replacing polluted equipment or replacing the engine with a clean engine. - AP4. Use low-sulfur fuel and alternative fuels that can be made from renewable sources (such as LNG, hydrogen, ammonia, renewable diesel, and methane). - AP5. Onshore power supply (OPS) for ships. - AP6. Supply of alternative fuel bunkering for vessels. - AP7. Eliminate truck traffic congestion in ports using the Economic Operator System, which includes automatic clearance and extended gate hours, as well as off-dock staging yards and chassis.

		- AP8. using dust and smoke recycling methods for dry bulk ships. - AP9. Reduce emissions of volatile organic compounds (VOCs) from liquid bulk ship operations.
2	**Noise pollution (NP)**	- NP1. A noise level monitoring system. - NP2. Noise control laws and regulations. - NP3. Decreasing the amount of noise and vibration generated by cargo-handling equipment and ships. - NP4. Minimizing the noise impact on the locals and communities during the development and expansion of infrastructure.
3	**Water pollution and waste (WPW)**	- WPW1. Control, prevention, and monitoring of cargo and oil leaks during ship operations. - WPW2. pipe disconnections, and engine oil and lubricants. - WPW3. Waste Recycling.
4	**Freshwater consumption (FC)**	- FC1. Utilize less water for both drinking and irrigation. - FC2. Control water use and leaks. - FC3. Treatment and reuse of water on-site.
5	**Hazardous cargo (HC)**	- HC1. During construction and operation, separate dangerous cargo. - HC2. Dangerous goods handlers' training. - HC3. Training employees using past incidents. - HC4. Practice emergency reaction, mental and psychological preparedness, script reading and recognition, and response time. - CH5. Supervision of dangerous goods storage. - CH6. Supervising equipment repairs and maintenance. - CH7. Good and bad performance incentives. - CH8. Implement safety policies.

		- CH9. Using various methods, measure firms' safety environment, culture, and performance.
6	**Climate Change**	● <u>Measures:</u> - C1. Increase breakwater size. - C2. Raise the height of the port. - C3. Improve the flood resilience of transportation infrastructure. - C4. Increase beach nourishment and coastal protection. - C5. Dredging should be increased or expanded. - C6. Improve port/terminal access. ● <u>Mitigation:</u> - C7. Reducing greenhouse gas emissions and increasing energy efficiency. - C8. Shipping and land transportation energy utilization and carbon footprint inventory. - C9. Utilization of renewable energy systems such as wind, solar, ocean, and geothermal. - C10. Reducing energy usage by insulating, coating, and painting facilities, stores, and warehouses, and utilizing refrigerated sheds. - C11. Provide LED lighting with sensors that turn on and off automatically - C12. Use of smart grids, microgrids, smart load management, regenerative energy reclamation, virtual power plants, energy storage systems, and energy-saving tires. - C13. Management of the heating, ventilating, and air-conditioning systems (HVAC). - C14. Effectiveness planning for example cranes and yard planning. - C15. Carbon capture and storage projects.
7	**Marine Biology (MB)**	- MB1. Reduce and treat sedimentation. - MB2. Reusing dredged sediments.

		- MB3. Control of silt entering the port and erosion of the coastline. - MB4. Putting the sediment in a different place. - MB5. Prevent destructive dredging. - MB6. Observe dredging activities (pre and after dredging sampling). - MB7. Use environmentally friendly dredgers whether renting, leasing, or approving them. - MB8. Turbidity reduction and remediation of contaminated places. - MB9. Wetland monitoring, protection, and restoration in port areas. - MB10. Habitat restoration by tidal expansion. - MB11. Protecting birds and fish by creating wildlife refuges around ports. - MB11. Controlling floods. - MB12. Food safety training and innovative technology.
8	**Visual pollution (VP)**	- VP1. Consider the visual impact of noise barriers when designing them. - VP2. Providing minimum illumination to retain a nighttime setting. - VP3using aesthetically pleasing flares when releasing gas wastes or other industrial activity. - VP4. utilize illumination that mimics the biological spectrum contributes.

Chapter 3: Research Methodology

3.1 Methodology overview:

The usual definition of research is the pursuit of knowledge. Some individuals view research as a movement, from the known to the unknown. It is essentially a discovery expedition. Curiosity is a fundamental instinct we all possess. Research is the process through which man acquires information about the unknown (Kothari, 2004). Researchers hold opinions regarding existence, reality, and truth. This method highlights issues concerning the nature of knowledge (epistemology) and how researchers approach the research process (methodology) Lincoln et al. (2011) (Chamberlain-Salaun et al., 2013).

A methodology is a research approach that integrates ontological and epistemological concepts into guidelines that illustrate how research should be performed. These guidelines explain how the analysis should be carried out. Each different study approach comes with its own set of advantages and disadvantages. No one study approach is guaranteed to be perfect, and any selection process will invariably entail both loss and gain (Nayak & Singh, 2015). A study's strategy and plan are defined by its methodology. To address a research issue, researchers use a variety of methods. Data collection, recording, analysis, and reporting are all influenced by the research methods and study objectives (Chamberlain-Salaun et al., 2013).

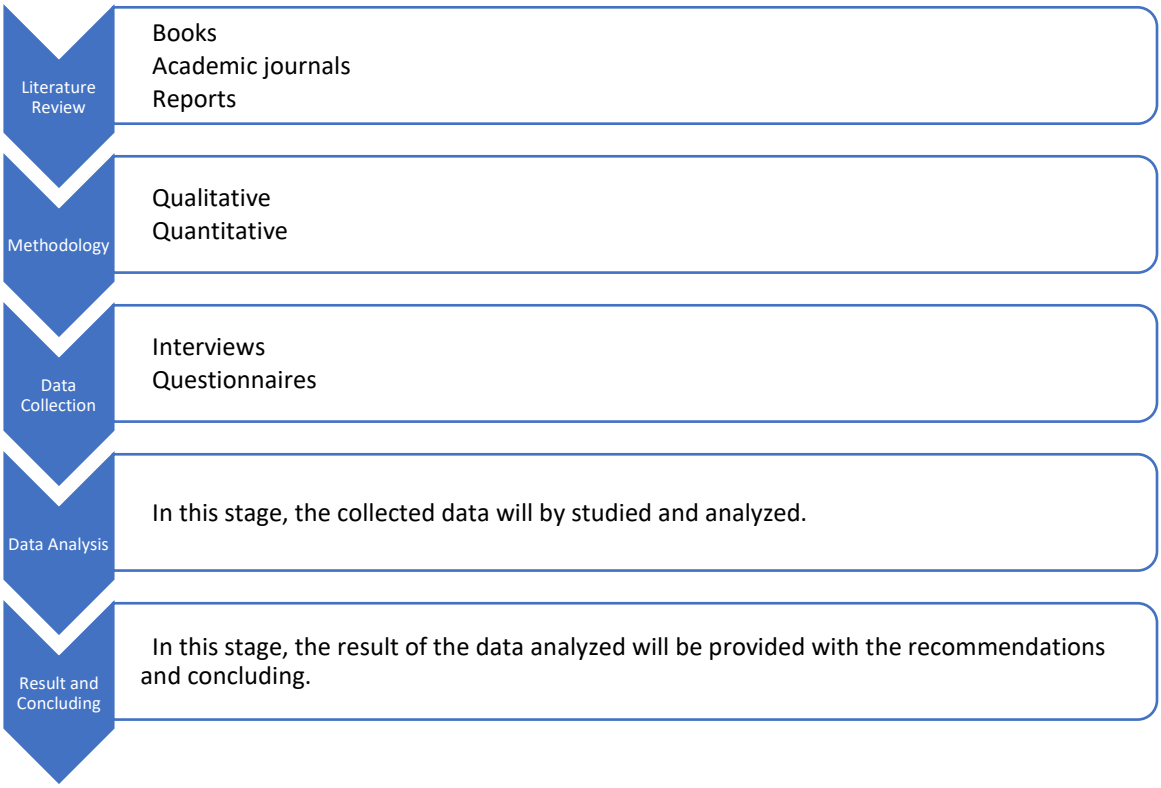
The data for this study was collected via the use of semi-structured interviews, questionnaires, as well as policy and plan documentation. The qualitative approach of semi-structured interviews consists of primary questions explaining the subjects that will be discussed. These questions also invite the interviewer or interviewee to extend their discourse to address the direct questions. This study also employs a questionnaire to obtain qualitative data. The surveys that have been filled out are then sent out and collected. The findings of this research were derived via a comparison of case studies and a survey of the relevant literature (i.e., books, academic journals, papers, etc.).

3.2 Research Design and Framework.

The "conceptual design" of an interdisciplinary research project is the first step in identifying the shared aims that will guide the entire process (Fischer et al., 2011). The design of a study refers to the thought-out and methodical approach taken to planning and executing the study. It is the byproduct of applying a generic scientific model to a wide range of specific research issues. The reality is that most research plans are just that—plans—vague, tentative documents that undergo significant revisions as the research unfolds (Nayak & Singh, 2015). Researchers have created the following structure to serve as a road map for this research.

