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The Port Environmental Performance Index

Development of a Framework for Strategic Assessment of Port Environmental Performance

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Abstract

The motivation for this thesis originated from the Port Environmental Performance Index project (PEPI), which is part of SETS II, initiated and financed by the EU program Interreg.

Port environmental issues are usually multidimensional and lead to difficulties for port decision makers to act based on port environmental data coming from large, heterogeneous, multi-numbered data sources. Performance measurement is critical if any organization wants to thrive, and when it comes to ports and environmental performance there is great challenge in the increasing availability of data sets with a huge amount of information, coded in many different features. The challenge for port management in this context is the translation of raw data into useful information that can be used to improve port environmental strategic decision-making processes, detect relevant profiles, understand relationships among operational features and detect environmental measures. As such, integration of the heterogeneous and uncertain information demands a systematic and understandable framework to organize the environmental information and processes to interpret and use in actual port advising or decision-making context.

This thesis proposes: (1) an integrated port environmental indicator model which can serve as a strategic tool for port environmental performance management; (2) a multidimensional framework for port environmental management to control and monitor the port environmental process to achieve the overall environmental goals of the port; and (3) a specified strategic approach to guide implementation of port environmental performance measurement.

The thesis discusses the proposed multidimensional framework, integrated model, and the related specified strategic approach for implementing port environmental performance. The results will be used by the participating ports in the SETS II project to guide the development, implementation and assessment of the proposed framework and indicators for port environmental performance through the PEPI model with continuous improvement.

The Port Environmental Performance Index is an impact assessment tool that is strategic in nature and has the objective of facilitating environmental integration and the assessment of the opportunities and risks of strategic actions in a port environmental development framework.

Keywords: PEPI, ports, environmental performance, measuring, strategy, KPIs

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1. Introduction

This chapter gives a short description of the research background of the thesis, states the research problems, enumerates the research purpose, objectives, and questions, and explains the research scope, limitations, and structure.

1.1 Research background

"*People can't respond to information they don't have. They can't react effectively to information that is inadequate. They can't achieve goals or targets of which they are not aware. They cannot work towards sustainable development if they have no clear, timely, accurate, visible indicators of sustainable development*" (Meadows, 1998).

Maritime transport underpins global supply chain linkages and the economic interdependency with shipping and ports estimated to handle over 80 % of global merchandise trade by volume and more than 70 per cent by value (UNCTAD, 2020). Even with only modest assumptions of economic growth, port cargo volumes are expected to rise by 50% by 2030 and even more for the fast growing traffic of containers (EC, 2013). In 2018, the International Maritime Organization (IMO) member states, as a response to the vast emissions from maritime activity set an absolute target of GHG emissions to 50% reduction by 2050 compared to 2008, referred to as the "*Paris Agreement for shipping*" (Bjerkan & Seter, 2019). Bjerkan and Seter (2019) further shows to that meeting these reduction goals will require tremendous effort in terms of new technologies and other measures for adapting the maritime sector towards zero-emission.

The focus of global regulation of the maritime sector in relation to climate change has so far been to regulate the energy efficiency of ships. Since ships spend most of their time outside the reach of national regulators, and as nodes in the multi-modal transport system linking maritime transport to other transport modes (Papaefthimiou et al., 2017), ports are of crucial importance in relation to the success of transitioning the maritime sector towards environmental sustainability (Bjerkan & Seter, 2019). The ports are directly impacted by shipping's emissions, which in most ports represent the main source of air pollution (OECD, 2018). To encounter this, some ports provide a deduction of port fees based on one or more indexes that express the environmental performance of an individual ship. The scores of these indexes are used as justification for the reduction of regular port fees. There exist several indexes of this type and a vast diverse of incentives of other so called green port fees are widely used, such as: The Environmental Ship Index (ESI), the Green Award, the Clean Shipping Index (CSI), the Environmental Port Index (EPI), the GHG Emissions Rating of

RightShip, VSI, EEDI, Blue Angel amongst others. One key observation in this context is: The ports are measuring the ships in regard to their environmental performance and based on this measurement ships are subject to differentiated port dues. Despite the sophistication of some of the green port fee schemes, there exists a lack of empirical evidence on the impacts of the environmental performance of the ports themselves. Considering this irregularity, the idea of the Port Environmental Performance Index (PEPI) came into existence.

The 2030 Agenda, with the Sustainable Development Goals (SDGs), together with the Paris Agreement have reinforced the commitment of the international community in achieving a sustainable development path. They underscore the importance of mainstreaming sustainability principles and climate action criteria into all economic activities and sectors (ESCAP, 2020). As a result, ports respond to worldwide, regional, and domestic challenges, such as climate change, mobility, digitalization, migration, and social integration, whilst adding value to international supply chains. The UN (2020) states that ports add value to the economy and generates social gains, including by supporting trade, linking supply chains, enhancing connectivity, allowing market access, generating employment, and enabling business opportunities. The UN (2020) further states that in these regards, the nexus between the 2030 Agenda, the SDGs, the Paris Agreement, and sustainable port development is strong.

Sustainably useful business is neither a new idea nor one which is particularly at odds with the fundamental conventional purpose of business – to sell things which people want or need. However, demonstrating sustainable utility has becoming rather a burning issue in recent years, spurred not just by the slow growing questioning of the current mode of international capitalism, but also by the rather more pointed challenges to the purpose of whole sections of the economy raised by the environmental awareness of society. Port environmental issues are usually multidimensional and lead to difficulties for port decision makers to act based on port environmental data coming from large, heterogeneous, multi-numbered data sources. As such, integration of the heterogeneous and uncertain information demands a systematic and understandable framework to organize the environmental information and processes to interpret and use in actual port advising or decision-making contexts.

1.2 Research context and project motivation

This thesis is part of the Port Environmental Performance Index (PEPI) project. The PEPI project is one of five work-packages included in the executive Interreg project SETS II (Scandinavian Electrification of Transport Systems II).

Interreg is one of the key instruments of the European Union (EU), supporting cooperation across borders through project funding. Interreg aims to jointly tackle common challenges and find shared solutions in fields as health, environment, research, education, transport, sustainable energy and more.

The participants in the SETS II project are a mixture of Nordic ports, knowledge institutions and organizations operating with green conversion. The SETS II project seeks to contribute to the green transition through:

- Reduction of CO2 emissions in Nordic Ports
- Electrification of Nordic Ports
- Sustainable strategies for Nordic Ports

The purpose of SETS II is to create a "*Nordic Plan*", which initially will be used in Scandinavia, but in the long run will be spread to the whole world.

In SETS II the overall goals for the PEPI project are:

- That ports and other parties involved in the project can clarify and realize their potential in relation to making a green transition.
- The development of an Index to measure/document the environmental adaption and performance of ports.
- The index should be generic and be able to be used throughout the area of KASK (Kattegat and Skagerak).
- The index should be able to be used by several stakeholders and the results will contribute to increased focus on electrification and sustainability.

The overall goals for the PEPI project are:

- The creation of a tool for port strategic and political decision making related to "*green investments*".
- The creation of a tool for ports to identify and/or benchmark environmental risk related to port operations.

1.3 Problem statement

As discussed above, multifaceted challenges in the port industry require the development of a framework for port environmental performance measuring. Problems identified in the initial exploratory study include the following:

- **Problem 1:** Lack of a strategic tool to provide insights that are useful for identifying practices, informing policy agendas, and setting priorities in environmental port governance.
- **Problem 2:** Lack of a multidimensional environmental indicator framework for port environmental management.
- **Problem 3:** Lack of a specified strategic approach to guide implementation of port environmental performance measurement.
- **Problem 4:** Lack of a tool for visualising port environmental performance.

1.4 Research purpose and objectives

To deal with these problems the main purpose of this research is to develop a strategic, multi-criteria, hierarchical tool, and an integrated multidimensional framework for port environmental performance management. The specific objectives of the research are to provide insights that are useful for identifying practices, informing policy agendas, and setting priorities in environmental port governance. These objectives will be obtained by:

- **Objective 1:** Developing a strategic tool to provide insights that are useful for identifying practices, informing policy agendas, and setting priorities in environmental port governance.
- **Objective 2:** Developing a port environmental performance implementation approach for port environmental management which can be improved continuously.
- **Objective 3:** Developing a novel approach to assessing port environmental performance indicators.

Table 1.1

Connections between research problems and objectives

Problems	Objective 1	Objective 2	Objective 3
1	X		
2	X	X	
3	X	X	X
4	X	X	X

1.5 Research questions

To achieve the stated purpose and objectives, the following research questions have been formulated:

- **Research question 1:** What is a strategic tool to provide insights that are useful for identifying practices, informing policy agendas, and setting priorities in environmental port governance?
- **Research question 2:** How can the developed port environmental indicator tool be implemented through port strategy?
- **Research question 3:** How can port environmental indicators be assessed using a novel approach?
- **Research question 4:** How can the developed port environmental KPI framework be improved continuously?

The research questions are formulated to achieve the research objectives presented in Section 1.3.

The main connections between the research questions and research objectives:

Table 1.2

Connections between research questions and objectives

Research question (RQs)	Objective 1	Objective 2	Objective 3
RQ 1	X	X	
RQ 2		X	
RQ 3			X
RQ 4		X	X

The hypotheses based on the research questions above are:

"***A strategic port environmental tool will provide insights that are useful for identifying practices, informing policy agendas, and setting priorities in environmental port governance***".

1.6 Research scope and limitations

The scope of this research is the study of an integrated port environmental KPI framework for port environmental performance management. The research covers port environmental KPI development, implementation, and assessment. Specifically, this research develops a four-level environmental KPI framework with indicators which can be used as a strategic facilitator for port management. The research further explores the implementation of the proposed KPIs in port environment.

Based on the research questions and objectives, the scope of the research is limited to:

- Studying and identifying the issues and challenges associated with port environmental performance measurement and development of the PEPI framework. This is because; knowing the associated issues and challenges, it is possible to develop a balanced PEPI framework.
- The PEPI framework needs to consider the hierarchical levels of the organization and multiple criteria for the port environmental performance indicators.
- The study is limited to the issues related to the measurement of port environmental performance.
- The emphasis in this thesis is on developing a new port environmental performance assessment, so the proposed model in this thesis uses only a few KPIs as examples.
- KPIs for different/specified ports, processes, strategies are not studied separately.
- The port strategic-based methodology of the PEPI model is based on the Strategic Environmental Assessment (SEA) works of Partidário (2007).

The information given in the proposed PEPI model and related framework is intended to be generic in recognition of the variety of activities and operations in ports, their size, location, and administrative framework. The PEPI model and framework should be applicable to most ports and is not intended to be exhaustive and cover the environmental aspects of all port-related and supporting industry. The PEPI model and framework are, however, intended to provide guidance on the environmental effects and management of ports. The PEPI model and framework are intended to provide information on environmental issues so that ports can find guidance, with some additional information relevant to specialised operations. Further work is required to minimize these limitations.

1.8 Necessary ethical considerations and applications

The Norwegian Data Protection Regulations, NSD, have reviewed the project and find that the project is reporting obligation and that the personal information collected in this project is regulated by Section 31 of the Personal Data Act. The project is approved and NSD have confirmed that the project can start processing personal information (appendix A). Please see http://www.nsd.uib.no/personvern/en/index.html

1.9 Outline of thesis structure

The structure of the thesis is divided into different chapters, where each chapter of the thesis illustrates different aspects of the performed research.

Chapter 1 provides background information on the relevance of this research and its contextual perspective, introduces the research problem, describes the research purpose, introduces the research questions and hypotheses, objectives of the research and explains the scope, limitations, and structure.

Chapter 2 contains the theoretical framework, foundation and literature review of port related environmental performance.

Chapter 3 consists of the research methodology describing the research approach, research design, research strategy, data collection and analysis, and quality of the research design are discussed.

Chapter 4 presents the findings of the research and the PEPI framework.

Chapter 5 discusses the research findings for each research question (RQ), and the fundamental aspects underlying the establishment of a strategic-based methodology for the PEPI model and its integrated framework for port environmental performance management are described in this section, namely the functions and expected outcomes, the methodology components, the structural elements, and the methodological principles.

Chapter 6 explains the contribution of the research and discusses the findings with reference to research questions and objectives. In addition, the scope for future research and conclusions are also included in this chapter.

2. Literature Review, Theoretical Framework, and Foundation

This chapter presents the theoretical framework of this research through defining and describing related terms like port environmental performance, indicators, measures, and a literature review which includes conference proceedings, journals, international standards, and other indexed publications.

2.1 Ports and Port Activities

Europe constitutes the densest port regions worldwide and has more than 1200 commercial seaports along the 70,000 km of coastal zone, and over 200 ports in its inland waterways (Tatar, 2017). These ports of Europe are vital gateways, linking its transport corridors to the rest of the world, where over 74% of goods entering or leaving Europe go by sea (EU, 2021). Ports are regional multimodal intersections of global supply chains which function in the context of complex infrastructure, business transactions, and regulations (Molavi et al., 2020). The port industry has a significant economic impact in terms of employment and activity in the port industry itself (direct impacts), down the supply chain (indirect impacts) and in the wider economy (induced impacts) (EC, 2013). The ports are further not only great for moving goods around:

- over 400 million passengers embark and disembark in European ports every year.
- over 1.5 million workers are employed in European ports.
- more than 2 million workers are employed indirectly across the 22 EU maritime Member States.

(EU, 2021).

Ports are diverse in the functions they fulfil, the role they play in the modal shift, and in their size (Seguí et al., 2016). According to Puig et al. (2014), ports are, because of the range of interests and responsibilities of the parties involved, complex organisations from many points of view: economically, socially, culturally, and administratively. There is a wide range of industrial activities located in ports, such as petro-chemical, steel, automotive, energy production, and the European ports are also at the heart of economic activity for wider maritime clusters, including shipyards, marine equipment, crane and terminal equipment producers, salvage companies, offshore companies, marine construction firms, dredging firms, naval bases, etc. (EC, 2013). Ports are composed of different companies, dealing with different activities and offering a wide range of services (Özispa & Arabelen, 2018). Bichou and Gray (2005) shows to that ports manage, maintain assets, facilities, utility networks, utility consumption, coordinate and optimize transportation, coordinate leases and tenants and monitor performance and they must coordinate all these activities to ensure unencumbered throughput to protect profit and sustainability. In conjunction with the local geography and hydrography these factors mean that each port is unique (Bichou & Gray, 2005).

Port activities vary widely, however as Papai et al. (2000) shows to, some activities are common to most ports, if not all. Port activities can be divided into two major groups: (1) the development activities; and (2) the operational activities. For instance, as Papai et al. (2000) gives: building renovation, new building construction, land reclamation, quay extension and capital dredging are some of the development activities common to all ports. The majority of port development activities on land and at the land-water interface concern construction works with the associated transfer stations for construction material and possibly demolition works and debris (Paipai et al., 2000). Whereas, according to Paipai et al. (2000), maintenance activities such as paint stripping and painting, the storage and handling of cargo, and vehicle and equipment maintenance are some of the most common operational activities in ports. Some of the operational activities such as cargo handling, equipment maintenance and vessel repair occur at the land-water interface as well as on-land (Paipai et al., 2000).

Typical port activities as classified by Paipai et al (2000):

(1) Port Development activities:

i) Land-water interface

- Land reclamation and associated land filling works
- Quay construction, extension and restoration
- Raising of quay/berth/pavement level

ii) On-land

- Demolition of old buildings and structures
- Construction of new buildings and structures
- Placement/restoration of aboveground and underground storage tanks

iii) In water

- Channel deepening
- Piling works

- Pontoon placement

(2) Port Operational activities:

- Commercial shipping and recreational boating
- Building/vessel repair and maintenance
- Vehicle and equipment maintenance
- Site cleaning and clearance
- Cargo handling
- Cargo storage
- Bunkering
- Yard maintenance
- Port traffic

2.2 Port activities and associated potential environmental impacts.

As shown to above, ports are integral hubs of maritime supply chains and contribute to socio-economic development for communities through port activities which contribute significantly to maritime transport development and economic growth through direct, indirect and induced impacts, however, ports can create negative impacts and impose adverse effects on the host community (Hossain et al., 2020). Port activities can have significant impacts on several environmental resources, and environmental impacts are likely to result from the two major groups of port activities mentioned above (Paipai et al., 2000). According to Hua et al. (2020), research show that environmental impacts can be linked to internal port activities, shipping traffic, and emissions from intermodal transports. Normally the impacts are of local nature, however activities in rivers or estuaries can be of regional nature. Paipai et al. (2000) gives that from development activities the impacts are normally of a similar time scale as the development activity itself, except in cases where the alterations to environmental resources are permanent as the disappearance of a fisheries nursery grounds or changes in sediment transport on the coast. On the other side, impacts from the operation activities last at least as long as the operations do, unless the cumulative effect over a prolonged period of operation has resulted in permanent and irreversible change or loss of the environmental resource (Paipai et al., 2000).

As Paipai et al. (2000) underlines, port activities can also provide opportunities for enhancing environmental resources (eg. the beneficial use of dredged material) and benefiting local communities (eg. the local economic benefit as a result of a new ferry terminal or the establishment of wind farms on harbour piers, which produce energy for the local network). These opportunities are normally obvious at the stage of project conception and/or design, where environmental criteria are an integral part of that stage (Paipai et al., 2000).

According to Paipai et al. (2000) the primary environmental resources at risk from port activities are:

- surface and groundwater quality
- harbour sediment quality
- ambient air quality
- soil quality
- ambient noise levels
- status of natural habitats and individual species
- human health and welfare
- local community interests
- cultural heritage

The number and nature of environmental impacts vary amongst ports and only some impacts need to be considered for any port activity. These impacts on the environmental resources can be either: (1) short or long-term, (2) reversible or irreversible, (3) local or regional, and (4) direct or indirect.

Paipai et al. (2000) shows to that dredging and disposal activities, for instance, resuspend port sediment into the water column and that this resuspension is a direct impact on the water quality. This resuspended sediment further reduces the amount of sunlight entering the water column which is being used by algae for their photosynthetic activity to reproduce. The algae are the food source for some fish species and the reduction in their reproduction means reduced food supply available to fish. The resuspension of harbour sediment in the water column is also an indirect impact on fisheries resource, because the resuspended sediment can clogg the fish gills, hence directly impact the fisheries resources.

There is a plethora of published documents on environmental impacts from port activities, and Paipai et al. (2000) found in their research that parameters determining the magnitude and significance of environmental impacts are:

- Nature, extent, intensity, and frequency of the activity.
- Proximity of activity to environmental resources.

- Pathways between the activity and potential environmental target.
- External parameters influencing the accessibility through the pathways.
- Degree of sensitivity and state of health of the environmental resource.
- Control measures in place to prevent or reduce impacts.

Paipai et al. (2000) shows to that the impacts on the physical environment are the impacts on the three media, air, surface and groundwater, and soil (including sediment). Paipai et al. (2000) further shows to that depending on the nature and magnitude of an impact, more than one media can be affected, although the time scale and significance of the impacts on the two or more medias can be different. As example Paipai et al. (2000) gives that excavation works on land can mobilise contaminants in the soil, release them into the water in the pores of the soil and facilitate their travel to groundwater resources. Similarly, the release of fugitive emissions into the atmospheric air is also responsible for soil contamination because of the fall out process and contaminated dust particulates, which fall out on paved surfaces can eventually find their way into the waterways and precipitate onto the sediments (Paipai et al., 2000). There is, Paipai et al. (2000) states, in other words, more than one pathway which contaminants can follow to reach environmental targets, and the effective elimination or reduction of environmental impacts requires an identification of all possible pathways.

Today Ports are also facing increased pressure to reduce negative impacts on climate and environment (Bjerkan & Seter, 2019) and to optimize their performance in terms of the impact of economic, environmental, energy and functional challenges (Molavi et al., 2020). It is now acknowledged that port operations and activities also have adverse consequences on the environment (Gupta et al., 2005) and their roles and functions in transport systems and economy make them a key factor in promoting sustainability (Bjerkan & Seter, 2019).

2.3 The moral imperative of sustainable development

Sustainably useful business is neither a new idea nor one which is particularly at odds with the fundamental conventional purpose of business – to sell things which people want or need. However, demonstrating sustainable utility has becoming rather a burning issue in recent years, spurred not just by the slow growing questioning of the current mode of international capitalism but also by the rather more pointed challenges to the purpose of whole sections of the economy raised by the environmental awareness of society.

In 1987, the concept of sustainable development was popularized by the report Our Common Future by the World Commission on Environment and Development, known as the Brundtland Commission, and defined as:

"*A development that meet the needs of the present without compromising the ability of future generations to meet their own need*".

(World Commission on Environment and Development, 1987).

In 1997, Elkington described a sustainable perspective for balancing economic, social and ecological/environmental performance for profit, the planet and humans, thus creating the triple bottom line (TBL) (Elkington, 1997). With TBL, Elkington (1997) argues that corporate responsibility covers aspects that extend beyond the financial. He suggests the need for a suitable balance between economic, environmental, and social aspects to achieve sustainability in organizations. This is called the three dimensions of sustainable development and this definition of sustainability is often presented in the form of the three circles of economic, ecological and social affairs, where the overlapping middle part is declared to be sustainable development (Connelly, 2007). Connelly (2007) shows to that the connection between the dimensions determines whether something is sustainable. Another typology used for sustainable development is "*weak*" or "*strong*", where the initiatives can be graded on an axis between them (Conelly, 2007). The "*weak*" extreme means that the social, ecological and economic resources are exchangeable as long as the total amounts of resources are not weakened (Moore, 2011). Moore (2011) further states that on the other side of the scale, the "*strong*" extreme, environmental resources remain intact and, if necessary, at the expense of economic and social development. Conelly (2007) mapped an adjusted discharge where the three circles were arranged in a triangle, where each corner consisted of environmental protection, economic growth, and social justice, respectively. Connelly (2007) gives that the area of the triangle here is the field of sustainable development and that all views on sustainable development fit in here. If there is a strong focus on ecology, the center of gravity is placed close to the corner of environmental protection within the triangular area (Öberg et al., 2017). Jerkø (2009) shows to that the fact that a development is sustainable means that it is both ecologically, economically, and socially sustainable. Casini (2015) gives that many other definitions have been suggested in the following years, specifying the concept better, giving different interpretations, and because of this it is not easy to find a definitive definition that allows to translate the sustainable principles into practice.

Sustainable development has, in context of present contemporary global environment and society, emerged and developed into a normative value system, equal and on par with human rights, democracy and freedom (Holden et al., 2017). Closely interlinked with all these systems, sustainable development is a strong ethical and moral pronouncement as to what should be done. Holden et al. (2007) call such a pronouncement a moral imperative and further claim that the concept of sustainable development rest on three moral imperatives: (1) satisfying human needs; (2) ensuring social equity; and (3) respecting environmental limits. These ethical imperatives were considered by Daly (2007) categorical, interpreting them as moral values when referring to them as "*fundamental objective values, not subjective individual preferences*". The moral imperative of respecting environmental limits (acknowledged in Our Common Future) is grounded on two claims: (1) that as members of the present generation, we hold Earth in trust for future generations (Weiss, 1992), hence not respecting environmental limits most likely prevents future generations from having resources vital to meeting their needs (Holden et al., 2017); and: (2) since we are enormously more powerful than other species (Sen, 2008), we have responsibility towards them, which means that we must respect environmental limits (Holden et al., 2017).

The 2030 Agenda, with the Sustainable Development Goals, together with the Paris Agreement have reinforced the commitment of the international community in achieving a sustainable development path. They underscore the importance of mainstreaming sustainability principles and climate action criteria into all economic activities and sectors (ESCAP, 2020). As a result, ports respond to worldwide, regional, and domestic challenges, such as climate change, mobility, digitalization, migration, and social integration, whilst adding value to international supply chains. The UN (2020) states that ports add value to the economy and generates social gains, including by supporting trade, linking supply chains, enhancing connectivity, allowing for market access, generating employment, and enabling business opportunities. The UN (2020) further states that in these regards, the nexus between the 2030 Agenda, the goals, the Paris Agreement, and sustainable port development is strong.

The environmental sustainability of port activities is today increasingly valued as an element of economic competitiveness, also by authorities, and environmental awareness is slowly spreading among port operators (Casini, 2015). Cassini 2015 states that the port sector is interested in preserving or restoring the nature and the image of "*green ports*" to maintain its competitiveness by reducing the local impact and friction with the community, cooperating to maintain the liveability of the area. Cassini further shows to that the environmental performance of the port areas therefore have been the focus of many regulatory initiatives and that the European Community affects the development and the environmental performance of the port areas at the regulatory level in an indirect manner through specific directives, such as those relating to sulphur content of fuels (Directive 2005/33/EC), pollution from ships (Directive 2295/35/EC), greenhouse gas emissions (Directive 2003/87/EC and Decision 405/2009/EC), port services (Directive 2000/59/EC), water quality (Directive 2000/60/EC), noise pollution (Directive 2002/49/EC), waste (Directive 2008/98/EC and Regulation n.1013/2006), protection of biodiversity (Directive 92/43/EC Natura 2000). The European Union (EU) is considered by some to have the most extensive environmental laws of any international organization and protection of the environment is a well-established policy in the European Union (Tatar, 2017).

2.4 Environmental port management

Society as a whole has increased it awareness of environmental issues and effective environmental management in port operations has become essential if stakeholders are to continue their support for port operations and development (Hossain et al., 2020) (Hua et al., 2020)(Ashrafi et al., 2020). Environmental management of port activities comply with several specific regulations in particular concern with the sectors of water, air, waste, fire prevention, dangerous substances, energy, noise, soil and subsoil, greenhouse gas emissions, safety at work, port security and maritime pollution (Casini, 2015). Ports offer services for the protection of the environment in the field of intervention and prevention, in case of environmental damage (Casini, 2015). Effective port environmental management needs to take into account the potential impacts on the environment, mitigating options, methods of prediction, information on environmental indicators and legislation (ESPO, 2012).

Lundberg (2009) shows to that monitoring is an important tool for gaining insight into an organisation's environmental performance, learning about the environmental condition and the effectiveness of environmental management measures. This implies that environmentally sustainable development is becoming an increasingly important concept in the practice of port administration. Port authorities, as a means of achieving these objectives, integrate environmental concerns and resource management into their activities and promote ecological sustainability within their sector in line with the national and international environmental quality objectives. A variety of tools for communicating environmental and sustainability performance of products, services, activities and organizations exists today: environmental labels, Environmental Product Declarations (EPDs), Life Cycle Assessments (LCAs), Environmental Performance Indicators (EPIs), Ecological Footprints, Environmental Management Systems (EMS) and Environmental Impact Assessments (EIA) (Vincent, 2014).

Environmental Management Systems (EMS) play a large part in environmental communication, as well as for the port industry. It exists several guidelines to implement an EMS, such as:

- EMAS,
- ISO 14001
- Corporate Social Reporting (CSR)
- Global Reporting Index (GRI)
- PERS
- SDM
- PSHEMS
- OHSAS 18001

2.5 Port environmental measures

In reports by the American Association of Port Authorities (2004) the following environmental concerns were commonly referred to: (1) air pollution from port operations, including smog and particulate pollution, (2) loss or degradation of wetlands, (3) destruction of fisheries and endangered species, (4) wastewater and stormwater discharges, (5) severe traffic congestion, (6) noise and light pollution, (7) loss of cultural resources, (8) contamination of soil and water from leaking storage tanks, (9) air releases from chemical storage or fumigation activities, (10) solid and hazardous waste generation, (11) soil run off and erosion, and so forth (Bailey & Solomon, 2004). Bailey and Solomon (2004) concluded that numerous approaches would be necessary to reduce pollution for ports moving toward a sustainable operational model that serves a local region without damaging the health and integrity of local communities and ecosystems. Darbra et al. (2005) discovered significant environmental aspects in sea ports and classified them into: (1) emissions to air (including gases, solid particles, and energy; dust is a significant contribution), (2) discharges to water (e.g., waste waters, accidental releases during loading/unloading operations), (3) releases to soil due essentially to industrial activities, (4) releases to marine sediments and activities affecting the seabed (such as dredging), (5) noise (with its potential impact on population and fauna), (6) waste generation and dredging disposal, (7) loss/degradation of terrestrial habitats,

(8) changes in marine ecosystems, (9) odours, (10) resource consumption, and (11) port development (land and sea occupation) (Darbra et al., 2005). Peris-Mora et al. (2005) indicated that 21 port activities in industrial ports can cause a total of 63 forms of potential environmental impact. These environment impacts could be classified as air pollution, noise pollution, odour pollution, water pollution, soil pollution, waste creation (urban waste and dangerous waste), resource consumption, and others (Peris-Mora et al., 2005).

In assessing the greenness, Pak et al. (2009) provided comprehensive evaluation factors which included resources recycling within the port area, technical developments of the industries for the ocean waste disposal, development of the breakwater system for waterfront revitalization; dredging sand recycling, creation of the artificial sandbar and wetland, introduction of an environmental impact assessment, use of alternative fuels, introduction of a port environment management system, port facilities and equipment improvement, incentives for the pollution reduction, use of renewable-energy sources, modal shift, construction methods for the noise reduction, and expansion of prevention facilities for the ocean pollution on the coastal region (Pak et al., 2009). Chiu and Lai (2011) identified through their review 12 types of green port measures: air pollution, water pollution, noise pollution, land and sediments pollution, materials selection, water consumption, energy usage, general waste handling, hazardous waste handling, habitat quality and greenery, community promotion, and education, as well as port staff training. These measures where then classified into five dimensions including environmental quality, use of energy and resource, waste handling, habitat quality, and greenery, as well as social participation. Hi and Lee (2011) shows to that "*greening*" the port construction is a long, comprehensive, systematic, and complex task and is a matter concerning the overall situation and long-term strategic perspective. Park and Yeo (2012) states that in properly analysing the greenness of a seaport, various quantitative and qualitative factors are needed, and they further underlines that there in the literature of port science exist a deficiency regarding an adequate evaluation structure for properly analysing environmental factors (Park & Yeo, 2012). Klopott (2013) shows to the top ten environmental priorities of three Polish ports in 2012 which are (1) ship waste (sewage), (2) noise, (3) dust, (4) dredging (disposal), (5) port development (land), (6) conservation areas, (7) ballast water, (8) ship exhaust emission, (9) energy consumption, and (10) relationship with local community. Chiu et. Al (2014) further evaluated green port factors and performance and this time included major criteria and 13 subcriteria each with several detailed actions (total 72) included for measuring port performance. Whereas four categories in describing port management tools where provided by Lam and Nottebom (2014); pricing, monitoring, market access control and environmental standard regulation (Lam & Notteboom, 2014). Kang and Kim (2017), in their review of potential sustainability practices in greening ports, refer to the following dimensions: (1) environmental technologies, (2) monitoring and upgrading, (3) process and quality improvement, (4) active participation, (5) communication and cooperation. Through reviewing academic papers Bjerkan and Seter (2019) developed a structure for sustainable ports which consists of four main categories with included subcategories: (1) Port management and policies: Port plans, Management of environment and energy, Monitoring, Concession agreements, Modal split, Port dues, Collaboration, Other managerial policies; (2) Sea activities: Speed reduction, Efficient vessel handling, Other; (3) Land activities: Technological shift: trucks and drayage, Modal shift, Efficient truck operations, Efficient loading/unloading, Automation and intelligence, Clean industrial activity; (4) Power and fuels: Wind energy, Solar energy, Wave and tidal energy, Geothermal energy, Electrification, LNG, Biofuels, Methanol and hydrogen, Low sulfur fuels. Following Paipai et al. (2000), an understanding of how and why port development and operation activities impact on environmental targets (including the human health and interests), and primarily the identification of the pathway between activities and environmental targets, is the basis of successful environmental protection and management measures.

Vincent (2014) shows to that ports around the world are demonstrating a commitment to environmental stewardship and sustainable port operations through a variety of actions, mandates and initiatives. Hossain et al. (2020) further shows to that many seaports claim to operate green or sustainably, but still sustainable port initiatives and approaches are poorly described in the academic literature. As of today, according to Vincent (2014), there is no standard for measuring the environmental impacts of ports. There are numerous opportunities and challenges regarding measuring environmental performance at any given port, and published research on ports and environmental performance shows to that there can only be individual solutions based on individual circumstances (Vincent, 2014).

2.6 Performance measurement

Hedlund and Sternberg (2000) characterise real-world practical problems as being poorly defined, lacking in information and having multiple correct answers (Hedlund & Sternberg, 2000). Real-world decision problems are rarely mono-criterion based (Longaray et al., 2019). Longaray et.al (2019) points out that these decisions generally incorporate a variety of criteria, often contradictory. Elzarka and Elgazzar shows to that the multi-criteria decision-making process (MCDM) is one of the most critical challenges facing decision makers in different industries and businesses (Elzarka & Elgazzar, 2014). Huang et al. (2011) shows to that decision-making in environmental projects requires consideration of trade-offs between socio-political, environmental, and economic impacts and is often complicated by various stakeholder views.

Environmental measuring of ports are complicated due their nature, various services and a wide range of environmental issues (Özispa & Arabelen, 2018), but performance measurement and improvement are essential activities that Port Authorities use to enhance their productivity and competitive position (Ibrahimi, 2009). Puig et al. (2014) further shows to that to deliver compliance, environmental protection and sustainable development, effective port environmental management needs to take into account the potential impacts on the environment, mitigating options, methods of prediction, information on environmental indicators and legislation. Ibrahimi (2009) underlines that port performance level and progress should, as for every industry, be measured and monitored through many tangible indicators, because no single indicator alone can reflect efficiency or productivity for ports and port operators. Ibrahimi (2009) follows this up with the statement that a range of critical indicators, complementing each-other by considering different port performance issues, need to be established, applied and analysed, based on data which must carefully be identified, collected, structured and interrelated, processed, presented and stored (Ibrahimi, 2009). As such, integration of the heterogeneous and uncertain information demands a systematic and understandable framework to organize the technical information and requires expert judgment (Huang et al., 2011). Bourne, Melnyk, and Bititci (2018), shows to that performance measurement (PM) is critical to the success of organizations. Lingle & Schiemann, (1996), states that those using a balanced or integrated performance measurement system perform better than those that do not. A framework is a basic structure underlying a system or concept (Saari, 2019) and has also been defined as a meta-level model or a higher-level abstraction through which a range of concepts, models, techniques, and methodologies can either be clarified and/or integrated (Jayaratna, 1994). According to Muchiri et al. (2011), performance measures provide an important link between strategies and action and thus support the implementation and execution of improvement initiatives.

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Ibrahimi (2009) further shows to that a range of critical indicators, complementing each-other by considering different port performance issues, need to be established, applied, and analysed, based on data which must carefully be identified, collected, structured, and interrelated, processed, presented and stored. Kang et. al (2016) gives that within a performance measurement system (PMS), the strategic goals are first determined according to the enterprise's needs to success, then each goal is supported by a set of detailed indicators contributing to fulfil the strategic goals.

2.7 KPI ontology and taxonomy

Pritchard et. al shows to that performance indicators (PIs) are numerical or quantitative indicators that show how well an objective is being met, and further that they are numerical or quantitative indicators that show how well an objective is being met (Pritchard et al., 1990). Sari (1990) gives that PIs highlight opportunities for improvement within companies and are applied to find ways to reduce downtime, costs and waste, operate more efficiently, and get more capacity from the operational lines (Parida & Chattopadhyay, 2007). PIs are numerical or quantitative indicators that show how well an objective is being met (Pritchard et al. 1990), and provide measures of how many resources are being used in relation to available ones (Saari, 2019), access the extent to which management targets are met and evaluate the general impact of management strategies (Alegre et al., 2016). According to Saari (2019) all PIs, as a rule, are tied to long-range corporate business objectives and when aggregated to the managerial or higher level, PIs at the shop floor level or functional level are called key performance indicators (KPIs). As Kang et. al (2016) shows to, KPIs are defined as a set of quantifiable and strategic measurements in a PMS that reflect the critical success factors of an enterprise, and further that the appropriate selection and better understanding of the KPIs can help a firm achieve the desired business success (Kang et al., 2016). Saari (2019) shows to that performance measuring requires the formulation of KPIs, which Parmenter (2007), describes as a set of measures that focus on those aspects of organizational performance that are most critical for current and future success. According to Saari (2019), KPIs demonstrate how effectively a company is achieving key business objectives, and further that they evaluate the company's success in reaching targets and the degree to which areas within the company (e.g., environmental) achieve their goals (Saari, 2019).

In philosophy, ontology is the study of the nature of being, existence, or reality (Saari, 2019). Diamantini (2014), states that KPI ontology supports the construction of a valid reference model that integrates KPI definitions proposed by different engineers in a minimal and consistent manner to increase interoperability and collaboration. Several researchers as Popova & Alexei (2010); Del-Río-Ortega et al., (2010); Del- RíO-Ortega et al. (2013); Negri et al. (2015) shows that KPI ontology models have been proposed in the literature in the context of the performance-oriented view of organizations. Saari (2019), argues for that these models typically dwell on description logic and first-order sorted predicate logic to express on an axiomatic basis the relations among indicators, using concepts like causing, correlated and aggregation of. Further it can be argued that these models do not take compositional semantics into account, the models are conceived to define KPIs in a single process-oriented enterprise, and the issue of consistency management is not taken into account. Diamantini et al. (2014) have considered compositional semantics in developing their KPI model, where the proposed method serves as a formal way of describing indicators, with the core of the ontology composed of a set of disjoint classes, detailed as indicator, dimension and formula. Indicator signifies the key class of the KPI ontology, while its instances (i.e., indicators) describe the metrics enabling performance monitoring. Saari (2019), shows to that in this relation the properties of the indicator include name, identifier, acronym, definition (i.e., a detailed description of meaning and usage), compatible dimensions, formula, unit of measurement chosen for the indicator, business object and aggregation functions. Dimension on the other hand is the coordinate or perspective along which a metric is computed; it is structured into a hierarchy of levels, where each level represents a different way of grouping elements of the same dimension (Saari, 2019). Formula in this setting is an algebraic operation used to express the semantics of the indicator, describing the way the indicator is computed and is characterized by the aggregation function, the way the formula is presented, the semantics (i.e., the mathematical meaning) of the formula, and references to its components, which are, in turn, formulas of indicators (Saari, 2019). Diamantini (2014) demonstrates that KPI composite indicators can be represented in a tree structure and calculated with full or partial specification of the formula linking the indicator to its component.

Taxonomy is a hierarchical classification system, often depicted as a tree that starts from a root concept and progressively divides into more specific off-shoot concepts (Saari, 2019). Related to port strategy, taxonomy refers to the type of relationships among data and it is essential to understand the ontology and taxonomy of KPIs if data are to be transformed from information into the knowledge required to develop, implement, assess, and optimize a KPI framework for port environmental management.

In any planning and development activity, there are several alternatives available, and one has to choose the alternative that is best suited (Parida, 2006). Normally, the objectives of the decision maker can be expressed in terms of criteria (Parida, 2006), and if there are a number of criteria, multi-criteria choice problems arise, which is solved by having the information on the relative importance of criteria (Noghin, 2005). Ray and Sahu (1990), shows to that the selection of factors or variables constituting various performance criteria are an important step in developing a performance measurement system in an organization, conceived essentially as multi-criteria decision making (Ray and Sahu, 1990). Parida (2006) shows to that all these measures of the criteria normally will stimulate behaviour in a direction encouraged by the organisation, and that this will contribute to an alignment towards the same goals, objectives and strategy of the management. Parida (2006), further shows to that to meet these multi-faceted demands within the competitive environment of the 21st century, multi-criteria approach or goal functions need to be considered from different stakeholders' requirements, so as to satisfy their needs. These indicators need to be integrated from the functional level to the strategic level. Andersen and Fagerhaug (2002) and Engelkemeyer and Voss (2000) discussed the development and implementation process for indicators and stated that the development and identification of performance indicators for an organization is cascaded down from the vision, objectives, and strategy points of view and on the requirements of both the external and the internal stakeholders' as given in the following figure:

Figure 2.1

Developing and identifying indicators from the vision, objectives and strategy points of view Engelkemeyer and Voss (2000).

The performance indicators need to be considered from the perspective of the multi-hierarchical levels of the organization (Parida, 2006). Kutucuoglu et al. (2001) shows to that organisations need a framework to align their PM system with the corporate strategic goals of a company by setting objectives and defining key performance at each level. Parida (2006) states that depending on the organizational structure, the hierarchical levels could be different and can consist of three or more than three levels. Parida (2006) shows that the first hierarchical level could correspond to the strategic or top management level, the second to the tactical or middle management level, and the third to the functional/operational level. Parida (2006) further states that it is a challenge to cascade down the performance indicators derived from the corporate objectives and strategy, from the strategic or top management level to the functional level through the tactical or middle management level, which is a top-down approach. According to Parida (2006), similarly, under a bottom-up approach, the challenge lies in collecting performance measurement data and information and to integrate the PIs from the functional level to strategic or top management level through the tactical or middle management level. Parida (2006) shows to that this will ensure evaluation of the PIs with that of the corporate objectives and necessitates transparency of information flow across the organization.

2.8 Structural modeling

In 2007, Parida and Chattopadhyay proposed a multi-criteria hierarchical framework for maintenance performance measurement, MPM. This framework includes multi-criteria indicators for each level of management, i.e. the strategic, tactical and operational levels. These multi-criteria indicators were categorized, with indicators proposed for each level of management in each category.

Parida (2006) shows to that in the past two decades performance measurement (PM) and management have received a great amount of attention from researchers and practitioners. According to Neely (1999), major issues related to this field concern what to measure and how to measure it in a practically feasible and cost-effective way. Senge (1992) and Eccles (1991) states that organizations need to learn how to cope with a continuously changing business and technological environment in order to remain competitive and be successful. Various researchers as Dixon et al. (1990) and Ghalayini and Noble (1996) stress the need for reflective action concerning measures to ensure that they are effective in coping with the continuously changing environment. Parida (2006) further underlines that improper implementation and management of measurement system development aiming to use new measures to reflect new priorities often lead to ineffective results. Meyer and Gupta (1994) show to that this is due to the failure of the organization to discard measures reflecting old priorities, uncorrelated and inconsistent indicators, and inadequate measurement techniques. Al-Turki and Duffuaa (2003) gives that the characteristics of performance measures include relevance, interpretability, timeliness, reliability, and validity. Parida (2006) states that measurement gives the status of the variable, compares the data with target or standard data and points out what actions should be taken and where they should be taken as corrective and preventive measures, and further claims that an operational performance measurement system acts like an early-warning system.

The ability to effectively and efficiently identify, model and communicate information about systems is becoming more valuable (Simpson & Simpson, 2014). Complexity reduction and complexity management has always been a key objective of systems engineering activities and as more systems populate any given operational context, the ability to evaluate, rank and structure the concurrent impacts and features associated with the contextual aggregate of systems and objects becomes a valuable tool (Simpson & Simpson, 2014).

Structural modelling, developed by Warfield (1974), addresses the structuring of unknown and poorly defined systems. Warfield's basic structural modelling focuses on modelling methods, practices and theories associated with logic and mathematics. Simpson and Simpson (2014) states that basic structural modelling techniques are not limited to any domain-specific application and apply equally well to any domain of interest. Rational inquiry is based on the laws of logic, which are required to demonstrate that the processes and outcomes are not arbitrary and/or illogical (Simpson, J, Simpson, 2014).

A system may be defined in many ways, Simpson and Simpson (2006) show to the "'*construction rule*" definition: "*a system is a set of two or more objects with a structural relationship (or relationships) mapped over the object set*". Even the most intelligent and gifted of human beings possess cognitive and communication barriers and limits (Simpson & Simpson, 2014). Simpson and Simpson (2006) further states that consequently, the creation of a structured system from a previously unorganized set of objects plays a key role in cognitive complexity reduction and establishes a mechanism to communicate the structured system parameters. Human, short-term working memory is limited to a small number of items, in the range of 5 to (Miller, 1956). Warfield based his Law of Triadic Compatibility on this short-term limit of human working memory (Warfield, 1994**).** This law states that the human mind is capable of evaluating the relationships among at most three objects. This limit impacts the design of the process of decision making in port environmental performance evaluation. This same general process can be used to order a set of objects using a natural language relationship that requires human judgment, since the number of items that must be evaluated are within the short-term working memory limit of humans (Simpson & Simpson, 2014).

Visualization is one of the cornerstones of knowledge extraction from large databases and is absolutely central to the communication of complex information in a way that is rapidly absorbed and conveys the necessary insight (Vellido et al., 2011). More generally, the role of visualization is the last cognitive step in intelligent data analysis, linking individual observations to the structure of the rest of the data set, which involves mapping as much of the data as possible into a low dimensional projection, while retaining the proximity structure and with as little distortion as possible (Vellido et al., 2011). According to Vellido et al. (2011) network visualization and structural analysis is a fast growing area of research, and visualization has grown to encompass projections of the geometric distribution of data points, usually to show the proximity between rows in the data matrix, but also becoming an integral part of the methodology actively involved in unlocking networks of functional relationships between covariates, from which to derive deep insights into the mechanisms driving the processes under study (Vellido et al., 2011) .

Hierarchical visualisations and manifold learning constitute two of the main approaches to produce visualisations that can extract knowledge from data sets and to visually explore port environmental subclasses in detail, thus obtaining a map of factors and actions that can qualify the differences between sequences belonging to different strategic groupings (Vellido et al., 2011). Hierarchical methods can produce visualizations at different levels of the hierarchy of detail, thus obtaining both main coarse relationships and detailed information, depending on the level of the hierarchy we focus on (Martínez-Martínez et al., 2011).

As shown to in the literature review above, port environmental issues are usually multidimensional and lead to difficulties for port decision makers to act based on port environmental data coming from large, heterogeneous, multi-numbered data sources. As such, integration of the heterogeneous and uncertain information demands a systematic and understandable framework to organize the environmental information and processes to interpret and use in actual port advising or decision-making contexts.

3. Research methodology

This chapter presents the research methodology, including research design and process, data collection and analysis, and a discussion of validity and reliability are presented. A brief introduction to the background of the research is also presented.

3.1 Background of the research

The motivation for this thesis originated in the University of South-Eastern Norway (USN) project PEPI, which is a part of the SETS II project, initiated and financially supported by the EU program Interreg. The main purpose of the PEPI project is to propose an impact assessment tool that is strategic in nature and has the objective of facilitating environmental integration and the assessment of the opportunities and risks of strategic actions in a port environmental development framework.

The PEPI team consisted of a project coordinator, the project leader and specialists in the maritime industry, port sector and environmental dimensions of port development with a strong team approach to methodological development, the scoping of issues and indicator testing. There was also close contact with the project sponsors, USN, SETS II and the Interreg, during the course of the project with regular (typically monthly) meetings held between SETS II members, port directors, Interreg representatives, USN representatives and the PEPI project team.

3.2 Introduction

A research design is an overarching plan for the collection, measurement and analysis of data (Gray, 2018). Researchers have various options on how to answer their research questions (Woo et al., 2011). One of the problems here is not only the bewildering array of theoretical perspectives and methodologies, but the fact that the terminology applied to them is often inconsistent and even contradictory (Crotty, 1998). Van De Ven (2007) argues for that collaborative research have tended to be one-sided and focus on the relevance of academic research *for* practice. Crotty (1988) suggests that an inter-relationship exists between: (1) the theoretical stance adopted by the researcher, (2) the methodology and methods used, and (3) the researcher`s view of the epistemology.

A particular focus in this research was skills required to solve real-world practical problems. Hedlund and Sternberg (2000) characterise these as being poorly defined, lacking in information and having multiple correct answers (Hedlund & Sternberg, 2000). Given the limited understanding of real-world practical problems, a multi-stage strategy was adopted where the first stage would be an exploratory study. The exploratory study aims to investigate practice as a way of informing theory (Shawcross & Ridgman, 2019). Flick et.al (2004) states that this "*object*" driven approach is considered appropriate to identify theoretical basis, as long as it is sufficiently open to the complexity of the study (Flick et.al, 2004). According to Creswell (2009) this involves adopting a strategy of emerging methods, as selecting methods as the study progresses that address the aspects being investigated at that time (Shawcross & Ridgman, 2019). Shawcross and Ridgman (2019) further states that the combination of requiring an open approach over multiple stages leads to the adoption of a "*mixed-methods*" approach. Johnson et.al (2007) shows to that mixed methods research is the type of research in which a researcher or team of researchers combines elements of qualitative and quantitative research approaches (e.g. use of qualitative and quantitative viewpoints, data collection, analysis, inference techniques) for the broad purposes of breadth and depth of understanding and corroboration (Johnson et al., 2007). Creswell and Tashakkori (2007) shows to that mixed-methods studies are often multi-stage and enable combinations of quantitative or qualitative methods to be employed as appropriate to the response to the emerging needs of the enquiry.

3.3 Research Design

In the quest for a research design, specific multi-stage, mixed method research strategies were identified as Engaged Scholarship (Van De Ven & Johnson, 2006) and Action Research (Stringer, 2007)(Koshy, 2005). An alternative also came up, which was to view the research as a two-stage sequential process with an exploratory study leading to an investigation of a particular aspect. Creswell (2009) identifies three such strategies – explanatory, exploratory, and transformative. These strategies were evaluated on the following criteria adopted from Shawcross and Ridgeman (2019):

- Is the strategy suitable for social science research in an educational context?
- Is the strategy suitable for understanding/describing a specific example of complex practice?
- Will the strategy be capable of supporting theory generation?
- Will the strategy be flexible in terms of method?
- Will the strategy be less weighted towards the initial research stage rather than subsequent stages? – as the initial stage in this research is shorter.

Shawcross and Ridgeman (2019) did a comparison of mixed-method strategies which this study finds highly relevant. Out of the range of approaches in this comparison, Table 3.1, Engaged Scholarship was judged the best fit for this study as all the evaluation criteria earlier set were met.

Table 3.1

Comparison of mixed-method strategies (Shawcross & Ridgman, 2019).

Table 1. Comparison of mixed-method strategies.

Research strategy	Description	Suitable for an education context	Suitable to investigate an example of complex practice	Capable of supporting theory generation	Flexibility in terms of method	Weighting by stage
Action Research	A systematic and participatory approach that enables evidence-based improvements to practice – considered to be grounded in the qualitative research paradigm	Yes – widely applied in education and teaching	Yes – good for developing understanding	Limited	Yes	No pre-determined predominant stage
Engaged Scholarship	A systematic and participatory approach that works across the theory–practice boundary to advance improvements in both	Yes – applied in professional practice	Yes – good for understanding complex practice	Yes	Yes	No pre-determined predominant stage
Sequential Explanatory	Typically quantitative followed by qualitative research used to explain and interpret quantitative data – particularly useful for explaining unexpected results	Limited	No	Yes	Some	The first stage is more heavily weighted
Sequential Exploratory	Typically qualitative followed by quantitative research to assist in the interpretation of qualitative findings to explore a phenomenon and/or develop an instrument	May be – dependent on study	Yes – but potential problems with small sample sizes	Yes	Some	The first stage is more heavily weighted
Sequential Transformative	Used for a two-stage study with a theoretical lens, e.g. gender, race applied over both stages – can be any combination of quantitative and qualitative methods	Yes	May be – unlikely to be the main purpose of such research	Yes	Yes	Weighting adjustable

Van de Ven (2007) defined Engaged Scholarship as a "*participative form of research for obtaining the different perspectives of key stakeholders in studying complex problems*". Shawcross and Ridgeman (2019) shows to that this approach is designed to work across the theory–practice boundary and, through a pluralistic methodology, to advance knowledge by leveraging multiple perspectives.

3.4 Philosophy of Science

Van De Ven (2007) emphasises that the philosophy underlying scientific practice is a choice, and that understanding the implications of this choice is important for any reflective and responsible scientific inquiry. Philosophy of science is what we use to provide us with the conceptual tools and frameworks to reflect on our practice, and to understand alternative ways to do social science (Van De Ven, 2007). According to Van De Ven (2007) underlying any form of research is ontology and epistemology. Ontology is the study of being, *what is*, (Gray, 2018) and is a philosophy of science that informs us of the nature of the phenomenon examined (Van De Ven, 2007). According to Campbell (1988) ontology focuses on the nature of things. Epistemology, on the other hand, deals with how we gain knowledge about these things (Campbell, 1988). Epistemology tries to understand *what it means to know* (Gray,

2018) and is methods for understanding it. Gray (2018) states that epistemology provides a philosophical background for deciding what kinds of knowledge are legitimate and adequate.

This research seeks to be part of a scholarship that is engaged *with* (rather than for) practice and through this contribute to advance basic scientific knowledge. Engaged scholarship emphasizes that research is a collective achievement instead of a solitary exercise (Van De Ven, 2007). Bechara and Van De Ven (2007) argues that the philosophical underpinnings of Engaged Scholarship are more complex than those of most other methodologies and there is only space for a short summary in this section. Shawcross & Ridgman (2019) states that "*Engaged scholarship adopts a philosophy that includes, and integrates, aspects of what might traditionally be considered alternative philosophies, incorporating key ideas from positivism, relativism, pragmatism and realism*". They further show to that ontologically, Engaged Scholarship adopts the critical realist position of Bhaskar, with its mid positioning between positivism and relativism, and the realistic pragmatism position of Rescher. Epistemologically it adopts Campbells' relativist evolutionary position (Bechara & Van De Ven, 2007).

The version of engaged scholarship this research enhances adopts a critical realist perspective. Van De Ven (2007) shows to that this view takes on an objective ontology, where reality exists independent of our cognition, and a subjective epistemology where the standards one must meet if one's beliefs are to be rational are those that one would regard as intellectual defensible were one to be ideally reflective (Foley, 1987) (Foley, 1993) and that one's beliefs are rational if they meet the standards of one's community (Rorty, 1979) or the standards of the recognized experts in one's community (Stitch, 1985).

The Engaged Scholarship perspective of this thesis is based on the following principles:

1. There is a real world out there, but our individual understanding of it is limited.
2. All facts, observations and data are theory-laden implicitly or explicitly.
3. Each form of inquiry is value-full. No form of inquiry can be value-free and impartial.
4. Knowing a complex reality demands the use of multiple perspectives.
5. Robust knowledge is invariant across multiple models.
6. Models that better fit the problems they are intended to solve are selected allowing an evolutionary growth of knowledge.

(Van De Ven, 2007)(Van de Ven, 2010).

3.5 Research Perspective and Implementation

Having discussed the underlying philosophical perspectives of applying an Engaged Scholarship approach the practical aspects will now be considered.

The research perspective of this thesis follows the diamond model by Andrew H. Van De Ven (2007):

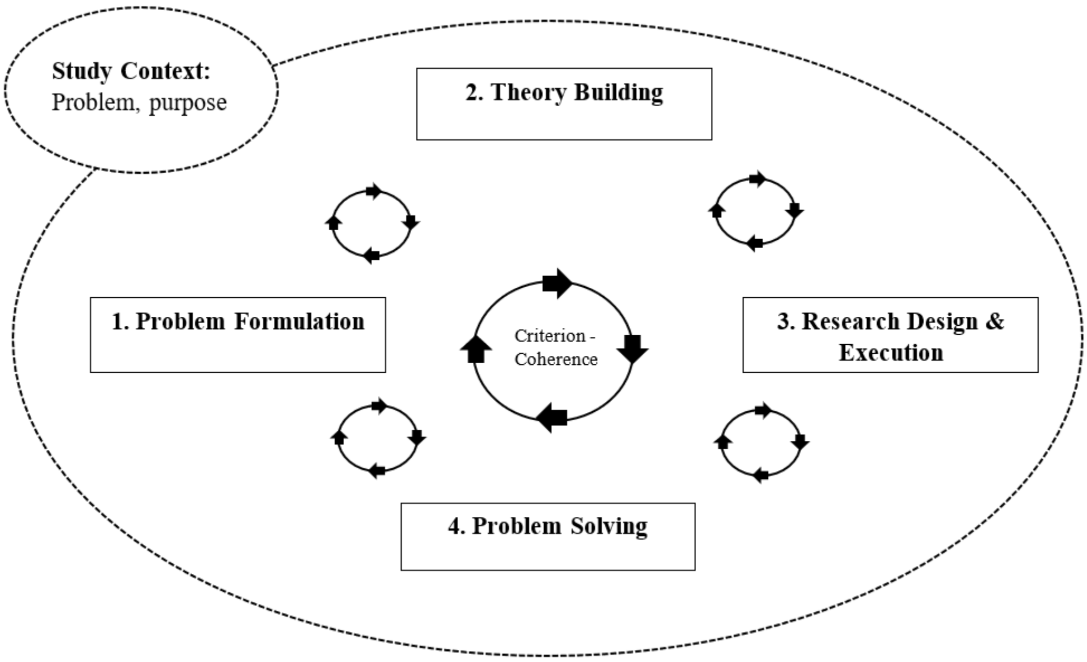
Figure 3.2

The diamond model by Andrew H. Van De Ven (2007).

In the study context of this thesis, the Port Environmental Performance Index (PEPI), engagement means that I as a researcher step outside of myself to obtain and be informed by the interpretations of others on performing each step of the research process. Van De Ven (2007) proposes that scholars, through using the diamond model as illustrated in figure 3.2, significantly can increase the likelihood of advancing fundamental knowledge of a complex phenomenon by engaging others whose perspectives are relevant in each of the given study activities: research design, theory building, problem formulation and problem solving (Van De Ven, 2007). Van De Ven (2007) argues that these four research activities can be performed in any sequence and that there are many possible starting points and sequences. These research activities were applied in this thesis in a problem-solving sequence, as showed in figure 3.3, beginning with: (1) problem formulation, then (2) searching for theories relevant to the problem, (3) testing them, and (4) applying the findings.

Figure 3.3

The applied Engaged Scholarship research activities in a problem-solving sequence.



3.5.1 Problem formulation

The first issue was selecting an aspect of the overall problem, of suitable size and scope, for the first round of research. The early recognition that port environmental practical problem skills could be seen as an instance of the general problem was a major factor. Van De Ven (2007) shows to that as part of the Engaged Scholarship practice, a detailed and systematic grounding and diagnosis of the problem in terms of practice and literature is recommended as an important step. This was found to be the case.

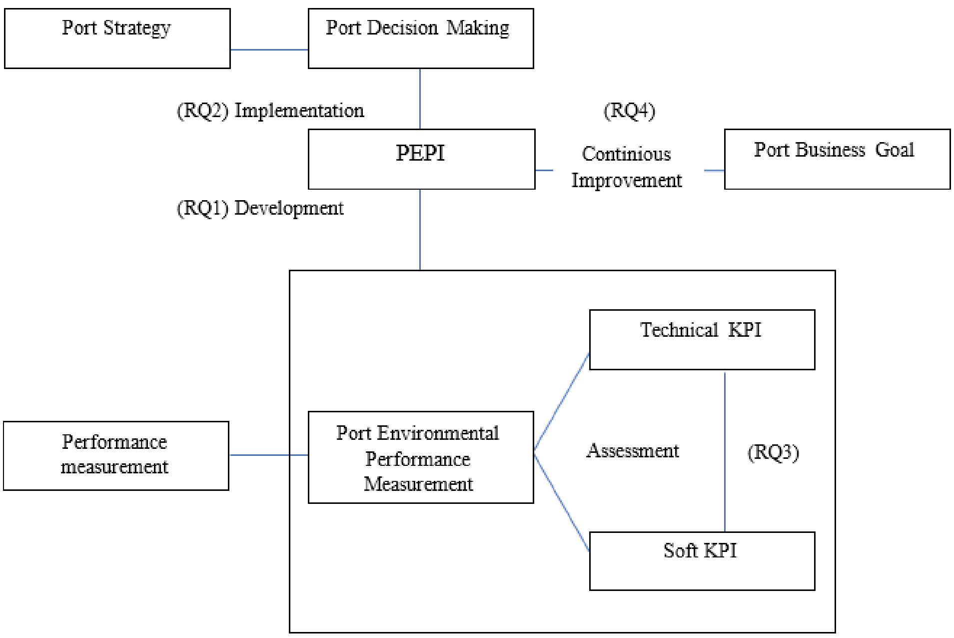
The insight of port environmental practice considerably narrowed the focus onto the most relevant aspects and informed the decision of which fields of literature were most important to review. The literature review enabled a much deeper appreciation of the complexity of the problem area and identified models that provided explanations of why some aspects were more effective in practice than others and generated insights for practise.

3.5.2 Theory building

In the Engaged Scholarship methodology theory building comprises three activities: creating, constructing, and justifying a theory (Van de Ven 2007). In the first round of the research, the theory construction activity involved combining multiple different performance models and strategic perspectives for organizations. A plausible port environmental performance measurement development theory was constructed and evaluated along with a conceptual model by drawing on the findings of the problem formulation activities. From this, a port environmental performance conceptual development framework was generated to provide an analysable format suitable for theory testing. Over the next rounds, a plausible port environmental performance activity framework was developed by combining multiple perspectives from literature which could then be compared with what SMEs experienced in practice. Then the perspectives of how experienced "*green*" ports approach practical environmental problem-solving were further combined with known environmental weaknesses of ports and a mapping of relevant environmental KPI`s to produce a theoretical performance model of what ports do regarding environmental issues. An approach that really helped in the theory construction processes was the use of visual representations. Visual representations appeal as they are a familiar way of communicating and they challenge thinking on boundaries and relationships between different elements – two crucial elements of a theory (Van de Ven 2007).

Figure 3.4

The research questions in relation to the PEPI model.

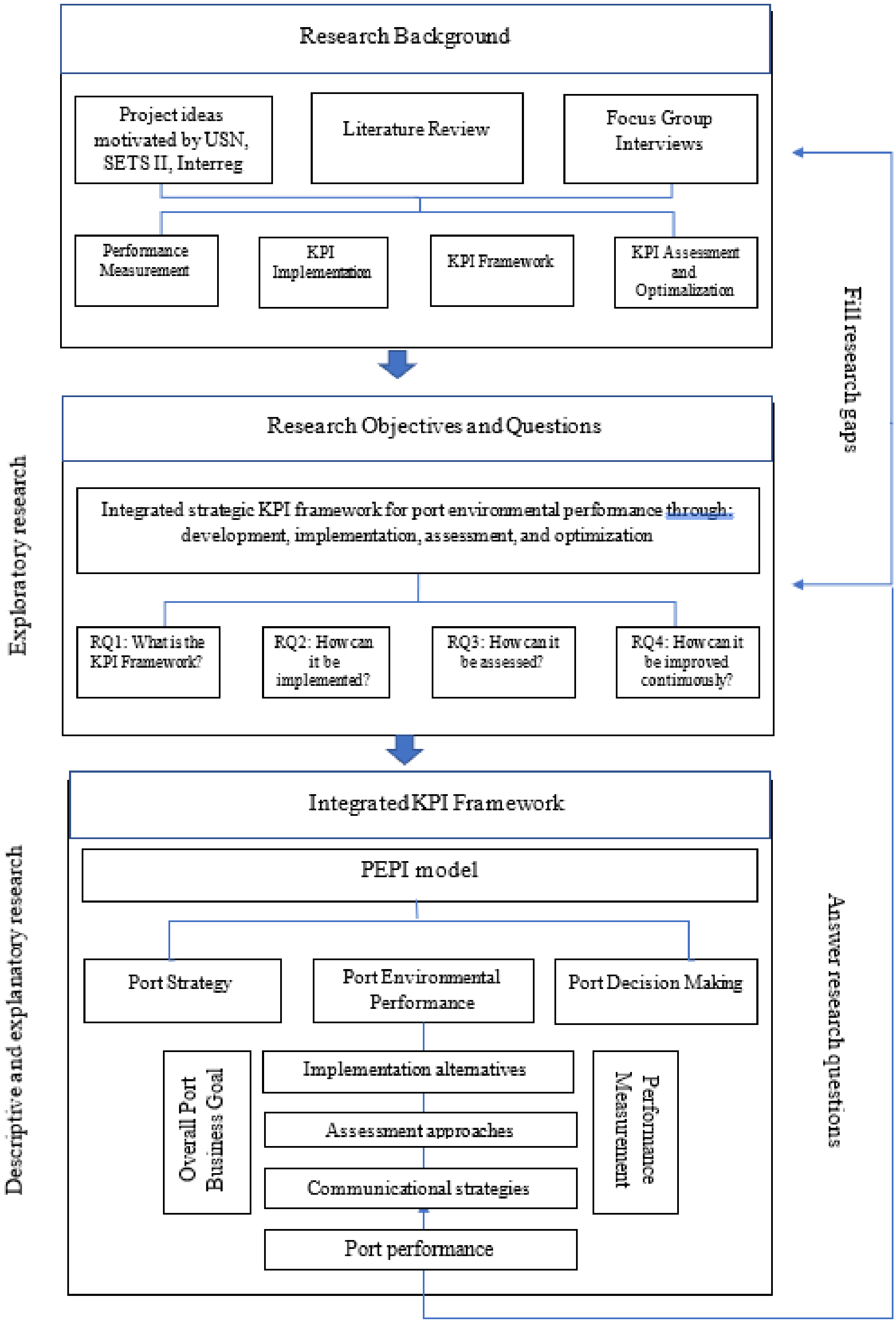


3.5.3 Research design

As shown in Figure 3.4 the research design for this study can be divided into three stages.

Figure 3.5

Design of the research.



The first stage of the PEPI project included a literature review, interviews with port managers and consultations with Interreg project partners and researchers and a selection of varied subject matter experts. The focus group interviews, combined with the literature review, revealed research gaps in port's current strategic environmental framework development, implementation, assessment, and optimization and allowed the formulation of a problem statement. This, in turn guided the formulation of the research purpose, objectives and four research questions: RQ1, RQ2, RQ3 and RQ4.

The second stage of the project, the exploratory research, examined port environmental technical and "*soft*" KPIs, the connections between them and how the RQs could be answered. The port companies have many technical KPIs (linked to port activity operations) but very few soft KPIs (linked to port management workflow). Whilst it measures the former, it does not measure the latter.

In the third stage, the work drew on both descriptive and explanatory research to construct an integrated conceptual strategic KPI framework for port environmental performance management. The framework includes port environmental technical and soft KPIs which are proposed to measure port environmental performance and streamline port strategic processes.

The studies indicate that the integrated strategic KPI framework will allow the overall port business goals to be reached and the system to be optimized continuously. Generally speaking, the first stage revealed the research gaps, the second stage analysed them, and the third stage resolved the research problems and filled the research gaps.

3.5.4 Problem-solving

This research activity involved a critical evaluation of the data and results by the author as a researcher, and then with the rest of the PEPI project group to see if there were concerns or conflicting perspectives. Some of the key questions used at this stage were: What results are unexpected or conflicting? What are these data telling and not telling? What perspectives have been missed? At all stages, the raw data were reviewed, analyzed, and the proposed results were then discussed together in the group and agreed findings negotiated.

The particular value of the Engaged Scholarship approach at this stage was the dissemination and negotiation of the findings. The academic dissemination process of preparing papers and presentations within the project group and for the SETS II partners proved valuable to reflect on the theory and practice contributions and to engage in a broader peer review process. The internal negotiation of findings was helpful in challenging and aligning viewpoints within the PEPI group, as well as agreeing on how final findings related to practice could be implemented to make improvements.

Each round of the Engaged Scholarship methodology generated multiple findings and presented further questions. The choice of question for the next round was made on the basis of its potential to make the most significant contribution. At the end of Round 1 the choice was to focus on improving environmental strategic reflection for Ports as the literature review revealed there was a larger gap in knowledge rather than on defining KPI`s where there is an extensive literature already.

The key practice findings were that despite a poor definition of environmental KPI`s and weak strategic reflection activities, the combination of multiple, constructively aligned, relevant experiences still enabled the ports practice to be effective. The key findings related to theory were that the results aligned with the proposed theories but needs expanding to include port understanding of strategic environmental skills and how they are developed.

During the research it became quickly clear that the four activities in a problem-solving sequence are highly interdependent and did not complete in one pass. Multiple iterations and revisions of these research activities were needed throughout the duration of the study. Van De Ven (2007) emphasizes that social research is an intensely social process where all four research activities are equally important in conducting a study, and that each activity entails a different set of tasks that can be accomplished better by engaging relevant stakeholders rather than going at it alone (Van De Ven, 2007).

3.6 Data collection

Langley et al. (2013) shows to that central to the study of processes is the temporality of research. As the sample size in process studies is defined by the number of temporal observations rather than the number of cases (Langley et al., 2013) it became necessary to include a multitude of data sources, as in line with the exploratory process guiding the research.

Data was collected through a mixed method naturalistic enquiry research approach consisting of:

(1) Literature review of relevant port environmental research, laws, regulations etc.
(2) Focus group interviews with subject matter experts, relevant port administrations, authorities, and other stakeholders.

(3) Port site visits were conducted, and industry statistics and annual reports were examined to increase research validity.

Van De Ven (2007) shows to that as part of the Engaged Scholarship practice, a detailed and systematic grounding and diagnosis of the problem in terms of the practice and the literature is recommended as an important step. This was found to be the case. In the analysis of the port environmental practice the focus onto the most relevant aspects was considerably narrowed and informed the decision of which fields of literature were most important to review. The analysis of the research literature enabled a much deeper appreciation of the complexity of the problem area and identified models that provided explanations of why some aspects were more effective in practice than others.

3.6.1 Literature review

Gray (2018) states that without first understanding the literature in the field of study, a researcher cannot conduct significant research. Finck (2019) defines literature review as "*a systematic, explicit, and reproducible method for identifying, evaluating, and interpreting the existing body of recorded work*". The research commenced with identifying possible influencing factors of port environmental performance based on literature review. The literature review in this thesis identifies empirical studies on tools, technologies, strategies, and measures for transitioning ports towards an awareness of environmental performance.

To collect relevant literature comprehensively and systematically, multiple databases was used, and the literature search was limited to scientific journal publications in English, identified and selected through searches in ResearchGate, Academia, Researcher, Google Scholar and ScienceDirect. The literature search was divided into two main categories of search words:

(1) The first category identifies ports as the main interest;

(2) The second category reflects the interest in any measure related to the environmental performance of ports.

This approach enabled a broad approach in determining what the relevant tools, technologies, strategies, and measures for port environmental performance are. This study focuses on the identification of factors affecting port environmental performance and the relationships among them and thus, regarding the vast difference in port operations, the scope of this study is broad. An important delineating factor in selecting publications for detailed review, was the exclusion of publications from conferences and proceedings that are not published through journals. Selected publications falling under each category were first reviewed by reading titles, abstracts, and introductions, before publications deemed relevant were included in a literature base. The personal knowledge and experience of the author, brainstorming with subject matter experts (SMEs) in the field of ports, and literature identified through snowballing (e.g. additional publications from the reference lists of publications already included in the review) also identified relevant studies. These articles were examined to identify whether they met the following criteria: (1) articles should be published in peer-reviewed international journals; (2) the topic of the articles should be related to port environmental performance or performance measuring.

Several publications were excluded from the review because they did not refer to specific strategies, indicators for monitoring, controlling for port environmental performance and did not account for potential measures for solving these problems. It is also interesting to note that a subsegment of publications on port strategies in the face of environmental challenges is not dedicated to understanding how ports can slow or mitigate these issues, but rather how ports can compare to each other and how they should adapt to the consequences related to port environmental performance.

Prominent topics of the perspectives of publications included in the literature review are ports, management, sustainability and environment, terminals, emissions, shipping, and energy. In addition to the search on ports and environmental related performance issues, a search on considered related topics in the context of implementing a relevant tool for port environmental measuring were conducted. Following topics were found of interest: sustainability, decision making, strategy, structural modeling, visualization, environmental management, performance measuring, stakeholder involvement and coding of framework. These issues related to port environmental performance are identified through the publications' reference to, mentioning or discussion of instruments and measures which can be or have been implemented in ports. In this review it is therefore included both publications that refer to implemented tools, and publications with conceptual descriptions, models, or estimations of tools. Several publications address one or more issues related to port environmental performance and/or performance measuring and are therefore quite prominent in the literature review.

3.6.2 Project Consultative Process

A central part of the PEPI project approach alongside desktop research ("*top-down*" approach) was consultation with the port industry and other stakeholders ("*bottom-up*" approach). The principal method of enquiry that were employed to consult stakeholders were focus group interviewing. Anderson and Arsenault (1998) shows to that interview is "*a specialized form of communication between people for a specific purpose associated with some agreed subject matter*" (Anderson & Arsenault, 1998). The purpose of the research interview is to obtain research-relevant information from the interviewee (Rana & Muhammad, 2013). Cohen et al. (2007) gives that interviewing is centred on the evidence to be generated for achieving the research objectives of describing, predicting or explaining the phenomenon (Cohen et al., 2007). The use of interview is highly desirable for obtaining information based on: (1) experiences; (2) insider experience; and (3) privileged insights and experiences (Wisker, 2007). Gray (2018) shows to that a focus group, in essence, is an organized discussion among a selected group of individuals with the aim of eliciting information about their views, where the purpose is to gain a range of perspectives about subjects and situations (Gray, 2018). According to Anderson and Arsenault (1998), a focus group is "*a group comprised of individuals with certain characteristics who focus discussions on a given issue or topic*" (Anderson & Arsenault, 1998). Patton (2002) states that the focus group interview aims at collecting high-quality data in a social context (Patton, 2002), and Khan and Manderson (1992) states that the focus group interview primarily help understand a specific problem from the viewpoint of the participants of research (Rana & Muhammad, 2013). As this research follows the Engaged Scholarship methodology, the choice of focus groups was considered as the appropriate principal method of enquiry in engaging stakeholders.

All interviewed took part enthusiastically, entering the discussion with the researchers and contributing their opinions. All interviewees were informed of the research objectives at the beginning and were inspired to talk about influencing factors of port environmental performance (see Appendix B).

3.6.3 Workshop consultation

The workshops brought together the members of the SETS II project, renowned experts and stakeholders to refine and prioritize ideas for ongoing and future research and innovation that could be part of the project. The workshops addressed priorities for the SETS II program and regarding the PEPI project implementation of the addressed environmental

KPIs, technologies not covered by the PEPI as beyond road map-based research and the internet of things. The workshops validated the draft of the PEPI model to be used for functional analysis, design and development of an integrated monitoring and reporting system for ports to support and facilitate the reporting of environmental data and information.

The objective of the PEPI project is to strengthen capacities of port policymakers to develop evidence-based policy and planning for sustainable use of environmental resources at national and regional levels. The targets are: (1) increased capacity to assess, forecast and track energy development trends and future scenarios using data, policy, and analytical tools, (2) apply knowledge gained from informational tools and project activities to evidence-based policymaking, and (3) to comprehensively understand informational sources to monitor and evaluate port environmental targets. This included an assessment of where relevant information is currently stored and where it should be stored in the future to make the required policy decisions.

Future activities and workshops will be targeted towards this focused topic and the newly gained information will be applied to support developing new or revised port environmental policies. Particular attention will be paid to the institutionalisation of evidence-based policymaking, and methods introduced during the project.

3.6.4 Issues Scoping Site Visits

A key activity undertaken by the PEPI team concerning scoping of issues was a series of port industry site visits. The purpose of these visits was:

- To improve understanding of, and gain feedback on, environmental issues pertaining to port industry at company level.
- To explain project aims and relevance to port company managers and establish ground which would benefit the project during the development and piloting of the port environmental business practice indicator framework.
- To provide a key input alongside other stakeholder consultation and desk research to the development of the port business practice indicator framework. Port site managers were also asked for their comments on operational use in ports as an input to the development of environmental indicators.

3.7 Data analysis

The analysis and interpretation of data require a great deal of judgment and care, regardless of whether the analysis relies on quantitative or qualitative procedures (Stewart et al., 2006). Stewart, Shamdasani, & Rook (2006) gives that there are many approaches to the analysis of data. These approaches range in complexity and depth, and Stewart et al. (2006) underline that the appropriate analysis is the one that answers the research question. If the research question is simple, the analysis may be no more complex than a list of the reasons (Stewart et al., 2006).

The analysis of the literature review in this study takes form of a within-study literature analysis. A within-study literature analysis is pertinent whether each work is important for synthesizing the existing body of knowledge, which then will be utilized for making inferences about the topic of interest (Onwuegbuzie et al., 2012). Onwuegbuzie et al. (2012) further shows to that a within-study literature analysis helps to optimize the quality of the synthesis of the selected works.

The first step in the analysis of the focus group data was to have the entire interviews transcribed based on an audio recording. According to Stewart et al. (2006) transcription not only facilitates further analysis, but it also "*establishes a permanent written record of the group discussion that can be shared with other interested parties*" (Stewart et al., 2006). Then the scissor-and-sort technique, which is sometimes called the cut-and-paste method, was performed. This is a quick and cost-effective method for analyzing a transcript and a very useful and efficient approach to analysis of a focus group discussion (Stewart et al., 2006). The first step in applying this technique was an initial reading of the transcripts and an identification of those sections of it that was relevant to the research question(s). Then a classification system for major topics and issues was developed based on the literature reviewed, and material in the transcripts related to each topic was identified. Color-coded brackets were then used to mark different topics within the texts with colors. Stewart et al. (2006) states that the amount of material coded for any one topic depends on the importance of that topic to the overall research question and the amount of variation in the discussion. Stewart et al. (2006) further shows to that the coded material may be phrases, sentences, or long exchanges between individual respondents, and that the only requirement is that the material must be relevant to the particular category with which it has been identified (Stewart et al., 2006). During the different steps of the research, this coding exercise required several passes through the transcripts as categories of topics evolved and greater insight into the contents of the research was gained. Once the coding process was complete each piece of coded material was cut out (the scissors part of the technique) and sorted so that relevant material to a particular topic could be placed together.

3.8 Research quality and relevance

3.8.1 Reliability and validity of the research

Research must be both valid and reliable (Saari, 2019), and validity and reliability are two criteria by which research results are assessed (Lundberg, 2009). Creswald (2003) shows to that in their broadest sense, reliability and validity address the quality of the research data and the appropriateness of the methods used. Saari (2019) gives that validity refers to studying the right things, while reliability refers to conducting a study in the right way. According to Karim (2008) validity allows the researcher to measure what was designed to be measured, and Yin (2014) states that reliability ensures consistency and repeatability of research procedures, such that the same findings and conclusions are achieved if the same procedure is followed by another researcher.

As Yin (2003) explains, validity is often discussed in terms of construct validity and external validity. Lundberg (2009) shows to that construct validity refers to the rigour with which the study was conducted, while external validity deals with knowing whether the results are general or transferable beyond the immediate case. The construct validity of the studies performed within this thesis was increased primarily through the use of multiple sources of evidence, contributing to triangulation of data. The validity was increased through the multiple sources of information, combining interviews with direct observations within the ports and collection of administrative documents. The external validity of the study was enhanced as the evidence in the research was based on analytical generalisation and statistical generalisation, and previously developed theory is used as a template with which to compare the empirical results of the study.

The reliability of a research study is decided by its potential repeatability (Lundberg, 2009) and according to Kvaale (1996) the objective of high reliability is to ensure that any other investigator at some other time, using the same set of collected data, comes to the same conclusions. The goal of reliability is, as Yin (2003) describes, to minimise errors and bias in a study. According to Lundberg (2009) achieving high reliability can be done for example through careful documentation of data collected and analyses performed. To increase the reliability of the studies performed within this thesis, such careful documentation of data and analyses was carried out, case study notes were kept and categorised and case study documentation was classified and stored. In addition, to increase reliability the methods used for data collection as well as the approach to data analysis were described as clearly and transparently as possible. However, a major obstacle to increasing the reliability of the research, as according to Scholz & Tietje (2002), is that the behaviour of the organisation (in this case the ports) may change over time after a case study is performed.

3.8.2 Inductive, deductive and abductive reasoning

The rationale of the research in this thesis is founded on a common interest among industry and academia in exploring problems that are important in practice, but described in an unsatisfactory manner in the literature. The research could therefore have a deductive or an inductive approach, but in using the Engaged Scholarship research methodology an approach similar to abduction was found to be more appropriate. This approach enabled the researcher's engagement in a back and forth movement between theory and data in a bid to develop new or modify existing theory.

According to Dewey (1933) a general paradigm of inquiry can be outlined that underpins the scientific approach: (1) induction – consisting of inductive discovery; and (2) deduction – deductive proof (Dewey, 1933). Peter (2005) describes deductive reasoning, also called deductive logic, as the process of reasoning from one or more general statements on what is known to reach a logically certain conclusion. Gray (2018) shows to that deduction begins with a universal view of a situation and works back to the particulars. Whereas, in contrast, induction moves from fragmentary details to a connected view of a situation (Gray, 2018). Peter (2005) further gives that inductive reasoning, also called induction or bottom-up logic, constructs or evaluates general propositions derived from specific examples.

Gray (2018) underlines that the deductive and inductive processes are not mutually exclusive, they can be combined. Whereas Peter (2005) shows to that both have shortcomings: (1) A weakness of induction is that a general rule is developed from a limited number of observations; (2) a weakness of deduction is that it establishes a rule, instead of explaining it.

Peter (2005) gives that abductive reasoning, also called abduction, is used in many case studies. He further states that with this approach, a single case is set within an overarching hypothetical pattern where the interpretation is corroborated with new observations. According to Peter (2005), abduction may be considered a combination of induction and deduction, and that during the research process, the empirical application is developed, and the theory adjusted. This is also a development of Peirce's initial thoughts on abduction (Peirce, 1955), where Peirce's theory of abduction is meant to cover both practical reasoning and scientific inquiry (Svennevig, 2001).

This research contributes to the literature both theoretically and empirically through the iterative abductive approach which, through the Engaged Scholarship research methodology, combines port environmental management theory and practice.

3.8.3 Appropriateness of research methodology

In this section I as a researcher sets out to evaluate if the research strategy using Engaged Scholarship was appropriate for this study and to answer the question: what strengths and challenges were identified when undertaking Engaged Scholarship research in the given context of the research.

The essential steps in performing the four activities of the Van de Ven diamond model can be evaluated in terms of five criteria: (1) relevance, (2) validity, (3) truth, (4) impact and (5) coherence (Shawcross & Ridgman, 2019). In the engaged scholarship process all these criteria are equally important. Van de Ven (2007) shows to that the problem should be grounded in a reality that is relevant to an intended research audience in the scholarly and professional communities. Further the theoretical model should be expressed clearly, it should consist of a logically valid argument and the design and conduct of the research should apply the standards and methods that a scientific community believes will produce a truthful solution (Van De Ven, 2007). The findings of the research should further on have an impact in advancing science and enlightening practice in a profession (Van De Ven, 2007). In the light of this, challenges for academics are undertaking research relevant to practice and disseminating it such that it has an impact, and for practitioners being aware of relevant research and then using this knowledge in their practice (Shawcross & Ridgman, 2019).

The main strengths and challenges of Engaged Scholarship according to Van der Ven (Van De Ven, 2007)(Van de Ven, 2010) and Van der Ven and Johnson (Van De Ven & Johnson, 2006) can be summarised as follows (not presented in a rank order):

Strengths:

- an increased chance that the research will be applied in practice.

- an increase in the likelihood that the research will advance knowledge for theory and practice.
- it facilitates understanding of real-world complex problems.
- it is suitable for interdisciplinary research.

Challenges:

- creating and managing an effective engagement between researchers and stakeholders.
- spending sufficient time interacting in the study.
- applying the Engaged Scholarship method to leverage its strengths.
- being reflexive and objective as a researcher.

Shawcross and Ridgeman (2019) presented tables of strengths and challenges of the Engaged Scholarship, where each table contains an evaluation of how they might relate to research study. However, both require an explanation of how they are realised in practice to fully evaluate their potential impact (Shawcross & Ridgman, 2019).

Table 3.3

Engaged Scholarship strengths.

Strength	How they are achieved
A. Increased chance that the research will be applied in practise	A1. By engaging both researchers/scholars and practitioners
	A2. By framing a given problem as an instance of a more general case
B. Increases the likelihood that the research will advance knowledge for theory and practice	B1. Choice of research methods based on the study context and purpose
	B2. Arbitrage – a process of engaging with practitioners and working with different views
	B3. A research process of four interrelated activities – problem formulation, theory building, research design and problem-solving
	B4. Through research collaborations between multiple scholars and practitioners and addressing dual hurdles of quality and relevance
	B5. Triangulation of methods and models increases reliability and validity
C. Facilitates understanding of real-world complex problems	C1. Use of arbitrage – between researchers and practitioners
	C2. Multiple investigators and perspectives
	C3. Multiple frames of reference
D. Suitable for interdisciplinary research	D1. Pluralistic process (multi-model/theory) and arbitrage

Table 3.4

Engaged Scholarship challenges.

Challenge	The importance of addressing the challenge
E. Creating and managing an effective engagement between researchers and stakeholders	E1. To increase the likelihood that the research will be applied
	E2. To ensure all research stakeholders have clear expectations and are clear about their roles, responsibilities and use of study findings
	E3. To ensure the research team is balanced in terms of skills and background and all research collaborators are motivated and able to work on the project
	E4. To ensure there is regular communication between collaborators, they get to know each other and reflect on how the collaboration is performing
	E5. To deal with conflicting views and interpersonal tensions arising through use of arbitrage
F. Time interacting in the study	F1. To increase likelihood of making significant advances in knowledge
	F2. To build relationships and trust
	F3. To be able to observe directly
	F4. Longer study durations can enable deeper learning via repeated trials
G. Applying the Engaged Scholarship method to leverage its strengths	G1. Problem Formulation – to ground the research question/problem in observable phenomena and to make sure that the size and scope of the study is achievable
	G2. Theory Building – to develop plausible concepts and models that provide a base for new theories to address the research question
	G3. Research Design – to design the research and obtain empirical evidence
	G4. Problem-Solving – to apply and disseminate the findings from the perspective of different academic and practitioner users
H. Being reflexive and objective as a researcher	H1. To achieve internal and external validity
	H2. To ensure research goals are not compromised
	H3. To view the study from both a researcher and practitioner perspective
	H4. To undertake problem-driven research

After evaluating how the strengths were achieved, the aims and context of this research study appeared to align with the strengths of Engaged Scholarship.

Regarding the challenges, each of the four challenges will be reviewed in turn:

- **Challenge E (Effective engagement with stakeholders):** I as a researcher, although a novice researcher, has significant experience of working in multiple academic environments, and has worked in and managed collaborative teams. As such I, as a researcher in this study, was well equipped to tackle such a challenge.
- **Challenge F (Time interacting in the study):** As a researcher based at the USN and the research project being a part of Interreg and the SETS II project my everyday environment provided plenty of opportunities to interact both formally and informally with most stakeholders.
- **Challenge G (Applying Engaged Scholarship):** As a researcher without prior experience and as a novice researcher applying Engaged Scholarship, required careful reference to the literature regarding the methodology, and some discussions and checks with other researchers who have applied this in practice.
- **Challenge H (Being a reflexive and objective researcher):** The range of experience of myself as a researcher in the maritime industry and in lecturer/trainer roles coupled with an awareness of potential issues enabled this challenge to be managed.

The most significant identified of the challenges discussed above was Challenge G "*applying the Engaged Scholarship methodology*", as this was something that I as a researcher had no experience of doing. I further considered challenges E and H manageable and I consider Challenge F to be fully addressed.

3.8.4 Ethics as reflection, duty, compassion, and inspiration

Ethics can be stated as the moral principles that govern a person's behaviour (Parveen & Showkat, 2017). Related to research ethics, ethics may be referred to as doing what is morally and legally right in research (Parveen & Showkat, 2017). Parween and Showkat (2017) further shows to that ethics actually are norms for conduct that distinguish between right and wrong, and acceptable and unacceptable behaviour. In encountering the ethics of engaged scholarship it is necessary to consider how we as researchers approach and position ethics (writ large) in our work (George Cheney, 2008). Cheney (2008) invite all of us to focus on the critical moments of decision, voice, and action where ethical judgment may be seen not only as a specific decision but as something situated within broader streams and contexts of experience. This calls for a kind of meta-ethical reflection, rather than using ''*retheorizing*'' of ethics to make them seem entirely relative, but not one that goads us toward excessive abstraction. Cheney underlines the need to keep grounded in the case(s) at hand, just as the method of casuistry would guide us to do (G. Cheney, 2004). In this research this meant that I as a researcher has the responsibility to be aware of and include the topics of honesty, objectivity, integrity, carefulness, openness, competence and show respect for intellectual property, confidentiality, responsible publication, and social responsibility. Cheney further propose five dialectics that ought to be confronted, if not embraced, as we do the work of engagement: (1) openness versus protection, (2) privilege versus equality, (3) distance versus empathy, (4) listening versus advising, and (5) representation versus intervention.

All of these responsibilities and dialectics were consciously regarded in interfacing with the different participants of the research.

3.9 Final note on methodology

In summary, the methodology was implemented in seven key stages:

1. An initial assessment of the port industry and review of the issues associated with its potential environmental impacts was comprehended. In addition, the impacts of the environment, communities and the economy on the port were also considered. This generated a large number of issues, of varying levels of relevance and significance.
2. During the assessment of potential issues, work was also undertaken to identify stakeholders that had a significant interest in the ports sector. The most important stakeholders included employees, customers, suppliers, local communities, regulatory bodies, and environmental/public interest pressure groups. Some of these were consulted throughout the project in order so that they could have an input into the work from outset to completion (although not all participated in each stage of the project).
3. Preliminary visits were made to a representative group of ports included as participants in SETS II in order to consult formally and informally with employees and managers. All sites had been sent in advance a standard information sheet outlining the aims of the project, the purpose of site visits and asking a set of key questions about the operation of the site. The findings were then used to revise PEPI's initial assessment of potential issues and assist in the preliminary development of issue-specific environmental performance indicators.
4. Based on the revised assessment of potential environmental issues, plus consultation with the industry, SETS II, USN and other interested groups, the PEPI project group

drew up a provisional lists of indicators for environmental issues. This list then formed the basis of further work.

5. A further round of more formal port consultation was then undertaken. The researchers used focus group interviews and all of those interviewed took part enthusiastically, entering into the discussion with the researchers and contributing their opinions, which were then used to ensure that the coverage of issues was still valid.
6. The grouping of issues and the selection of indicators was guided by a "*top-down*", expert- driven working framework, complemented by a parallel "*bottom-up*" approach that involved interviewing or surveying internal and external stakeholders, in order to define the issues of concern that selected stakeholders of the industry wished to see addressed. It also defined what for them would constitute progress, so as to guarantee positive contributions to the overall PEPI goals, noted in chapter 1. The PEPI overall goals in part define the types of outcome that the port industry will need to generate in order to contribute to, and not detract from, the environmental sustainable development process
7. The seventh stage included construction of the PEPI model and framework.

This methodology section has reviewed the approach adopted by the author and research team to develop the port environmental performance index for the port sector. The aim of providing this detail is two-fold. First to demonstrate the research rigour underlying the development and validation of the PEPI: it was not "*bought off the shelf*". Second to enable the same methods to be followed in future work to identify new environmental indicators as conditions change. To reiterate, the methodology of the project is an output in itself.

The limited time scale within this thesis to develop product/discussion underlines the challenge of doing research. Sometimes the PEPI team ran up against "*cul-de-sacs*", but nonetheless there is value in demonstrating the methodological process for future work, since port environmental indicators and port environmental strategies represent an important need for port business and related stakeholders.

4. Results

This chapter presents the process of developing the PEPI model by integrating the research findings derived from the Engaged Scholarship methodology.

4.1 Findings

Extracts from the literature review combined with focus groups interviews, workshops and port site visits show:

4.1.1 Identification of port environmental performance issues

- Each port has a unique set of geographic, political, regulatory, community, operational and financial circumstances that shape and define their environmental initiatives.
- Environmental measuring of ports are complicated due their nature, various services and a wide range of environmental issues.
- Major issues related to this field concern what to measure and how to measure it in a practically feasible and cost-effective way.
- Each port take slightly different approach to environmental initiatives, based on their unique circumstances.
- Decision-making in port environmental projects requires consideration of trade-offs between socio-political, environmental, and economic impacts and is often complicated by various stakeholder views.
- Port environmental performance measuring incorporate a variety of criteria.
- There exists an extensive literature on port KPIs.
- Appear to be a trend in the ports sector to adopt and adapt a best practice in terms of environmental management.
- No standard for measuring the environmental impacts of ports.
- Published research on ports and environmental performance shows to that there can only be individual solutions based on individual circumstances.
- Ports around the world are demonstrating a commitment to environmental stewardship and sustainable port operations through a variety of actions, mandates and initiatives.

4.1.2 Environmental management tools

- There exist a number of environmental management tools for ports such as:
  - The environmental management system (EMS).
  - Port-wide or operation-based environmental review.
  - Site-based environmental audit against set environmental procedures.

  - Environmental aspects and impacts recognizing.
  - Environmental awareness training programme.
  - Good documents and records keeping systems.
- There exists no environmental management program which is suitable for all ports.
- It is possible for ports, by focusing on certain environmental management tools or operations-specific environmental management practices, to improve environmental performance.
- Each port has a different management structure and culture. This is reflected generally in their approach to tackling environmental management.
- Port management initiatives and skills related to port environmental measuring varies.
- Numerous opportunities and challenges regarding measuring port environmental performance exists (see Appendix C).
- Port management wish to set or improve existing environmental performance goals.

4.1.3 Identification of essential model attributes

- Port performance level and progress, as for every industry, should be measured and monitored through many tangible indicators, because no single indicator alone can reflect efficiency or productivity for ports and port operators.
- A range of critical indicators, complementing each-other by considering different port performance issues, need to be established, applied and analysed, based on data which must carefully be identified, collected, structured and interrelated, processed, presented and stored.
- Integration of the heterogeneous and uncertain information demands a systematic and understandable framework to organize the technical information.
- Performance measurement (PM) is critical to the success of organizations.
- Those ports using a balanced or integrated port environmental performance measurement system perform better than those that do not.
- Performance measures provide an important link between strategies and action and thus support the implementation and execution of improvement initiatives.
- Need to include multi-criteria indicators for each level of management, i.e. the strategic, tactical and operational levels.
- These multi-criteria indicators need to be categorized, with indicators proposed for each level of management in each category.

- A port environmental model need the ability to effectively and efficiently identify, model and communicate information.
- The port environmental model need to able to express communication of complex information in a way that is rapidly absorbed and conveys the necessary insight.
- The characteristics of port environmental performance measures must include relevance, interpretability, timeliness, reliability and validity.

4.1.4 The key port environmental performance practice findings were:

- Port environmental practical problem skills could be seen as an instance of the general problem was a major factor.
- That despite a poor definition of environmental KPIs for the involved ports and weak environmental strategic reflection activities, the combination of multiple, constructively aligned, relevant experiences still enabled the ports practice to be effective.
- There is a larger gap in port environmental knowledge rather than on defining KPIs where there is an extensive literature already.
- A tailor-made environmental management program can lead to a successful port environmental management if it:
    1. address operations with the potential to significantly impact on the environment.
    2. identifies actions to prevent or minimise the impacts.
    3. improves communications between those responsible for environmental protection.
- In order to deliver compliance, environmental protection and sustainable development, effective port environmental management needs to take into account:
    1. the potential impacts on the environment,
    2. mitigating options,
    3. methods of prediction,
    4. information on environmental indicators and legislation.
- Experience indicates that the more that environmental management is integrated into port business and operational plans, the more effective is its impact and the greater the cost- benefits.
- There is a need for reflective action concerning port environmental measures to ensure that they are effective in coping with the continuously changing environment.

- There is a need for a systematic and understandable framework to organize the environmental information and processes to interpret and use in actual port advising or decision-making contexts.

4.2 Identification of port environmental performance indicators

A critical review, as discussed in the literature review, was conducted to identify the key environmental port performance indicators. The indicators provided were reviewed in the research to ensure that they meet the general characteristics of Port Indicators as described in Peris-Mora et al. (2005):

Table. 4.1

General characteristics of Port Indicators as described in Peris-Mora et al. (2005)

General characteristics of port indicators	
Representativeness	The indicators should represent environmental behaviour as accurately as possible
Conciseness	The indicator should allow for the simplification of the number of variables, which characterises a phenomenon of condensing the information with the least possible loss of information
Purpose	The indicator should allow an activity to be evaluated in such a way that goals are accomplished
Usefulness	The indicator should be a useful tool for the activity
Relevance	Within the environmental awareness framework
Adaptability	Being adapted or easily adapted to other indicators, models and prediction systems (EEA, OCDE, EC, etc.)
Comparability	Over time (the development of a phenomenon), and within regional, national and international frameworks
Sensitivity	The indicator should be sensitive to environmental changes with fast, adaptable and appropriate responses to them. Thus, they should have variable values according to the changes in the phenomenon
Clarity	The system should be coherent and focus on essential data. The indicators should be concise, accurate, simple and easy to interpret
Reliability and objectivity	In obtaining and developing the data
Easy to obtain	From the phenomenon being evaluated
Continuity	The collecting data criteria should be constant over time in order to compare results
Regularity	The indicators should be determined at appropriately short intervals for the purpose of having the opportunity to actively pursue and influence the desired data
Scientific verification	The indicator should be preferably quantitative. If this were not possible, it should be hierarchically categorised
Well-defined limits	The indicator should provide information about its own limitations
Cost-effectiveness	The indicator should be administratively efficient in terms of the costs involved in obtaining the data and use of the information

In all, 884 KPIs is so far registered in the PEPI model framework. Port environmental performance indicators has 779 technical KPIs (listed in Appendix D), Port management environmental performance indicators has 43 soft KPIs (listed in Appendix E), port operational environmental performance indicators has 62 soft KPIs (listed in appendix F).

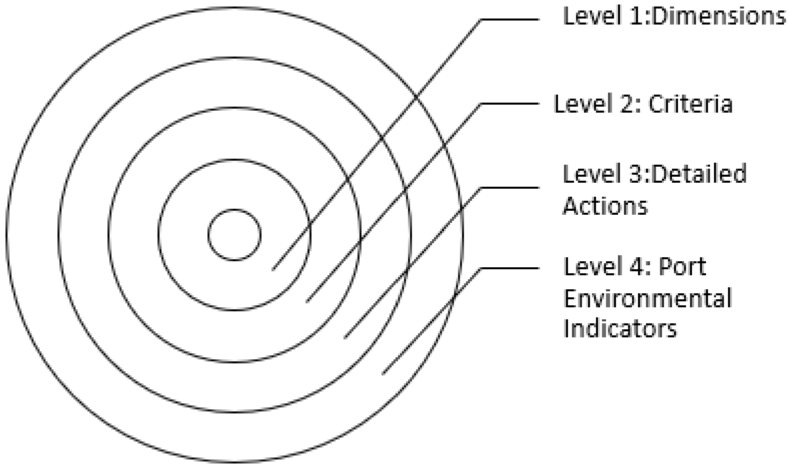
4.3 Establishing initial hierarchy structure

The PEPI model includes a large body of port environmental performance knowledge, associated with logic and mathematics, and is available to assist port management and other stakeholders in their port environmental systems identification, analysis and evaluation tasks. Empirical data (factual truth) and logical inference (formal truth) are used in the ordering process to reduce the effort and cost of collecting port enviromental empirical data, as well as the complexity associated with the structuring process of these.

The proposed conceptual PEPI model consists of a KPI framework which makes use of four hierarchical levels, consisting of different components. The first level, which is the highest level in the framework, encapsulates the second, third and fourth levels.

Figure 4.1

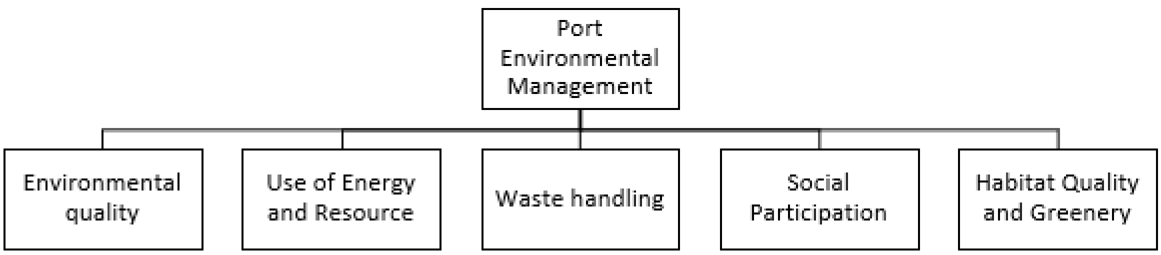
The hierarchical levels of the proposed PEPI model



From the hierarchical point of view, the top level, the inner circle, considers port corporate or strategic issues on the basis of soft or perceptual measures from stakeholders, which in turn is devided into level 1 which in the proposed conceptual PEPI model consists of five broad dimensions: (1) Environmental quality management, (2) Use of Energy and Resource management, (3) Waste handling management, (4) Social Participation management, and (5) Habitat Quality and Greenery management.

Figure 4.2

The top level and its 5 level 1 dimensions.



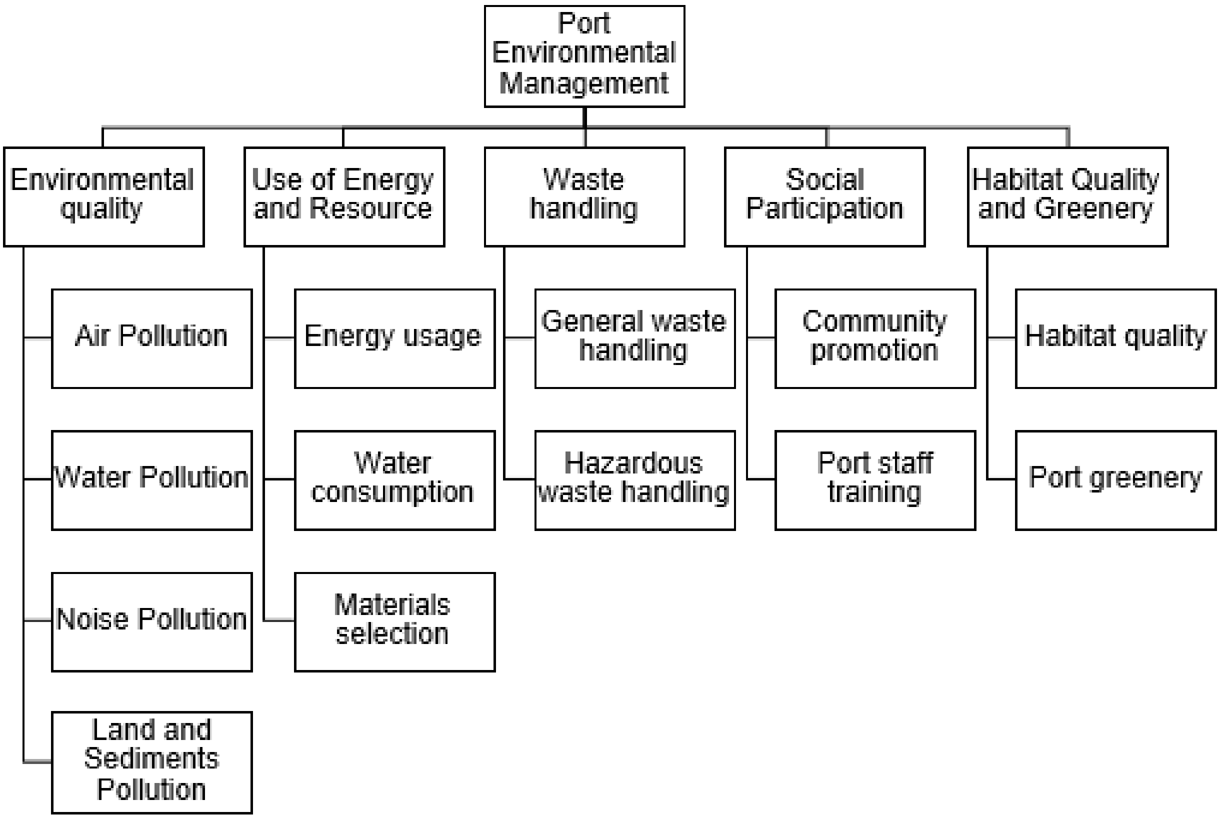
These five dimensions of environmental port operation are categorized based on reviewing port authorities' green port measures and earlier research studies, such as Chiu et al., 2014, Darbra et al. , Peris- Mora et al. (2005), Bailey and Solomon (2004), Klopott (2013) , and Chiu and Lai (2014).

In a way the strategic level is subjective, as it is linked to the vision and long-term goals, though the subjectivity decreases down through the levels, with the highest objectivity existing at the functional level (the outermost circle). This first level is represented by the senior managerial level.

The second level is represented by the managerial/supervisory level and considers tactical issues both from the effectiveness and the efficiency point of view and consists in the conceptual proposed PEPI model of 13 criteria distributed amongst the dimensions in the above level. These criteria provides more detailed information about what kind of actions the port authorities should do to enhance its environmental performance.

Figure 4.3

The break-down of level 1 dimensions with the cohesive categories.



As the above figure 4.3 shows, Environmental quality management (Level 1) is broken down into four level 2 categories: Air Pollution, Water Pollution, Noise Pollution and Land and Sediments Pollution. Use of Energy and Resource management (Level 1) is broken down into three categories of criterias: Energy usage, Water consumption and Materials selection. Waste handling management (Level 1) is broken down into two categories: General waste handling and Hazardous waste handling. Social Participation management (Level 1) is broken down into two categories: Community promotion and education, and Port staff training. Habitat Quality and Greenery management (Level 1) is broken down into two categories: Habitat quality and Port greenery.

The third and fourth levels are represented by the functional personnel and port operators. The indicators of the PEPI model framework at the functional level are integrated and linked to the tactical or middle level to help the management with analysis and decision making at the strategic or tactical level. The PIs at the strategic or top port management level may appear to be subjective, when seen from the functional level, but after cascading down the levels, the PIs need to be objective and specific at the functional level. The role of port managers at the tactical or middle management level is equally critical as they have to translate the port environmental objectives and PIs to the functional level and vice-versa.

4.4 Indicator and issue categories

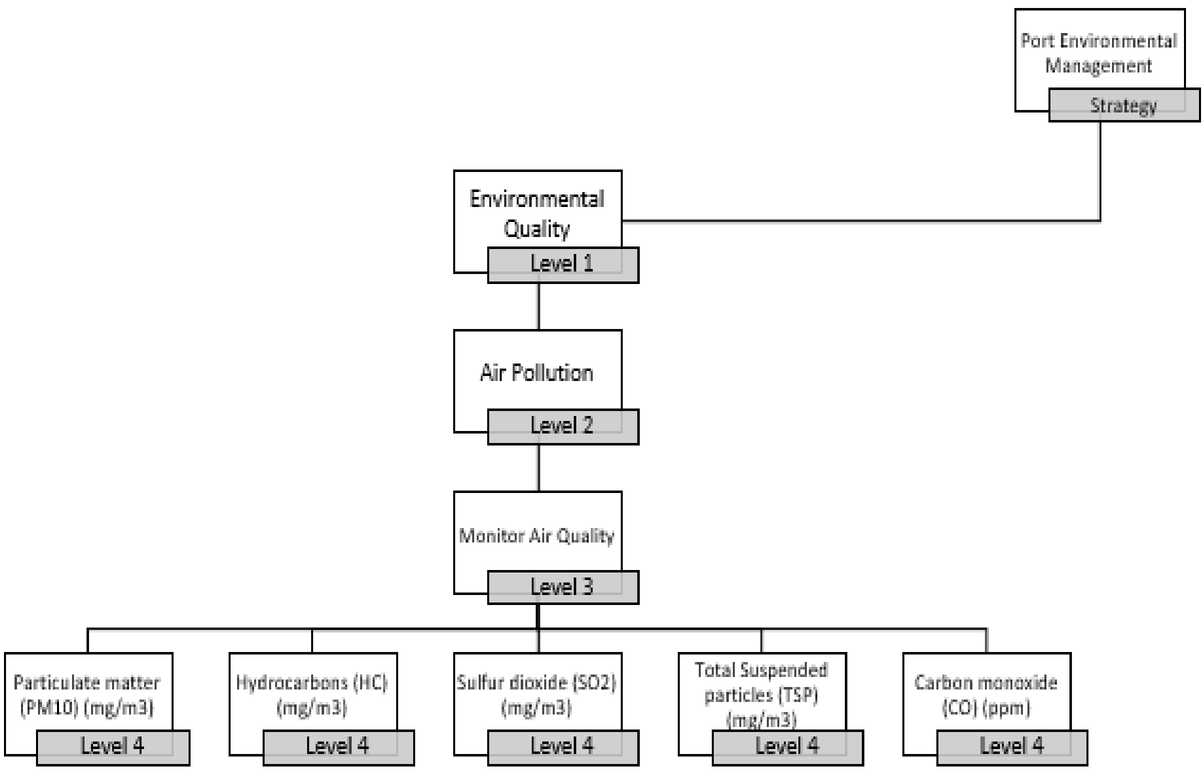
The PEPI approach to developing indicators is "*issue-based*". Issues included in the PEPI model are derived from a combined process of top-down expert driven categories, through reference to related research, port expert knowledge, different subject matter experts and existing "*off the shelf*" environmental indicator categories and "*bottom-up*" stakeholder scoping exercises where information is gleaned from interviews and observations through site visits and public consultation. The PEPI research has suggested that the port environmental issues and indicators that are identified need to be categorised and be of a manageable number. During this research, indicators and issues were arranged according to the generic PEPI model levels. categories:

- Level I: relates to the contribution that the port sector makes to the aims and objectives of global environmental sustainability.
- Level II: relates to the port sector, or in a limited number of cases within that sector, to large business units.
- Level III: relates to the individual port companies that make up the port sector.

The third level is a further breakdown of the second-level categories, and at the third and the fourth levels the objectives are converted to detailed actions and specific measuring criteria.

Figure 4.4

The functional level with the objectives converted to detailed actions and specific measuring criteria.



To assist in understanding the interrelated nature of issues and indicators, the following points should be considered:

- While indicators are derived from consideration of issues, issues cannot be generated from indicators. Therefore, in any process to define suitable port environmental indicators, a comprehensive review of issues must be undertaken first.
- By definition, Level I issues are "*Environmental Sustainability*" and represent the end goal for the port sector in contributing to global environmental sustainable development.

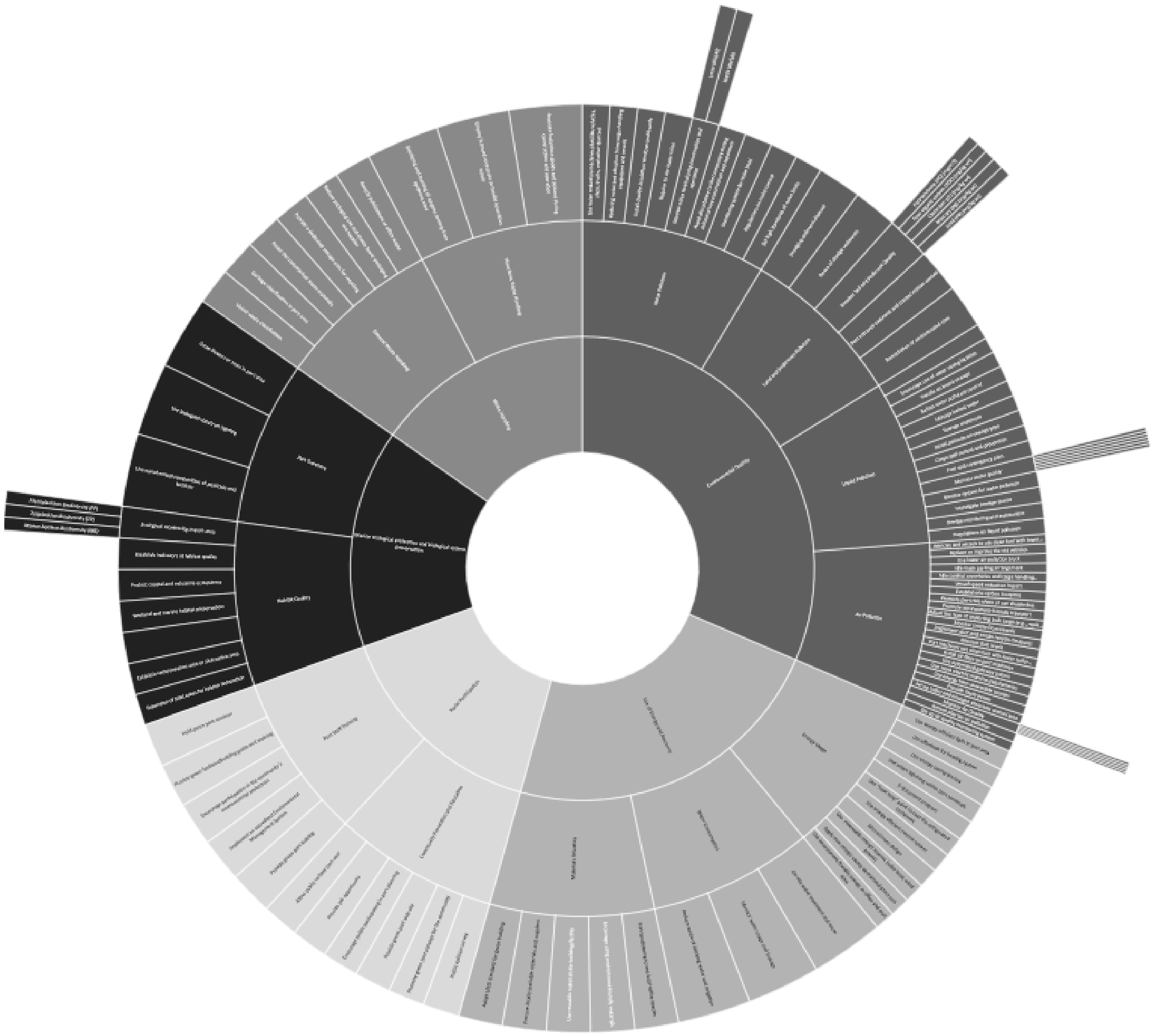
- Level II issues can be defined by a “*top-down*” approach where each Level I issue is split into two or more issues that are relevant to the port sector. Alternatively Level II issues can be defined by a “*bottom-up*” approach where Level III issues relevant to individual companies are aggregated to form the Level II issues, informed by the “*top-down*” approach.
- Level III issues are defined at port company-level and can be aggregated to generate port sectoral Level II issues. While it is theoretically possible to split Level II issues to produce Level III issues, this approach was not considered practical in the context of this project.
- Unlike issues, the relationship between Level I, II and III indicators is one that is linear and one-way only. Level I indicators are produced only be aggregation of Level II indicators.
- Finally, it should be noted that aggregation works only vertically within each of the dimensions of port environmental sustainability, and not across them.

4.5 The Port environmental Performance Index (PEPI) model

In this section a proposed model of the PEP is visualized to demonstrate how the PEPI model will appear. When completed the PEPI model will consist of several more different port environmental indicators. The proposed conceptual model consists of 130 types of port environmental performance indicators.

Figure 4.5

The structure of the proposed PEPI model with its 4 levels of integrated hierarchy. Text appears on the model only for illustrational purposes.



As described in the sections above, the PEPI model is set up as a hierarchy system, which is composed of several hierarchies and includes port environmental goal, criteria of various types of influence, sub-criteria, and decision alternatives to determine the best choice and option for port environmental performance management.

Table 4.2

Example of the proposed PEPI structural hierarchy

Level	Description	
	Environmental Health	Component
1	Environmental Quality	Dimension
2	Air Pollution	Sub-criteria
3	Monitor Air Quality	Detailed Action
4	Particulate matter (PM10) (mg/m3)	PEI

The five proposed dimensions (components) in this conceptual model of the PEPI are categorized based on the works of Chiu et al. (2014) and other researchers as shown to above. The thirteen sub-criteria (factors) provide detailed information about what kind of actions port management should do to enhance port environmental condition and performance.

