Abstract

In this paper, the concept of environmental indicator is reviewed as a relevant element used in the environmental management of any organisation. The importance of this element within an Environmental Management System (EMS) is also justified. Although EMS standards recognise the relevance of using indicators, they do not specify any methodology to identify which indicators have to be implemented. In addition, the present research demonstrates that although there is a high percentage of European ports that have already implemented performance indicators, most of them do not mention the method applied to obtain the indicators. This suggests that some of the procedures used by ports to identify indicators may not necessarily be science-based or systematic in approach. For these reasons, the need to develop a new methodology able to identify the ports most adequate indicators was detected. Therefore, a Tool for the identification and implementation of Environmental Indicators in Ports (TEIP) was developed. It aims at identifying performance indicators in ports and providing guidelines for their proper implementation. This is a computer and science-based tool (www.eports.cat/teip) that provides a quick calculation and outputs, and it is designed to be as user-friendly and practical as possible in order to facilitate its completion by the user. This new methodology is applicable to all types of ports no matter the size, geographical location or its commercial profile; it provides targeted and specific results for each one. TEIP aims at helping port managers at easily determining their significant port indicators, which provides valuable elements for the decision-making processes.

Keywords: *Environmental Performance Indicator, Environmental Management, Sustainable Development, Port Management*

1. Introduction

Performance indicators are developed and used worldwide predominantly to highlight the performance of a biological, physical, chemical, environmental, economic or social system (Jakobsen, 2008). In particular, an environmental indicator according to the United Nations (1997) is “an information tool that summarises data on complex environmental issues to show overall status and trends of those issues”.

The use of environmental indicators is essential in order to ensure that daily port activities and operations are consistent with sustainable development. In order to evaluate environmental performance of port authorities and to track progress towards continuous improvement, relevant Environmental Performance Indicators (EPIs) may be utilised (Donnelly et al., 2007). In this way, port authorities can demonstrate compliance and continuous improvement through scientific evidence and quantifiable measures.

Apart from port authorities, there are other stakeholders within the port area that may use environmental indicators. It includes companies and industries that invest in the port area, such as customers, terminal operators, and shipping companies; policy and legislation stakeholders; and community stakeholders, such as non-governmental organisations (NGOs) and environmentalist groups.

The use of EPIs has been continuously encouraged by several port organisations around the world among their members. For instance, in Europe, the European Sea Ports Organisation (ESPO) expressed the importance of identifying EPIs and carrying out environmental monitoring in the *ESPO Environmental Code of Practice 2003* (ESPO, 2003), and it is also presently in force in the *ESPO Green Guide* (ESPO, 2012). Other organisations, such as the International Association of Ports and Harbours (IAPH) or the Baltic Ports Organisation (BPO) also promote the use of indicators.

The identification of performance indicators is strictly related with the environmental aspects of the port. According to ISO 14001 (2015), an environmental aspect is an element of an organisation's activities, products and services that can interact with the environment. Examples of them are the water discharges, emissions to air, waste generation or noise emissions. Indicators are necessary to control the performance of these aspects, especially those that are significant. For example, in the case of emissions to air, associated indicators could be the concentration of sulphur oxides (SO_x) or nitrogen oxides (NO_x). