The Impact of Implementing Green Port Indicators in Improving Environmental Sustainability in Iraqi Ports

Hasanain Shakir Lafta and Abbas Abdulhameed Abdulabbas

Abstract With the ever-looming threat of climate change and global warming for all life forms, the world is making efforts to achieve carbon neutrality to avoid dire consequences for ecosystems around the world. The maritime industry is therefore part of the factors that can significantly impact greenhouse gas emissions. The naval industry moves more than 80% of global trade by volume, making it a large and growing source of global greenhouse gas emissions that contribute to climate change. Ships are also a source of pollution for local communities living near ports due to their energy consumption when they are at berth. Currently, the most common way to mitigate this problem is to provide shore-side electricity to ships at berth. This paper presents the Green PORT project that aims to establish an energy management system for a green energy port.

Keywords Greenport · Environmental sustainability · Renewable energy

1 Introduction

Sustainability, linked to the depletion of global resources, has become a critical requirement in all areas. Since the beginning of the twenty-first century, sustainability has affected every aspect of life. The concept of sustainability is defined by the triple bottom line that includes three components: social commitment, environmental management, and economic well-being, Environmental management of the sustainability concept used the green port approach [1]. The green port had to deal with the increasing commercial activity as well as environmental demands. The green port approach includes the use of electric-powered equipment, devices, and vehicles, the use of alternative and renewable energy sources, slow steaming, which reduces

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the speed of the ship, the use of waste and oily residues, and the protection of marine life towards the sea and land in the port area. These benefit the ports economically and create a new economic field linked to the market [2].

2 Green Ports: Addressing the Challenges

With a focus on sustainability through "green logistics" and "green ports" port authorities in industrialized countries are giving top priority to development and investment to meet the technical and regulatory requirements for efficient port operations. Coordination with seaport authorities to develop effective regulations that support sustainable growth while addressing many issues, most notably oil spills, greenhouse gas emissions, ballast water pollution, and port security gaps, is a major challenge. Given the significant logistical and legal challenges associated with the shift to greener methods, raising awareness among port staff is also essential to meet green port standards.

At present, the idea of a green port seems to be voluntary. In the context of legislation, ports must meet and apply green performance standards to be classified as green ports [3].

3 Green Port Indicators

Through the analysis and criticism of previous literature, thirty-two green performance criteria were collected, where we concluded that eight main indicators were adopted to implement green ports [4], which are:

3.1 **Cybersecurity management related to port security**
3.2 **Air pollution management (GHG)**
3.3 **Oil and noise pollution management**
3.4 **Reducing water pollution by harmful marine organisms**
3.5 **Applying green performance standards**
3.6 **Use of renewable energy sources**
3.7 **Waste reduction**

3.1 Cybersecurity Management Related to Port Security

Research highlights the significance of including digital assets, like information and communication technology, in port facilities security checklists as part of the ISPS evaluation. To find possible security issues, use DTTAS procedures and ENISA threat scenarios from the SAURON project. This enhances operators' training to

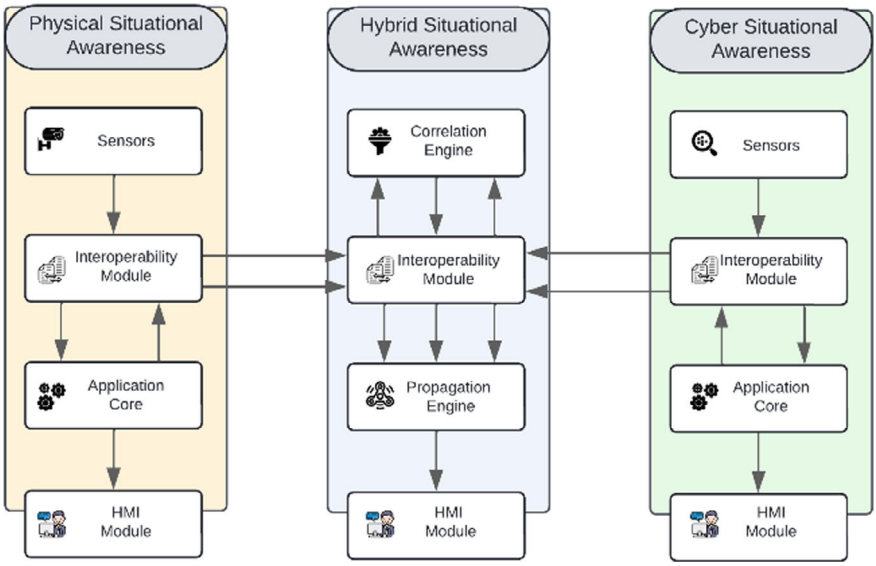

Fig. 1 Physical, cyber, and hybrid situational awareness system for security integration [6]

handle "hybrid threats" by improving their knowledge of both physical and cyber security independently, as shown in [5], Fig. 1.

3.2 Air Pollution Management (GHG)

With more than 82% of products traded by water, ports play a critical role in the economic and social development of the world. But ports are also a major source of greenhouse gas emissions and air pollution. By 2050, shipping is expected to raise its carbon dioxide emissions by 250%, according to the International Maritime Organization. Despite the Kyoto Protocol's exclusion of shipping emissions, there has been a recent surge in interest in lowering marine emissions. Research focuses on how fine particulate matter (PM), nitrogen oxides (NOx), and sulfur oxides (SOx) affect human health and coastal habitats. Inland transportation emissions, ship berthing problems, and port operations problems are the three categories into which the environmental effects of ports are divided [7], as shown in Fig. 2.

3.3 Oil and Noise Pollution Management

MARPOL began to provide regulation for the prevention, treatment, and reduction of pollution from petroleum chemicals and other hazardous substances, ballast water,

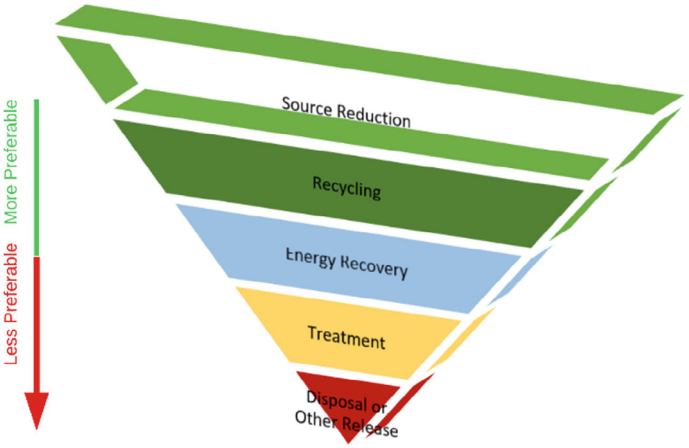

Fig. 2 Pollution prevention hierarchy [8]

and in relation to the use of harmful paints, and the reduction of emissions from ships and port operations according to Accidents, oil spills, and ballast water pollution are among the major environmental concerns at sea. According to the European Shipping Agency, there were 3296 accidents involving 3669 ships in just one year, with 36 ships lost and 115 people killed. More than (278) of these accidents resulted in water pollution due to the leakage of ship fuel, oils, and residual lubricants, which was attributed to human error in 62% of cases [9].

3.4 Reducing Water Pollution by Harmful Marine Organisms

Since it spreads microorganisms across the world and seriously harms native species, ballast water poses a serious threat to the environment. Thirteen years after it was ratified, the IMO Ballast Water Management Convention finally went into effect, a process that took decades. The goal of the convention is to lessen the spread of organisms via ballast water, which has the potential to destroy local fisheries along the shore. Furthermore, estimates indicate that human error is responsible for 62% of events involving ballast water. Water pollution has also occurred in several cases because of ship fuel, oil, and lubricant leaks [10], as shown in Fig. 3.

3.5 Applying Green Performance Standards

Port representatives' awareness of the necessary environmental procedures is raised to design green logistics concepts. Enhancing the quality of the air and water, cutting

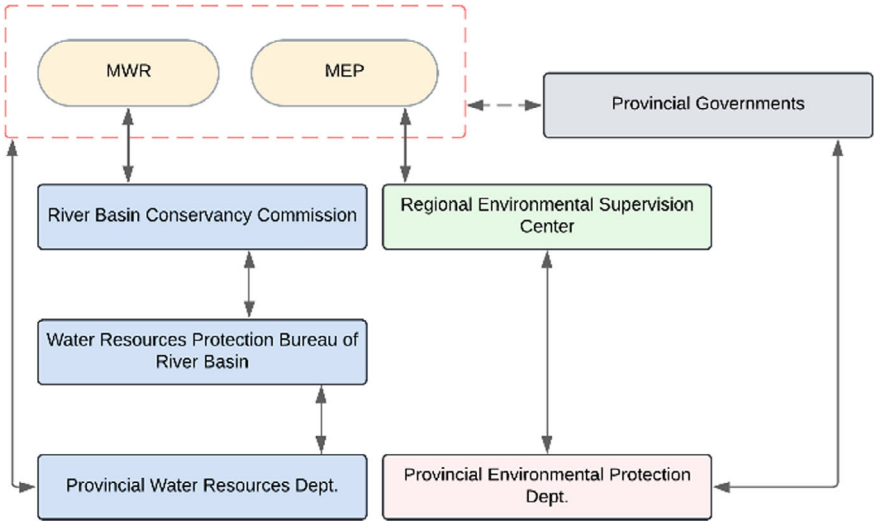

Fig. 3 China's current structure of water pollution management [11]

down on noise, and lowering pollution from ballast water are priorities. To lower CO_2 emissions from ships, the IMO energy efficiency index is utilized. With an emphasis on green fuels and oil transportation, green practices are also mapped using environmental performance indicators. Enforcing environmental laws and regulations and putting sustainability plans into action are two aspects of green port management [12].

3.6 Use of Renewable Energy Sources

To reduce pollution, ports are increasingly using battery-powered equipment and electricity to power cranes. Fuel usage is reduced by up to 50% with hybrid systems and energy storage. Wind and solar energy are examples of renewable energy sources that ports are using to cut CO_2 emissions. Energy-saving techniques include start-stop motors and automated coupling systems, which cut fuel usage by 10–15%. Alternative fuels and renewable energy can be used together to increase energy efficiency, as the Port of Rotterdam and its marine terminal project show [13], Fig. 4 shows renewable energy sources.

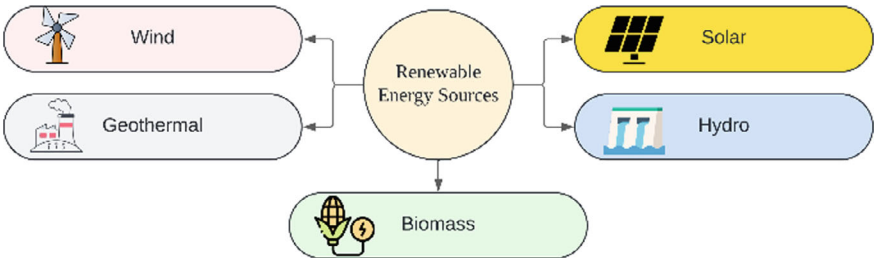

Fig. 4 Renewable energy sources [14]

3.7 Waste Reduction

A sustainable approach at ports and ships must include efficient waste management and pollution control. Metals and plastics are recycled, while hazardous waste is disposed of securely. Wastewater treatment facilities lower pollution and guarantee compliance, while ballast water systems safeguard the marine environment. Green features like heat recovery and efficient engines are adopted by modern ships. Programs for recycling and reuse in the building industry also support sustainability. Ports are backed by ISO certifications for environmental compliance, and these procedures comply with MARPOL, Fig. 5 illustrates the waste treatment process.

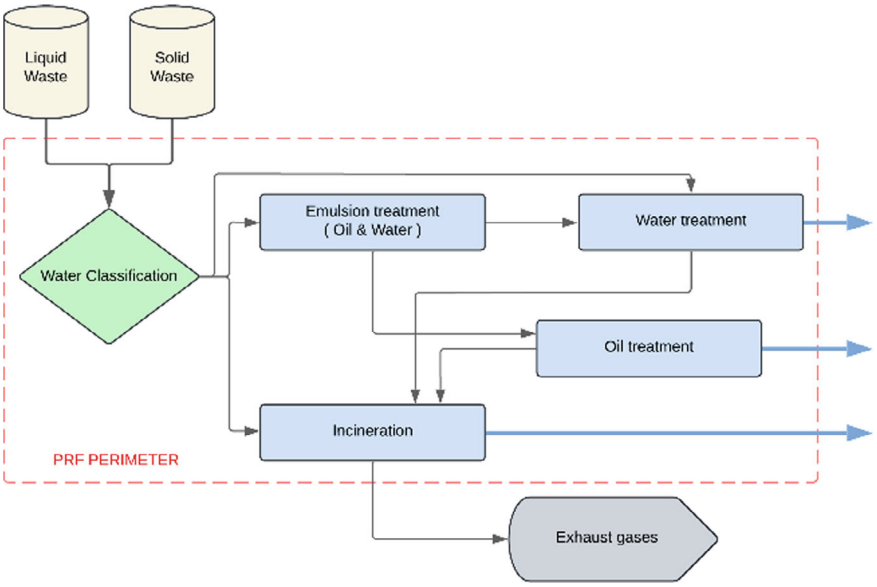

Fig. 5 Waste treatment procedure [15]

4 Related Studies

Table 1 shows a summary of the studies covered in the research paper.

Harilaos N. Psaraftis et al. highlighted in their research paper the concept of green maritime logistics that aims to achieve acceptable environmental performance. A balance between environmental and economic performance was achieved by defining "win-win" criteria [16].

In this paper, Aneta Oniszczuk-Jastrząbek et al. reviews the concept of green ports in Polish ports, where these ports seek to achieve environmental sustainability. It also aims to review the extent of awareness and behaviors related to sustainability, and

Table 1 Summary of related studies

Author/year	Indicator	Importance
Psaraftis et al. (2016)	GHG, Applying green performance standards	Reduce emissions in maritime logistics while maintaining economic and environmental efficiency
Oniszczuk-Jastrząbek et al. (2018)	GHG, Applying green performance standards, Waste reduction	Significance of green ports in Polish ports for lowering emissions and enhancing environmental sustainability
Mostafa Mohamed et al. (2020)	Applying Green Performance Standards, Use of renewable energy sources, Waste reduction	Stresses the need for improved use of clean energy and environmental investments
Adams et al. (2021)	Cybersecurity Management Related to Port Security	Suggests combining physical and cyber measures to lessen hybrid port attacks
Simanjuntak et al. (2021)	Cybersecurity Management Related to Port Security	Improving the International Maritime Security Management (ISM)
Esteves et al. (2022)	Use of renewable energy sources, GHG	Focuses on developing a green energy system
Sangho Park et al. (2023)	Reducing water pollution by harmful marine organisms	Develop an effective environmental treatment system
Jalil et al. (2023)	Applying Green Performance Standards Use of renewable energy sources, Waste reduction	The importance of green practices in ports
Zhang et al. (2024)	Applying Green Performance Standards, GHG, Use of renewable energy sources	Emphasizes that digitization contributes to improving energy efficiency and reducing emissions in green ports
Li et al. (2024)	Oil and noise pollution management	Improve the accuracy of oil spill detection

its results include increased awareness among administrators and workers in ports [17].

The paper reviews the assessment of the main challenges facing Egyptian ports in implementing the concept of the "green port" carried out by Sobhy Mostafa Mohamed et al. to determine the requirements necessary to achieve environmental sustainability in the ports of Alexandria and Dekheila. These ports also face a shortage of resources, which hinders the complete transformation towards the concept of the green port [18].