Table 4.3

The conceptual key Environmental Port Performance Components and Factors

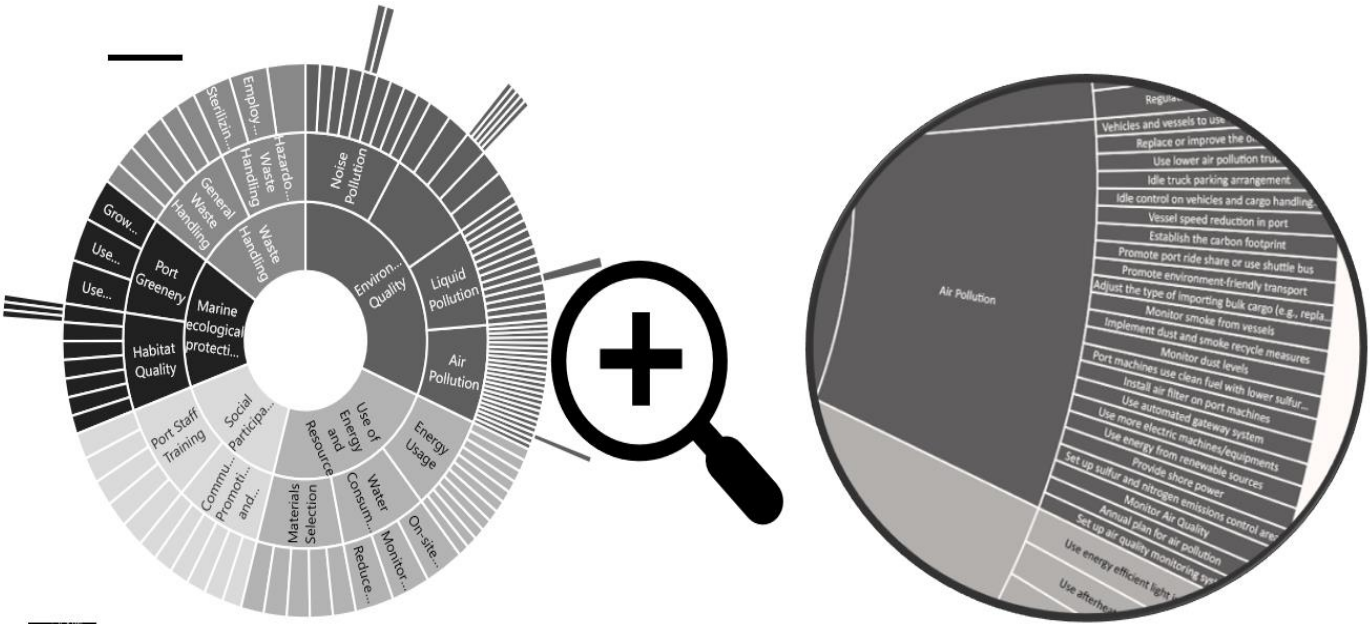
Component	Factor
Environmental Quality	Air Pollution Water Pollution Noise Pollution Land and Sediments Pollution
Use of Energy and Resource	Materials Selection Water Consumption Energy Usage
Waste Handling	General Waste Handling Hazardous Waste Handling
Habitat Quality and Greenery	Habitat Quality Port Greenery
Social Participation	Community Promotion and Education Port Staff Training

For this study, based on the literature review, focus group interviews, workshop and port site visits, the conceptual port environmental performance index model is formulated as shown in Figure 4.6.

This multidimensional, integrated port environmental performance model includes five dimensions and thirteen sub-criterias, which can be used in its temporarliy state to measure, estimate and guide port environmental performance.

Figure 4.6

The conceptual PEPI model with the detailed actions of the element of Air Pollution enlarged.



The proposed conceptual PEPI measures and detailed actions are shown in Appendix G.

5. Discussion

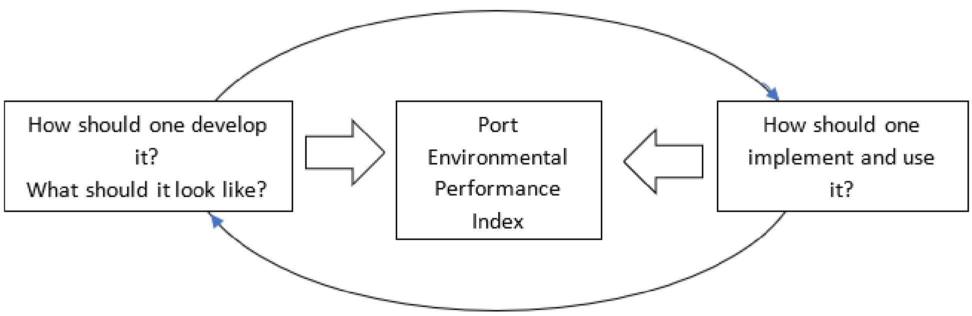
This chapter discusses the research findings for each research question (RQ), and the fundamental aspects underlying the establishment of a strategic-based methodology for the PEPI model and its integrated framework for port environmental performance management are described in this section, namely the methodology components, the structural elements, and the methodological principles.

5.1 Introduction

The initial exploratory research study identified multifaceted challenges in the port industry. To deal with these problems specific objectives of the research were set and it became clear that a strategic, multi-criteria, hierarchical tool and a multidimensional framework for port environmental performance management were required. As shown to in the literature review there are various concepts proposed by researchers for measuring port environmental performance. Still, the literature review showed that there is a need to identify and analyze the issues related to port environmental performance and to develop a framework, which can systematically address the related issues and challenges of port management, performance measures, indicators and environmental performance measurement. This framework includes key performance indicators (KPIs), metrics and measurement techniques. For the whole process, it needs to cover across strategic, tactical and operational, hierarchical levels of the port organization. Therefore, it became essential that, various issues and challenges associated with failure of measurement initiatives needed to be studied and examined, prior to the development and implementation of the PEPI model. Understanding the need for the PEPI model in the port business and its work process is critical for development and successful implementation of the port environmental performance index.

Figure 5.1

Questions involved in the development and implementation of the PEPI.



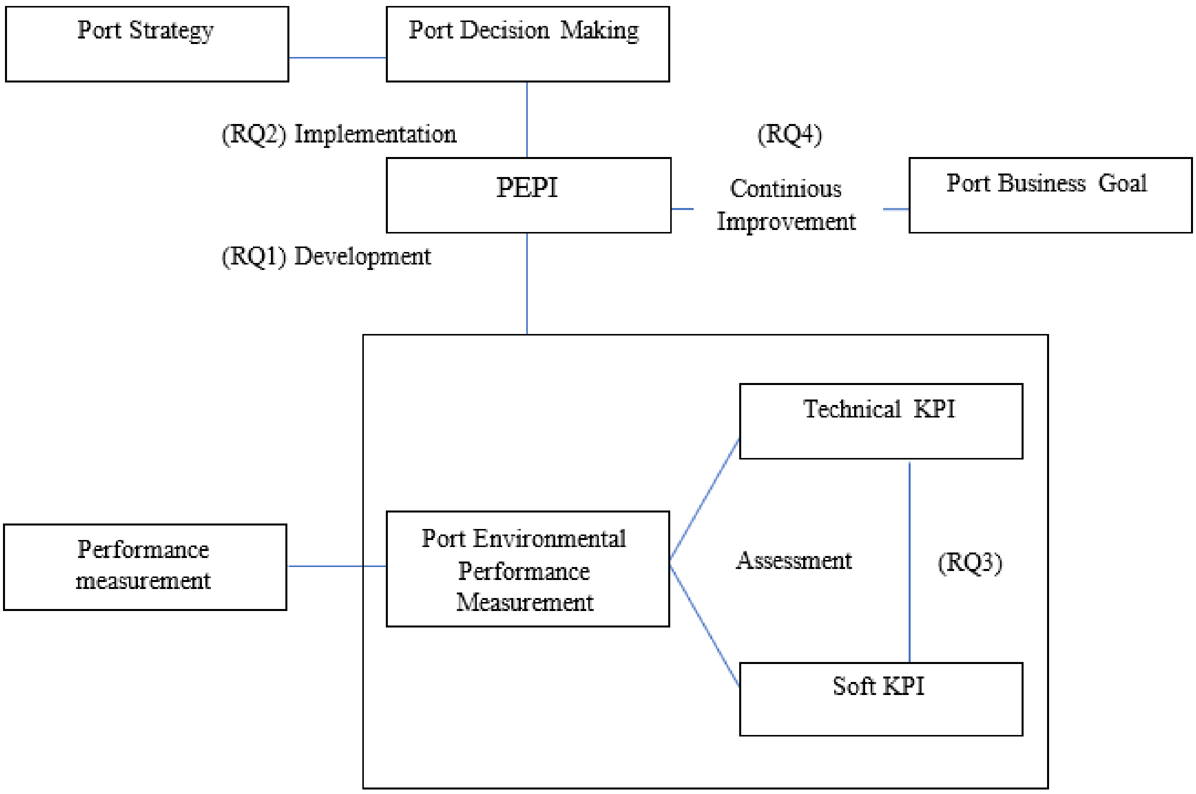
The basic questions involved in the design, development and implementation of the PEPI model presented in Figure 5.1 lay the foundation for how the research questions needed to be formulated to achieve the stated purpose and objectives:

- **Research question 1:** What is a strategic tool to provide insights that are useful for identifying practices, informing policy agendas, and setting priorities in environmental port governance?
- **Research question 2:** How can the developed port environmental indicator tool be implemented through port strategy?
- **Research question 3:** How can port environmental indicators be assessed using a novel approach?
- **Research question 4:** How can the developed port environmental KPI framework be improved continuously?

The PEPI model as a strategic facilitator of the port environmental performance process with the research questions in relation to the PEPI model:

Figure 5.2

The research questions in relation to the PEPI model.



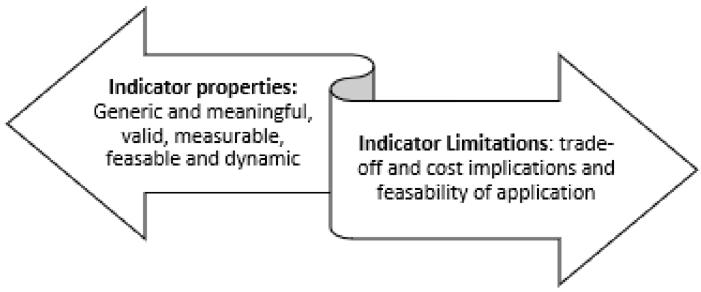
5.2 The PEPI model and environmental indicators

The starting point of the research was the concept of environmental development as a sustained improvement in ports. Environmental indicators for the PEPI model are about communicating meaningfully to different stakeholders the extent to which a port operation, project or initiative is contributing to, or detracting from, the health and well-being and quality of life of individuals and communities and ecosystem health. From a port management system perspective, the author considered that there was a need to develop indicators that are meaningful at a company level (in the first instance) to help ports understand the actions that need to be taken to ensure its activities contribute towards sustainable environmental development.

Properties of the PEPI indicators were chosen to be generic and meaningful, valid, measurable, feasible, and dynamic. However, indicator limitations can be trade-off and cost implications, and feasability of application.

Figure 5.3

PEPI indicator properties and limitations.



The figure above captures the properties of indicators in terms of both the characteristics of a relevant indicator and their limitations. The literature research also suggests that the indicators chosen must be generic and therefore transferable, and meaningful to different port stakeholders and potential users across business, government and civil society. Some of the indicators suggested will be more relevant or acceptable than others for different groups of stakeholders. However a goal was that, all indicators must ultimately be comprehensible and capable of communicating meaningful progress, or otherwise, towards sustainable environmental development goals. The suggested port environmental indicators would also have to be scientifically valid, cost-effective, measurable and feasible to collate.

The port environmental indicators must be capable of indicating progress over time and therefore must have a dynamic quality and be capable of capturing both positive and negative qualities. In constructing the port environmental performance index indicators framework there was an awareness of limitations such as the trade-offs that may be implicit in selecting one indicator over another. Also some indicators may be more costly to employ and report on than others.

The port environmental issues and indicators developed for the PEPI model represents an amalgamation of existing port company, research and governmental social issues and indicators and existing standards and regulations. These are complimented by port sector specific issues and indicators derived from the researchers own expertise and experience and from stakeholder input through field research. The issues and indicators have been selected to be generic enough to be applicable and comparable in different ports companies, industries and sectors, both in their content and their presentation, while being tailored to the specific operating environment of the ports. As such, the indicators developed by the PEPI project have a generic and a more port sector specific component.

The port environmental issues and indicators developed by the PEPI project for the SETS II were selected to encompass all significant areas of port corporate environmental responsibility. As such, they are designed to be comprehensive and manageable rather than exhaustive and inoperable. Nevertheless, many smaller port companies adopting the environmental indicator model, may, for financial or logistical purposes, require a more restricted collection of core environmental indicators, on which they can draw and utilize. Given that the PEPI indicator model has evolved multidimensional, highlighting core issues and indicators is potentially problematic. In particular it is complicated by the fact that stakeholder interests and concerns will vary from port site to site, depending on the size and type of port business unit and its environmental operating environment and an a priori indicator focus cannot account for this.

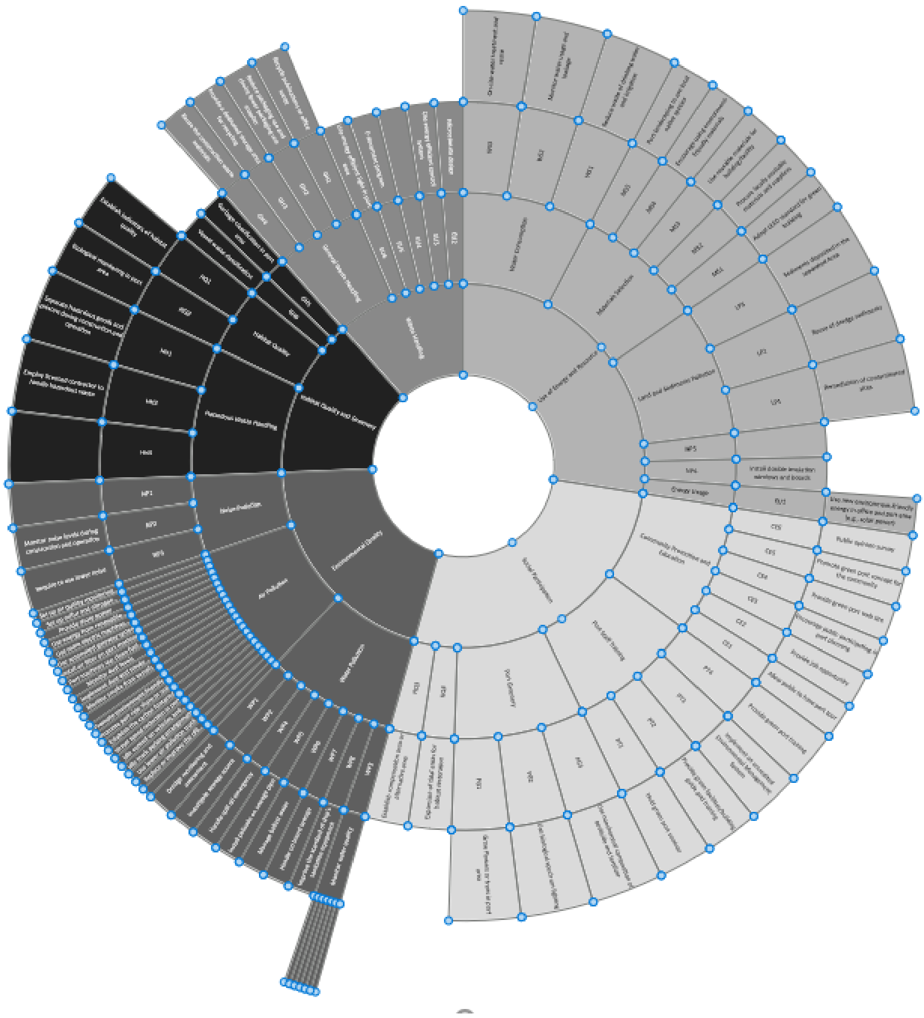
5.4 Results and discussion related to RQ 1.

Research question 1: "*What is a strategic tool to provide insights that are useful for identifying practices, informing policy agendas, and setting priorities in environmental port governance?*".

The first research question is answered by the development of a new KPI framework for port environmental performance management, the Port Environmental Performance Index, the PEPI. The PEPI model is constructed as a composite index consisting of a port environmental performance indicator hierarchy which is structured in several levels. Port environmental aspects and control measures was through the research identified, which made it possible to classify the different dimensions.

Figure 5.4

The PEPI model.



When it comes to ports and environmental performance the research findings showed there is great challenge in the increasing availability of data sets with a huge amount of information, coded in many different features. The great challenge for port management in this context is the translation of the raw data into useful information that can be used to improve port environmental strategic decision- making processes, detect relevant profiles, find out relationships among features, etc. In this setting of port environmental performance, a visualization method would likely be the most appealing and one of the most relevant kinds of knowledge extraction methods, because it is undoubtedly true that a picture is worth a thousand words.

This led to the idea to the technical creation of the PEPI model and to present a visualization method based on a pie chart that does allow a simultaneous and compact visualization of the different hierarchy levels and simultaneously the data information at each level of the hierarchy. This method is tested in synthetic and real data sets with internal hierarchical structure (Vellido et al., 2011), and Vellido (2011) further shows to that the satisfactory performance achieved reinforces the viability of this method in hierarchical data visualization, since it enables the extraction of information by inferring relationships among features, factors and detailed action levels of the performance hierarchy.

In the context of the PEPI model, hierarchical approaches appeared as a natural solution since global research methods regarding port environmental performance producing a single "*picture*" of the data may provide either too complicated or too simplistic visualizations, as they may lack the detail crucial for data understanding and knowledge extraction for the port management. There is clearly a need for a tool to assist port stakeholders in decision making regarding port environmental performance evaluation.

The Port Environmental Performance Index can be defined as the materialization of environmental information aimed to support port decision making. Its solutions integrate information with port environmental strategies, creating innovative ways to support port decisions.

An effective port decision-making process needs a trusted decision support system based on knowledge discovery, defined as data acquisition, data transition, data fusion, data mining, information extraction and visualization.

5.5 Results and discussion related to RQ2.

- RQ2: "*How can the developed KPI tool be implemented through port strategy?*"

The second research question is answered by proposing the use of the PEPI model, which can improve the quality of port environmental plans and programs through better environmental integration, using strategic, multidimensional, and cross-sectoral approaches, and steering plans and programs towards environmental sustainability objectives, thus contributing to an improvement of the port environmental development context.

The Port Environmental Performance Index is an impact assessment tool that is strategic in nature and has the objective of facilitating environmental integration and the assessment of the opportunities and risks of strategic actions in a port environmental development framework. The strategic actions are strongly linked to the formulation of policies, and they are developed in a context of planning and programming procedures (Partidário, 2007).

The general objectives of the PEPI model are:

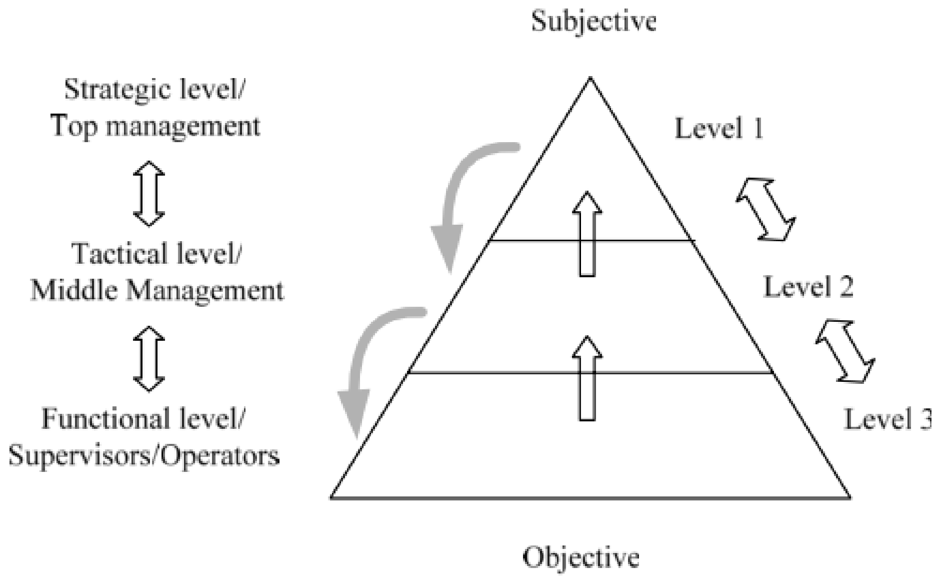
1. Contribute to an environmental and sustainable port decision-making process.
2. Improve port policy, plan and programme quality.
3. Strengthen and facilitate ports environmental assessments.
4. Foster new means of port making decisions.

The PEPI model is, nonetheless, more efficient with respect to its objectives if more strategically oriented methodologies are used. With a strategic-based methodology the objective is to include environmental issues in the port planning and programming cycle as early as possible, discuss and assess the major strategic options and ensure an iterative tracking to assist in the decision of choosing the best options that allow port sectoral, environmental and sustainability objectives to be achieved, and assist in the implementation of the port strategic decisions (Partidário, 2007).

The port corporate or business objective at the strategic level needs to be communicated down through the levels of the organization, in such a way that this objective is translated into the language and meaning appropriate for the tactical or functional level of the hierarchy.

Figure 5.5

The strategic hierarchy levels (Parida, 2006).



The port environmental objectives and strategy, as derived from the stakeholders' requirements and port corporate objectives and strategy, considering the total effectiveness, front-end processes and back-end processes, integrate the different hierarchical levels in a both from top-down and bottom-up manner involving the employees at all levels. At the functional level, the objectives are converted to detailed actions and specific measuring criteria. Similarly, the PIs of the functional level aggregate to KPIs at the tactical and strategic level. It is essential that all the employees are totally involved and speak the same language throughout the entire organization for a successful port environmental performance system.

The overall objective of the PEPI model is to provide methodological guidance for good practices in port environmental assessment, thus ensuring that a strategic-oriented assessment is carried out, in compliance with European and domestic legislation.

What makes the PEPI model essential for port management is the ability to help reflect opportunities and risks of opting for certain environmental development directions in the future and not taking expected outcomes of plans and policies to be highly probable, in order to assess their positive and negative impacts, and to propose measures to minimise or compensate for the negative impacts.

A port management strategic-based stance needs to be adopted by the ports in order to increase the possibilities of success. The port strategic-based methodology of the PEPI model is based on the Strategic Environmental Assessment (SEA) works of Partidário (2007).

There are at least two ways of integrating a strategic-based port environmental approach using the PEPI model.

(1) One relates to the process of selection of what needs to be studied and analysed. Port management need to decide what should be within the scope of the strategy. The bottom-line is that analysing few, though relevant factors, are more important than carrying out exhaustive descriptions that, generally, are not compatible with the deadlines of a strategic decision.
(2) The second way of being strategic for port management, relates to the moment in which the decision can be influenced. The port management must be strategic with respect to the decision-making moments in which a technical contribution, or a procedural recommendation, may be critical to the decision and to the choice of an environmentally more integrated and sustainable option and pathway. The PEPI model will influence the port management planning and programming process a number of times during the preparation and drawing up of plans and programs, and not just at the end, when the Port Environmental Report is produced.

Implementation of the developed PEPI model is important and will for the ports answer to questions like; how to measure and how to take care of the associated activities in this stage. Employing a combined top-down and bottom-up approach, the port organization is informed of the likely port environmental performance system implementation from the very beginning and various people from the port organization would be involved in the project. Correct and timely flow of information, aggregating from the data from functional level to the management level through the managerial one, for evaluation, analysis, and appropriate decision making, are the requirements at this stage. Port management needs to record and analyze relevant data on a regular basis and use it for monitoring, control of maintenance and related activities.

The following issues have been found pressing demands for effective port management of environmental performance even more challenging:

(a) Measuring value created by the PEPI model. The most important reason for implementing the PEPI model is to measure the value created by the port environmental performance process. As a port manager, one must know what is being done is what is needed by the business process, and if the environmental output is not contributing/creating any value for the port business, it needs to be restructured. This brings the focus on doing the right things keeping in view the business goal of the port.

(b) Revising port resource allocations. The basic purpose for measures of environmental effectiveness is to determine if additional investment is required and to justify the investment if management needs more of what you are doing. Alternatively, such measurement of environmental activities also permit you to determine whether you need to change what you are doing or how you are doing it more effectively by using the resources allocated.

(c) Other challenging issues. The other challenges to be taken care of during implementation stage:

- The environmental performance measures need to be linked to the business goal.
- All the users need to be involved in the development and implementation of and training in the environmental measurement system.
- The need to reduce excessive focus on the data collection, collecting only the required data and improving the data analysis for decision support.
- The need to provide feedback on the data collection or analysis and to inform concerned managers.
- The need to link the individual/team/department to business unit goals.
- The need to be pro-active using predictive aspects of port environmental performance measuring rather than isolated values.
- The need to limit the measurement to manageable port environmental performance indicators and data.

(d) The concept of sustainability development, which integrates and balances the environmental factors and the following sustainability issues, need to be considered by port management during the implementation stage:

- How to apply a port environmental performance strategy properly for sustainability improvement?
- How to develop port environmental performance culture across the organization?
- How to implement internal and external communication supporting port environmental performance?

- How to review and modify port environmental performance strategy and system at regular intervals?
- How to develop and build trust in the PEPI model and port environmental performance systems at various levels?

(e) Port performance drivers and killers of implementations.

- Port performance drivers for successful implementation of the PEPI model: top management commitment, and the perceived benefits arising from implementing and using the performance measures.
- Port performance killers: difficulty of implementing the PEPI model due to the non-availability of required managerial support, time and resource required due resistance to port environmental performance measuring.

5.6 Results and discussion related to RQ3.

RQ3: "*How can the KPIs be assessed using novel approaches?*"

The third research question is answered by developing approaches through the PEPI model to assess port environmental performance. Port environmental assessment requires strategic thinking in the decision-making process and in the organisations involved. Defining a vision, major objectives, targets and follow-up indicators are typical ingredients of strategic approaches, which require a strategic culture and flexibility in decision-making in order to permit the rapid adjustment to changes in context (Partidário, 2007).

Analysis of the data from the implementation of the PEPI framework and continuous feedback of the information to the appropriate level at the right time will result in continuous improvement of the port environmental system and the organizational performance. Performance monitoring and control will be the most common usage of the PEPI model. The analysis and feedback of the PEPI framework will focus on:

a. Continuous monitoring of the PEPI model at different levels and improvement of the port organizational performance.
b. Providing daily decision support at different levels for port operations.
c. Performing self-audit and diagnosis of the port organization.
d. Carrying out a bench marking of the port organization's performance with respect to the best in the industry.

e. Facilitating improvement of the port organization and its environmental process.

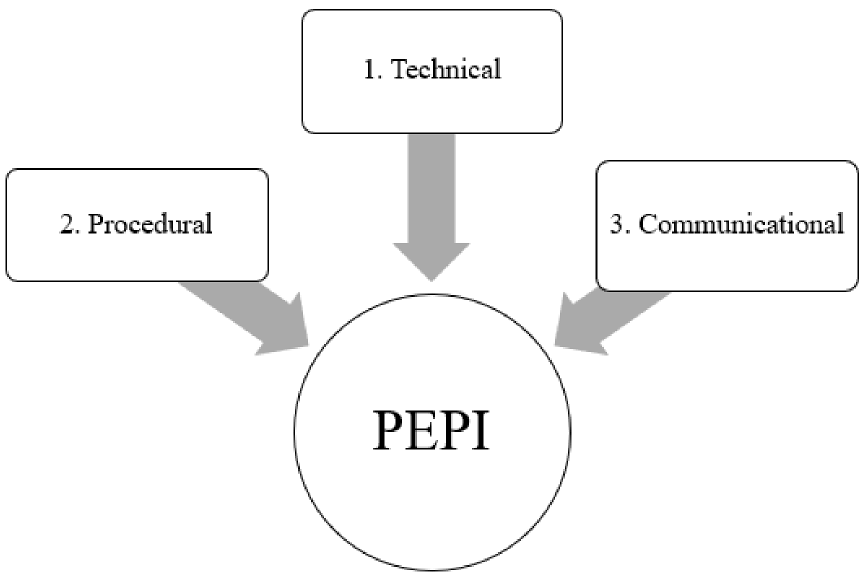
Major challenges for ports are the capacity to assess possible opportunities and risks of sectoral and territorial environmental development strategies to obtain sustainable environmental development objectives. The PEPI model, as a strategic environmental tool, aims to "*judge*" the merit (opportunity) or the risks of pursuing those sectoral and territorial environmental development strategies and it may propose better "*directions*" for the ports to follow. In the strategic context in which the PEPI model develops, its application requires a stable port policy framework and guidelines in relation to what may be a desirable and sustainable future, which may serve as a benchmark to provide a sounder reference for port environmental assessment.

5.6.1. Components of the PEPI framework

The innovative nature of the proposed strategic approach framework, customized after the works of Partidário (2007) for the PEPI model, is also evident in the combination of an array of (1) technical, (2) procedural and (3) communicational aspects forming the component parts of the framework:

Figure 5.6

The combination of components of the PEPI framework customized from the SEA works of Partidário (2007).



(1) In the PEPI model there is a technical component underpinning the definition of port environmental objectives, targets, and indicators. This component identifies and carries out relevant studies for each of the critical factors for environmental port decision-making, allowing the necessary and sufficient information to be collected from within the available data. Partidário (2007) shows to that he technical component must be directed to providing a contribution at critical decision moments, which are specified in the procedural component, and it selects the appropriate assessment techniques.

(2) There is also a procedural component that ensures the linking of an environmental strategic process and the port decision-making planning and programming processes, establishing the governance rules for the integration of the processes. According to Partidário (2007) this articulation between a strategic assessment process and the strategic decision-making processes is what makes the PEPI model a flexible process that is adaptable to each port.

(3) In a SEA approach, following Partidário (2007), there is in addition a communicational component, which is crucial for public participation and involvement, that assures the exchange of information and the cross-referencing of the multiple perspectives, the opinion making, an integrated vision and participative processes suited to the problem and to the critical decision moments. The communicational component is adjusted through the transparent objective of the PEPI model hierarchy.