Figure 6

Research Framework



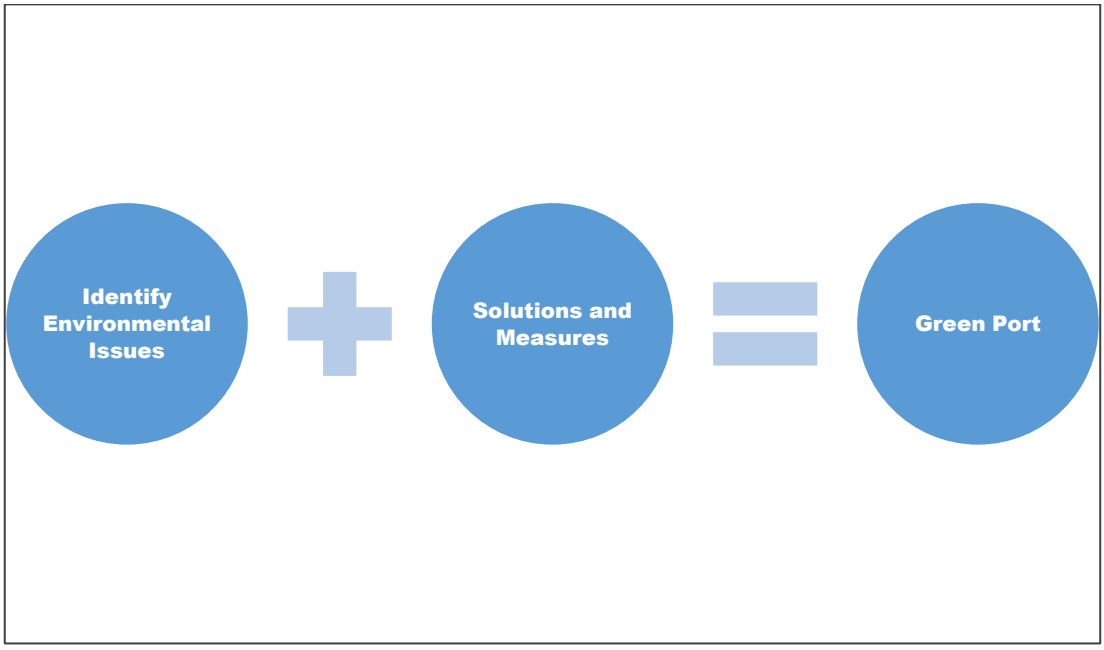
Note. Developed by Author.

3.3 Conceptual Framework

A conceptual framework is "a skeletal structure of justification, rather than a skeletal structure of explanation," as articulated by Eisenhart (1991). A conceptual framework justifies the concepts and their ties to one another as well as their applicability to the research subject at hand. Conceptual frameworks, like theoretical frameworks, are grounded in prior research, but unlike theoretical frameworks, conceptual frameworks are constructed from a wide variety of up-to-date and perhaps distant sources. The researcher's ability to articulate what is relevant and vital to address about a study problem will dictate the theoretical and practical underpinnings of the framework chosen (Lester, 2005).

Figure 7

Conceptual Framework



Note. Developed by Author.

3.4 Design of a case study

A case study is empirical research that investigates a contemporary phenomenon in its real-world environment, particularly when the boundaries are unclear. There are many factors to consider. Therefore, it uses several sources of information and triangulates data to make sense of everything. Also, theoretical hypotheses to guide data collection and analysis are advantageous (Ebneyamini & Sadeghi Moghadam, 2018). This study's primary concentration is on the green port's technique and principle, as viewed from the point of view of Saudi ports. During the construction of the questionnaire, should provide answers to the "how" and "why" questions in response to various scenarios. If this were done, it would pave the way for a more fruitful case study analysis, which could then be used to collect data and investigate the differences between Saudi ports and the ports of other developed countries.

This study is focused on two case studies of Jeddah ports and King Fahad port, which are overlooks Red Sea.

The Jeddah Islamic Port, located in Western Saudi Arabia on the shore of the Red Sea, is the subject of the case study on which this research is based. Green port management and its future initiatives were studied through interviews and surveys. After thoroughly assessing the relevant literature, the discussion contributed to understanding the most critical points. Before the interview, ports' data had been studied and analyzed, and any questions and concerns had been highlighted so they could be addressed. The interview data were used to design or build the case study and integrate it into the literature review. Furthermore, secondary data sources included scholarly articles, annual report reports, and other publications. The considerable challenges of implementing a green port management system in Saudi Arabia will be exposed due to this study, which will establish a connection between Saudi green port management and the experience of developed countries.

King Fahad Industrial Port in Yanbu is Saudi Arabia's largest Red Sea oil and petrochemical outlet. The 1980 port is halfway between East Asia, Europe, and North America via the Suez Canal and Bab Al Mandab Strait. The port supports national industrial complexes that export and import petrochemicals.

3.5 Research Ethics

Qualitative studies, particularly those conducted in educational settings, can raise ethical concerns because human subjects are involved in the research process. Considering this, what are some possible study questions? For a researcher, the first rule is to "not harm," which means considering the study's potential negative consequences on any of its participants before moving forward with it (Dooly et al., 2017). While data collection involves human interactions, ethics play a vital role. As a result, the WMU Ethics Committee reviewed and analyzed the survey questionnaire before approval. Anonymity, confidentiality, data protection, and the freedom to withdraw from the study are strictly adhered to protect the participants' rights and maintain their right to privacy. Participation is entirely optional and uncompensated. All data obtained and utilized for the study will be deleted upon the dissertation's submission.

3.6 Case study selection

As with any port in the world, Jeddah Islamic Port is responsible for the export and import of goods, as well as the export of oil, all of which are critical to the Kingdom of Saudi Arabia's economic well-being. Jeddah Islamic Port is strategically located in the heart of the international shipping route connecting east and west. The port is located on the Red Sea coast at latitude 28° 21 (Elentably, 2015). In the next chapter, the role and importance of Jeddah Islamic Port will be highlighted in detail.

3.7 Data Collection

The case study comprises qualitative information obtained through the website, online reports, and semi-structured interviews. This information is from the official website of the government. The questions for the discussion have been organized in a manner predicated on one of the most important aspects of green port instruments, which is port activities.

The Zoom meeting was used to conduct interviews with three interviewees. The first interview was conducted with the Director General of Environment at the General Authority for ports, the second interview was conducted with the Director of Environment at Jeddah Islamic Port, and the third interview was conducted with the Director of Environment at King Fahad Industrial Port. Everyone has professional experience of over 15 years and has been working in the port.

Table 8

Details of the interview

#	Organization (company)	Working experience
1	Saudi Port Authority	greater than 15 years
2	Jeddah Islamic Port	greater than 15 years
3	King Fahad Industrial Port	greater than 15 years

3.8 Data analysis

Interviewees were given a list of techniques for achieving green port status based on the examined literature, and those strategies were utilized to identify the ways being used in port. Important points and issues raised during interviews were noted in a recorded and transcribed transcript for the research. Each interviewee's notes were taken separately to offer messages for the three overarching interview questions in the port case study.

To determine the primary factors affecting Saudi Arabia's green port development, a SWOT analysis (Bunting, 2015) was conducted. The literature study provides a set of critical parameters that, when analyzed, may be utilized to quantify a port's eco-friendliness. The Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis is a strategic technique used by individuals and businesses to assess the merits, flaws, prospects, and dangers of a given project or business strategy. The study's strength lies in its focus on the features of efficient environmental management instruments. For the weaknesses, it cites several features of green port tools that make it inferior to competitors. Opportunity refers to environmental conditions the port can use to its advantage in terms of strategy, economy, and technology. Finally, the port's risks could be the barriers that prevent it from being a green port.

3.9 Reliability and validity

The consistency of the results is referred to as reliability, while the validity of the findings is represented as the veracity of the findings (Mohajan, 2017). The questionnaire was prepared after careful and methodical planning to yield helpful information for the study's objectives. Every step of the way, the Professor in charge of this study meticulously examined it, making improvements based on his vast experience and understanding. The WMU Research Ethnic Committee Protocol examined and approved the questionnaire for usage and dissemination after determining that it was appropriate and relevant to answering the research questions of this study.

Chapter 4: Maritime Industry in Saudi Arabia

4.1 Overview

The Kingdom of Saudi Arabia is located in the far southwest of Asia, with a total area of over 2,000,000 square kilometers. The Kingdom of Saudi Arabia covers almost four-fifths of the Arab Peninsula. Saudi Arabia is bounded west by the Red Sea and east by the Arabian Gulf. About ten seaports along the Kingdom's coastline are about 3.5 kilometers long.

Figure 8

Strategic geographical location of Saudi Arabia

The Ministry of Transport and Logistics serves (MOT) as the lawmaker for the daily planning and implementation of land, sea, and air transportation services inside the Kingdom, and it works to coordinate the system. To develop the Kingdom's transportation and logistics sector and achieve real integration across all modes of transportation, the Kingdom's transportation and logistics sector is being restructured in the Kingdom. By the Kingdom's Vision 2030, will this reorganization aim to contribute to the Kingdom's economic development and competitiveness in the international area. In addition, one of the objectives is also for the Maritime Transport Sector to reduce the environmental impact of shipping. The Ministry of Transport

supervises the Transport General Authority (TGA) for transport represented by the Maritime Transport Sector and oversees the General Authority for ports (Mawani), which organizes the work of ports in the kingdom (MOT, n.d).

4.2 Shipping:

The maritime transport industry aspires to expand the fleet of ships flying the Saudi flag and to rehabilitate the capacities of seafarers on board these ships to meet International Maritime Organization (IMO) requirements for safety and protection of the marine environment and maritime security (TGA, n.d).