Neal Adams et al. highlight the SAURON project, which aims to protect European ports from cyber, physical, and hybrid threats by providing a multi-dimensional platform for raising security awareness and posture. The research explores how ports can be helped to prepare for common threats and secure their critical infrastructure by linking cyber and physical measures [6].

In this paper, Carry Anggun Simanjuntak et al. examines the application of the maritime security concept in the port of Tanjung Pinang, Indonesia, based on the International Safe Management Code (ISM Code) which aims to improve safety and prevent marine pollution. The study uses qualitative methodology to analyze the effectiveness of the code in providing safe maritime transport. The study concludes that the implementation of the code in the port has not yet been fully effective, as the port faces challenges related to the awareness of workers [19].

The study by João Esteves et al. presents the "Greenport" project, which aims to develop an energy management system for green ports using renewable energy sources to supply electrical power to ships while they are in port. The project builds an energy load model based on 2019 Lisbon Port data, to reduce carbon emissions and pollution in coastal areas near ports. The project has contributed to reducing the use of diesel engines in ships, reducing local pollution, and enhancing the environmental sustainability of ports [20].

The study deals with the analysis of the components of wastewater resulting from the management of marine pollution associated with organisms attached to ship hulls, which may carry invasive species that threaten marine ecosystems, conducted by Sangho Park et al. The study aims to understand the nature of wastewater and determine the optimal technologies for sterilization and removal of heavy metals and other pollutants resulting from the removal of organisms attached to the hull, and to conclude that wastewater contains biological pollutants and heavy metals that require advanced treatment technologies in addition to developing a comprehensive treatment system that includes filtration, electro sterilization, and thermal decomposition, to ensure that wastewater complies with environmental safety standards [21].

Iznoorhakmal bin Ibrahim et al. presented a conceptual model for promoting sustainable green port practices, focusing on Northport Port in Malaysia. The study addresses environmental issues related to port operations and their impact on climate, with an analysis of the level of environmental awareness in the port community and strategies for adapting to environmental requirements to enhance environmental awareness in the port community and implement green port initiatives, such as solar energy use, water quality monitoring, and carbon emission reduction [22].

In this paper, Zhechen Zhang et al. discuss the current challenges and future trends of digitalization and innovation in green ports, focusing on how to improve work efficiency and reduce the environmental impact of maritime operations by adopting modern technologies in maritime logistics, while improving sustainability practices in ports. The paper also discusses how digital technologies such as real-time monitoring, data analysis, and life cycle management can support environmental practices and reduce emissions. The study emphasizes the role of advanced technologies and the importance of digitalization in reducing energy consumption and reducing environmental impacts [23].

This paper highlights a model for detecting dark spots resulting from oil spills using the "MTMCMC" algorithm under the energy function framework proposed by M. M. Li et al. The study uses synthetic aperture radar (SAR) technology to detect dark spots in marine images and identify their characteristics. This technique aims to improve the detection accuracy by dividing the image into sub-regions instead of relying on the analysis of individual pixels. The results show that the "MTMCMC" algorithm achieves high accuracy in detecting dark spots of more than 98%, outperforming traditional detection methods, which enhances the accuracy of evaluation and classification [9].

5 Conclusion

Green ports, which use cutting-edge technologies to improve energy efficiency, decrease greenhouse gas emissions, and lessen air and water pollution, are an essential step towards a sustainable maritime industry. To improve operational effectiveness and environmental health, these ports rely on green infrastructure, such as waste management and renewable energy. Green ports gain an economic edge by lowering energy costs, adhering to environmental regulations, and drawing in sustainable investments as global trade places a greater emphasis on sustainability. By lessening their impact on the environment, they also strengthen community relationships. Nevertheless, they encounter obstacles that necessitate substantial financial investment and thorough preparation. To create a sustainable marine future that blends economic growth with environmental care, they need everyone's collaboration and ongoing innovation.

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