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Sustainable small ports: performance assessment tool for management, responsibility, impact, and self-monitoring

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Abstract

This paper proposes a conceptual performance assessment tool for evaluating the environmental performance in small seaports. The developed tool is based and built based on a literature review. Ports, depending on their size, tend to have several sustainability and environmental management needs. However, especially small or cargo specialized ports do not often have sufficient resources to implement environmental effectiveness enhancing tools, even if they need them. This paper reviews international quality and environmental management tools, standards, and selected frameworks. These include International Organization for Standardization standards, and Global Reporting Initiative and Corporate Social Responsibility concepts. Because checklist type self-diagnosis solutions are the easiest to adopt, and universally most applicable, the proposed environmental performance measurement tool has four specific categories: (1) environmental management; (2) responsibility; (3) impact assessment; and (4) self-monitoring. The proposed tool allows the ports to assess whether their environmental management practices are comparable to more expensive standards and certificates. The paper concludes with a discussion on the limitations and challenges related to different port types and their specific needs.

Keywords: Quality management, Environmental performance, Ports, Assessment tool

Introduction

Ports are service providers who are in competition with each other. At the same time, the maritime operating environment (markets and economies) are undergoing major changes. Climate change being one of the vital themes, sustainability has become increasingly important to gain a competitive advantage (Groenleer et al. 2010; Brunila et al. 2021; Luo et al. 2022; Svaetichin and Inkinen 2017). This issue is significant as maritime transport emits around 1000 million tonnes of carbon dioxide (CO_2) annually and is responsible for about 2.5% of global greenhouse gas emissions (Wu et al. 2022). In the EU, shipping traffic accounts approximately 11% of all EU CO_2 emissions in transport and 3–4% of total EU CO_2 emissions. Empirical estimations indicate that emissions from the shipping and maritime sector will continue to increase if no action is taken (Winnes et al. 2015; Smith et al. 2015).

In maritime affairs, the International Maritime Organization (IMO) defines international regulations and guidelines for emissions. IMO's MARPOL Convention Annex VI sets the general limits on ship emissions into the air. The convention covers sulphur oxide (SOx) and nitrogen oxide (NOx) emissions, but also shipboard incineration, ozone-depleting substances (ODS), volatile organic compounds (VOC), and fuel quality and availability (IMO 2022). In 2015, a strict sulphur limit (0.1%) was implemented for Emissions Control Areas (ECAs) and in 2020 (0.5%) for other sea areas. In 2021, a regulation for NOx emissions was adopted for new ships.

The UN Sustainable Development Goals (SDGs) are a set of 17 global goals adopted by the United Nations General Assembly in 2015 as part of the 2030 Agenda for Sustainable Development (see Appendix). SDGs aim to end poverty, protect the planet and ensure peace and prosperity for all people. They include 169 targets that provide a detailed roadmap for achieving the goals. The targets are designed to be achievable within a 15-year timeframe (2015–2030) with a clearly defined action plan (United Nations 2023). SDGs are large system-level goals requiring top-down implementation. Targets are set for country-level decision making and different stakeholders and companies execute smaller targets and tasks in their daily operations and strategies.

SDGs are too large for ports. In daily operations, this means that they can actively concentrate only on certain targets, and not try to implement them all. There are several studies focusing on the port SDG selections and target setting. According to Lähdeaho et al. (2020), Finland's largest universal port estimated that most relevant SDGs are: #8, #9#, #12, #13, #14, #15 and #16. Other research Wang et al. (2020) has showed that the maritime industry focuses on #8, #9 and #11. Similarly, MacNeil et al. (2021) compared SDG and GRI in a Canadian environmental performance framework (Green Marine Environmental Program). According to the study, these following #6, #11, #12, #14 and #15 targets affects to Canadian environmental performance framework. Targets vary depending on the focus and size of the company or industry.

The size of a port and the handled cargo volumes are related to the produced amounts of emissions, thus more handled cargo means more emissions. As an example, in the Baltic Sea Region (BSR) there are approximately 200 ports operating in international traffic. The Baltic Sea itself is shallow and a relatively small sea area, but shipping volumes in the BSR are extensive. Approximately 15% of global cargo traffic is handled in BSR ports. In the year 2021, the total handled cargo volume was 906 million tonnes and the top ten Baltic Sea ports handled over 470 million tonnes (Eurostat 2023; Pasp 2023; Madjidian et al. 2013). There are multiple factors that influence the definition of small ports, including quantitative criteria such as infrastructure, annual cargo volume, and geographical locations (i.e., sea or hinterland connections), as well as economic and political contexts. In the Baltic Sea Region (BSR), small ports are typically defined as those with an annual cargo volume of less than 10 million tonnes, while medium-sized ports handle cargo volumes between 10 and 50 million tonnes. Similarly, in South-East Asia, definitions may align with those in the BSR, but annual cargo volumes can vary. According to Lu et al. (2018), ports with an annual handled cargo volume of less than 300 million tonnes are categorized as small or medium-sized ports. For comparison, the largest port in Europe, the port of Rotterdam, handled almost 470 million tonnes of cargo in 2022.

The ownership of ports is typically either private or public. The spectrum of ports varies from very small privately owned ones that often serve only one customer, to large publicly owned ports with annual cargo levels of over 100 million tonnes. The main owners are either cities, municipalities, or even regional or national governments depending on the country. The financing of the ports depends on the ownership, and in the cases of financial support, the given support can be a significant factor, e.g. in resourcing for environmental monitoring. Ports must also fulfil environmental requirements of international and national regulations depending on their size and nationality.

Depending on geographical factors and contexts, the number of ports varies extensively in the BSR: in some countries (e.g. Lithuania) there are only two ports, while in Finland, for example, there are 20 sea ports in commercial use. While EU legislation for ports applies to all its member countries, the level of implementation and actual transposition into national legislation varies between member states (Steunenberg and Rhinard 2010). According to (Darbra et al. 2009; Gritsenko and Yliskylä-Peuralahti 2013; Pallis 2006), there are differences between nations in their attitudes, legislation, and policies towards environmental regulation and permits. In environmental legislation, the main goal is to reduce GHG gases, waste, and emissions into water.