The maritime transportation sector in the Kingdom is well developed. Saudi Arabia is a leading player in the marine industry's growth. The Saudi government has shown unwavering support for the transportation and maritime transport sectors, particularly helping to propel the Kingdom to the 20th spot among the IMO's 174 member states in maritime transport. The Kingdom's maritime fleet increased in size, with the combined tonnage of its 368 tankers and ships rising by 3.5 million tons to a total of 13.5 million tons from 2017 to 2020 (UNCTAD, 2020).

Table 9

Tonnage of Saudi fleet from 2017 to 2020

	2017	2018	2019	2020
Number of vessels	242	301	312	368
Tonnage	3.5 million	6.9 million	7.6 million	13.5 million

Note. Transport General Authority of Saudi Arabia (TGA, 2022).

4.2.1 Shipping strategic plan

Saudi Arabia's massive maritime fleet is vital to the maritime transport industry, which accounts for 90% of world trade. This confirms the Kingdom's goal to be a worldwide

logistics center aligned with Vision 2030. The Kingdom focuses on sustainable marine development by organizing international conventions and treaties and linking three continents. Saudi Arabia's extensive coasts, the Arabian Gulf, and the Red Sea carry 13% of this industry's global traffic. The Kingdom implements the finest approaches to promote sustainability in the maritime transport industry, which is vital to worldwide trade. Saudi Arabia strengthens its partnerships with organization members by contributing to the UN's sustainable development strategy, strengthening maritime security and safety, and conserving the marine environment. The Kingdom retains a distinguished position and works to become a model in this crucial industry, as accomplishing the national strategy for transport and logistics demands integrating and harmonizing the public and private sectors. Integration and harmonization would be achieved by activating existing plans and projects and using ample investment opportunities to attract local and international investment. Diversifying the economy and increasing local content would result (Government of Saudi Arabia, 2020).

4.3 Ports:

Saudi Arabia is a significant oil exporter. It has the largest and most diverse economy in the Middle East, with international industrial exports. The kingdom requires adequate, well-equipped ports. By processing imports and exports, the Port Authority boosted the economy (Mira et al., 2019). One of the world's most important maritime hubs, "Mawani," overlooks two important oceans and coasts that cover a large area. Mawani oversees nine national ports, seven commercial ports, and two industrial ports, as shown in Table 3. The Seven commercial ports are Jeddah Islamic port, King Abdulaziz port Dammam, Jubail port commercial, Yanbu port commercial, Jazan port, Duba port, and Ras Al-Khair port. The two Industrial ports are King Fahad Industrial port Yanbu and King Fahad Industrial Jubail. In all, these ports will help bring the number of re-export logistics hubs in Saudi Arabia to 30, raising the country's ranking on the cross-border commerce index to 35th by the year 2030. To improve the regulatory character of the authority and its operational model and to ensure an

efficient and trustworthy regulatory and commercial environment, the plan intends to facilitate growth and innovation in the marine ecosystem in the Kingdom (Mawani, n.d).

One of its the government responsibilities is expanding maritime trade and passenger transportation on a local, regional, and global scale. The authority oversees the Saudi port system, one of the most developed in the region and worldwide, and significantly influences maritime navigation. The authority's goal is to create a successful and long-lasting naval economy. To strengthen the Kingdom's global logistics center position and allow its economic and social ambitions. It also contributes to making the Kingdom of Saudi Arabia a leader in the port ecosystem, which is supported by operations that are reliable and efficient as well as an environment that is safe and sustainable, all while creating economic and social value with its partners, promoting innovation, and developing capabilities that are leading the industry (Mawani. n. d).

Table 10

List of Saudi Ports

Commercial Ports	**Industrial Ports**
1. Jeddah Islamic Port. 2. King Abdulaziz port Dammam. 3. Jubail port commercial. 4. Yanbu port commercial. 5. Jazan port. 6. Duba port. 7. Ras Al-Khair port.	1. King Fahad Industrial port Yanbu. 2. King Fahad Industrial Jubail.

Note. Saudi Port Authority.

As shown in Table 4, these ports are responsible for 95 % of the export and import of commodities that pass through the kingdom's seaports. However, only 55 % of the

cargo handled is related to exports. In addition, about 5 million Twenty-Foot Equivalent Units (TEUs) are processed each year, and 11,000 ships call on Saudi Arabian ports each year (Elentably, 2015).

Table 11

Development of annual throughput at all ports from (Tonnes) 2015 to 2019

Commodity	2015	2016	2017	2018	2019
Foodstuff	27,697,544	28,212,233	28,360,632	27,490,172	23,682,341
Construction material	17,785,274	14,738,068	10,932,346	10,401,827	12,108,795
Cement	661,040	560,050	393,684	357,153	215,348
Vehicles	3,388,251	2,486,714	2,156,465	2,138,049	2,451,746
Equipment	520,447	509,702	44,795,442	244,787	238,230
General cargo	53,312,119	61,315,454	20,783,528	67,406,210	67,493,832
Total import	103,364,675	107,822,221	107,422,097	108,038,198	106,190,292
Total export	130,587,791	144,523,376	150,469,938	159,058,438	156,126,623
Total handled	233,952,466	252,345,597	257,892,035	267,096,636	262,316,915

Livestock (head)

Sheep & Goats	7,034,080	8,110,718	9,438,962	6,785,122	6,153,855
Cattle, Calves, Camels	120,965	102,596	83,516	63,912	72,268

Vehicles (number)	1,234,880	922,632	764,613	691,315	798,185

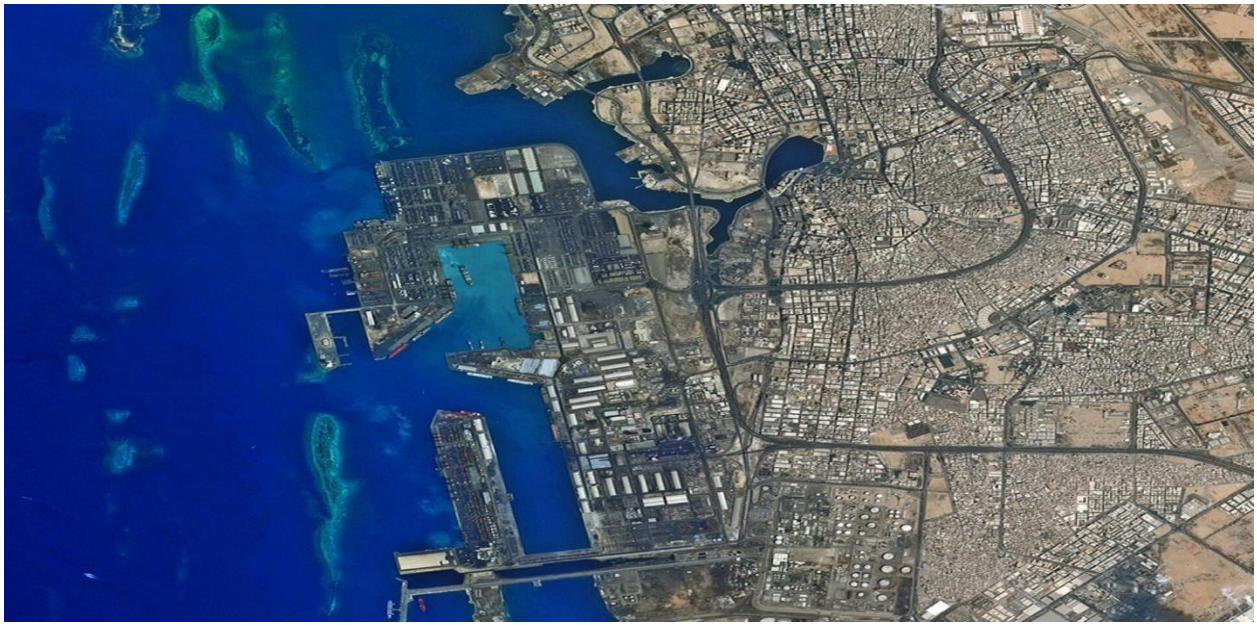
Note. Saudi Port Authority

4.3.1 Jeddah Islamic Port:

The Islamic Port of Jeddah is the most important in the Kingdom, ranked one among the ports on the Red Sea. It is the first port for the Kingdom's exports and imports and the first re-export point in the Red Sea since 75% of the maritime trade and transshipment flowing into Saudi ports currently flow via it. Jeddah Islamic Port is distinguished by its position on the international shipping line, which enables it to connect the three continents to be the first port on the Red Sea coast in terms of maritime trade and transshipment of containers and goods, receiving approximately 5,000 ships annually (Mawani, n.d).

Figure 9

Jeddah port location



Note. Jeddah Islamic Port.

Table 12

Summary of cargo throughput Jeddah Islamic Port year in 2019

Port throughput by type of cargo (Tons).

Cargo type	Discharged	Loaded
Bulk cargo (Solid)	5,623,716	10,800
Bulk cargo (Liquid)	417,722	-
General cargo	1,134,391	317,417
Containers	25,678,090	20,752,741
Ro-Ro & Vehicles	841,689	184,961
Livestock	222,071	18
Total	33,917,679	21,265,937
Total port throughput	55,183,616	

Passengers	Arrived	Departed	Total
	272,986	220,492	493,478

	Discharged	Loaded	Total
Vessels	3,734	265	3,999
Containers (TEUs)	2,221,361	2,212,630	4,433,991
Vehicles	382,687	54,897	437,584
livestock	6,226,122	1	6,226,123

Transshipment cargo	Discharged	Loaded	Total
Containers (Tonnage)	11,771,630	11,677,066	23,448,696
Cargo (Tonnage)	87,524	76,652	164,176
Containers (TEUs)	1,066,227	1,057,985	2,124,212
Restow	85,775		

Note. Saudi Port Authority.

4.3.1.1Assets and Facilities

It has a total of 62 berths, which are multi-purpose berths (containers, general goods, livestock, passengers, loose grain, cars). It includes a logistics services area for deposit and re-export, accelerating the movement of ships' turnover by including handling equipment, warehouses, yards, bunkering for ships, and direct trucking. It has several specialized stations and advanced equipment, such as two container handling stations with a capacity of 7.5 million TEUs. An integrated zone that serves as a logistic village for deposit and re-export. There are two general merchandise stations. Two yards for ship repair and marine part maintenance. Pavements for live livestock handling, with a capacity of 7 million heads per year. A group of berths for maritime services and navigational guidance. System to and from the port. Additionally, it has a direct trucking system to and from the port (Mawani, n.d).

Table 13

Jeddah port services

Space	12.5 Km
Number of berths	62
Number of terminals	4
Carrying capacity	130 million tons
Terminals operators	9

Note: Saudi Port Authority.

4.3.1.2 Jeddah port strategic plan

The Port of Jeddah (Port) announced a new strategic plan in 2006. It was developed by Port personnel with input from tenants, community members, and stakeholders to guide the Port's future growth. This is the Strategic Plan's second update. While the Port's broad ideals have remained essentially constant, this plan outlines the Port's five-

year goals. The goal is a commitment to sustainable development and continual improvement of its environmental performance, as well as the provision of solutions and suggestions for environmental issues, by being proactive on environmental solutions, such as lowering energy use and developing environmental management systems. Each aim defines a sequence of acts or strategies meant to resolve a problem or enhance a situation; the Port will use a new approach to achieve that objective. While these goals are organization-focused and need Port-wide resource coordination, each will be championed by a bureau and its divisions (Elentably, 2015).

One of these is the environmental plan that Elentably (2015) referred to, which is compatible with this study greener ports are those that focus on fixing problems and improving the environment, as well as innovative ways of thinking about the environment and their impact. Climate Change, Clean Air/Greenhouse Gases, Adapting, Sustainability. Healthy Soil and Groundwater, Environmentally Sound Habitat Management.

4.3.2 King Fahad Industrial Port Yanbu

One of the essential ports in Saudi Arabia is King Fahad Industrial Port in Yanbu, the largest outlet for crude and refined petroleum and petrochemicals on the Red Sea coast of the Kingdom. The port, which opened in 1980, sits on a major shipping artery connecting the Far East, Europe, and North America via the Suez Canal and the Bab Al Mandab Strait on each side of the Red Sea. The port handles crude and refined petroleum and gas products, liquid and solid petrochemicals exported by national industrial complexes, and the machinery and equipment required to operate (Mawani, n.d).

Figure 10

King Fahad port location

Note. King Fahad Industrial Port.

4.3.2.1 Assets and Facilities

The Red Sea is Saudi Arabia's primary shipping lane for exporting petroleum and petrochemicals in their crude and processed forms. Three berths and extensive terminals mean vessels up to 500,000 tons in size may dock here annually, and the port handles 210 million tons of cargo.

Table 14

King Fahad port services

Space	6.8 Km
Number of berths	34
Number of terminals	10
Carrying capacity	210 million tons
Terminals operators	11

Note. Saudi Port Authority.

Table 15

Summary of cargo throughput King Fahad year in 2019

Port throughput by type of cargo (Tons).

Cargo type	Discharged	Loaded
Bulk cargo (Solid)	1,213,087	3,475,552
Bulk cargo (Liquid)	29,594,343	49,384,915
General cargo	6,904	-
Containers	604	-
Ro-Ro & Vehicles	2,749	-
Livestock	-	-
Total	30,817,687	52,860,467
Total port throughput	83,678,154	

Passengers	Arrived	Departed	Total
	-	-	-

	Discharged	Loaded	Total
Vessels	426	1,542	1,968
Containers (TEUs)	138	-	-
Vehicles	260	-	-
livestock	-	-	-

Transshipment cargo	Discharged	Loaded	Total
Containers (Tonnage)	-	-	-
Cargo (Tonnage)	-	-	-
Containers (TEUs)	-	-	-
Restow	-		

Note. Saudi Port Authority.

4.4 Saudi Ports Strategy towards Green Ports.

The concept of green ports is consistent with the Kingdom's Vision 2030, which is concerned with strengthening the Kingdom of Saudi Arabia's position and development. It has made the environment and sustainable development one of its main goals, stating the importance of preserving them and promising it from the essential components of quality of life and the need to reduce pollution levels in the environment. The Green Port Strategy's main objective is to support ports' sustainable growth by minimizing the adverse effects of freight movements as well as enable port authorities to prevent negative impacts and control ship emissions by supporting environmental management systems and technology and creating incentive programs to enhance the environmental condition of port areas (Mawani, 2022).

Chapter 5. Survey and findings

5.0 Analysis of study findings

The case studies presented in this chapter will give a detailed review of result from individual interviews and findings are summarized in the form of a SWOT matrix so that a clear and comprehensive picture can be obtained, particularly regarding the primary factors in green port. Every response in the questionnaires or interview will be subdivided and analyzed to determine what might have prompted that response. During the discussion portion of the research project, an attempt will be made to generalize the findings on the ports of Jeddah and King Fahad.

5.1 General results of the interviews

On Sunday, 24/7/2022, the Director General of Environment at the General Authority for ports was interviewed. He discussed the environmental issues in Saudi ports, the authority's main challenges regarding environmental impacts, and plans and strategies to reduce the environmental effects.

Where he explained that Saudi ports, like other ports in the world, suffer from the environmental impacts resulting from the maritime transport industry and that the authority believes that one of the effective solutions in reducing the environmental impacts in the ports is the application of the green port's strategy especially since maritime transport is one of the most important means of transportation in global trade.

He added that the authority faces challenges in environmental legislation with some relevant authorities in the Kingdom, which is reflected in the overlapping powers and work duplication. In addition, some ports face infrastructure problems, such as narrow spaces.

He also emphasized that the General Authority of Ports aims to strengthen the Kingdom's standing as a global logistics hub with its new plan update by boosting the performance index of logistics services and the number of containers each port can process. The Authority aims to strengthen the Kingdom's position as a worldwide

logistics hub and give rise to the country's economic and social aspirations by developing a sustainable and profitable maritime sector.

As Authority's mission is to create economic and social value with its partners, promote innovation, and create industry-leading capabilities, this will help to position the Kingdom of Saudi Arabia as a leader in the port ecosystem by providing stable, efficient operations and a secure, sustainable setting. In addition, one of the primary objectives is to emphasize safety and sustainability. This will be accomplished by lowering the number of people who lose their lives in accidents, reducing the rate at which carbon emissions are produced, raising the effectiveness of the regulatory environment in the maritime and port sector, and digitizing business transactions. Strategic pillars include enabling growth and innovation in the Kingdom's marine ecosystem, strengthening the authority's organizational character and operational model, and ensuring an effective and dependable regulatory and business environment.

After conducting the interviews, it was determined that all Saudi ports have identical environmental issues; hence, the authority allotted a budget to turn them into green ports. In addition, the authority is working on updating its strategies and plans to transform all the kingdom's ports into green ports.

5.2 Survey Questionnaire from the port Jeddah

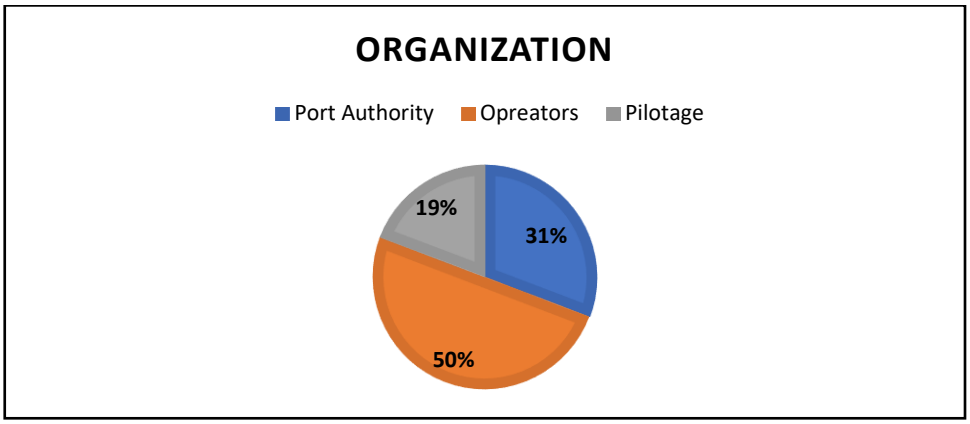
The questionnaire gathered a total of 26 participants from several sectors within the port, administrative and operational.

5.2.1 Professional Backgrounds of the participants from the port Jeddah

A compilation of experiences with each participant from the Maritime Industry sectors, based on the survey questionnaire responses of 26 participants. Port authority had 8 participants, representing 31%, operators had 13 participants, representing 50%, and pilotage had 5 participants, representing 19%.

Figure 11

Professional Backgrounds of the participants Jeddah port

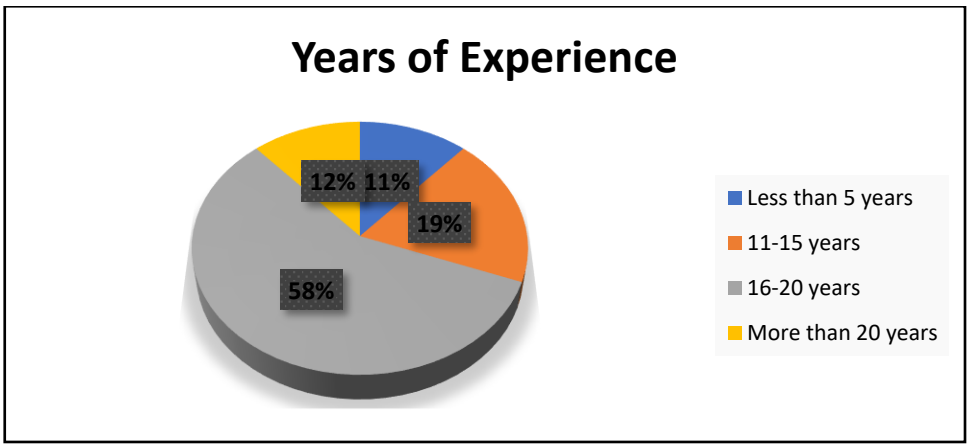


5.2.2 Participants' level of experience from the port of Jeddah

Three participants had less than five years of professional experience, comprising 11% of the sample; five participants had 11 to 15 years of experience, comprising 19%; fifteen participants had 16 to 20 years of experience, comprising 58% of the sample; and three participants had more than 20 years of experience, comprising 12% of the sample.

Figure 12

Level of experience of participants from Jeddah port



5.2.3 Jeddah Port interview result

On Thursday, 28/7/2022, Environmental Department Manager at Jeddah Islamic Port was interviewed. He discussed the environmental issues in the Islamic port of Jeddah and the main challenges regarding environmental influences, and the port's role in the green port strategy and application.

He explained that the most critical environmental problems facing the port in the current period are air and water pollution, in addition to the fact that the port is facing difficulty in establishing reception facilities for ships due to the limited space in the port.

A SWOT analysis of the situation in Jeddah port is shown in Table 2, along with a summary and illustration of the information gathered during the interview.

Table 16

The SWOT analysis for Jeddah port

	Strength	**Weaknesses**
Internal Factors	- Jeddah Port is the most significant and largest commercial seaport on the Red Sea. - Launching the appointment booking service for trucks inside the port to organize the transit of trucks at the Port and minimize congestion on the routes leading to the port.	- The port faces environmental problems caused by ballast water. - There is no mechanism to deal with Anti-fouling Systems. - There are problems with reception facilities due to the limited spaces in the port. - The majority of port cargo handling does not utilize an energy-efficient system.

	Opportunities	Threat
External Factors	- There is an opportunity to transform the port into a green port so that it contributes to getting rid of all environmental problems and becomes less harmful to the environment.	- The current challenges are many law enforcement centers for the environment, resulting in overlapping powers. - Environmental and financial risks are increasing.

5.3 Survey Questionnaire from the King Fahad port

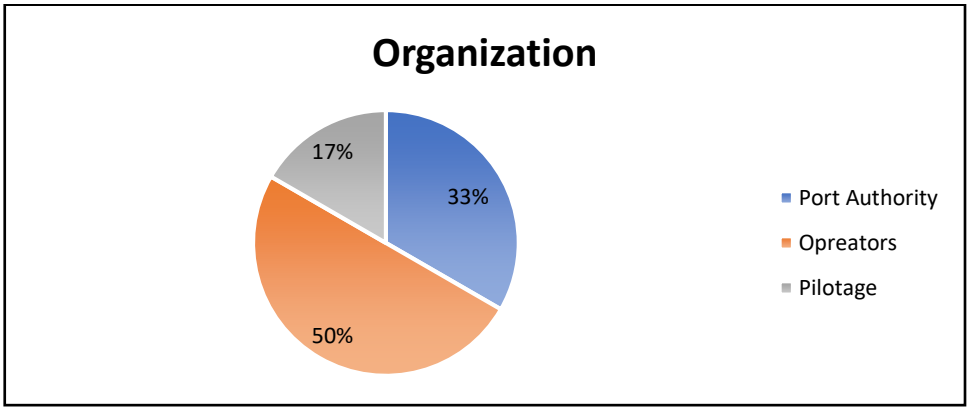
The questionnaire gathered a total of 12 participants from several sectors within the port, administrative and operational.

5.3.1 Professional Backgrounds of participants from King Fahad ports

A compilation of experiences with each participant from the Maritime Industry sectors, based on the survey questionnaire responses of 12 participants. Port authority had 4 participants, representing 31%, operators had 6 participants, representing 50%, and pilotage had 2 participants, representing 19%.

Figure 13

Professional Backgrounds

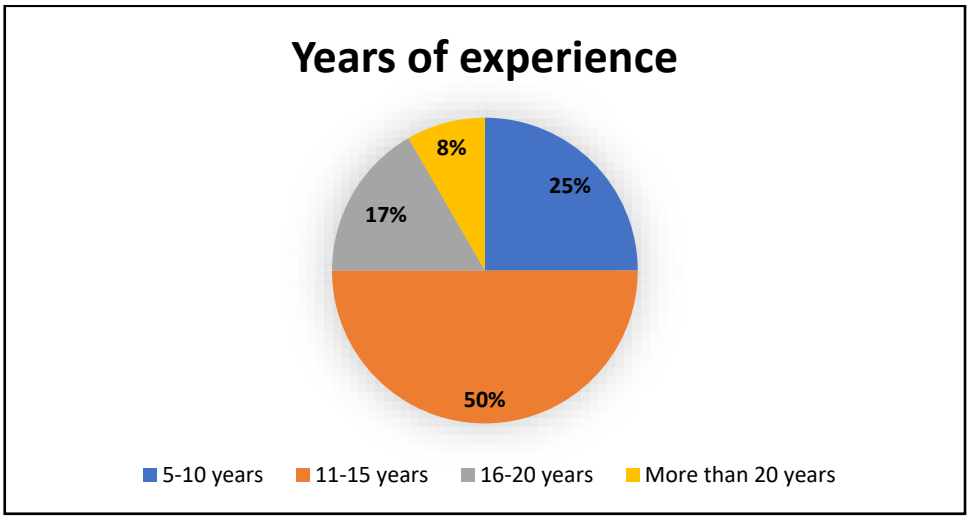


5.3.2 Participants' level of experience from King Fahad port

Three participants had 11 to 15 years of professional experience, comprising 25% of the sample; six participants had 11 to 15 of experience, comprising 50%; two participants had 16 to 20 years of experience, comprising 17% of the sample; and one participant had more than 20 years of experience, comprising 8% of the sample.

Figure 14

Level of experience of participants



5.3.3 King Fahad Industrial Port interview result

On Monday, 01/8/2022, Director of Environment at King Fahad Industrial Port was interviewed. He discussed the environmental issues in the port of King Fahad, the main challenges regarding environmental influences, and the port's role in the green port strategy and application.

He explained that the most severe environmental issues confronting the port are air and water pollution and pollution caused by oil spills, mainly because the port is an industrial port.

A SWOT analysis of the situation in King Fahad port is shown in Table 2, along with a summary and illustration of the information gathered during the interview.

Table 17

The SWOT analysis for King Fahad port

	Strength	**Weaknesses**
Internal Factors	- King Fahad is the most significant and largest industrial seaport on the Red Sea; it's the central Red Sea port for crude oil, processed goods, and petrochemicals. - The port was established to serve industrial complexes, meet their needs, and export liquid and solid petrochemicals to international markets. It imports equipment, machinery, and factory components for the industrial complex. - The port accepts all sizes of oil tankers, container ships, general cargo, and ro-ro ships.	- The port faces environmental problems caused by ballast water. - There is no mechanism to deal with Anti-fouling Systems. - There are problems with reception facilities due to the limited spaces in the port. - The majority of port cargo handling does not utilize an energy-efficient system.
	Opportunities	**Threat**
	- There is an opportunity to transform the port into a green port so that it	- Pollution resulting from oil spills, especially since the port is an industrial port.

External Factors	contributes to getting rid of all environmental problems and becomes less harmful to the environment.	- The current challenges are many law enforcement centers for the environment, resulting in overlapping powers. - Environmental and financial risks are increasing.

5.4 General result from questionnaire

According to the questionnaire results, there are environmental issues in Saudi ports and a lack of awareness among personnel in both the public and commercial sectors about the ecological repercussions of the maritime transport business in general or from port operations in particular. Sustainable development was also restricted to individuals who work only in maritime environment departments. The data was examined using the port's risk assessment, and the eight topics were placed into high, medium, or low-risk categories depending on their potential threat level.

5.4.1 Classification of environmental risks in ports

Based on the interviews and the questionnaire results, it became clear that all Saudi ports have similar environmental issues. It can see from figure 1 that most environmental issues facing the port were classified as high-risk threats, which are as follows, air pollution, noise pollution, water pollution, climate change, and marine biology. At the same time, the medium risk included freshwater consumption and visual pollution. As for the least dangerous, it is dangerous goods, as it most minors the most negligible threat facing the port among the eight issues. In addition, table 3 shows the classification of the eight topics in terms of risks.