5.6.2 Structural elements of the PEPI model

The structural elements of the PEPI model in the following section is adapted from the works on the SEA strategic-based methodology of Partidário (2007).

Success in the application of the environmental strategic-based PEPI model depends on how these structural elements are defined and applied. The structural elements of the PEPI framework are:

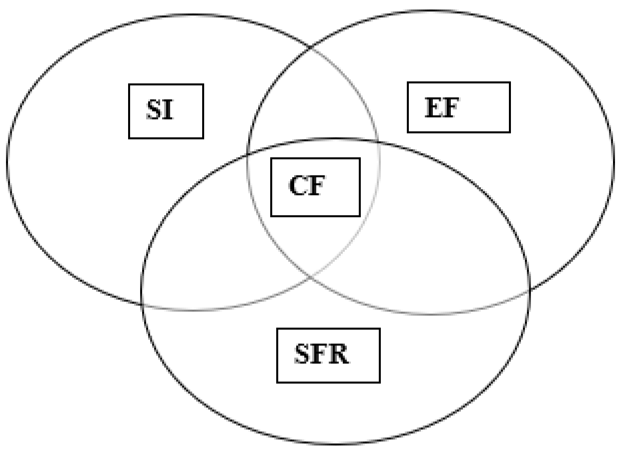
1. Critical factors for decision-making (CFD) constitute the fundamental decision-making factors that should be under port management focus. These identify the aspects that must be considered in the port management decision process concerning the port environmental strategy design and the implementing actions in order to best meet environmental objectives and a more sustainable future. These factors satisfy the

scope of the port environmental performance and are generated out of an integrated analysis of the following elements (Fig. 4):

- Port Strategic Reference Framework (SRF)
- Port Strategic issues (SI)
- Port Environmental factors (EF)

Figure 5.7

Critical Factors for Decision-Making as an integrating and structuring element of Port Environmental Assessment based on the model of Partidário (2007).



These resulting port environmental CFDs provide the structure to the analysis and assessment of opportunities and risks for the port management. These CFDs defines the technical studies that need to be performed to gather the information required for a decision (Partidário, 2007). An example of a critical factor considered for decision-making can be climate change or biodiversity.

2. Strategic issues (SI) and object of assessment in the PEPI model. The first step for port management in the strategy process is a clear identification and definition of the object of assessment. This must preferentially coincide with the environemental objectives and the major strategic options considered in the port planning and programming process. The strategic issues or the driving forces contributing to the definition of the port environmental CFDs are associated with the object of assessment (Partidário, 2007). An example of identification of the object of assessment and strategic issue can be to promote environmental gains.

3. The Port Strategic reference framework (SRF) constitutes the strategic macro-framework of the PEPI model. This creates an assessment benchmark. It gathers under its umbrella the sustainability and environmental policy macro-objectives established in an international, European, and national context that are relevant to assessment and are legally required (Partidário, 2007). In the setting of the PEPI model it also links to other port management plans and programmes with which the object of assessment establishes relationships, which is also a legal requirement. General reference themes for the identification of a port strategic macro-framework target and objective can be technology, type of energy, transport-mode, land use planning, sustainable development, or climate change.

4. The Environmental factors (PEF) defines the relevant environmental scope, the environmental factors to be analysed, and which who contributes to the CFD (Partidário, 2007). The EFs must be adjusted to each specific case according to the port management strategic focus, the assessment scale and, as a result, their relevance (Partidário, 2007). An example of the adjustment of environmental factors can be climate factors and type of energy use, human health and noise levels, air pollution and energy use etc.

5. Opportunities and risks correspond to the positive and negative strategic impacts which indicate the direction of a trend as the result of selecting a specific pathway (Partidário, 2007). The port environmental management opportunities, positive strategic impacts, and the risks, negative strategic impacts, provide the assessment on how the environmental, social, and cultural values are expected to be used and their integrity affected, and what this can mean in relation to a sustainable development processes for the port.

6. Follow up is ensuring the checks of assumptions and estimates and how the port system respond to the stimuli generated by the adopted strategies. The follow up is fundamental in contexts of great uncertainty for port management. It is likewise important to track the strategy and detect the changes that occur upon its implementation, or even when it is put into practice (Partidário, 2007). This timely detection allows a rapid reaction to strategic route changes, thus ensuring the continuity in the facilitating role of the PEPI model for port management. The PEPI

model strategic follow up relies heavily on monitoring and on the assessment of performance, frequently and swiftly adjusting to the decision cycle, which means that the port management must follow the port strategy's drive through the PEPI model implementation.

7. Perspective is the creation of a transparent process regarding port management strategy decisions and one of the assets of the PEPI model. Partidário (2007) shows to that transparency not only consists of clear information relative to the decisions taken, and the reasons behind the same, but also the fact that different perspectives representing the values of society are taken into consideration, which is fundamental in sustainability processes. The PEPI model thus ensure an ample, multidimensional, cross-sectoral and integrated perspective in a long-term horizon.

8. Decision facilitator – The capacity to facilitate decision making, is for port management, one of the fundamental characteristics of strategic-orientated environmental assessment processes. The purpose of the PEPI model is not to control, but rather to create conditions that ensure the formulation of environmentally sound and sustainable action strategies. The PEPI model will therefore encourage sustainable decisions. The PEPI model is strategy, and not results, oriented. The model will, when used strategically by port management, work with processes and use decision windows to frequently and systematically influence the decision-making process.

9. The communication strategy is a structural part of the PEPI model. Communicating and encouraging the adoption of different attitudes and development options is essential in port environmental processes. The PEPI model acknowledges different perspectives, which can be adjusted by port management to the target groups by communicating, using dialogue, persuasion and negotiation as working techniques, and establishing an environmental framework of institutional governance and participation.

The strategic-based PEPI model in implementing the SEA focus of Partidário (2007), as proposed, encompasses an innovative approach, whereby it invites port management to:

- use dialogue, persuasion, and negotiation as techniques throughout the entire startegic process of port environmental measuring and implementation.

- establish a framework of port institutional governance and participation.
- to recognise different port environmental perspectives.
- create a strategic environmental reference framework (SRF) for port management.
- work on a sustainable future, port environmental development objectives and creating an assessment benchmark for port environmental performance.
- identify Critical Factors for Decision-Making (CFD) through focusing on the fundamental strategic issues (SI) in the proposal, the environmental factors (EF) and the macro-framework defined by the SRF.
- analyse port environmental performance trends and not moments. The description of the starting point, accoridng to Partidário (2007), is based on an analysis of trends. It is the dynamic analysis that matters, not the static analysis.
- perform studies that contribute to the analysis of the port environmental CFDs and provide information to the decision. The PEPI model is not just a strategic environmental assessment (SEA) study that ends in an environmental report.
- analyse port environmental strategies and assess port environmental strategy options for different future scenarios.
- prioritise the exploration of port environmental options that permit a choice, and not only mitigation, foreseeing and avoiding risks (or negative impacts) and exploring opportunities (or positive impacts).
- strongly base its environmental strategy on follow-up. It takes on the form of a process: design, assessment, monitoring - following the planning or programming cycle (Partidário, 2007).
- produce diverse short and successive opinions and reports that track the various PEPI strategic phases and activities and provide information on decision windows.

Based on the Strategic Environmental Assessment (SEA) works of Partidário (2007).

5.7 Results and discussion related to RQ4.

RQ4: "*How can the developed KPI framework be improved continuously?*"

The PEPI model with its KPI framework must be improved continuously. This is ensured possible through the development of new strategies which results from an informal re-analysis of previous strategies, in the context of evolving scenarios and priority objectives, thereby influencing the following environmental port planning or programming cycle. This notion of continuity is crucial to the PEPI model since the object of port environmental assessment is an on-going and iterative process.

The PEPI model share this continuity behaviour to better influence the port decision process. The PEPI model is a tool articulated to be used in the form of a process that accompanies the port planning and programming process. The PEPI model preferentially acts on the port policy, plan, and programme design process, to facilitate the integration of port environmental and sustainability issues, and not on their outcomes. The PEPI model must be strategically adapted to the port decision-making process to increase its effectiveness.

Based on the Strategic Environmental Assessment (SEA) works of Partidário (2007), impact factors in the PEPI model relate to the intentions, or the port strategic environmental development objectives, corresponding to operational, land, economic and social development models, with environmental objectives and targets that are defined in view of both a long- and short-term vision, based on a framework of major development options that allow these same environmental objectives and targets to be achieved. The PEPI model can consider the concrete environmental port actions in plans and programmes, that are proposed as planning or programming solutions, as means of achieving the proposed objectives, but not as ends. The object of port environmental assessment must always be kept fully centred on the development strategy that is implemented through that set of actions. The purpose of assessment through the PEPI model should never be each one of the actions or projects that comprise the solution for plan or programme implementation.

The PEPI model enhances the port management to adopt an environmental strategic approach based on both a long- and a short-term, multidimensional, and cross-sectoral perspective that is highly focused on few, though significant, factors of analysis that are strategic for port environmental decision-making.

The PEPI model used in a strategic approach has three very concrete objectives:

1. Ensure the integration of environmental aspects in port planning, programming, and policy-making processes.
2. Detect opportunities and risks, assess, and compare alternative port environmental development options while these are still open for discussion.
3. Contribute to the establishment of port environmental development contexts that are more appropriate to nest future port environmental development proposals.

The PEPI can through these objectives further contribute to:

- Ensure a strategic view and a wide-ranging perspective in relation to port environmental issues, within a sustainability framework.
- Assist in identifying, selecting, and justifying win-win options relative to the port environmental and development objectives.
- Contribute to the discussion of major options and to a more sustainable environmental port decision.
- Detect strategic port environmental problems and opportunities in the options under analysis and facilitate the appraisal of cumulative effects.
- Suggest port environmental follow-up programmes, through strategic port management and environmental monitoring.
- Ensure participative and transparent processes that involve all relevant stakeholders.
- Foster more integrated decisions in relation to the array of relevant viewpoints (defined according to technical factors and port management political-cultural values).

5.8 Function and expected outcomes of the PEPI model.

The PEPI plays three fundamental, complementary, and non-exclusive functions relative to the port management environmental decision-making process, in a strategic approach:

(1) the integration function of port environmental and sustainability issues into the cyclical strategic processes of port management planning and programming, allowing for the improvement of current and future decisions.

(2) the assessment function of strategic options relative to the opportunities and risks to the environment and to the sustainability processes inherent to the follow-up of certain port strategies.

(3) the validation function of how the PEPI model contributes to greater efficiency in strategic processes and for better quality in the expected outcomes.

The integration function is decisive of the success of remaining functions and of the PEPI model. According to Partidário (2007) there are fundamental aspects in the integration function, which include: understanding which are the critical factors for decision-making (CFD), identifying the critical moments at which fundamental decisions must be made and where the PEPI model contributions are relevant, and ensuring that those contributions are made available for decision-making in an iterative, useful, and timely manner. It further includes defining the structure and interconnection of the port environmental performance and port planning or programming teams, ensuring the sharing of techniques, approaches and the integration of procedures. Partidário (2007) underlines that the integration function, particular mention should be made to the involvement, in different ways, of individual agents and organisations, which ought to be seen as a strategic technique and not just as a mere procedural obligation of public and institutional consultation to comply with legal requirements (Partidário, 2007).

Partidário (2007) shows to that the assessment function corresponds most typically to the assessment of impacts, deemed in a strategic context to be opportunities and risks that must be considered in the selection of the best strategic action. Partidário (2007) further states that it requires the contextualisation in a strategic macro-framework of environmental policy and sustainability. For the PEPI model it creates a benchmark for port strategic assessment, as well as an objective focus on critical factors for port decision-making (CFD), which are associated to criteria and indicators for port environmental assessment. It further requires an analytical component that enables assessment in great uncertainty contexts (Partidário, 2007).

The validation function corresponds to the verification of the PEPI model performance in relation to evolving trends, strategic options, risks, and opportunities during the preparation of port plans and programmes, and the follow-up and verification of uncertainties during implementation. According to Partidário (2007) it encompasses the validation of the assessment and of respective estimates of uncertainties and assumptions by means of a systematic follow-up program that need to be part of the port environmental strategy which tracks the decision-making cycle in its implementation and review phases. Partidário (2007) also shows to that the varied involvement of third-party institutions and civil society is equally fundamental in validation, in a participative context appropriate to the nature of a strategic approach .

The outcomes that can be expected with the application of a strategic-based port environmental assessment using the PEPI model, considering these three functions, summarised:

(1) An institutional and communication strategy aimed at creating the socio-political context required for strategic decision-making and for port environmental assessment.
(2) A strategic port environmental performance reference framework, defined by global environmental and sustainability macro-objectives, establishing the benchmark for integration and assessment.
(3) Critical factors for port management decision-making that provide the structure, the focus and the content to integration and assessment in port environmental related issues.
(4) A real-time suggestion of port environmental situations or initiatives that ensure the proactive integration of port environmental and sustainability issues.
(5) An assessment of the port management risks and opportunities of the port environmental performance development strategy, supported on the compared assessment of major strategic options.
(6) Port environmental planning, management, monitoring and assessment guidelines.
(7) An effective follow-up programme that safeguards port management strategic approach and allows validation of the port environmental performance choices made.

The data in this research supports the initial hypothesis: "***A strategic port environmental tool will provide insights that are useful for identifying practices, informing policy agendas, and setting priorities in environmental port governance***". The relevance and usefulness of the proposed Port Environmental Index model has been confirmed by the scientific community and practitioners alike. In April 2021, Peter Enevoldsen, Director for the Department of Business Development at the University of Aarhus in Denmark, presented the PEPI model for "*Danske Havne*", the trade association for Denmark's commercial ports and a selection of the largest ports in Denmark, with the result that a piloting model of the PEPI will be implemented for further research by this selection of the Danish ports.

6. Conclusions and Recommendations for Further Studies

This chapter explains the contribution of the research and discusses the findings with reference to research questions and objectives. In addition, the scope for future research and conclusions are also included.

6.1 Conclusion

A particular focus in this research was the skills required to solve real-world practical problems. Port environmental impact assessment is a complicated multi-objective decision making problem, where the analysis of the environmental criteria creates a complex environment consisting of (1) conflicting criteria, (2) uncertainties and (3) inaccurate information, which all characterize many decision problems present in the real world.

In this thesis, an indicator framework, the PEPI model, to measure the environmental performance of port companies is proposed. The framework is defined as a system that combines facets of environmental actions into a set of measures focusing on aspects of environmental performance that are most critical for the current and future success of the port organization, thus providing a means to quantify the efficiency and effectiveness of its environmental actions. The importance of an integrated indicator framework for controlling and monitoring the port environmental process cannot be underestimated. It will enable the port organization to create internal benchmarks, produce high quality, transparent environmental reports, and retain the port organization's place as a community leader. At this point, there is no integrated strategic approach to measuring the environmental performance of all components of ports. The ports lack an integrated KPI framework to monitor its environmental activities. The literature research revealed research trying to measure the environmental impacts of ports, but these were not compatible with the port organizational culture. The port companies have many technical KPIs (linked to port activity operations) but very few soft KPIs (linked to port management workflow). Whilst it measures the former, it does not measure the latter. Therefore, this study develops a KPI framework consisting of technical and soft KPIs to enable ports to control and monitor the entire environmental process to achieve the overall goals of the port organization. Besides the port environmental performance framework, another contribution and novelty in this study is addressing its implementation by introducing a comprehensive strategic approach based on the Strategic Environmental Assessment (SEA) works of Partidário (2007).

The PEPI model as a conceptual framework provides a generic approach to developing port environmental performance with room for customization for individual port needs. The proposed PEPI model can be generalized to evaluate the overall greenness of the port in any country with respect to environmental law and based on the relative importance weights assigned to the key selected green port performance indicators. The PEPI model can be used as an assessment tool to reveal the overall greenness of the port and as a monitor tool to ensure maintaining the concentration of pollutants below maximum permissible limits. Moreover, the PEPI model can also be used as a benchmark tool by which a port can compare its performance with other competitive ports.

The novelty of this study is to reveal the underlying relationships among representative factors of port environmental performance by applying the PEPI model. Not only the links among factors were identified, but also the types of links in the forms of driving and dependence powers among different factors were understood. It is expected that researchers and practitioners could benefit from understanding the hierarchy structure of factors. From a practical point of view, the research findings in this study could assist port policymakers to make more effective strategies. Future studies can further explore the interaction mechanism between influencing factors based on this study.

Despite these advantages, this study has several limitations:

- First, the proposed PEPI model in this study only considers linear indicator relationships and the strength of the interaction between factors is not taken into account. Future research regarding the impact intensity among factors should be conducted.
- Secondly, the developed PEPI model is static and does not consider the dynamics of the influence among factors. Future studies are suggested to explore the dynamic interactions among factors.
- Third, the proposed PEPI model is a strategic system model. It is assumed that the identified factors and interaction may appear in ports of different types, sizes, and functions. However, the intensity of interaction among influencing factors may vary with the type, size, and function of ports. It is suggested that future studies should consider the port types, sizes and functions when exploring the impact intensity among influencing factors.

Most importantly, the PEPI model holds a low implementation complexity. The model can be singlehandedly executed by the port owner and/or port authority, and implementation relies less on other actors. The PEPI model provides a multidimensional view of ports environmental performance. The proposed PEPI model enables the port to drill down to different indicators to trace the contribution of each indicator to the overall performance, and consequently recommend improvement strategies for those indicators that need improvement. The PEPI model can be adjusted to any port according to the records of its performance, and to enhance the environmental performance, the port authority should propose strategies to improve the indicators that would need improvements.

6.3 Further Work Required

Under this research program, surveying refers to questionnaires that will be administered to specific stakeholder groups. A survey will be deployed into the project participating ports and become an important tool in improving environmental measurement targets and indicators for the ports.

In having developed a working framework of port environmental practice indicators and received positve detailed feedback from the SETS II directors, a second set of port site visits (referred to as the "*indicator piloting*" site visits) will be undertaken. The purpose of these visits will be to discuss the working framework with site managers to help the PEPI project group arrive at a more concise and workable framework. Port managers will be asked to assess each proposed indicator for its feasibility of implementation at their site in terms of availability of data, confidentiality and ease of implementation. It is here the hope that ideas on amended or alternative indicators, if there will be perceived to be problems, will be proposed.

A further stage in testing the working framework of port environmental practice indicators will be a SETS II member piloting survey. This will be coordinated by the SETS II directors as it is considered that this would help to maximize the response rate. The simplified framework of proposed port site level business practice environmental indicators and explanatory notes used in the indicator piloting site visits (above) will be sent to all SETS II member sites. The respondents will be asked to indicate the feasibility of use of each proposed indicator at their site by simply indicating "*yes*" or "*no*" in the appropriate column. Further comments on individual indicators will be invited if the respondent considered it appropriate.

A great deal of more work is required to integrate the total of registered indicators in this project with a workable Port Environmental Performance Index Management System, not least with respect to ensuring its applicability to all kinds of sizes of ports and the types of training programs that would contribute to the dissemination of the strategic port management systems. Further for ports, size does matter in respect of the nature of issues that are articulated at Level 1, and therefore the type of issues that cascade down. The author has considered situations in which Level 0 and Level 5 might be required. Nonetheless, the logic of the framework architecture is sound and in the next research round the applicability of the PEPI model will be introduced into several Scandinavian ports management system operations.

6.4 The appropriateness of research methodology design

The design of this engaged scholarship research was able to address the the research questions presented in the first chapter. This methodology does pose challenges though, particularly related to perspective awareness, dealing with conflicting views, finding the relevant academic literature and the thinking involved in developing a theory. Three rounds of engaged scholarship have been carried out and each round succeeded in its objectives of building further understanding and contributing to port environmental sustainability practice.

Of the four strengths claimed for Engaged Scholarship B (advancing knowledge) and C (facilitating understanding) were clearly demonstrated. A (increased chance of application) was true in the local area of the study but remains untested at a broader level. D (suitable for interdisciplinary research) was only tested to a limited extent as the disciplines drawn on in this research were already closely related.

In terms of the challenges, those posed related to E (effective engagement) and F (time) were able to be managed. G (applying the method) was found to be the biggest challenge because developing an understanding of the Engaged Scholarship methodology, while simultaneously applying it, adds additional complexity. H (objectivity) was also a challenge because the greater intimacy with the subject of port environmental performance and engagement with the practice make it harder to recognise hidden bias.

Port environmental research is often constrained by being carried out by practitioner/ researchers and being subject to the annual academic time cycle. A further challenge is convincing colleagues, whose research background is primarily engineering science, that the work has similar rigour. The Engaged Scholarship method provides an opportunity to harness the benefits of the unique context while demonstrating rigour and addressing complex theory–practice boundary spanning issues.

Engaged Scholarship should be an appropriate approach for other studies within Maritime Management Education with similar aims. An effective way of undertaking such research in practice and overcoming traditional research boundaries might be collaborations with those familiar with this methodology and social science research. The author plan to continue the work with the PEPI model to implement the findings in practice and undertake research to address the unanswered questions parked on the journey so far.

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8. Appendices

8.1 Appendix A
NSD project approval

MELDESKJEMA

Meldeskjema (versjon 1.6) for forsknings- og studentprosjekt som medfører meldeplikt eller konsesjonsplikt (jf. personopplysningsloven og helseregisterloven med forskrifter).

1. Intro		
Samles det inn direkte personidentifiserende opplysninger?	Ja ● Nei ○	En person vil være direkte identifiserbar via navn, personnummer, eller andre personentydige kjennetegn. Les mer om hva personopplysninger er. NB! Selv om opplysningene skal anonymiseres i oppgave/rapport, må det krysses av dersom det skal innhentes/registreres personidentifiserende opplysninger i forbindelse med prosjektet. Les mer om hva behandling av personopplysninger innebærer.
Hvis ja, hvilke?	□ Navn □ 11-sifret fødselsnummer □ Adresse □ E-post □ Telefonnummer ■ Annet	
Annet, spesifiser hvilke	Lydopptak av samtaler	
Skal direkte personidentifiserende opplysninger kobles til datamaterialet (koblingsnøkkel)?	Ja ○ Nei ●	Merk at meldeplikten utløses selv om du ikke får tilgang til koblingsnøkkel, slik fremgangsmåten ofte er når man benytter en databehandler.
Samles det inn bakgrunnsopplysninger som kan identifisere enkeltpersoner (indirekte personidentifiserende opplysninger)?	Ja ○ Nei ●	En person vil være indirekte identifiserbar dersom det er mulig å identifisere vedkommende gjennom bakgrunnsopplysninger som for eksempel bostedskommune eller arbeidsplass/skole kombinert med opplysninger som alder, kjønn, yrke, diagnose, etc. NB! For at stemme skal regnes som personidentifiserende, må denne bli registrert i kombinasjon med andre opplysninger, slik at personer kan gjenkjennes.
Hvis ja, hvilke		
Skal det registreres personopplysninger (direkte/indirekte/via IP-/epost adresse, etc) ved hjelp av nettbaserte spørreskjema?	Ja ○ Nei ●	Les mer om nettbaserte spørreskjema.
Blir det registrert personopplysninger på digitale bilde- eller videoopptak?	Ja ○ Nei ●	Bilde/videoopptak av ansikter vil regnes som personidentifiserende.
Søkes det vurdering fra REK om hvorvidt prosjektet er omfattet av helseforskningsloven?	Ja ○ Nei ●	NB! Dersom REK (Regional Komité for medisinsk og helsefaglig forskningsetikk) har vurdert prosjektet som helseforskning, er det ikke nødvendig å sende inn meldeskjema til personvernombudet (NB! Gjelder ikke prosjekter som skal benytte data fra pseudonyme helseregistre). Les mer. Dersom tilbakemelding fra REK ikke foreligger, anbefaler vi at du avventer videre utfylling til svar fra REK foreligger.
2. Prosjekttittel		
Prosjekttittel	Innovations in multi-organizational operations: Green transformations in ports and terminals Innovasjoner på tvers av organisasjoner: Det grønne skiftet i havner og terminaler	Oppgi prosjektets tittel. NB! Dette kan ikke være «Masteroppgave» eller liknende, navnet må beskrive prosjektets innhold.
3. Behandlingsansvarlig institusjon		
Institusjon	Universitetet i Sørøst-Norge	Velg den institusjonen du er tilknyttet. Alle nivå må oppgis. Ved studentprosjekt er det studentens tilknytning som er avgjørende. Dersom institusjonen ikke finnes på listen, har den ikke avtale med NSD som personvernombud. Vennligst ta kontakt med institusjonen. Les mer om behandlingsansvarlig institusjon.
Avdeling/Fakultet	Fakultet for teknologi, naturvitenskap og maritime fag	
Institutt	Institutt for maritime operasjoner	
4. Daglig ansvarlig (forsker, veileder, stipendiat)		

Side 1

Fornavn	Atle	Før opp navnet på den som har det daglige ansvaret for prosjektet. Veileder er vanligvis daglig ansvarlig ved studentprosjekt. Les mer om daglig ansvarlig. Daglig ansvarlig og student må i utgangspunktet være tilknyttet samme institusjon. Dersom studenten har ekstern veileder, kan biveileder eller fagansvarlig ved studiestedet stå som daglig ansvarlig. Arbeidssted må være tilknyttet behandlingsansvarlig institusjon, f.eks. underavdeling, institutt etc. NB! Det er viktig at du oppgir en e-postadresse som brukes aktivt. Vennligst gi oss beskjed dersom den endres.
Etternavn	Christiansen	
Stilling	Stipendiat	
Telefon	92208929	
Mobil		
E-post	ac@usn.no	
Alternativ e-post	atmchri@gmail.com	
Arbeidssted	Bakkenteigen	
Adresse (arb.)	Raveien 215	
Postnr./sted (arb.sted)	3184 Borre	
5. Student (master, bachelor)		
Studentprosjekt	Ja ○ Nei ●	Dersom det er flere studenter som samarbeider om et prosjekt, skal det velges en kontaktperson som føres opp her. Øvrige studenter kan føres opp under pkt 10.
6. Formålet med prosjektet		
Formål	Prosjektet formål er å foreta en longitudinell studie av det grønne skiftet i havner og terminaler knyttet til maritim logistikk. Studiens problemstilling er hvordan og i hvilke sammenhenger dette skiftet kan sees som innovasjoner og hvilke innovasjoner som eventuelt skjer mellom forskjellige organisasjoner som opererer i havnene og terminalene.	Redegjør kort for prosjektets formål, problemstilling, forskningsspørsmål e.l.
7. Hvilke personer skal det innhentes personopplysninger om (utvalg)?		
Kryss av for utvalg	□ Barnehagebarn □ Skoleelever □ Pasienter □ Brukere/klienter/kunder ■ Ansatte □ Barnevernsbarn □ Lærere □ Helsepersonell □ Asylsøkere □ Andre	Les mer om forskjellige forskningstematikker og utvalg.
Beskriv utvalg/deltakere	Ansatte i havner og terminaler som arbeider med markedsføring, strategi, forretningsutvikling, ledelse eller prosjektledelse	Med utvalg menes dem som deltar i undersøkelsen eller dem det innhentes opplysninger om.
Rekruttering/trekking	Primært gjennom direkte søk etter personer som havner og terminaler presenterer som kontaktpersoner på egne nettsider. Sekundært gjennom kontakter fra messer, havnekonferanser og etter forslag fra primærkontakter.	Beskriv hvordan utvalget trekkes eller rekrutteres og oppgi hvem som foretar den. Et utvalg kan rekrutteres gjennom f.eks. en bedrift, skole, idrettsmiljø eller eget nettverk, eller trekkes fra registre som f.eks. Folkeregisteret, SSB-registre, pasientregistre.
Førstegangskontakt	Ved epost fra Atle Christiansen, Stipendiat HSN.	Beskriv hvordan førstegangskontakten opprettes og oppgi hvem som foretar den. Les mer om førstegagskontakt og forskjellige utvalg på våre temasider.
Alder på utvalget	□ Barn (0-15 år) □ Ungdom (16-17 år) ■ Voksne (over 18 år)	Les om forskning som involverer barn på våre nettsider.
Omtrentlig antall personer som inngår i utvalget	30	
Samles det inn sensitive personopplysninger?	Ja ○ Nei ●	Les mer om sensitive opplysninger.
Hvis ja, hvilke?	□ Rasemessig eller etnisk bakgrunn, eller politisk, filosofisk eller religiøs oppfatning □ At en person har vært mistenkt, siktet, tiltalt eller dømt for en straffbar handling □ Helseforhold □ Seksuelle forhold □ Medlemskap i fagforeninger	

Side 2

Inkluderes det myndige personer med redusert eller manglende samtykkekompetanse?	Ja ○ Nei ●	Les mer om pasienter, brukere og personer med redusert eller manglende samtykkekompetanse.
Samles det inn personopplysninger om personer som selv ikke deltar (tredjepersoner)?	Ja ○ Nei ●	Med opplysninger om tredjeperson menes opplysninger som kan identifisere personer (direkte eller indirekte) som ikke inngår i utvalget. Eksempler på tredjeperson er kollega, elev, klient, familiemedlem, som identifiseres i datamaterialet. Les mer.
8. Metode for innsamling av personopplysninger		
Kryss av for hvilke datainnsamlingsmetoder og datakilder som vil benyttes	□ Papirbasert spørreskjema □ Elektronisk spørreskjema ■ Personlig intervju □ Gruppeintervju ■ Observasjon □ Deltakende observasjon □ Blogg/sosiale medier/internett □ Psykologiske/pedagogiske tester □ Medisinske undersøkelser/tester □ Journaldata (medisinske journaler)	Personopplysninger kan innhentes direkte fra den registrerte f.eks. gjennom spørreskjema,intervju, tester, og/eller ulike journaler (f.eks. elevmapper, NAV, PPT, sykehus) og/eller registre (f.eks.Statistisk sentralbyrå, sentrale helseregistre). NB! Dersom personopplysninger innhentes fra forskjellige personer (utvalg) og med forskjellige metoder, må dette spesifiseres i kommentar-boksen. Husk også å legge ved relevante vedlegg til alle utvalgs-gruppene og metodene som skal benyttes. Les mer om registerstudier. Dersom du skal anvende registerdata, må variabelliste lastes opp under pkt. 15 Les mer om forskningsmetoder.
	□ Registerdata	
	□ Annen innsamlingsmetode	
Tilleggsopplysninger		
9. Informasjon og samtykke		
Oppgi hvordan utvalget/deltakerne informeres	■ Skriftlig □ Muntlig □ Informeres ikke	Dersom utvalget ikke skal informeres om behandlingen av personopplysninger må det begrunnes. Les mer.Vennligst send inn mal for skriftlig eller muntlig informasjon til deltakerne sammen med meldeskjema. Last ned en veiledende mal her. Les om krav til informasjon og samtykke. NB! Vedlegg lastes opp til sist i meldeskjemaet, se punkt 15 Vedlegg.
Samtykker utvalget til deltakelse?	● Ja ○ Nei ○ Flere utvalg, ikke samtykke fra alle	For at et samtykke til deltakelse i forskning skal være gyldig, må det være frivillig, uttrykkelig og informert. Samtykke kan gis skriftlig, muntlig eller gjennom en aktiv handling. For eksempel vil et besvart spørreskjema være å regne som et aktivt samtykke. Dersom det ikke skal innhentes samtykke, må det begrunnes. Les mer.
10. Informasjonssikkerhet		
Spesifiser	Digital lydopptaker vil bli brukt til opptak under intervju av informanter	NB! Som hovedregel bør ikke direkte personidentifiserende opplysninger registreres sammen med det øvrige datamaterialet. Vi anbefaler koblingsnøkkel.
Hvordan registreres og oppbevares personopplysningene?	□ På server i virksomhetens nettverk □ Fysisk isolert PC tilhørende virksomheten (dvs. ingen tilknytning til andre datamaskiner eller nettverk, interne eller eksterne) □ Datamaskin i nettverkssystem tilknyttet Internett tilhørende virksomheten □ Privat datamaskin □ Videoopptak/fotografi ■ Lydopptak □ Notater/papir □ Mobile lagringsenheter (bærbar datamaskin, minnepenn, minnekort, cd, ekstern harddisk, mobiltelefon) □ Annen registreringsmetode	Merk av for hvilke hjelpemidler som benyttes for registrering og analyse av opplysninger. Sett flere kryss dersom opplysningene registreres på flere måter. Med «virksomhet» menes her behandlingsansvarlig institusjon. NB! Som hovedregel bør data som inneholder personopplysninger lagres på behandlingsansvarlig sin forskningsserver. Lagring på andre medier - som privat pc, mobiltelefon, minnepinne, server på annet arbeidssted - er mindre sikkert, og må derfor begrunnes. Slik lagring må avklares med behandlingsansvarlig institusjon, og personopplysningene bør krypteres.
Annen registreringsmetode beskriv		
Hvordan er datamaterialet beskyttet mot at uvedkommende får innsyn?	Digital lydopptaker oppbevares nedlåst og har ikke tilkobling til datamaskin eller internett.	Er f.eks. datamaskintilgangen beskyttet med brukernavn og passord, står datamaskinen i et låsbart rom, og hvordan sikres bærbare enheter, utskrifter og opptak?