As ports are transport connection points, all transportation modes (e.g. ships, harbor machinery, trucks, and trains) increase the total emission volumes affecting the air, land, and water in ports. At the moment, almost all emissions derive from combustion engines that mainly use diesel. In the future, alternative fuel and hybrid technologies will become increasingly important for port logistics operations. Ports also have the added layer of national and international legislative and regulative framework of the location they are situated in. The European Union has launched the Green Deal and the "Fit for 55 package" including the Emission Trade System (ETS) for the port and maritime sector. The target of these legislative frameworks is to reduce greenhouse gases (GHG) by at least 55% compared to 1990-levels by the year 2030 and to ensure the maritime sector achieves zero-emission by 2050 (Álvarez 2021; Animah et al. 2018; European Parliament 2022; Cariou et al. 2021; Lovcha et al. 2022).

The sustainable development of ports involves reducing emissions from both maritime and land-based transport. Ports (in their role as landlords) are able to help their customers in reducing their emissions up to a certain point. While each company is responsible for their own emissions reductions, ports must also have resources to maintain the competitiveness of their customers. According to previous research (e.g. Woo et al. 2017; de Langen et al. 2017; Kunnaala-Hyrkki et al. 2015; Puig et al. 2015; Schipper et al. 2017), ports stand to benefit financially, if they act quickly and decisively in adopting environmental measures into their operations, as they can bring competitive advantage to their customers.

A comprehensive outlook on all the actions taken and a strategy going forward is usually managed under environmental management. Adopting an environmental management system establishes the port's preparedness to comply with environmental legislation as well as the port's willingness to become more sustainable (Madjidian et al. 2013). The share of ports that have incorporated different kinds of environmental initiatives into their operations is increasing. The effectiveness of the ports' environmental

efforts depends on the tools chosen and adopted by the individual ports (Papaefthimiou et al. 2017; Puig et al. 2017).

Because the port's legislative environment is evolving and competition between ports is ever increasing, it is important to study how and what type of sustainability actions ports have implemented. Ports have adopted different kinds of environmental management systems, standards, and frameworks and, as a result, they measure their environmental performance with varying metrics and criteria. Beyond existing standards (such as the International Organization for Standardization, ISO), frameworks and ratings, there are also numerous benchmarking systems, environmental measurement instruments, and self-diagnosis tools. Their goal is to assess their operations, find issues that should be rectified, and compare their performance metrics with other organizations operating in the same industry. Developing a framework for sustainability indicators in ports can facilitate a competitive advantage for ports.

Methodology, research questions and structure

In this study, a wide spectrum of environmental measurement tools are reviewed in a port context. From a variety of sources the authors identified a suitable combination of metrics that an easy to use, free, customizable self-diagnosis tool might include, and determined the most important factors for measuring a port's own performance, reducing environmental impacts, and increasing sustainability. Methodologically, the paper is both a case study as well as an introduction of a new self-assessment tool, yet it also includes heuristics characteristics especially in the testing process. The tool is based on the UN SDGs, a number of other certification systems, as well as research literature and professional reports on environmental management. The paper reviews existing standards, reporting tools, and management systems to justify the proposed tool. It also critically considers the limitations and contextual specifics that are required for the successful implementation of a monitoring system (environmental or other) in an industrial platform such as ports.

The applicability of different frameworks and standards for the use of ports is analysed, and the features of the existing (reviewed) systems and standards that are applicable in port operations, are included in the tool (also Woo et al. 2017). In this regard, several existing systems face issues concerning comparability. For this reason, the presented interpretations are focused on small ports that are operating in peripheral locations (i.e., the case of Finland). Organizations can be very different from each other, even if operating in the same industry or country. In some cases, the evaluation criteria can be either too general to be useful, or alternatively, too narrow. Thus, the proposed indicators are not applicable to all organizations even in the case location. This makes also comparisons difficult, if not impossible.

The research questions of this paper are:

1. What frameworks and standards are applied to measure an organization's environmental performance? Are these also applicable to ports?
2. What key environmental factors and indicators should be included in an evaluation tool for assessing a port's environmental performance?

3. What environmental factors and indicators would be comparable in terms of a port's environmental performance?

As mentioned, this paper's approach includes methodological elements that are common to a heuristic research approach. This refers to a methodology that emphasizes problem-solving and decision-making through the use of rules of thumb or intuitive judgment. Heuristic research is often used when traditional scientific methods are not suitable, either because of the complexity of the problem, lack of data or time, or other practical constraints (e.g. for applications, see Geiger et al. 2018). It typically involves gathering data from a variety of sources, such as literature reviews, case studies, expert interviews, and observations. In general, the goal of heuristic research is to provide insights, hypotheses, or practical solutions that can be tested and refined through further investigation or experimentation. This is a widely applied approach in social sciences, including fields such as psychology, education, and management, where the focus is on understanding decision-making processes (e.g., Leech and Onwuegbuzie 2009; Barkin 2015; Fischhoff 2015).

The structure of the paper is as follows: "Introduction" and "Methodology, research questions and structure" sections establish the background and structure of the paper. "Measuring a port's environmental performance" section consists of a literature review of the existing tools and methods for assessing and managing environmental effects. It also includes an assessment of their applicability to ports. "Environmental performance measurement tool for ports" section establishes the developed environmental performance measurement framework. The final "Testing and feedback responses from three ports" and "Review of the tool properties and conclusions" sections assesses the framework and propose the future research needs with concluding remarks.

Measuring a port's environmental performance

Methods for assessing and managing environmental effects

Legislation

Sustainability, the green economy, and environmental protection have become increasingly important values to businesses also in the maritime sector over the past few decades. Environmental management systems are implemented in operations and sustainability goals are incorporated in company strategies. Different standards and systems have been developed to help corporate environmental management and processes to be applied to various organizations and operations (Puig et al. 2015). Even though there are a variety of tools and methods, legislation has been and remains the strongest incentive for companies to operate in an environmentally sound way.

Legislation provides the legal framework for company operations. In general, port operations and port environments are quite strictly regulated both nationally and internationally. For example, there are several European Union Acts and Directives that regulate the operations of European ports. There are over 80 international and EU pieces of legislation that are related to port operations and port environments (ESPO 2021). In addition, there are more wide-reaching horizontal documents to consider (as well as other EU priorities and strategies). These include the European Green Deal and United Nation's Sustainable Development Goals (ESPO 2021). Outside the European Union

context, the most important legislation that affects the sea, marine environment and subsequently also ports includes the IMO's MARPOL convention, the United Nations Convention on the Law of the Sea (UNCLOS) and the Helsinki Convention (HELCON). To summarise, the relevant legislation can be divided into the following main categories:

- Energy
- Waste and circular economy
- Noise
- Water
- Air
- Soil
- CO_2 and greenhouse gases
- Nature
- Research and funding

The European Union's first and oldest environmental legislative action was the "Birds Directive" (Council Directive 79/409/EEC on the conservation of wild birds) that was accepted in 1979. It was amended in 2009 to its current form (Directive 2009/147/EC) (Council Directive 1979). Another important EU level environmental directive is the "Habitats Directive" (Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora). It is not directly aimed at ports, but with the Birds Directive and the Natura 2000 network, it establishes the cornerstone of Europe's nature conservation policy.

Even though there are clear differences in the legislation, voluntary standards and certifications, there are similarities between the instruments. For example, laws and regulations can also provide operators with different measurements that are performed regularly, checklists that are required to be reviewed, and target values that must be met. As an example from Finland is that all ports are required to follow the strict national environmental regulations and they have to obtain environmental permits for their operations. The ports' environmental permits can include some requirements for port operations, such as specific emission values that the port has to sustain. Ports are also required to go through an environmental impact assessment (EIA) process. The EIA process is an important step in identifying and evaluating the sustainability impacts of the assessed operations (Zelenákova and Zvijáková 2017; Cashmore 2004; Galas et al. 2015; Wang et al. 2005).

Frameworks, standards and ratings

In the following, the main frameworks are presented in order to answer the first research question: according to Siew (2015), sustainability reporting tools can be divided into three categories: (1) frameworks, (2) standards, and (3) ratings. Frameworks refer to principles or guidelines that assist companies in their disclosure efforts. These frameworks include, for example, the Global Reporting Initiative (GRI) and the UN Global Compact. Standards are quite similar, but they take the form of more formal documentation, which establishes requirements and characteristics that can be used to ensure

that the environmental metrics in place are achieved. Ratings and indices are evaluations done by a third party to assess organizational performance.

Standardization started in the United Kingdom in 1901 (British Standards), and the first standard called Kitemark came out in 1903. Since then, several voluntary management systems and standards have been developed for use in organizations to answer to the environmental demands of company stakeholders such as employees, shareholders, consumers, and the general public. (D'Souza 2004). Environmental standards provide guidelines on how to perform in an environmentally sound way. Guidelines on environmental management include for example, ISO14001 and the Eco-Management and Audit Scheme (EMAS) (Siew 2015).

The most common voluntary management system is the ISO system. ISO14001, for example, provides only generic requirement for environmental management as the system tries to remain applicable to various organizations in all phases of operations. It provides criteria for an environmental management system that can be certified. If a company decides to incorporate ISO14001 in its operations, it commits to the continuous improvement of its environmental protection level. The requirements also include that legal obligations must be met and enough resources must be allocated for the implementation of the environmental management system. ISO14001 has many benefits as it provides organizations with a way to include environmental issues in their management systems in a cost-effective way, increasing environmental awareness. Adopting the standard also helps with compliance with current legislation and anticipation of future legislation, which makes it easier for companies to anticipate future changes and investment needs. The standard also acknowledges the importance of stakeholder cooperation in environmental management (Peris-Mora et al. 2005; Puig et al. 2015; Segui et al. 2016).

The ISO 14000 standard includes various "sub-tools" and techniques to help organizations with their environmental management system development. There are tools for environmental systems (ISO 14001), environmental system auditing (ISO 19011), level of environmental protection (ISO 14031), planning that considers environmental issues (ISO 14006), material flow cost analysis (ISO 14051), water footprint (ISO 14046), environmental communication (ISO 14063), environmental labels (ISO 14020), carbon footprint of products (ISO 14067) and greenhouse gas calculation and reporting (ISO 14064 and 14065). These tools for the ISO 14000 standard are comprehensive and applicable for different needs of environmental management (Peris-Mora et al. 2005; Hillary 2017).

In 1993, the European Commission developed the European Union's eco-management and audit scheme (EMAS) for organizations to evaluate, report, and continuously improve their environmental performance. The performance reporting must be done through an independently verified third party (Siew 2015). The scheme is globally applicable and open to all types of organizations. In order to register with EMAS, organizations must meet the requirements of the EMAS-Regulation (Alvarez-Garcia and del RioRama 2016).

One of the most popular frameworks for environmental assessment is the GRI, which was initiated in 1997. Its intention was to create a universally applicable sustainability reporting framework. GRI provides organizations with detailed guidelines on reporting which are suitable for all organizations, regardless of their size, sector or location (Global

Reporting Initiative 2013; Clarkson et al. 2008). GRI also provides sector supplements that are guidelines that can be used in a specific industry sector. A typical GRI report should address the following areas: vision, strategy and corporation profile; governance and management systems; GRI content; and economic, social and environmental performance criteria. The performance criteria are divided into core and additional criteria, in which the core criteria are generally applicable criteria relevant to most organizations and additional criteria are not necessarily applicable to all organizations (Siew 2015). There are several environmental aspects in GRI reporting. The extensiveness of the list and the needs for data management can pose challenges especially to smaller organizations as they try to comply with the reporting requirements.

GRI is an increasingly popular guideline for several reasons. It is one of the few frameworks that incorporates Elkington's (1994) triple bottom line concept on sustainability (economic, social and environmental). GRI is also a widely accepted sustainability reporting system, since it has been developed through a vast, global multi-stakeholder process. GRI also answers the external demands for companies to provide non-financial information, such as social and environmental information and thus adopting GRI guidelines can reduce the time and effort spent by the organization to disclose this information, especially if the GRI reports are made publicly available (Hopkins 2004; Chester and Woofter 2005).

Sustainability models and frameworks

Sustainability is an integral part of an organization's management. Thus, sustainability is a value that can improve organizations' operations and subsequently also improve their financial performance. On the other hand, demands for sustainability can also be sparked from outside the organization, for example in the form of stakeholder demand or legislation (Sorsa 2010; Puig et al. 2022). Two widely used sustainability terms are Corporate Social Responsibility (CSR) and Environmental, Social and Governance (ESG) monitoring. Roughly, CSR can be defined as a business model that holds organizations accountable in a qualitative manner, whereas ESG helps measure an organization's sustainability efforts. ESG standards and criteria take into account an organization's environmental performance, their impact on the area they operate in, including employees, customers and the surrounding community, as well as the organization's leadership. (Karwowski and Raulinajtys-Grzybek 2021; Kotsantonis and Serafeim 2019).

CSR is a self-regulating business model, in which companies voluntarily take part in actions that contribute to sustainability. The goals are achieved by integrating sustainability into business operations and through interaction with stakeholders. Well established CSR can also lead to economic benefits (Kujala 2009). CSR includes environmental, social and economic aspects of the organization's operations. It also strives to find a balance between these different aspects. A socially responsible company strives to operate so that it causes minimal harm to the environment and continually tries to improve its environmental performance. These include aspects such as energy consumption, waste management and the circular economy. In the long run, being environmentally sustainable can also be beneficial for the organization (Elkington 1994).

There are a number of general standards that consider CSR, including guidance providing ISO 26000. It should be noted that the ISO 26000 standard is not intended as

a basis for certification as it is meant to establish the guiding principles for CSR (ISO 26000, 2010). In addition, ISO 14001 provides requirements for environmental management (ISO 14001, 2004) and ISO 9001 provides requirements for quality management (ISO 9001, 2008). Other related standards include SA 8000 that covers nine main criteria for social sustainability, such as child labour, health and safety and management systems and OHSAS 18001 addressing occupational health and safety aspects (Siew 2015).

Sometimes, the incentive to adopt CSR into company management and operations is based on external pressure from stakeholders or the surrounding community. Thus, CSR activities are not necessarily deemed that important by companies that operate in a traditional business-to-business industry: ports being a text book example here, as their stakeholder pressure is not (in several cases) as significant as in some other industries with a more delicate customer interface. Yet, CSR is becoming important also to ports as an increasing number of companies are becoming more aware of the sustainability requirements of their investments and supply chains. Stakeholder involvement is an important part of CSR and it does not only concern commercial stakeholders, such as customers, but also non-financial stakeholders, such as local communities. Open and continuous dialogue gives the organization insight into stakeholder expectations (Vanelslander 2016; Santos et al. 2016; Poulovassilis and Meidanis 2013).

ESG helps measure an organization's sustainability and environmental performance, but the established measurements and criteria have their hindrances. As ESG is aimed to be useful in various kind of organizations, the sheer variety and inconsistency of the data collected is massive. In addition, organizations report the results differently, which makes it difficult to assess and compare organizations even if they operate in the same field. This also makes benchmarking difficult. It is suggested that companies should aim to cooperate with other organizations in the same industry to form a baseline of jointly developed ESG criteria which would allow for comparability as well as benchmarking (Kotsantonis and Serafeim 2019).

The benefits that the organization can gain from applying CSR and ESG are ultimately dependent on the chosen measures, related costs and the measured time-period. Benefits concern environmental performance but also improved reputation and customer relations, financial performance, as well as employee relations. Benefits tend to be connected to each other, e.g. energy saving measures commonly lead to cost savings. Sometimes clearly stated and defined organizational values can be the only thing that separates a firm from the competition. In addition, environmentally sustainable companies are often also considered to be innovative and of good quality (Holmgren 2010; Fasoulis and Rafet 2019). As such, engaging in sustainability requires inordinate resources and commitment from the organization especially at the beginning. However, the main goal of social sustainability actions should be to obtain long-term benefits. These long-term benefits do not only include financial profits, but also social and environmental benefits that can sometimes be challenging to measure. The positive outcomes of those benefits are visible only after a certain period of time (Poulovassilis and Meidanis 2013).

Benchmarking and best practices

Benchmarking is a process, in which an organization measures its performance against other similar organizations. Learning from other organizations can highlight what has to

be done to improve the organization's performance and efficiency and benchmarking is an efficient tool for continuous improvement. Sometimes, benchmarking is considered to be "copying", but it is actually more of a concept that fosters innovation, not imitation (Dattakumar and Jagadeesh 2003).

With benchmarking organizations can learn quickly from others and thus leap ahead in the competition (Garvin 1993). Systematic benchmarking has the following steps: (1) Plan; (2) Do; (3) Check; and (4) Act. Methodologically this is known as the PDCA cycle (Wong and Wong 2008). In the benchmarking process, it is important to be able to identify the highest standards of operations, and based on these make the changes and improvements necessary to achieve the said standards in each organization. It gives organizations an external goal to aim for and forces the organization to study what their competitors are doing. It is important to be able to identify the critical performance criteria in order to benefit from the benchmarking process. A benchmarking process cannot be performed in isolation since it has to contribute to the organization's operational objectives (Bhutta and Huq 1999). Corporate environmental benchmarking is often considered challenging due to the range and inconsistency of the available environmental data. Using environmental management systems can help organizations in their benchmarking processes (Matthews 2003).

Benchmarking is closely linked to "best practices", which are good operational practices from the organization's industry peers. It also helps them to choose the most cost-effective ways to improve their environmental performance. Best practices are also being developed and shared in port operations as ports are seeing the potential advantage of sharing their innovations. An additional useful concept is that of Best Environmental Practice (BEP) which refers to the application of the most appropriate environmental control measure, or combination of measures that show better results than those achieved with other measures (e.g. GHD 2013). However, the problem with BEPs is that organizations have their own specific needs and requirements and therefore good practices are different even for organizations that operate in the same industry (Hiranandani 2014).

Tools for environmental performance measurement in ports

Environmental management tools and reporting in ports

Environmental standards can be quite high-level, as they are developed to be generic and applicable to different types of organizations. Still, they often include good environmental practices that are applicable also for ports. Adopting an environmental management system also establishes the port's preparedness to comply with environmental legislation as well as the port's willingness to become more responsible in terms of sustainability (Madjidian et al. 2013).

As stated before, environmental management systems are not mandatory. An increasing number of ports have adopted management systems, such as the widely used ISO 14001 environmental management system and the ISO 9001 quality management system into their daily operations (Darbra et al. 2004; Puig et al. 2016). The incentive to adopt environmental management systems or standards may come from external pressure. According to previous studies, particularly large companies are increasingly demanding environmental sustainability. In practise, they require voluntary environmental and

quality management systems from their business partners such as ports (MacDonald 2005; Boiral 2011).

In addition to the more general standards, the Port Environmental Review System (PERS) is the only port-sector specific environmental management system as it defines the environmental challenges specifically in port areas. What is special about the standard is that it is developed 'by ports for ports' in Europe. PERS includes the main requirements of the more common environmental management systems, such as ISO14001, but also gives clear objectives specific to ports. It clearly identifies the measures that are needed in order to be eligible for the certification. One of the benefits of PERS is that it is not too demanding in terms of time and required resources and thus, it is easily applicable in all types of ports. (ESPO 2015; Puig et al. 2017).

If a port chooses to adopt a management system standard, they must incorporate environmental policy into their operations and demonstrate their commitment. They must define the related goals, plans and objectives and provide an assessment on the current situation. Personnel, whose work and tasks may have a significant adverse effect on the environment, should receive training and information. Management systems also require appropriate, regularly updated documentation and reporting. For environmental management, emissions and emission levels must be systemically measured and compared with target values and all non-conformities must be rectified. In addition, regular environmental audits are required, and the environmental management system has to be periodically reviewed within the organization (Boiral and Sala 1998).