Figure 15

The percentage of danger in the port regarding environmental issues

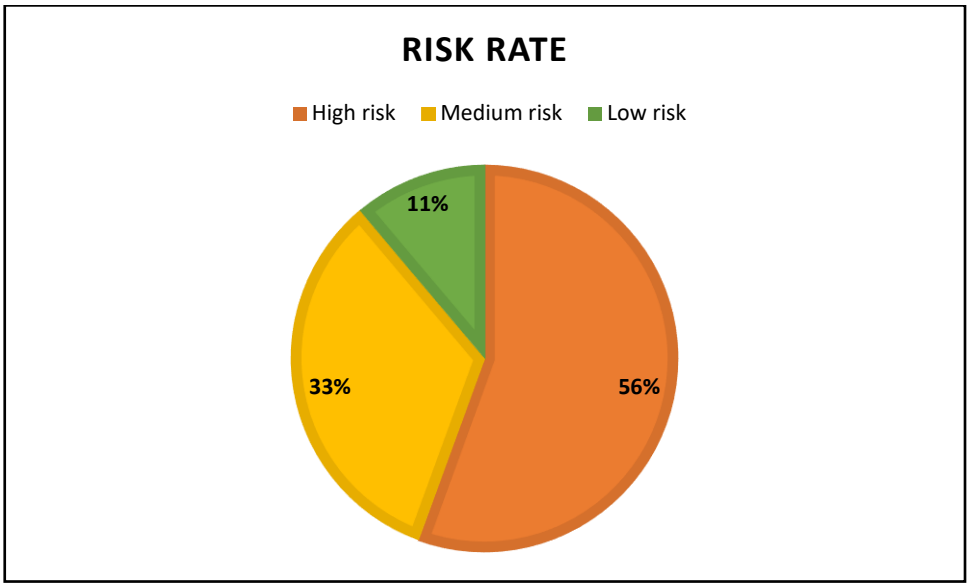


Table 18

Classification of environmental issues in terms of risk

Domain	High Risk	Medium Risk	Low Risk
1. Air pollution	• Air pollution is a significant concern as air pollution is high in the port, and no alternative fuels have been used.		

	● Most port cargo handling isn't energy efficient.		
2. Noise pollution	● The port faces a high noise rate in operations; so far, there is no clear policy to reduce noise inside the port.		
3. Water pollution and waste	● The excessive use of water resources and limited non-renewable groundwater stocks are causing severe problems.		
4. Freshwater consumption		● There are systems to control water use, but so far, there is no recycling inside the port, but recycling is carried out outside the port	

		by specialized companies.	
5. Hazardous cargo			● The port handles dangerous goods professionally by assessing workplace risks and detecting hazardous materials, and the staff is educated to manage them.
6. Climate Change	● Greenhouse gas emissions from vehicles and operational equipment are high. ● No choice of environmentally friendly fuels (such as LNG or hybrid) and energy-efficient vehicles and equipment.		

7. Marine Biology	• Dredging activities are not monitored before and after dredging. • There is no protection of birds and fish by creating wildlife refuges around ports.		
8. Visual pollution		• There is no optical distortion in the port buildings. • Minimal lighting is provided to maintain the night mode.	

Note. Based on the analysis.

5.5 Priorities for the environment

The findings discussed in part before this one paint a prominent picture of the environmental concerns that are most important to the Saudi ports industry. Table 4 below compares the environmental priority of Saudi and European ports, where there is a remarkable similarity in environmental priority.

Table 19

Top-10 environmental priorities of the European and Saudi ports in 2020

#	European Port	Saudi Port
1	Air quality	Air quality
2	Climate change	Climate change
3	Energy efficiency	Energy efficiency
4	Noise	Noise
5	Relationship with the local community	Marine biology
6	Ship waste	Ship waste
7	Water quality	Garbage/ Port waste
8	Garbage/ Port waste	Dredging operations
9	Dredging operations	Water quality
10	Port development (land related).	Port development (land related).

Note. Based on the analysis of the author and (ESPO, 2021).

Chapter 6: Green port strategy

6.0 Green Ports

"Port" is a common noun that connotes a struggle between human activity and the natural world. The port and the surrounding environment have a mutual impact. In the future, port programming, design, and operation will have to adjust to these new factors. Currently, both domestic and international ports have suggested and actively implemented green port building, which has raised public concern about the concept of "eco-ports," "green ports," "environment-friendly ports," and other conceptions of green ports. Despite this, the term "green port" has not been defined definitively (Ying & Yijun, 2011). The economic and environmental efficiency of a sustainable port must be considered. Competitiveness at ports is becoming more dependent on the port's environmental reputation. To maintain the environment while running a company, one must incur significant expenses, such as purchasing environmentally friendly technology. Over time, concerns about ecological protection expenses shifting from companies to the local community are a major public worry. The district may bear the initial investment in environmental protection. As a result, it is advised that stakeholders and maritime policies be employed to solve this issue (Lam & Li, 2019b).

6.1 Green port concept implementation

The first stage in green port implementation is assessing current operational processes and environmental management practices. First, self-evaluate energy and environmental management strategies and procedures. Self-assessment results help to determine the scope of activity, environmental audit, and energy (Pavlic et al., 2014). Energy and environmental audits assess energy usage trends and environmental management techniques to improve efficiency. Energy and environmental audits must incorporate the investigation of technical systems and evaluate the human factor's role and impacts. Performance monitoring relies on audit output with energy and environmental managers should establish a policy and strategy based on audit suggestions. Top management adopts policy and strategy with several strategies and instruments have been developed to help sustain business energy and environmental

performance gains, but the first step requires top-management support and commitment.

Table 20

Green port implementation, activities, and actors

Activities	Actors
Energy and environmental self-assessment.	Manager of Energy. Manager of the Environment.
Audit of energy and environmental practices and performance.	Supported by environmental and energy managers.
Performance monitoring baseline.	Manager of Energy. Manager of the Environment.
Environmental policy/strategy definition.	Manager of the Environment.
Energy policy/strategy definition.	Manager of Energy.
Adoption of an environmental strategy and policy. Adoption of an energy strategy and policy.	Tob management.
Plan for implementing energy and environmental projects.	Top management confirms energy and environmental managers' goals.
Decentralization (individualization) of roles and organizational structure is needed to empower shop-floor employees to increase performance.	Top management confirms energy and environmental managers' plans.
Training and motivation for all staff, including management.	Manager of Energy. Manager of the Environment. Expert outside groups.
Environmental and energy performance monitoring.	Shop-floor leaders support energy and environmental management.

Assurance of performance enhancements.	Manager of Energy. Manager of the Environment.
Continuous learning, communication.	Shop-floor leaders support energy and environmental management.
Continual adaptation and reinvention of energy and environmental policy, performance targets, and goals.	Shopfloor leaders and external experts assist energy and environmental managers. Support and assurance from top management.

Note. (Pavlic et al., 2014).

6.2 Global green port practice

Ports will continue to expand as global trade increases. Wastes from ports will also continue to be a problem for the environment. Now is a perfect moment to be confident that most port authorities are investigating potential regulations to encourage green ports. Table 2 below describes current global activities (Bin Yahya, 2019).

Table 21

Global Efforts to Advance Green Port

#	Region	Actions taken
1	**Europe**	- promote the Self Diagnosis Method aggressively (SDM). This is an optional procedure that allows ports to investigate their environmental policy. To become a PERS Certified Port, SDM is essential. - The Port Environmental Reporting System (PERS) is the only environmental management standard dedicated to the port sector and was designed by the port specifically for use. PERS

		is now accessible in every region of the world because of the ECO Sustainable Logistics Chain Foundation (ECOSLC).
2	**USA**	The Ports Initiative of the United States Environmental Protection Agency (EPA) collaborates with the port industry, communities, and all levels of government to boost environmental efficiency and economic achievement. Two components are measured, including: ● Monitoring ports for air pollution and greenhouse gas emissions. ● Enhancing environmental performance throughout the movement of commodities and passengers through ports.
3	**Asia**	In 2016, the Green Port Award System was promoted by a paper authorized by the Asia-Pacific Economic Cooperation (GPAS). Ports that implement measures to lessen pollution at the port will be recognized with this award.
4	**Australia**	Whereas the Australian government does not offer any known direct incentives to the port sector, they are promoting: - ● A renewable energy target of 20% (RET). ● Australian Carbon Trust energy efficiency incentives.

Note. (Bin Yahya, 2019).

6.3 Processes for getting a green port certification

Over the last 20 years, organizations have adapted to societal pressures and environmental restrictions. The publishing of standards and legislation, most notably ISO 14001 and the Eco-Management and Audit Scheme (EMAS), has led to the certification of a growing number of organizational EMS (Tourais & Videira, 2016). Environmental management systems, often known as EMSs, are designed to codify the processes of managing and mitigating an organization's adverse effects on the

environment. An (EMS) consists of a collection of policies, objectives, information systems, task lists, data collecting and organization, emergency plans, audits, regulatory requirements, and yearly reports. Organizations use them to ensure compliance with environmental rules, decrease environmental costs and risks, train staff, and produce impact indicators (Christini et al., 2004).

6.4 Self-Diagnostic Method

The self-Diagnosis Method (SDM) can help managers and supervisors evaluate environmental performance indicators. The tool offers environmental management performance to past years to identify opportunities for improvement. The SDM focuses on the port's environmental management using a checklist. The goal is to review the port authority's environmental management activities and procedures. The results should be used to detail the port's environmental strategy and report results (Darbra et al., 2004). The Self Diagnosis Method (SDM) was developed within this framework. This tool offers a European benchmark for comparison, is port-specific, and can be implemented in one day. The SDM results are essential requirements for the Port Environmental Review System (PERS) (PERS). This tool helps ports implement ESPO's Environmental Code of Practice. SDM and PERS are essential steps toward the port's Environmental Management System (EMS), which allows for achieving ISO 14001/EMAS certifications (Hakam, 2015).

6.5 Port Environmental Review System (PERS).

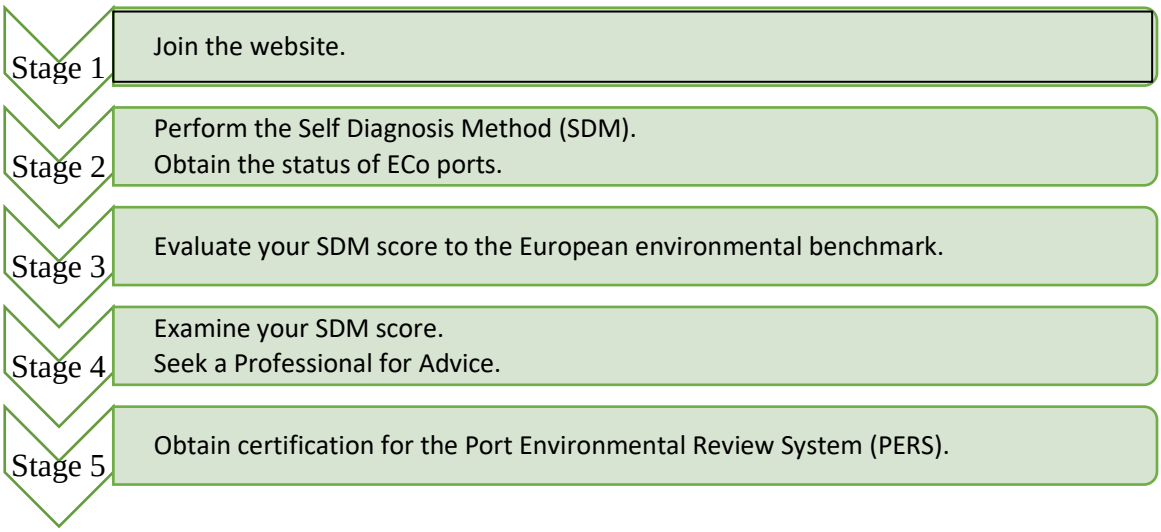
Port Environmental Review System (PERS) assists the port in preparing an available public environment policy statement, setting out strategies and methods for achieving these, regularly reviewing the plans in light of legislative changes, producing a publicly available Annual Environmental Review, considering the environmental monitoring required to assess environmental progress, establishing several relevant environmental indicators with targets to measure progress, and establishing several relevant environmental indicators with goals to evaluate environmental advancement (Tselentis, 2008).

6.6 Steps to obtain a certificate of PERS

The Eco Port tools were initially developed in Europe, supporting getting certified for SDM and PERS voluntarily. The PERS Certification is now the only internationally recognized green port standard in use worldwide. PERS certification applications are becoming increasingly common, but due to the voluntary nature of the certification procedure, they are not yet universally accepted (Bin Yahya, 2019).

Figure 16

Eco Port Tools



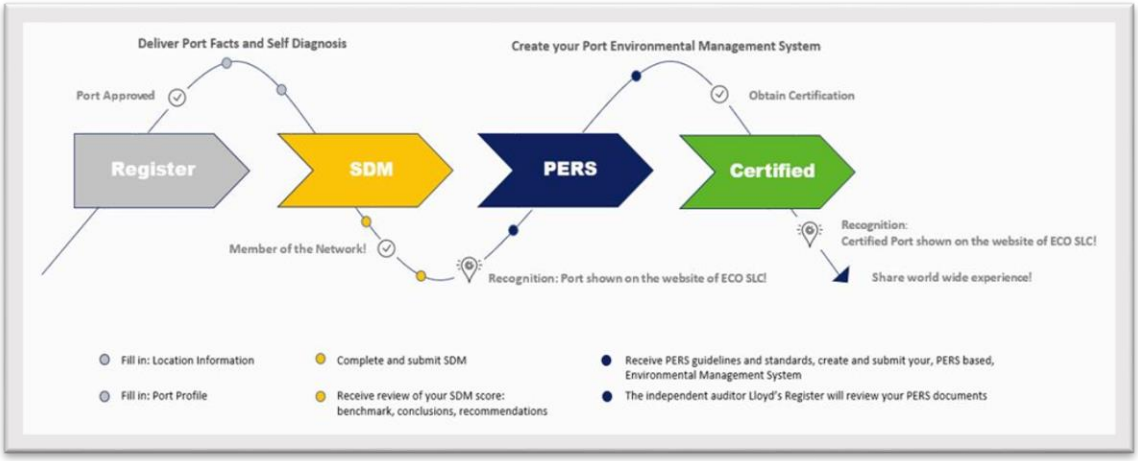
Note. Adopted by (Bin Yahya, 2019).

As shown in Figure 1, all required to make a port eligible for PERS certification have been laid out. To become an Eco Port, applicants must first register with the SDM. A port seeking PERS certification must have the SDM as proof of identity. Achieving Your PERS Credentials (Stage 5), There is a 2-year time limit on the PERS. For this reason, it serves as an incentive for the applicant port to maintain PERS Certification. The PERS considers the SO14001 standard but also accounts for and handles the unique aspects of each port. To help the ports reach an agreed-upon environmental goal, PERS expands on ESPO's policy proposals. Lloyd's Register provides impartial

oversight of the PERS system's implementation. ISO 14001 certifies environmental management systems worldwide. It helps organizations protect the environment and respond to changing conditions while meeting socioeconomic needs. By approving ISO 14001, organizations can develop environmental strategies that achieve their goals. Since 1996, more organizations have adopted ISO 14001. In 2015, (319,324) certificates were issued globally, an 8% increase (He & Shen, 2019).

Figure 17

Steps toward ECOSLC/ECOPORTS certification



Note. Eco SLC

https://www.ecoslc.eu/about

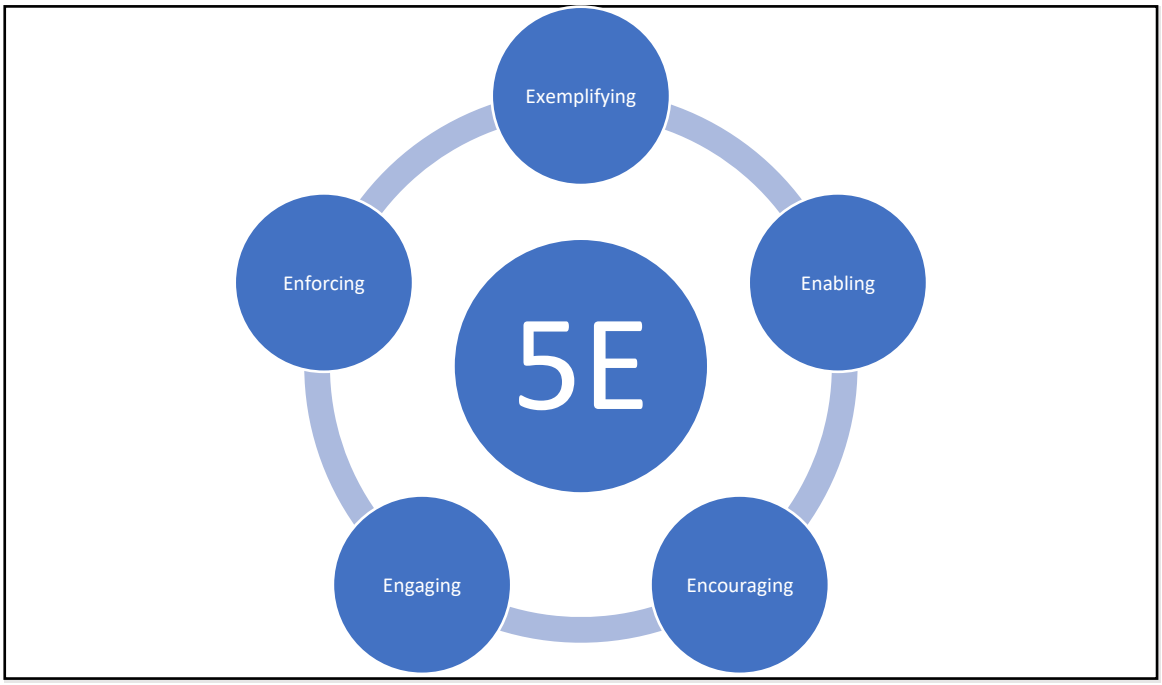
European port authorities focus on the following ESPO-recommended code of action to earn the certification. Commonly referred to as the "5E's Code," these guidelines entail the following (ESPO, 2012).