Side 3

Samles opplysningene inn/behandles av en databehandler (ekstern aktør)?	Ja ○ Nei ●	Dersom det benyttes eksterne til helt eller delvis å behandle personopplysninger, f.eks. Questback, transkriberingsassistent eller tolk, er dette å betrakte som en databehandler. Slike oppdrag må kontraktsreguleres.
Hvis ja, hvilken		
Overføres personopplysninger ved hjelp av e-post/Internett?	Ja ○ Nei ●	F.eks. ved overføring av data til samarbeidspartner, databehandler mm.
Hvis ja, beskriv?		Dersom personopplysninger skal sendes via internett, bør de krypteres tilstrekkelig. Vi anbefaler ikke lagring av personopplysninger på nettskytjenester. Bruk av nettskytjenester må avklares med behandlingsansvarlig institusjon. Dersom nettskytjeneste benyttes, skal det inngås skriftlig databehandleravtale med leverandøren av tjenesten. Les mer.
Skal andre personer enn daglig ansvarlig/student ha tilgang til datamaterialet med personopplysninger?	Ja ○ Nei ●	
Hvis ja, hvem (oppgi navn og arbeidssted)?		
Utleveres/deles personopplysninger med andre institusjoner eller land?	● Nei ○ Andre institusjoner ○ Institusjoner i andre land	F.eks. ved nasjonale samarbeidsprosjekter der personopplysninger utveksles eller ved internasjonale samarbeidsprosjekter der personopplysninger utveksles.
11. Vurdering/godkjenning fra andre instanser		
Søkes det om dispensasjon fra taushetsplikten for å få tilgang til data?	Ja ○ Nei ●	For å få tilgang til taushetsbelagte opplysninger fra f.eks. NAV, PPT, sykehus, må det søkes om dispensasjon fra taushetsplikten. Dispensasjon søkes vanligvis fra aktuelt departement.
Hvis ja, hvilke		
Søkes det godkjenning fra andre instanser?	Ja ○ Nei ●	I noen forskningsprosjekter kan det være nødvendig å søke flere tillatelser. Søkes det f.eks. om tilgang til data fra en registereier? Søkes det om tillatelse til forskning i en virksomhet eller en skole? Les mer om andre godkjenninger.
Hvis ja, hvilken		
12. Periode for behandling av personopplysninger		
Prosjektstart Planlagt dato for prosjektslutt	01.12.2017 31.12.2020	Prosjektstart Vennligst oppgi tidspunktet for når kontakt med utvalget skal gjøres/datainnsamlingen starter. Prosjektslutt: Vennligst oppgi tidspunktet for når datamaterialet enten skalanonymiseres/slettes, eller arkiveres i påvente av oppfølgingsstudier eller annet.
Skal personopplysninger publiseres (direkte eller indirekte)?	□ Ja, direkte (navn e.l.) □ Ja, indirekte (identifiserende bakgrunnsopplysninger) ■ Nei, publiseres anonymt	Les mer om direkte og indirekte personidentifiserende opplysninger. NB! Dersom personopplysninger skal publiseres, må det vanligvis innhentes eksplisitt samtykke til dette fra den enkelte, og deltakere bør gis anledning til å lese gjennom og godkjenne sitater.
Hva skal skje med datamaterialet ved prosjektslutt?	■ Datamaterialet anonymiseres □ Datamaterialet oppbevares med personidentifikasjon	NB! Her menes datamaterialet, ikke publikasjon. Selv om data publiseres med personidentifikasjon skal som regel øvrig data anonymiseres.Med anonymisering menes at datamaterialet bearbeides slik at det ikke lenger er mulig å føre opplysningene tilbake til enkeltpersoner. Les mer om anonymisering av data.
13. Finansiering		
Hvordan finansieres prosjektet?	Stipendiat ansatt ved HSN	Fylles ut ved eventuell ekstern finansiering (oppdragsforskning, annet).
14. Tilleggsopplysninger		
Tilleggsopplysninger	Intervju vil transkriberes fortløpende og lydopptakene vil slettes.	Dersom prosjektet er del av et prosjekt (eller skal ha data fra et prosjekt) som allerede har tilrådning fra Personvernombudet og/eller konsesjon fra Datatilsynet, beskriv dette her og oppgi navn på prosjektleder, prosjekttittel og/eller prosjektnummer.
15. Vedlegg		
Vedlegg	Antall vedlegg: 3. ● temaliste_atle_christiansen_2017.docx ● project_description_atle_christiansen_signed.pdf ● informasjonsskriv_atle_chri_2017.doc	

Side 4

8.2 Appendix B
Focus Group Interview Guide

Fokus gruppe intervju guide

Prosjektbakgrunn: Interreg, SETS II, USN.

Prosjekt: Port Environmental Performance Index (PEPI).

Prosjektmål: Et strategisk beslutningsverktøy for havners miljømessige utførelse.

Nøkkelord:

- Havner
- Det grønne skifte
- Bærekraft
- Bærekraftig utvikling
- Klimaforandringene
- SDG`r
- Elektrifisering
- Miljø
- Strategi
- Beslutningstaking
- Regelverk
- Lovverk
- Politisk innsats
- Skip-krav
- Havner krav
- Samfunnet/naboer
- KPIs-måleenheter
- Målbarhet
- Sammenlignbarhet/Benchmarking
- Informasjonsdeling
- Miljømessige verktøy
- Insentiver
- Fremtiden
- Forventninger
- Modelloppnåelse

8.3 Appendix C

Common port environmental challenges and non-conformities (adapted from Paipai et. al. (2000)

1	The role of the top management representative is not clearly defined
2	Environmental responsibilities and authorities of other personnel are not clearly identified
3	Environmental responsibilities are not communicated to relevant personnel
4	Significant changes to job descriptions to reflect environmental responsibilities are not clearly acknowledged and communicated to relevant personnel
5	Appropriate training is not delivered, particularly where the training needs assessment has identified potential environmental impacts associated with certain responsibilities and activities
6	Training of personnel and contractors with environmental responsibilities is found to be inadequate or not complete
7	Failure to maintain the training records
8	Failure to undertake an evaluation to determine competence of trained personnel with environmental responsibilities
9	The environmental policy is not made available to the public
10	Communications procedures are not established or maintained
11	Complaints from the public are not communicated to the appropriate personnel
12	Responses to the complaints from the public are not recorded
13	Internal communications are not effective in conveying environmental policy targets, training programmes, recommendations for improvement, significant changes to personnel responsibilities to include environmental responsibilities, etc
14	Procedures and responsibilities for setting up, updating and controlling an internal documentation system, on environmental management programme, are not properly defined
15	Environmental management documents are reviewed periodically to ensure that reference is made to current procedures and not out of date
16	There is no good cross-referencing between documents
17	Breaches of environmental legislation compliance are not recorded
18	The identification, traceability and retrievability of records is poor
19	The objectives and targets are not set out in the environmental policy
20	There is no link between the environmental objectives and targets and the relevant environmental legislation, particularly where there is a potential for non-compliance with an environmental legal requirement
21	There is no link with the analysis and evaluation of significant aspects and impacts
22	Environmental objectives and targets are not fully documented
23	The Environmental Policy is not defined by “top management”
24	The use of a corporate policy where a site/group of activities or operations policy is more relevant
25	The Environmental Policy is not relevant to activity and scope
26	The Environmental Policy does not include the objectives and targets towards improved environmental performance
27	Commitment to continual environmental improvement, eg. Continual improvement and prevention of pollution, is not clearly defined
28	Identification of relevant environmental legislation requirements is not sufficiently comprehensive

29	Access to environmental legislation documents cannot be demonstrated
30	Verification of compliance with environmental legislation requirements cannot be demonstrated

8.4 Appendix D
Port Environmental Indicators

1	Accidental leakage of petroleum and chemical substances
2	Adhere to get (by planning authority) working hours for noisy demolition/construction activities.
3	Adjust the type of importing bulk cargo (e.g., replace coal splinter with block coal)
4	Adopt LEED standard for green building certificate
6	Aesthetic interference/Visualimpact/Improving city scenery
7	Agricultural activity
8	Air Pollution
9	Air pollution avoidance (toxic gas regulation)
10	Air quality
11	Air quality(GHG)
12	Airborne particles
13	Allow public to have port tour
14	Anchor
15	Annual plan for air pollution
16	Any facility aiming at minimising/preventing contamination of water sediments or soils should be clearly signed and easily accessible.
17	Apply greenhouse gas emission inventory
18	Apply innovative green R&D and technology
19	Apply new energy-saving operational processes
20	Asthma
21	Automate port system
22	Automatic emergency shut down of flow system should be in place and regularly maintained.
23	Avoid decreasing community real estate
24	Avoid decreasing community real estate value du to the existence of cargo pipelines
25	Avoid decreasing community real estate value due to the existence of cargo pipelines
26	Avoid disturbance to the community during infrastructure construction and expansion
27	Avoid dust pollutant during loading and discharging
28	Avoid hosing down of vehicles and equipment near storm drains or natural watercourse.
29	Avoid using chlorinated solvents.
30	Avoiding disturbance to community during
31	Avoiding disturbance to community during infrastructure construction & demolishment
32	Avoiding the dustpollutant during loading & discharging
33	Ballast
34	Ballast water pollutant control
35	Ballast water pollutant prevention
36	Ballast water pollution
37	Beach beard
38	Biodiversity

39	Biodiversity and Natural habitats
41	Biology & wetl and impacta voidance/Reducing infrastructure disturbance to marine biology density
42	Boat
43	BOD (mg/L)
44	Body and Impeller sediment
45	Brightness
46	Cancer and mortality)
47	Car traffic
48	Carbon dioxide (CO2)
49	Carbon effects
50	Carbon footprint
51	Carbon monoxide (CO) (ppm)
52	Carbon monoxide (CO) and Volatile organic compounds (VOCs)
53	Carbon transport effects
54	Cargo spill control and prevention
55	Cargo transportation
56	CH4
57	Changing marine ecosystem
58	Chemical waste residues
59	Chemicals
60	Chromium (Cr) (mg/kg wt)
61	city scenery
62	Clarify the Permitted Development Rights situation early on at the planning stage of a development plan.
63	Clean regularly oil/water separators.
64	Clean ship
65	Clean Shipping index
66	Clean up frequently during dismantling to prevent material from either becoming airborne and/or being blown into water.
67	Clean up immediately afier spills and properly dispose off collected spills.
68	Clean up immediately after dry washing and before wet washing.
69	Clean up immediately after spillages – do not hose down near storm drains.
70	Clean up immediately after spills of chemicals/oils and debris.
71	Clean up spillages as soon as it is practicable and ensure regular sweeping of handling areas.
72	Clean up spills and dry paint stripping waste immediately particularly if it can become airborne.
73	Clean up spills immediately.
74	Clean up spills of fluids immediately and certainly prior to scrapping.
75	Clean up storage areas regularly to prevent wood chips from entering drainage system and/or natural watercourses.
76	Clearly identify asbestos-containing material and have it removed by a licensed professional.

77	Clearly identify hazardous material (e.g. asbestos, PCBs etc) and designate areas for their storage prior to being transported to a licensed disposal site.
78	Clearly identify, mask and/or fence-off sensitive areas.
79	Clearly label spill response equipment and make staff aware of trained employees to combat spills.
80	Clearly label storage areas.
81	Clearly sign sensitive areas and provide information on boards at key locations on reasons for sensitivity/designations (e.g. Nature reserve) and if possible fence off sites or provide buffer zones.
83	Climate change
84	CO
85	Coastal hydrology (Wave front variation
86	COD (mg/L)
87	Cold ironing (on-dock power supply)
88	Collect all forms of waste generated on board the ship
89	Collect ship waste water (ballast water)
90	Commercial fish losses
91	Communicate in advance with local community and notify close by residents of noisy activities, and their duration.
92	Community Promotion and Education
93	Compact waste (e.g. drums) as much as possible but ensure that no materials residues (e.g. paints, solvents) are present.
94	Concession agreements with companies operating in port
95	Conduct (as frequently as practicable) inspections of handling and storage facilities – maintain them as regularly as possible.
96	Conduct continuous inspection of dredging and disposal activities.
97	Conduct repair/maintenance work in a dry dock if possible, if not designate a paved and bunded area away from a natural watercourse.
98	Conduct spill response training and drills.
99	Consider hours of noisy handling operations.
100	Consider recycling and sorting of all appropriate materials such as brick/tiles, steel, glass, wood, plastic/rubber.
101	Consider recycling of washwater wherever possible.
102	Consider sloped paved areas to drains discarding into the sewerage system.
103	Consider the use of confined disposal facilities with the potential to reuse the dredged sediment beneficially at a later stage – pre-treatment to remove contaminated fraction may be necessary to maximise the potential for beneficial use.
104	Consider the use of silt controls as much as practicable, both structural (eg. Silt curtains) and natural (eg. During ebb tide) or time works at low tide.
105	Construction
106	Construction equipment
107	Consult with both statutory and non-government organisations on sensitive of aquatic habitats and nature conservation management policies and practices in place.

108	Consult with relevant competent authorities to ensure adequate protection of sensitive features (e.g. make one employee responsible for assuring that maintenance/restoration work does not cause any damage).
109	Consumption of resources
110	Consumption of resources and development of the port
111	Contamination of sediment
112	Cooperate with academia
113	Costs (Water consumption
114	Cover dust sources for as long as practicable.
115	Cover storage areas (eg. Stockpiles) and handling equipment (eg. Conveyor belts) (where practicable and necessary.
116	Cover transport vehicles and ensure regular inspection for spillages.
117	Cover work areas if possible, particularly while paint spraying takes place.
118	Crane
119	Create nature compensatory mitigation sites (green infrastructure)
120	Critical situation planning
121	Cruise ship
122	Crushers maintenance
123	Dangerous cargo
124	Death
125	Deforestation
126	Degradation of agricultural products
127	density
128	Designate and clearly mark vehicle wash areas for in-coming (external) vehicles.
129	Designate special areas for painting/paint stripping – covered if possible.
130	Destruction and loss of habitat
131	Destruction of habitat
132	Develop environmental concepts
133	Diesel and Petrol
134	Diesel oil
135	Disaster recovery planning
136	Discharge and Loading
137	Discharge and loading of hazardous materials
138	Discharge and Mooring
139	Discourage in-water boat cleaning.
140	Discourage unnecessary vehicle transport to reduce air emissions and keep noise levels and duration in control.
141	Dispose of sand blast/paint/metal residues to licensed disposal sites.
142	Dispose off properly of empty containers – ensure they are empty.
143	Dispose off properly of hazardous stripping wastes. • Avoid hosing down maintenance areas – opt for sweeping regularly.
144	Do not designate storage/handling areas near storm drains.
145	Do not keep oil filled containers near floor drains.
146	Do not leave drums on non-paved areas or close to watercourses/storm drains.

147	Do not locate fuelling areas near storm drains – if possible.
148	Do not overspray with weedkillers and choose a dry day to do so.
149	Do not overstock paints and solvents.
150	Do not overstock to prevent discarding of containers with residual detergents/soaps inside.
151	Do not overstock with chemicals-containing drums.
152	Do not overstock with cleaning agents/solvents to ensure that no half empty containers are left or discarded unresponsibly.
153	Do not overstock with weedkillers and other pesticides as they will require proper disposal once the have reached their expire date.
154	Do not rinse out empty containers near a storm drain or a water feature – do not hose down paved (landscaped) areas after spraying vegetation borders with weedkillers.
155	Do not sand blast over open water.
156	Do not wash vehicles near storm drain system – wash water should be directed to sewerage system.
157	Drain all fluids and remove batteries from vehicles and equipment which is to be destroyed.
158	Drain well containers of chemicals/oils before discarding to designated (well labelled) skips.
159	Dredge monitoring and assessment
160	Dredging
161	Dredging sediment disposal
163	Drilling
164	Dry port investment and maintenance operations
165	During oil/water separators cleaning prevent run-off from reaching a natural watercourse or unpaved areas.
166	Dust
167	Dust control
168	Early death
169	Ease port congestion
170	Ecologic
171	Ecological Footprint
172	Ecological monitoring in port area
173	Ecology preservation & environment protection training
174	Economic and Environmental Sustainability
175	Ecosystem of habitat
176	E-document program
177	Effects of greenhouse gases
178	Electrify port equipment
179	Embankment
180	Emission factors
181	Emissions
182	Emissions (NOx
183	Emissions of pollutants (CO2
184	Employ licensed contractor to handle hazardous waste
185	Empty waste receptacles for putrescible (garbage) as soon as they are filled up.

186	Empty waste receptacles frequently.
187	Empty waste receptacles regularly and inspect regularly for leaks.
188	Encourage participation in the community`s environmental protection
189	Encourage public participating in port planning
190	Encourage public transport mode development
191	Encourage reuse/recycling of drums.
192	Encourage ship captains to reach safe distances offshore before achieving full power.
193	Encourage ship masters to ensure regular deck clean-up.
194	Encourage skippers to adhere to set speed limits for manoeuvring near shore.
195	Encourage skippers to maintain on-board engines in good order to reduce exhaust emissions.
196	Encourage use of less toxic antifouling paints.
197	Encourage use of water saving facilities
198	Encourage using environment-friendly materials
199	Encouraging public transport mode development
200	Encouraging use of low-sulphur fuel
201	Energy
202	Energy consumption
203	Energy management
204	Energy Usage
206	Engine fuel leaks
207	Ensure adequate and regular inspection of fuel storage tanks and record inspection findings and corrective actions.
208	Ensure adequate containment measures (eg. Strength of surrounding mound) and inspect regularly for cracks and likelihood of wall failure.
209	Ensure adequate product inspection upon arrival to minimise risks of pests (see appropriate Guidance from Customs and Excise or LA).
210	Ensure adherence to management practices/protection measures by regular inspection and verbal reminding (as appropriate and if feasible).
211	Ensure all containers are marked and labelled properly.
212	Ensure available capacity to contain accidental (major) spills from storage facilities.
213	Ensure collection and disposal of demolition/restoration waste is handled by licensed waste management companies.
214	Ensure collection and off-site removal of waste by a professional waste handler.
215	Ensure containment of organic waste and prevent leachates from biodegrading waste from reaching storm drainage.
216	Ensure drums are empty and if possible mesh them in designated areas prior to discarding them.
217	Ensure handling and transport of hazardous material is done by licensed qualified professionals.
218	Ensure handling, transport and disposal are carried out by licensed and competent people.
219	Ensure maintenance of fuelling facilities in accordance with manufacturers guidelines.
220	Ensure regular inspection of protection measures for a sensitive site.
221	Ensure swift collection of organic waste if refrigeration is not possible particularly in the warmer months.

222	Ensure that adequate studies on environmental impacts are carried out and that advice from nature conservation authorities is fully sought.
223	Ensure that all construction staff are aware of why and how to protect sensitive areas.
224	Ensure that leak detection and overfill protection are working correctly.
225	Ensure that outside oil spill response is available if none exists in port/harbour (subject to size of port/harbour).
226	Ensure that sensitive/designated areas outside of the dredging/disposal area are not likely to be significantly affected by means of plume dispersion and subsequent resettlement of suspended solids or runoff from disposal site.
227	Ensure that stormwater is collected and pumped to sewerage – recycle water as much as possible.
228	Ensure that vibration during demolition/construction and from construction traffic does not damage listed buildings in and around the port/harbour grounds.
229	Environmental education and Awareness
230	Environmental management and energy management information system
231	Environmental Quality
232	Environmental Sustainability
233	Erosion
234	esablish environmental policies
235	Establish compensation area or alternative area
236	Establish indicators of habitat quality
237	Establish managerail organization for green port development
238	Establish the carbon footprint
239	Evapotranspiration
240	Expansion of tidal areas for habitat restoration
241	Explore beneficial uses of dredged materials with competent authorities and interested organisations
242	Fishing
243	Flood impact and control
244	Flood impact and control
245	Flow
246	Freight traffic volume
247	Fuel consumption
248	Fuel ferries
249	Fuel quality
250	Fuel spill contingency plan
251	Fuel storage
252	Garbage classification in port area
253	Garbage evacuation
254	Garbage in port
255	General health
256	General Waste Handling
257	Global warming
258	Gluten Gases (CO2

259	Greenhouse gas costs
260	Greenhouse gas emissions
261	Greenhouse gassing
262	Grow flowers or trees in port area
263	Habitat loss
264	Habitat Quality
265	Handle on board sewage
266	Harmful aquatic organisms (Dinoflagellate
267	Have a contingency plan in place and have emergency drills.
268	Have in place plans to deal with unforeseen discovery of contaminated ground, particularly drums, canisters, old spoil heaps. Contaminated soil may be a material consideration for the purpose of granting planning permission.
269	Hazardous
270	Hazardous cargo
271	Hazardous cargo management
272	Hazardous Waste Handling
273	HCFC
274	Health and safety
275	Heart
276	Heating
277	Heavy vehicles
278	Hold green port seminar
279	Hourly weather parameters (Temperature
280	Human life
281	Human migration
282	Humidity
283	Hydrocarbons (HC) (mg/m3)
284	Hydrocarbons (HC) (mg/m3)
285	Hydrological conditions (Precipitation
286	Identify and make employees aware of the importance of protecting designated areas (e.g. watercourses, woodlands) in or near the port/harbour.
287	Identify areas where hazardous materials are likely to be encountered and remove these materials or their residues before dismantling.
288	Identify energy consumption
289	Identify environmental categories of pollution
290	Identify environmental impacts
291	Identify environmental objectives and priorities
292	Identify impacts on aquatic life and appropriate mitigation measures.
293	Identify parts of buildings or ground which, if disturbed, may release contaminants or irritants, and contain/control them.
294	Identify potential recycling/other beneficial uses of wood chips/by-products.
295	Identify, remove and dispose prior to demolition of all PCB-containing equipment.
296	Idle control on vehicles and cargo handling equipments

297	Idle truck parking arrangement
298	If a waste management plan is in place review its applicability and effectiveness regularly and carry out corrective actions immediately.
299	If it is financially feasible, consider the use of concrete instead of steel as the latter may release paints and metals into the water over time.
300	If possible (feasible) provide separate storm drain system to the paved storage areas and shape them to ensure maximum trapping of oily waters.
301	If possible determine and stick to seasonal construction "opportunities" (eg. Avoid piling in channel during salmon migration season.
302	If possible fence off and provide signs to sensitive areas.
303	If possible use dredgers with the least possible sediment resuspension impact.
304	If possible, conduct noisy handling activities within working hours – but keep good communication links with local community.
305	If ship/vessel is at pier – prevent debris from falling in water.
306	If storm drains are near a fuelling activity, cover it whilst refuelling is taking place.
307	If the use of silt curtains is a cost prohibiting option – identify "windows" of time to carry out dredging/disposal activities with the least impact on sensitive environmental resources.
308	Implement an accredited Environmental Management System
309	Implement dust and smoke recycle measures
310	Implement wastewater assessment and reduction methods
311	Improve the standard of ship's sanitation equipment
312	Improvewilligness to reuse recyclable resources
313	Improving willingness to reuse recyclable resources
314	increase relevant stakholders adopting environmental policies
315	increase technical capacity of staff
316	Industrial and urban enrichment
317	Industrial effluent
318	Industrial facilities
319	Industrial production
320	Inform local community of timing of noisy (eg. Blasting) works and keep such works within working hours.
321	Inform vessel masters of waste collection/storage facilities and monitor (as much as practicable) proper use of these facilities (i.e. hazardous waste disposed off in designated receptacles),
322	infrastructure construction & demolishment
323	infrastructure disturbance to marine biology
324	Infrastructure impact avoidance
325	Inspect paved areas regularly for cracks and seal them as soon as possible.
326	Inspect regularly dampened stockpiles to ensure they are staying damp.
327	Inspect regularly repair/maintenance facilities and equipment and restore/repair accordingly.
328	Inspect regularly storage areas for damaged containers or damages to storage bunds or paved areas (e.g. cracks/voids) – and contain leaks as soon as identified.
329	Inspect regularly the sewage pump out and bilge water collection facilities.