Even if ports choose not to adopt specific environmental standards or management systems, also different environmental labels and statements, life cycle analysis, and even the ports' own environmental initiatives can increase their environmental status (Brunila 2013). Ports can also apply the BEP concept (e.g. GHD 2013). This also applies to ports, as each port and their surrounding area is always unique, and thus, the importance of the different environmental effects of the ports varies. In other words, best practices are not universal and application in one port does not guarantee success in another. Yet, several environmental concerns are common to the majority of ports, and they evidently face similar environmental challenges in their operations (Hiranandani 2014).

Best practices in ports are closely linked to the Green Port concept developed by the World Association for Waterborne Transport Infrastructure (PIANC). The key elements in the Green Port concept include long-term vision, transparent stakeholder participation, a shift from sustainability as a legal obligation to sustainability as an economic driver, active sharing of knowledge with other ports, and a continuous strive towards innovation. Measures that are addressed in the concept include: environmental quality; habitat and integrity of ecosystems; energy efficiency and energy transition; materials and waste management; climate change mitigation and adaptation; stakeholder participation and corporate social responsibility; and co-operation with the private sector, authorities, non-government organisations, academics, and other ports (PIANC 2014).

Sustainability reporting enables ports to set operative goals, measure their performance and manage the observable change in order to improve their operations. Internationally agreed measurement metrics make the information collected in sustainability reporting more comparable and accessible and they provide stakeholders with information they might require. Sustainability reports are the main platform for an organization

to establish and communicate their sustainability and environmental performance. Subsequently, the reports also present the organization's values and establish the link between the organization's strategy and its commitment to global sustainable development (Chen et al. 2015; Clarkson et al. 2008).

In addition to the environmental management system standards and frameworks generally used in ports, the Self Diagnosis Method (SDM) developed by the European Seaport Organisation (ESPO) requires specific recognition. This is well established and extensively used in large European ports and to some extent in smaller ones. The developer ESPO (2016) considers it to be a user-friendly environmental checklist and it consists of three parts: the SDM checklist, SDM comparison and SDM review. With the SDM tool, ports can self-assess their environmental performance and compare it to the performance of other actors within the sector enabling port sector benchmarking. Individual responses from ports are treated confidentially and the SDM is not merely a pass or fail exercise. The 2015 version of the SDM consists of a checklist of 253 qualitative questions (with YES/NO responses), classified into nine categories (Puig et al. 2017). After the completing the SDM checklist, a port's SDM score is reviewed and the ports can receive expert advice and recommendations for improving their performance (Bhutta and Huq 1999; Darbra et al. 2004). The SDM is relatively affordable and the threshold for participating it is quite low in terms of costs. After participating in the SDM analysis, the port receives an "EcoPorts" status that is valid for two years (ESPO 2022). ESPO has also conducted several port environmental benchmark performance studies, during which the data and results are collected from the SDM system (ESPO 2016).

The use of frameworks, standards and other measurement systems in ports

Ports vary greatly in their size, operations, locations, and resources. Therefore, not all environmental management systems are necessarily applicable as a one-size-fits-all solution. This applies also to the implementation and accreditation of standards (Peris-Mora et al. 2005; Puig et al. 2015). In addition, implementation and accreditation processes can be quite expensive and time consuming, and smaller ports might face difficulties in adopting them (Berechman and Tseng (2012). This also applies to other benchmarking or performance measurement tools as they are not always applicable in all ports and thus, proper performance assessment and comparison cannot be done.

The applicability of different measurement systems to different ports may be affected by the port's lack of ability to perform the required measurements. For example, smaller ports may not be able to perform similar emission measurements as larger ports with the result that their performance cannot be similarly assessed. The reasons for this are manifold, e.g. there may be alack of resources or measurement equipment. In addition, not all emission measurements are as relevant to all ports, since port operations and the surrounding areas are different. Thus, ports need measurement metrics that are relevant to their specific operations.

As argued, some ports cannot necessarily adopt the same environmental management systems (or certificates and ratings) as larger ports even though their environmental performance may be sufficient. Thus, these ports are not able to establish their commitment to sustainability and environmental protection to their stakeholders, which can lead to

competitive disadvantages. In order to tackle this problem, the aim of this paper is to draft a framework for evaluating and establishing environmental performance that is generically applicable to varying types of ports. To achieve this, the framework requires generalizable qualitative indicators and performance criteria.

It is suggested here that ports should aim to customize the provided measurement metrics (at least to some extent) as well as to self-regulate them in cooperation with other organizations (located at the port vicinities) to form a baseline of jointly developed criteria that would allow comparability as well as enable benchmarking (e.g. Kotsantonis and Serafeim 2019). This would correct some of the problems that the more general standards and management systems pose to data coherence and comparability. When environmental data is collected, basic principles that need to be taken into consideration include comparability, balance between the problematic questions and opportunities, continuity of routines, clarity, and transparency (Brunila 2013). In the "European Port Industry Sustainability Report" (2016) it is stated that 66% of the ports had identified some environmental indicators to monitor environmental performance. Almost 100 different environmental indicators or criteria were identified. The large number of indicators and criteria show that a common approach to choosing the best alternative is lacking, even though it is recognized that ports are becoming increasingly aware of the benefits of measuring their environmental performance (e.g. ESPO 2016).

Environmental performance measurement tool for ports

Generally, indicators can be classified as qualitative and quantitative (Puig et al. 2016). Yet, one of the reasons why sustainability report tools are criticized is the high degree of emphasis placed on qualitative information (Siew 2015). This is why both quantitative and qualitative criteria should be included in the tool. This enables better comparability between participating ports regardless of their size or operations. Because checklist type self-diagnosis solutions were seen to be the easiest to adopt and thew most universally applicable tools, the drafted environmental performance measurement tool consists of checklists under four themes. The checklists are based on the performed literature review and existing standards and frameworks that are used for the environmental management and monitoring or ports. The new tool proposes four sets of qualitative and quantitative indicators to assess the ports' environmental performance.

The proposed tool enables ports to assess whether their environmental management practices take into account selected key aspects and communicate them with their stakeholders. The tool also considers situations in which some environmental measures and their importance to the port have been assessed, but the measures have been deemed not applicable for that specific port. The tool includes an option in which a port can indicate that they have considered environmental criteria and analysed their applicability before deeming them not applicable for their specific operations. In most cases, only a selection of environmental or management systems are applicable to certain ports. Therefore, the tool includes the possibility to disclose that only parts of predetermined measures have been adopted.