1. Exemplifying: Inspiring other port community members to improve their environmental performance management practices.

2. Enabling: Encouraging port users to improve environmental performance by providing reliable port facilities.
3. Encouraging: Offering visible incentives to port users has increased mental engagement.
4. Engaging: Facilitating environmental improvement at ports and logistical hubs through training port user authorities.
5. Enforcing: Ensuring compliance by the port users for good environmental practice.

Figure 18

Code of actions (ESPO, 2012)



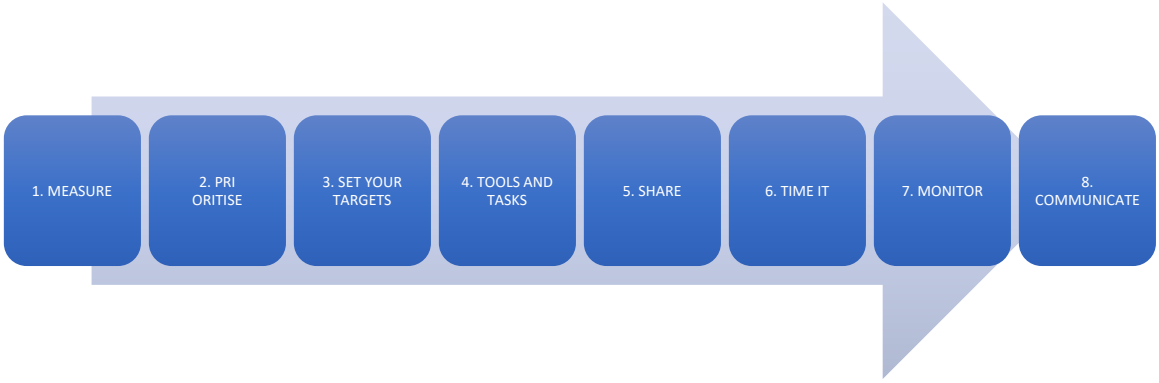
Note. (ESPO, 2012).

6.7 Port greening roadmap

ESPO recommends each port authority design a port-specific roadmap that accounts for the port's resources and conditions. This section of the Green Guide provides a checklist for port authorities. The list covers critical factors for ports to consider when building or upgrading an ambitious greening plan (ESPO, 2021).

Figure 19

Port greening roadmap



Note. Developed by the author based on (ESPO, 2021).

Table 22

Port-specific roadmap steps and activities

#	Auction	How to achieve
1. Measure	Create an environmental inventory of the port.	A. Determine the externalities, emissions, and environmental impact of port authority operations. B. If possible, do the same for the wider port area.

		C. Assess information sources. D. Identify practical and technical issues.
2. Prioritise	Identify priorities in environmental, climate, and sustainability (opportunities and challenges).	A. Discuss stage 1's technical results with all relevant departments (infrastructure, public affairs commercial, harbormaster, etc.). B. Raise conversations to a management level. C. Utilizing the ESPO Top 10 Environmental Priorities as a reference, make selections and establish priorities based on the inventory.
3. Set your target	Determine what you wish to accomplish and create goals properly.	A. Consider international, European, national, and upcoming laws for your step 2 goals. B. Considering the ESPO Green Guide's objectives. C. Establish ambitious, quantifiable objectives for the highlighted priority.
4. Tools and Tasks	Determine instruments, measures, and stakeholders.	A. Prepare a budget and invest (considering cost efficiency and social benefits). B. Considering mitigation, greening, and project/investment business cases.

		C. Consider budget and full-time employee's responsibilities while choosing tools.
5. Share	Share your plan and incorporate it into the port's DNA.	A. Communicate green priorities and strategy across departments and activities. B. Motivate roadmap work.
6. Time It	Create tangible steps	A. Create a timetable and milestones for each of the priorities/ objectives — when will something be achieved? B. Identify the involved parties and their roles - who should do what?
7. Monitor	Internally monitor implementation and results.	A. Communicate progress internally based on milestones and measurable actions. B. Determine issues and discuss enhancements and solutions. C. Transparently communicate flaws or challenges. D. Monitor achievements and utilize them as a foundation for updating the roadmap.
8. Communicate	Collaborate in external communication.	A. Identify and reach out to port stakeholders and the surrounding community, customizing communication methods and language.

		B. Transmit priorities, progress, and failures (share good practices, challenges, and background). C. Share examples of environmentally friendly company practices that have made a difference.

Note. (ESPO, 2021).

Chapter 7: Conclusion

7.1 Research Implication

This research was developed for those who participate in the process of policy creation or have advisory responsibilities at an executive level, regardless of whether they are employed in the public or private sector. It gives an in-depth awareness and advanced knowledge of the environmental implications of marine transport activities and sustainability of green port strategy, in addition to providing the critical environmental knowledge and understanding senior maritime workers require. In addition, from this analysis, significant policy consequences emerge. That includes how governments actively assess environmental sustainability in port development and the trajectories of environmental management for ports.

7.2 Limitation

Although the environmental impacts in the shipping industry are caused by three main factors, namely the pollution from ships, ports operation, and logistics areas, this paper focused on environmental impacts resulting from port operations.

In this research, we tried to select two ports in Saudi Arabia and examine the ports' status from the green port's application status. The questionnaire was used to know the status of the ports; however, many participants refused to participate due to their lack of knowledge of environmental issues and their focus only on some departments such as operations, control, and other administrative department in the ports.

7.3 Future Research

Finally, this report concludes with research instructions to evaluate port region efficiency as a compatible and relevant analysis that would supplement the ranked results and sustainability evaluations presented here. In addition, more studies might be dedicated to assessing the sustainability of port regions throughout Saudi to provide a complete picture of the topic. Moreover, the framework may be used in the subsequent study to investigate and examine the implementation of sustainability

measures at the Kingdom's remaining eight ports. In addition, future research can focus on the other two components, ship pollution, and logistics areas.

7.4 Conclusion

This study aimed to comprehend the academic attributes of port sustainability performance and measurement using a systematic literature review and to generate helpful suggestions for future research. The most important contributions of this research come from an overview of the managerial performance of ports in terms of sustainable development and green port strategy and an evaluation of such performance.

This study consists of semi-structured interviews, questionnaires, and plan documentation. Semi-structured interviews use primary questions to describe topics. These questions encourage the interviewer or interviewee to address straightforward questions. This approach was applied to one of the two most significant important the Kingdom of Saudi Arabia, namely the Jeddah Islamic Port and King Fahad Industrial Port, to investigate the environmental effects in the two ports and verify the application of green port implementation.

This study's contributions can be summarized as follows. Firstly, it helps the growth of the overall understanding of port sustainability performance and its evaluation by describing the green port strategy and its application.

Secondly, this study demonstrates very clearly the critical indicators for Environmental issues caused by port operations and solutions (measures) based on articles and technical reports classified the cases in ports from the environmental perspectives toward greening the port as a pillar of the sustainability triple bottom lines 3BLs into air pollution issues, noise pollution issues, water pollution issues, and waste issues, freshwater consumptions, hazardous cargo, visual pollution, climate change, and marine biology issues. The information presented here is practical for decision-makers in putting sustainability operations and management into practice.

Thirdly, the maritime transport industry in the Kingdom of Saudi Arabia was reviewed and represented in shipping and ports. Furthermore, the Kingdom's 2030 vision and future strategic plans for enhancing the maritime transport business were reviewed. This paper focused on the two most prominent commercial and industrial ports on the red sea and reviewed some statistics on the two ports, their importance, and their strategic position in the Kingdom.

Fourthly, this study's findings, based on an analysis of interviews and questionnaires developed for the two ports, reveal the environmental problems experienced by the ports and the difficulties they have in implementing the green port application. In addition, the authority confronts environmental legislation issues with some key authorities in the Kingdom, as evidenced by overlapping powers and job duplication. Furthermore, specific ports have infrastructure issues, such as no ship reception facilities due to limited spaces. This paper also identifies the environmental priorities in Saudi ports: flowing Air quality, Climate change, Energy efficiency, Noise, Marine biology, Ship waste, Garbage/ Port waste, Diverging operations, Water quality, and Port development (land related).

Finally, this research provides insight into the practical techniques for implementing green ports by comparing the approaches used by ports in Europe, the United States, Asia, and Australia. The European strategy of implementing green ports into practice has been highlighted, and it may be examined and summed up in numerous points, including the following:

- Implement audit suggestions for energy and environmental management. Executives develop strategy and policy. Several methods and instruments help firms preserve energy and environmental performance gains.
- Aggressively promote (SDM). This optional technique lets ports examine their environmental policy. SDM is required for PERS-certified ports.
- The Port Environmental Reporting System (PERS) is a port-designed environmental management standard. ECO Sustainable Logistics Chain Foundation makes PERS available worldwide (ECOSLC).

- Using the ESPO-recommended code of action to certify. The "5E's Code" includes the following: Exemplifying, Enabling, Encouraging, Engaging, and Enforcing.
- ESPO proposes that each port authority create a port-specific roadmap. Port authorities can use this Green Guide checklist. The list includes factors ports must consider while creating or revising a greening plan. The port greening roadmap categorizes into eight steps which are as follows: Measure, Prioritize, Set your targets, Tools, and tasks, Share, Time it, Monitor, and Communication.

Based on the above points, Port authorities should implement the framework of the system internally to increase awareness of environmental issues and commitment to environmental management while integrating it with their business objectives. This commitment necessitates supplementary methodologies, instruments, and auditing mechanisms.

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