330	Inspect storage areas regularly for leaks.
331	Inspect storage tanks and loading equipment regularly for leaks – maintain these facilities regularly.
332	Inspect vehicle storage area frequently for evidence of oil, brake fluid, battery leaks.
333	Install air filter on port machines
334	Install and maintain oil/water separators.
335	Install double insulation windows and boards
336	Install palisade on sewage pipe
337	Install wind screens and solids collection screens.
338	Insulation
339	Intercept storm water runoff to prevent it from reaching fuelling facilities.
340	Introduce electrical powered equipment
341	Introduce energy management system (e.g ISO 50001)
342	Introduce environmental risk management
343	Introduce incentive schemes
344	Introduce paperless port system in general
345	Investigate sewage source
346	Investment
347	Issue annual green port reports
348	Keep debris containers well labelled and away from storm drains.
349	Keep light masts to such angles so that security is enhanced but local residences are not affected.
350	Labor transport
351	Land and Sediments Pollution
352	Lead (Pb) (mg/kg wt)
353	Legg til rette for Clean energy (wind, solar, wave, renewable)
354	Leq24 (db/(A))
355	Light Pollution
356	Light pollution
357	Lighting
358	Limit the use of creosote-treated wood in the water because of the potential of toxic substances being released into water.
359	Liquid cargo spills
360	Liquid cargoes spilling contingency plan
361	Liquid Pollution
362	Lmax (db((A))
363	Local community
364	Locate stockpiles of demolition debris in places where sediment control is feasible.
365	Locate storage areas at considerable distance from a watercourse. Avoid long term stockpiling and cover product as much as possible to minimise/prevent leaking of wood preservatives into run off water.
366	locomotives
367	Lung cancer

368	Maintain and clean equipment used in repair works to eliminate/minimise build up of contaminants.
369	Maintain handling and storage facilities regularly.
370	Maintain or ensure the (external) provision of adequate supplies of spill response equipment in key locations.
371	Maintain original vegetation cover and replenish it as much as possible.
372	Maintain regularly and repair faulty CFC-containing refrigerating equipment.
373	Maintain ship to shore handling equipment in good order to reduce leaks of oils/greases in the water.
374	Maintenance
375	Make green port part of corporate culture
376	Make maximum use of the beneficial effect of vegetation cover on drainage and run offs. For example, create buffer zones (eg. Vegetation cover) between sensitive areas (eg. A watercourse) and development activity.
377	Make personnel aware of the environmental implications of badly handled/stored/disposed of wastes.
378	Make staff aware of consequences of neglect and provide training.
379	Make staff aware of environmental implications if environmental practices listed above are not followed.
380	Make staff aware of the risks of pests and the benefits of “good-housekeeping” with regard to timber by-products (eg. Bark fragments).
381	Make workshops staff aware of environmental consequences from failing to opt any of the above practices.
382	Manage ballast water
383	Maneuvering
384	Marine and Terrestrial ecosystem changes
385	Marine and Terrestrial ecosystems
386	Marine Benthos Biodiversity (MB)
387	Marine biology preservation & protection
388	Marine bird injuries
389	Marine ecological protection and biological system preservation
390	Marine ecosystem
391	Marine ecosystem changes
392	Marine traffic
393	Maritime traffic and shipping
394	Materials Selection
395	Mercury (Hg) (mg7kg wt)
396	Microclimate design
397	Minimise malodour to prevent the attraction of pests.
398	Minimize environmental damages
399	Monitor Air Quality
400	Monitor dust levels
401	Monitor noise levels during construction and operation
402	Monitor receptacles for disposed wastes which should be handled differently (e.g. batteries).

403	Monitor smoke from vessels
404	Monitor Soil and Sediment Quality
405	Monitor system for water pollution
406	Monitor water quality
407	Monitor water usage and leakage
408	Monitoring system for noise level
409	Mooring
410	Mortality
411	Motorcycle
412	Natural damage
413	Nitrogen oxides (NOx)
414	NO2
415	NO2 and SO2
416	Noise
417	Noise and Waste generation
418	Noise Pollution
419	Noise pollution management
420	NOx
421	Odor
422	Odor control
423	Oil and Grease (OG) (mg/L)
424	Oil pollution
425	Oil residues
426	Oil spill
427	Oil spill contingency plan
428	Oil spills from industries
429	Oil summit
430	On-site water treatment and reuse
431	Opt for brush-roller painting rather than spraying.
432	Opt for native vegetation to minimise the need for weedkillers and maintenance in general.
433	Ozone
434	Ozone concentrations
435	Ozone tropospheric
436	Particulate matter (pm)
437	Particulate matter (PM10) (mg/m3)
438	Particulates (PM)
439	Pathogenic bacteria such as bacteria)
440	Pave areas around storage tanks to prevent seepages into the spoil and groundwater – and inspect regularly for voids.
441	Pave, slope and bund the fuelling area to prevent spills/leaks from reaching groundwater, to collect spills towards an oil/water separator and to prevent storm water runoff escaping.
442	Pay attention to research and the application of clean energy technologies
443	pH

444	Phytoplankton Biodiversity (PP)
445	Pipeline changes
446	Pipeline operation
447	PM
448	PM10
449	PM2.5
450	Pollution emission
451	Pond damage
452	Port activities
453	port activity (Manoeuvring
454	Port and ship waste
455	Port call optimazation and just in time arrival of vessels
456	Port Cargo
457	Port Construction
458	Port development
459	Port development (water and land)
460	Port entrance sediment and coastal erosion control
461	port environmental index (PEI)
462	Port expansion
463	Port Greenery
464	Port landscaping to use local native species
465	Port machines use clean fuel with lower sulfur content
466	Port maintenance and pollution avoidance
467	Port Staff Training
468	Prefer intermodal solutions in ordeer tol lower dependence on trucks
469	Prevent as much as practicable storm water from entering maintenance area.
470	Prevent debris from entering storm drain and soil/water separators.
471	Prevent run off from flowing across disturbed soil
472	Prevent solid debris from entering drains into oil/water separators – clean them regularly.
473	Procure locally available materials and suppliers
474	Procure only sustainable logistics
475	Promote artifical intelligence (AI) in ports
476	Promote environment-friendly transport
477	Promote green marketing strategy
478	Promote green port concept for the community
479	Promote greening ports to the public
480	Promote port ride share or use shuttle bus
481	Propeller
482	Propulsion machinery
483	Protect coastal and estuarine ecosystems
484	Protect root system of trees (generally any area covered by the tree canopy) and overhanging trees from on-site demolition/restoration traffic.
485	Protect water features and habitats from run off.

486	Protect water features, species and habitats from runoff from demolition/restoration site.
487	Provide a dedicated storage area for recycling
488	Provide absorbent material at key locations.
489	Provide adequate and easily accessible solid waste storage facilities, and good signs to their location.
490	Provide adequate information on existing environmental protection controls to all contractors and sub contractors.
491	Provide adequate information on nature and timing of construction activities to other meter users (eg. Recreational clubs).
492	Provide adequate run off control from fish processing areas.
493	Provide adequate ship to shore waste handling facilities and ensure good signs to the location of waste skips.
494	Provide adequate solid waste storage facilities and good signs to their location.
495	Provide adequate space (eg. Sump) for capturing spills and leaks and clean the area regularly.
496	Provide adequate storage area for chemicals and waste.
497	Provide adequate supplies of oil spill response equipment.
498	Provide adequate waste reception facilities to reflect the number of passenger turnover – maintain these facilities in good order.
499	Provide and clearly identify storage space for paints and paint stripping material.
500	Provide and clearly identify storage space for weedkillers, fertilisers and restrict access to that space.
501	Provide and label clearly containers for receiving solid oily wastes.
502	Provide clearly labelled waste skips.
503	Provide containment and well labelled areas for detergents.
504	Provide cover over washing facilities and barriers to prevent storm water from entering them.
505	Provide cover to dismantling facility, if possible, and to scrap/debris particularly in wet weather.
506	Provide covered (ie. enclosed) and paved maintenance areas.
507	Provide data sheets on the properties of stored/handled materials.
508	Provide designated and clearly labelled storage areas for paints and solvents.
509	Provide environmental training if feasible.
510	Provide for easy passage of marine life (eg. Allow space between berths and berthed vessels).
511	Provide green facilities/building guide and training
512	Provide green port training
513	Provide green port web site
514	Provide information on how to protect sensitive/designated areas.
515	Provide job opportunity
516	Provide liners under storage for tank wash down and cleaning waters, to prevent them from entering drainage (storm) system.
517	Provide means of environmental awareness and training.
518	Provide measures to capture paint drips and strips if repair/maintenance activity takes place at a pier.
519	Provide oil/water separators (and maintain them regularly) to the storage areas.

520	Provide oil/water separators and maintain them regularly.
521	Provide oil/water separators on floor drains and connect drains to dead end sump.
522	Provide onshore paved and bunded space for boat restoration/maintenance activities.
523	Provide onshore power supply
524	Provide paved and bunded areas for dismantling and storage facilities.
525	Provide paved areas for storage and on-/off loading of vehicles to reduce airborne (dust) particles and protect groundwater from oil seeping.
526	Provide paved surfaces and cover to storage areas and protect them from storm water run-on and off.
527	Provide port waste reception facility
528	Provide protection measures to watercourses prior to demolition works.
529	Provide regular and frequent pest inspection.
530	Provide regular checks of storage and handling areas and keep good records of inspection finding and corrective actions.
531	Provide screens to trap dust and label waste skips correctly.
532	Provide secondary containment of fuel storage tanks, if possible.
533	Provide sediment and erosion control devices such as earth dikes (preferably with vegetation cover), interceptors, silt fences, storm drain protection against sediment.
534	Provide sediment trap measures for storm drain systems.
535	Provide sewage pump out and bilge water collection facilities and encourage their use by not making their use costly or access to them difficult.
536	Provide shore power
537	Provide spill response equipment or ensure their swift availability from sources outside the port/harbour.
538	Provide spill response training to employees or at the very least make them aware of environmental implications
539	Provide storage area which - allows easy collection/clean up of spills and leaks - prevents spills/leaks from reaching storm drains - prevents storm water from entering storage area - is connected to dead-end sump (also true for handling areas) - is paved and contained to prevent spills/leaks from reaching groundwater or escaping to other areas.
540	Provide storm water capture and pumping (to sewerage) systems.
541	Provide the public with information on key locations on environmental implications from not carrying out any of the practices listed above.
542	Provide training in handling and storage
543	Provide truck wash out facilities.
544	Provide truck wash-out areas for site leaving vehicles – clean these areas regularly.
545	Provide vegetation buffer zones between operational site and residential sites.
546	Provide, and maintain regularly, oil/water separators in on-shore maintenance and car parking areas.
547	Public opinion survey
548	pulmonary
549	Put cap on CO2 emissions during terminal lease agreements
550	Radical hydroxyl
551	Rail
552	Rail and truck transportation

553	Railroad
554	Railways
555	Record accurately storage and disposal activities.
556	Recycle publications or office waste
557	Recycling)
558	Reduce energy consumption
559	Reduce energy consumption
560	Reduce infrastructure disturbance to marine biology density
561	Reduce packaging use and choice fewer packaging use supplier
562	Reduce road vehicles CO2 emission
563	Reduce speed after landfall
564	Reduce transportation costs
565	Reduce waste of drinking water and irrigation
566	Reduced density
567	Reducing noise and vibration from cargo-handling equipment and vessels
568	Reducing road vehiclesâ€™ COx emission
569	Reducing vessel speed after landfall (reducing fuel consumption & pollution)
570	Regular and exclusive budgets for green port performance
571	Regulation on noise & vibration from discharging equipment
572	Regulation on noise & vibration from unloading equipment
573	Regulations of the emission of toxic gas
574	Regulations on liquid pollution
575	Regulations on noise control
576	Relationship with local community
577	Remaining agricultural goods
578	Remediation of contaminated sites
579	Remove fluids (e.g. battery fluids, lubricants) before dismantling.
580	Remove fluids from operating equipment prior to repair work.
581	Replace or improve the old vehicles
582	Require to use lower noise
583	Require trucks and vehicles to meet sulphur fuel limits
584	Respiratory
585	Restrict access to dismantling
586	Restrict access to storage areas.
587	Restrict and control (as much as practicable) access to storage areas.
588	Retrofit
589	Reuse blast material if possible.
591	Reuse of dredge sediments
592	Reuse reusable material.
593	Reuse the construction waste materials
594	Rigging
595	Runoff
596	Runoff conditions

597	Salinity and soil salinization
598	Secure all loose material – provide cover to prevent them from being blown out.
599	Sediment
600	Sediment and Dredging
601	Sediment of port entrance & coast erosion
602	Sedimentation
603	Sediments
604	Separate and clearly label different types of wastes.
605	Separate hazardous goods and poisons during construction and operation
606	Separate recyclable from non-recyclable waste and store them separately.
607	Set high standards of noise limits
608	Set up air quality monitoring system
609	Set up sulfur and nitrogen emissions control area
610	Sewage
611	Sewage and waste pollution of the ship
612	Sewage processing and water resource control
613	Sewage treatment
614	Ship bilge discharge management
615	Ship bilge discharge management
616	Ship characteristics such as engine size
617	Ship engine
618	Ship evacuation
619	Ship exhaust
620	Ship movements
621	Ship repair
622	Ship traffic
623	Ship waste
624	Ships
625	Ship's activity in the port (ship's Movement in port
626	Shoveling
627	Smart Port System
628	SO2
629	SO4
630	Social Participation
631	Social Sustainability
632	Soil and Sediment quality
633	Soil consumption
634	Soil contamination
635	Soil pollution
636	Soil quality
637	Soil recycling
638	Solar panels

639	Solid debris on roads to and from the construction/demolition sites should be removed regularly
640	Solid waste and liquid waste water
641	Solid waste dumping management
642	Solid Waste Management
643	Soot
644	SOx
645	Spill prevention during disconnection of cargo pipeline
646	SPM
647	Sterilizing and burning of cargoes coming from epidemic area
648	Storage of hazardous materials
649	Store and dispose of properly in accordance with WMLR – Duty of Care Requirements all demolition from debris.
650	Store compatible materials together.
651	Store equipment likely to leak oils, antifreeze, transmission fluid, in places away from storm drain or other natural watercourse and carry out inspections regularly for leaks.
652	Store hazardous waste – clearly labelled – separately.
653	Store oily wastes separately from rest of solid waste.
654	Storm increase
655	Study the impact of new structures on sediment transport and safe navigation.
656	Sucker
657	Sulfur deposits
658	Sulfur dioxide (SO2)
659	Sulfur dioxide (SO2) (mg/m3)
660	Support local social institutions (e.g schools, NGOs)
661	Support research regarding sustainable use of maritime resources
662	Suspended solid (SS) (mg/L)
663	Sustainability Indicators
664	Sustainability Measurement
665	Sustainability Performance
666	Sustainability Policy
667	Sustainability Reporting
668	Sustainable Coastal Development
669	Sustainable Development
670	Sustainable Management
671	Sweep up immediately after spillages.
672	Switch or convert vehicles and equipment from diesel to bio-fuels or electricity generated from renewable sources
673	Take particular care near traffic management if contaminated debris is being transported.
674	The publication of greenhouse gardens from the truck
675	The publication of greenhouse gases from trucks
676	Toilets
677	Total Kjeldahl Nitrogen (TKN)(mg/L)

678	Total organic carbon (TOC) (mg/kg wt)
679	Total Suspended particles (TSP) (mg/m3)
680	Tourism
681	Tow trucks
682	Towing
683	Traffic
684	traffic congestion
685	Traffic volume
686	Train (or at least make aware) employees of the environmental implications from vehicle storage, handling and transporting.
687	Train drivers of in-coming trucks to ensure that vehicles do not bring debris onto port/harbour grounds.
688	Train employees to deal with spill control and response and pollution control (e.g. discard washdown water into sewerage not into storm drains).
689	Transport traffic
690	Transportation
691	Transportation (Truck
692	Trench digging
693	Tropospheric ozone
694	Truck
695	Truck idle
696	Truck queue
697	Truck traffic
698	Try dry mop cleaning before washing floor of maintenance area and avoid hosing down work areas to the storm drain.
699	Turbidity and precipitation
700	Unloading and loading)
701	Use renewable energy sources (solar heat, wind power)
702	Use (as much as practicable) biodegradable detergents.
703	Use “heat stop” paint to coat the refrigerated containers
704	Use afterheat for heating system
705	Use AI to monitor environmental damage
706	Use and empty regularly drip pans and locate absorbent material at key points to prevent spilled oils/chemicals from entering storm drains.
707	Use automated gateway system
708	Use biological spectrum lighting
709	Use Cold Ironing
710	Use drip pans under dispensing equipment.
711	Use dry dock facilities as much as possible.
712	Use energy efficient control system
713	Use energy efficient light in port area
714	Use energy from renewable sources
715	Use energy saving devices

716	Use environment-friendly energy in office and port area
717	Use incentive and punitive masures to promote environmental protection
718	Use less toxic antifouling paints if possible.
719	Use low volatile paints.
720	Use lower air pollution truck
721	Use more electric machines/equipments
722	Use noise reduction machines (forklifts,vehicles, ships, trucks, and other devices)
723	Use nonchemical composition of pesticide and fertilizer
724	Use of electrically powered equipment (to replace diesel equipment)
725	Use of Energy and Resource
726	Use on deck power
727	Use pesticides, herbicides and fertilisers in accordance with directions.
728	Use pneumatic conveyors or continuous screw conveyors where possible.
729	Use recyclable resources
730	Use reusable materials for building/facility
731	Use simulations to recognize climate changes and to tak eactions
732	Use smart lightning within port terminals
733	Use telescopic arm loaders to reduce spillage (ie. free fall) of dry bulk.
734	Use water-based paints and solvents – if possible.
735	Using recyclable resources
736	Using substitute energy and energy saving device
737	Utilise water sprays where practical (but consider measures to control run off).
738	value due to the existence of cargo pipelines
739	Vehicle and equipment maintenance – workshops.
740	Vehicles and vessels to use clean fuel with lower sulfur content
741	Vessel speed reduction in port
742	Vessel waste classification
743	Virtual arrival
744	VOC
745	Volatile organic compounds (VOC)) vehicles
746	Washing areas should be paved, equipped with an oil/water separator.
747	Waste
748	Waste (Ship and Port)
749	Waste and Waste
750	Waste disposal
751	Waste generation
752	Waste Handling
753	Waste management
754	Waste management of ports
755	Waste production
756	Waste products
757	Waste recycling
758	Wastewater drainage

759	Water
760	Water balance control
761	Water balancing drainage
763	Water Consumption
764	Water Pollution
766	Water pollution costs
767	Water quality
768	Water resource control
769	Waves
770	Weather parameters
771	Weather quality
772	Wet over dust sources and use vegetation cover as sediment trap to minimise the volume of sediments reaching storm drain or a natural watercourse.
773	Wetland and marine habitat preservation
774	Wind
775	Wind and Relative humidity
776	Wind effects
777	Wind mills
778	Work with nature conservation bodies to identify ways of implementing developing plans with the least impact on nature conservation sites.
779	Zooplankton Biodiversity (ZP)

8.5 Appendix E
Examples of management environmental performance indicators adopted from Jasch (2000).

1	A.1. Implementation of policies and programs	
2		• number of achieved objectives and targets;
3		• number of organizational units achieving environ- mental objectives and targets;
4		• degree of implementation of specified codes of man- agement or operating practice;
5		• number of levels of management with specific environmental responsibilities;
6		• number of employees that have environmental requirements in their job descriptions;
7		• number of employees participating in environmental programs (e.g. suggestion, recycle, clean-up initiat- ives, reward and recognition, or others);
8		• number of employees trained versus the number that need training;
9		• number of environmental improvement suggestions from employees;
10		• results of employee surveys on their knowledge of the organization's environmental issues;
11		• number of suppliers and contractors queried about environmental issues;
12		• number of contracted service providers with an implemented or a certified environmental manage- ment system;
13		• number of products with explicit "product steward- ship" plans;
14		• number of products designed for disassembly, recyc- ling or reuse.
15	A.2. Conformity	
16		• degree of compliance with regulations;
17		• number of non-compliances
18		• degree of compliance with regulations by contracted service providers;
19		• time to respond to or correct environmental incidents;
20		• numbers of resolved and unresolved corrective actions;
21		• number of or costs attributable to fines and penalties;
22		• number and frequency of specific activities (e.g. audits);
23		• number of audits completed versus planned;
24		• number of audit findings per period;
25		• frequency of review of operating procedures;
26		• number of emergency drills conducted;
27		• percentage of emergency preparedness and response drills demonstrating planned readiness;

28	A.3. Financial performance	
29		• costs (operational and capital) that are associated with a product's or process environmental aspects;
30		• return on investment for environmental improve- ment projects;
31		• savings achieved through reductions in resource usage, prevention of pollution or waste recycling;
32		• sales revenue attributable to a new product or a by- product designed to meet environmental performance or design objectives;
33		• research and development funds applied to projects with environmental significance;
34		• environmental liabilities that may have a material impact on the financial status of the organization.
35	A.4. Community relations	
36		• number of inquiries or comments about environmentally related matters;
37		• number of press reports on the organization's environmental performance;
38		• number of environmental educational programs or materials provided for the community;
39		• resources applied to support of community environ- mental programs;
40		• number of sites with environmental reports;
41		• number of sites with wildlife programs;
42		• number of local cleanup or recycling initiatives, spon- sored or self-implemented;
43		• favourability ratings from community surveys.

8.6 Appendix F
Examples of operational environmental performance indicators adopted from Jasch (2000).

44	B.1. Materials	
45		• quantity of materials used per unit of product;
46		• quantity of processed, recycled or reused materials
47		• quantity of packaging materials discarded or reused per unit of product;
48		• quantity of auxiliary materials recycled or reused;
49		• quantity of raw materials reused in the production process;
50		• quantity of water per unit of product;
51		• quantity of water reused;
52		• quantity of hazardous materials used in the production process.
53	B.2. Energy	
54		• quantity of energy used per year or per unit of pro- duct;
55		• quantity of energy used per service or customer;
56		• quantity of each type of energy used;
57		• quantity of energy generated with by-products or pro- cess streams;
58		• quantity of energy units saved due to energy conser- vation programs.
59	B.3. Services supporting the organization’s operations	
60		• amount of hazardous materials used by contracted service providers;
61		• amount of cleaning agents used by contracted ser- vice providers;
62		• amount of recyclable and reusable materials used by contracted service providers
63		• amount or type of wastes generated by contracted ser- vice providers.
64	B.4. Physical facilities and equipment; supply and delivery	
65		• average fuel consumption of vehicle fleet;

66		• number of freight deliveries by mode of transportation per day;
67		• total land area used for production purposes;
68		• number of vehicles in fleet with pollution abatement technology;
69		• number of business trips saved through other means of communication;
70		• number of business trips by mode of transportation;
71		• land area used to produce a unit of energy.
72	B.5. Products	
73		• number of products introduced in the market with reduced hazardous properties;
74		• number of products which can be reused or recycled;
75		• percentage of a product's content that can be reused or recycled;
76		• rate of defective products;
77		• number of units of by-products generated per unit of product;
78		• number of units of energy consumed during use of product;
79		• duration of product use;
80		• number of products with instructions regarding environmentally safe use and disposal.
81	B.6. Services provided by the organization	
82		• amount of cleaning agent used per square meter (for a cleaning services organization);
83		• amount of fuel consumption (for an organization whose service is transportation);
84		• quantity of licenses sold for improved processes (for a technology licensing organization);
85		• quantity of materials used during after-sales servicing of products.
86	B.7. Wastes	
87		• quantity of waste per year or per unit of product;
88		• quantity of hazardous, recyclable or reusable waste produced per year;
89		• total waste for disposal;
90		• quantity of waste stored on site;
91		• quantity of waste controlled by permits;
92		• quantity of waste converted to reusable material per year.

93	B.8. Emissions	
94		• quantity of specific emissions per year;
95		• quantity of specific emissions per unit of product
96		• quantity of waste energy released to air;
97	B.9. Effluents to land or water	
98		• quantity of specific material discharged per year;
99		• quantity of specific material discharged to water per unit of product
100		• quantity of waste energy released to water;
101		• quantity of material sent to landfill per unit of product
102		• quantity of effluent per service or customer.
103	B.10. Other emissions	
104		• noise measured at a certain location;
105		• quantity of radiation released;
106		• amount of heat, vibration or light emitted.

Appendix G
The proposed conceptual measures and detailed actions

Table 8.7.1

The detailed actions of the element of Air Pollution

Measure	Detailed actions
Air Pollution	Set up air quality monitoring system Annual plan for air pollution Monitor Air Quality Set up sulfur and nitrogen emissions control area Provide shore power Use energy from renewable sources Use more electric machines/equipments Use automated gateway system Install air filter on port machines Port machines use clean fuel with lower sulfur content Monitor dust levels Implement dust and smoke recycle measures Monitor smoke from vessels Adjust the type of importing bulk cargo (e.g., replace coal splinter with block coal) Promote environment-friendly transport Promote port ride share or use shuttle bus Establish the carbon footprint Vessel speed reduction in port Idle control on vehicles and cargo handling equipments Idle truck parking arrangement Use lower air pollution truck Replace or improve the old vehicles Vehicles and vessels to use clean fuel with lower sulfur content

Table 8.7.2

The detailed actions of the element of Monitor Air Quality

Subcriteria		Detailed Action	Port Environmental Indicator
Air Pollution	AP3	Monitor Air Quality	Total Suspended particles (TSP) (mg/m3)
			Carbon monoxide (CO) (ppm)
			Particulate matter (PM10) (mg/m3)
			Sulfur dioxide (SO2) (mg/m3)
			Hydrocarbons (HC) (mg/m3)

Table 8.7.3

The detailed actions of the element of Liquid Pollution

Measure	Detailed actions
Liquid Pollution	Regulations on liquid pollution Dredge monitoring and assessment Investigate sewage source Monitor system for water pollution Monitor water quality Fuel spill contingency plan Cargo spill control and prevention Install palisade on sewage pipe Sewage treatment Manage ballast water Ballast water pollutant control Handle on board sewage Encourage use of water saving facilities Improve the standard of ship's sanitation equipment

Table 8.7.4

The detailed actions of the element of Monitor water quality

Subcriteria		Detailed Action	Port Environmental Indicator
Liquid Pollution	WP5	Monitor water quality	pH
			Suspended solid (SS) (mg/L)
			BOD (mg/L)
			COD (mg/L)
			Oil and Grease (OG) (mg/L)
			Total Kjeldahl Nitrogen (TKN)(mg/L)

Table 8.7.5

The detailed actions of the element of Noise Pollution

Measure	Detailed actions
Noise Pollution	Set high standards of noise limits Regulations on noise control Monitoring system for noise level Avoid disturbance to the community during infrastructure construction and expansion Monitor noise levels during construction and operation Require to use lower noise Install double insulation windows and boards Reducing noise and vibration from cargo-handling equipment and vessels Use noise reduction machines (forklifts,vehicles, ships, trucks, and other devices)

Table 8.7.6

The detailed actions of the element of Monitor noise levels during construction and operation

Subcriteria		Detailed Action	Port Environmental Indicator
Noise Pollution	NP5	Monitor noise levels during construction and operation	Leq24 (db/(A))
			Lmax (db((A))

Table 8.7.7

The detailed actions of the element of Land and Sediments Pollution

Measure	Detailed actions
Land and Sediments Pollution	Remediation of contaminated sites Port entrance sediment and coastal erosion control Monitor Soil and Sediment Quality Reuse of dredge sediments Dredging sediment disposal

Table 8.7.8

The detailed actions of the element of Monitor Soil and Sediment Quality

Subcriteria		Detailed Action	Port Environmental Indicator
Land and Sediments Pollution	LP3	Monitor Soil and Sediment Quality	Lead (Pb) (mg/kg wt)
			Mercury (Hg) (mg7kg wt)
			Chromium (Cr) (mg/kg wt)
			Total organic carbon (TOC) (mg/kg wt)
			Hydrocarbons (HC) (mg/m3)

Table 8.7.9

The detailed actions of the element of Materials Selection

Measure	Detailed actions
Materials Selection	Adopt LEED standard for green building Procure locally available materials and suppliers Use reusable materials for building/facility Encourage using environment-friendly materials Port landscaping to use local native species

Table 8.7.10

The detailed actions of the element of Water Consumption

Measure	Detailed actions
Water Consumption	Reduce waste of drinking water and irrigation Monitor water usage and leakage On-site water treatment and reuse

Table 8.7.11

The detailed actions of the element of Energy Usage

easure	Detailed actions
Energy Usage	Use environment-friendly energy in office and port area Apply new energy-saving operational processes Use renewable energy sources (solar heat, wind power) Microclimate design Use energy efficient control system Use "heat stop" paint to coat the refrigerated containers E-document program Use smart lightning within port terminals Use energy saving devices Use afterheat for heating system Use energy efficient light in port area

Table 8.7.12

The detailed actions of the element of General Waste Handling

Measure	Detailed actions
General Waste Handling	Recycle publications or office waste Reduce packaging use and choice fewer packaging use supplier Provide a dedicated storage area for recycling Reuse the construction waste materials Garbage classification in port area Vessel waste classification

Table 8.7.13

The detailed actions of the element of Hazardous Waste Handling

Measure	Detailed actions
Hazardous Waste Handling	Separate hazardous goods and poisons during construction and operation Employ licensed contractor to handle hazardous waste Sterilizing and burning of cargoes coming from epidemic area

Table 8.7.14

The detailed actions of the element of Habitat Quality

Measure	Detailed actions
Habitat Quality	Establish indicators of habitat quality Protect coastal and estuarine ecosystems Wetland and marine habitat preservation Reduce infrastructure disturbance to marine biology density Ecological monitoring in port area Establish compensation area or alternative area Expansion of tidal areas for habitat restoration

Table 8.7.15

The detailed actions of the element of Ecological monitoring in port area

Subcriteria		Detailed Action	Port Environmental Indicator
Habitat Quality	HQ5	Ecological monitoring in port area	Phytoplankton Biodiversity (PP)
			Zooplankton Biodiversity (ZP)
			Marine Benthos Biodiversity (MB)

Table 8.7.16

The detailed actions of the element of Port Greenery

Measure	Detailed actions
Port Greenery	Grow flowers or trees in port area Use biological spectrum lighting Use nonchemical composition of pesticide and fertilizer

Table 8.7.17

The detailed actions of the element of Community Promotion and Education

Measure	Detailed actions
Community Promotion and Education	Allow public to have port tour Provide job opportunity Encourage public participating in port planning Provide green port web site Promote green port concept for the community Public opinion survey

Table 8.7.18

The detailed actions of the element of Port Staff Training

Measure	Detailed actions
Port Staff Training	Hold green port seminar Provide green facilities/building guide and training Encourage participation in the community`s environmental protection Implement an accredited Environmental Management System Provide green port training