The response to the second research question is found in the elements of the tool that consists of a set of 15 questions (A-O), under three themes (Figs. 1, 2, and 3). These

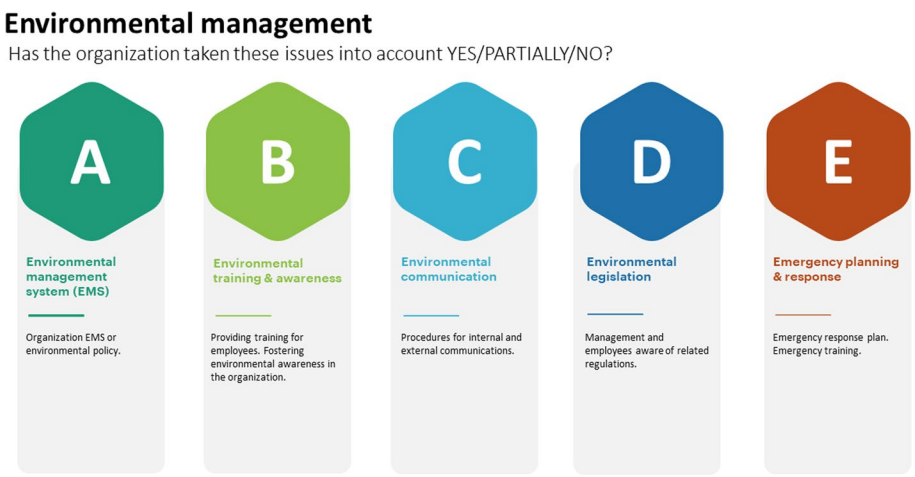

Fig. 1 Environmental performance tool for environmental management

Fig. 2 Environmental performance tool for sustainability

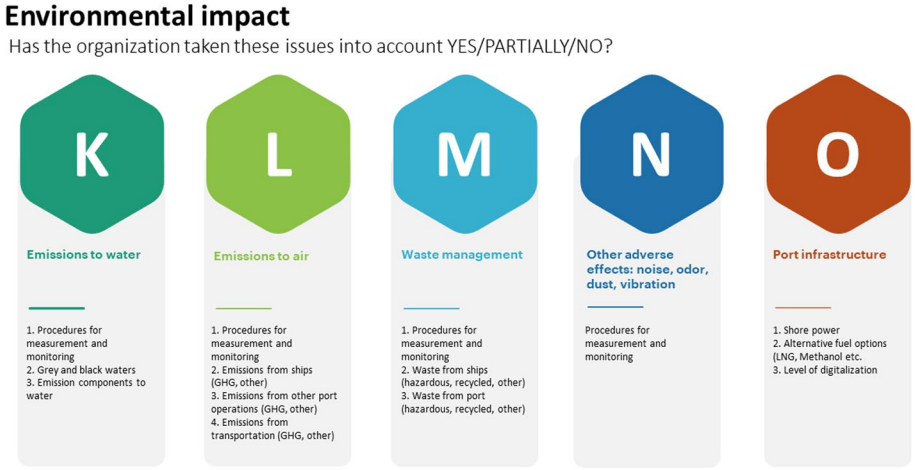

Fig. 3 Environmental performance tool for environmental impact

cover the checklist section of the tool. Figure 4 is a self-assessment process chart, which provides a roadmap for monitoring environmental aspects.

Figures 1, 2, 3, and 4 include suggested main categories (sections "management"; "sustainability"; "impact"; and "self-monitoring") that ports should consider, even if the ultimate outcome would be to leave some specific issues (partially or fully) out of the account. All the presented main categories include elements which ports should be able to carry out an assessment on of their environmental performance. Thus, the framework remains general enough, but it provides also specific sets of questions, for which responses are divided into three levels (Yes/Partially/No). However, the most appropriate indicators for environmental performance assessment remain contextual depending on the properties, locations and profiles of each port.

Testing and feedback responses from three ports

The self-monitoring tool was introduced to Finland's three major ports: the Port of HaminaKotka, the Port of Helsinki and the Port of Turku. The Port of HaminaKotka is Finland's largest universal port and the main export port. It handled 16.3 million tons of cargo in 2022. The Port of Helsinki is one of the largest cruise ports in the Baltic Sea area with 8 million passengers and 15.2 million tons of cargo. It is also Finland's most important import port. The Port of Turku is the second most important cruise port in Finland with 3 million passenger and 3 million tons of cargo. In Finland, every commercial port needs an environmental permit for port operations, monitored by the Centre for Economic Development, Transport and the Environment.

The following interpretations are based on interviews of representatives of these three ports who were officials responsible for environmental management and decision making. The authors requested the port organizations' thoughts about the tool itself and its

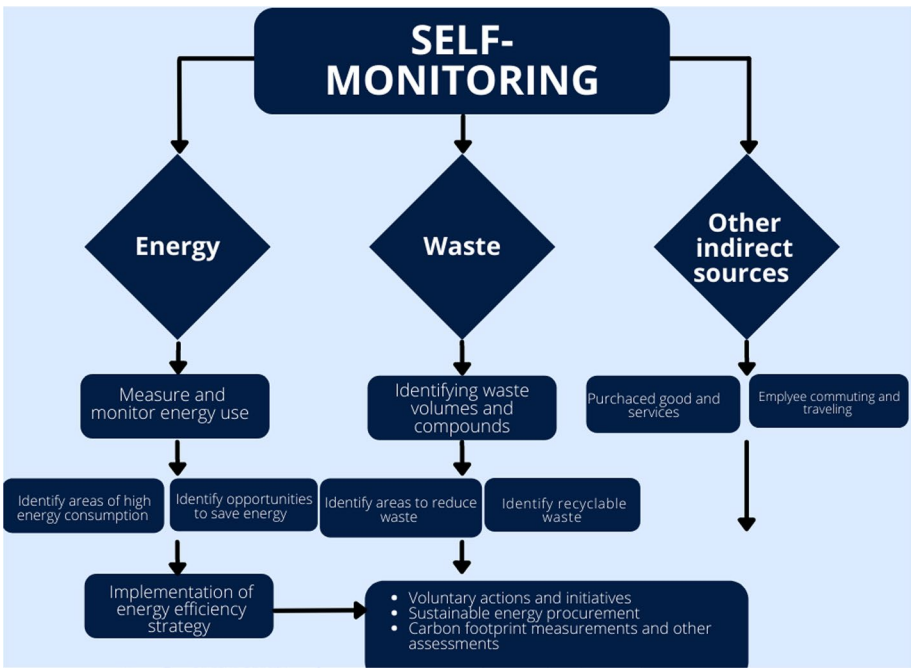

Fig. 4 Environmental performance tool for self-monitoring

functionality and suitability at an operational level. The port representatives were asked their opinions on what aspects were good regarding the tool and what issues should be further developed. They were also asked, whether they themselves would be interested in using the self-monitoring tool.

All the participating ports implement the ISO 14001 standard and, to meet the requirements of ISO 14001 the port organizations must identify their environmental impacts. One of the interviewed port representatives stated that many of the environmental issues and reflections are carried out based on ESPO publications and by using the Ecoports forum, where the SDM checklist can be used even without committing to the corresponding comparisons and reviews or without applying for the certificate (PERS). As the new self-monitoring tool also is also a checklist type tool, it could be used similarly. A second interviewed port representative mentioned that sections of the tool, such as in Fig. 3 "Environmental impact", could be used as a good tool support the implementation of ISO 14001 to help recognize the port's environmental impacts. At the same time, a conformity self-assessment could be carried out, for which the tool is also suitable. The tool was also seen to have other good points, such as the fact that emergency preparedness and alarm response were directly under the safety unit and not handled in the context of an environmental certificate (referring to Figs. 1 and 2 "Emergency planning & response" items E and J).

It was considered that for the "self-monitoring" elements, shown in Fig. 4, the operations of ports were described quite well, although not all ports have prepared similar process pictures. One port representative replied that the tool itself was "quite extensive" and "a lot of stuff has been fitted inside it" (direct translated quotes). When the ports' own activities are evaluated at a high level, e.g. when an environmental certificate is adopted or a responsibility program is drafted, it is highly beneficial to have a corresponding "check-list". Generally, all of the interviewed port representatives paid a significant amount of attention to these environmental issues.

One interviewed port representative considered the idea of a tool, such as the presented self-management tool, to be very good and future-oriented but the ability to perform comparisons was "a must", even though ports can be very different in their sizes and profiles. It was noted by the respondents that benchmarking motivates users to improve their own actions and increased tool adoption and result performance comparisons would have the potential to develop the entire industry over time. It was also mentioned that it is important (and good) that the tool allows individual selection of applied sections in different ports. Especially Fig. 2 "Sustainability" was considered as a well-structured entity. Figure 3 "Environmental Impact" made one of the port representatives consider whether it could be used to estimate the total carbon footprint of operations. The same applies to Fig. 4 "Self-Monitoring", where the carbon footprint is mentioned. One port considered that "even though there is always room for improvement, they already have the basics in order." Unfortunately, this is not the case for all ports or companies operating in them.

Review of the tool properties and conclusions

Assessing the properties of the draft tool

Ports' environmental impacts, volumes, and contents vary according to the port specialization and contexts. It is rare that performance measurement instruments are completely applicable to all organizations operating in the same industry field. In particular,

ports differ from each other in terms of ownership, location, profile, size, and societal context. Therefore, not all the measurement metrics included in this study necessarily apply to all ports (Puig et al. 2017). The implementation of standards and management systems and the possible accreditation required can also be expensive, especially for small ports that have limited resources (Kunnaala-Hyrkki et al. 2015). These considerations are relevant for the third research question of the paper.

The most significant environmental impacts of ports include emissions into the air and water caused by transportation or port machines and equipment, waste, in addition to the environmental effects of construction work, as well as the introduction of other adverse effects, such as noise, dust and odours. The draft environmental performance management tool considers all of these. Yet, their monitoring in not dependent only on the overall quality of operations and environmental management, but also on the availability of information to the surrounding community. The most effective way to influence relative and absolute reductions in traffic emissions for ports is to ensure the continuous development of the port infrastructure, deepening waterways and port basins (as the ship sizes continuously increase), and by removing bottlenecks in scheduling (Zhao et al. 2021; European Parliament 2022). Ports must also facilitate the proper disposal of waste and emissions that are produced by ships (e.g. grey and black waters, oily waste, ballast waters and other waste components) for recycling (see Viana et al. 2014, 2009; Dinwoodie et al. 2012; Corbett et al. 2007).

In order to enable comparability between different types and sizes of ports, a combination of qualitative and quantitative indicators is needed. This problem is even more prominent when it comes to measurement systems that require quantitative performance evaluation. If similar assessment criteria are used (in all ports despite their differences), the results of the assessment will most likely be distorted. Yet, using quantitative criteria enhances the measurability. This paper indicates that this is possible with a relatively simple monitoring tool. However, the beneficial use of the tool is dependent on the end-users, due to human behaviour. This is also one of the reasons why sustainability report tools have been criticized for their accuracy and the high degree of emphasis placed on qualitative information (see Siew 2015). In addition, the measurements can possibly be practically impossible for smaller ports to perform to the same extent as in larger ports due to lack of resources and lack of measurement equipment.

Assessing existing measurement frameworks and tools

The third research question is answered in the following section. The pros and cons of measurement tools and methods were discussed in the literature review in Sect. 3 to a varying degree, as there are numerous tools that could be studied. The tools selected for a detailed investigation were PERS and ESPO's SDM, since they both are tools specifically developed for ports. ESPO's SDM or the checklist part of the tool, is widely used in the port sector. At this moment ESPO have 103 EcoPort members and in total there are 633 entries in SDM, 31 are ports are certified PERS and 56 ports have certified ISO (ESPO 2022).

The determination of the level of implementation of different measuremernt tools can be problematic. Often there are measures taken in ports that may be considered to be included in their operations, but are not fully realized in practice. In order to tackle

the problem of subjective interpretation, the drafted tool includes the alternative: "partially". For example, the port's waste monitoring may include some waste management elements, but not necessarily all categories of disposed waste. A simple YES/NO response option can therefore be seen as two opposing end-points of a quality spectrum. It is more likely that most ports' operations are located somewhere between these two opposing ends. The drafted tool also takes into consideration situations in which some environmental measures and their importance to the port has been assessed, but the measures have been deemed not applicable for the port in question.

The drafted tool for assessing environmental performance is also flexible in terms of interpretation. Even though the answers and questions are written, it can also be converted into a numerical classification tool. In numerical form, each aspect would get a grading (e.g. 2, 1 and 0 points) and some threshold levels could be determined to support comparison between organizations, for example, by weighted averages, mediums or quintiles. In a previous study by Kunnaala-Hyrkki et al. (2015), it was found that ports may be interested in environmental management tools, but they are not necessarily interested in getting actual numerical grading points. Still, numerical indicators could be easily used as marketing tools for the ports eco-friendliness. Numerical tools would also make port comparisons easier in addition to reviewing the environmental status of single ports.

Conclusions

The competition between ports is hard and it is expected to become even harder in the future. In addition, environmental legislation is becoming stricter, and it does not make it easy for ports to operate. A port's competitiveness is dependent on several factors, such as the geographical location, logistical connections to the mainland and to other ports, the port infrastructure and facilities and the field of operations. A port's environmental status and a green image can be a significant competitive advantage for the future, but in order to benefit from a green image, the ports have to be able to establish their eco-friendliness with stakeholders somehow. This can be done by implementing environmental management systems, standards or frameworks, applying for eco-labels and certificates, or by other measurement means and reporting tools, such as the one proposed in this article.

The outcome of this study is the presented classification tool which enables ports to review their environmental performance and compare their current environmental status with other ports. In order to facilitate competition, but also to benchmark good practices and foster innovations, a port's environmental performance practices should be made more comparable. Unfortunately, this is not always the case. Ports have adopted different frameworks and standards and are implementing them in differing ways and to varying degrees. This leads to a situation, in which ports measure their environmental permits with different and non-comparable criteria. The presented draft tool is designed specifically for ports and is an alternative to traditional (and expensive) standards and measurement systems.

The academic contributions of the tool include the combination of an extensive literature review and identification of the key elements that are, or at least should be, easy-to-use for practitioners. The presented self-monitoring tool is designed for small ports and their stakeholders. The utilization of this tool empowers smaller ports with a

comprehensive and holistic understanding of their environmental emissions, environmental management, and sustainability practices. This tool facilitates self-monitoring of processes, even in smaller ports, enabling them to review and align their practices towards more sustainable approaches, while also seeking cost-effective means to achieve their environmental and climate targets. Practical examples of the tool's potential benefits for ports include critical assessments of energy and electricity consumption. Through the tool, ports can identify areas or facilities within the port that do not require constant illumination, resulting in significant reductions in electricity usage. The tool enables small ports to assess emissions sources, identify inefficiencies, implement best practices, benchmark performance, and integrate renewable technologies, contributing to sustainable environmental management. This comprehensive approach can help small ports achieve emission reduction goals, comply with regulations, and protect local ecosystems, while promoting sustainability in port operations.

The tool also has limitations and it focuses solely on environmental aspects and performance at the upper management level. For future research, the draft tool should first be introduced to a wider spectrum of ports in the BSR and the results should be compared based on different port types, ownership, and countries. In addition, it should be established whether larger ports see benefits in adopting the tool or whether it is usable only by smaller ports. The EU Green Deal with Fit for 55 and other future regulations will have a significant effect on ports in the BSR. In the next seven years, large investments will be made in shore power, alternative fuels for ship bunkering, and towards other improvements in digitalisation and infrastructure.

Currently, there are no universal requirements or legislation to force all ports to use certain performance assessment or reporting tools. Thus, environmental management activities are based on the port's own values and willingness to engage in CSR and environment. Fortunately, the share of ports that have incorporated environmental management systems or other similar environmental initiatives in their operations is increasing. In addition, there are other environmental performance indicators and tools, such as the SDM, and ports can participate in benchmarking and best practice sharing.

All improvements related to environmental and sustainability issues carried out in ports have a positive effect on the whole sector. A green and sustainable image will improve a port's status and gives competitive advantages compared to other ports of similar sizes and in similar markets. However, in order to gain credibility in terms of environmental progression, ports must implement (and report) actions and progress on the issues. As such, the conducted research yields the following future research directions: first, there is still a need to develop rigid environmental measuring of air and seaborne emissions. For example, actual measurement campaigns are required (see Aakko-Saksa et al. 2016). Second, the development of clean technology is progressing rapidly due to increasing regulative pressure and the resulting market demand. An essential question is how new technologies could be updated (incremental innovations) in transports so that they would deliver cleaner production for ports and their operations. Third, strategic management and corporate social responsibility (CSR) requires more research particularly in port communities: the joint development of measurement, management tools and easy-to-use data solutions require more research on best practices. Ports play

a significant role here, as they are logistic nodes, and they have to operate transparently and be committed to emissions control and monitoring.

Appendix

See Table 1.

Table 1 United Nations Sustainable Development Goals (SDGs) of the 2030 agenda. *Source*: United Nations 2023

Sustainable Development Goal	Target
Goal 1	End poverty in all its forms everywhere
Goal 2	End hunger, achieve food security and improved nutrition and promote sustainable agriculture
Goal 3	Ensure healthy lives and promote well-being for all at all ages
Goal 4	Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all
Goal 5	Achieve gender equality and empower all women and girls
Goal 6	Ensure availability and sustainable management of water and sanitation for all
Goal 7	Ensure access to affordable, reliable, sustainable and modern energy for all
Goal 8	Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all
Goal 9	Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation
Goal 10	Reduce inequality within and among countries
Goal 11	Make cities and human settlements inclusive, safe, resilient and sustainable
Goal 12	Ensure sustainable consumption and production patterns
Goal 13	Take urgent action to combat climate change and its impacts*
Goal 14	Conserve and sustainably use the oceans, seas and marine resources for sustainable development
Goal 15	Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss
Goal 16	Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable, and inclusive institutions at all levels
Goal 17	Strengthen the means of implementation and revitalize the global partnership for sustainable development

Abbreviations

BEP	Best Environmental Performance
CO_2	Carbon dioxide
CSR	Corporate social responsibility
ECA	Emission Control Area
EMAS	European Union's eco-management and audit scheme
EMS	Environmental management systems
ESPO	European Seaport Organisation
ESG	Environmental, Social and Governance
ETS	Emission Trade System
GHG	Greenhouse gas
GRI	Global Reporting Initiative
HELCON	Helsinki Convention
IMO	International Maritime Organisation
ISO	International Organization for Standardization
NOx	Oxides of nitrogen
ODS	Ozone-depleting substance
PERS	Port environmental review system

PIANC	World Association for Waterborne Transport Infrastructure
SDG	Sustainable Development Goals UN
SDM	Self-diagnosis method
SOx	Oxides of sulphur
UNCLOS	United Nations Convention on the Law of the Sea
VOC	Volatile organic compounds

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Author contributions
O-PB is the corresponding author and VK-H and TI are co-authors. O-PB was the main responsible for the structure, chapters and main text of manuscript, VK-H was a major contributor especially in chapter 2, TI was a supervisor and give commentary and guidance to article. All authors read and approved the final manuscript.

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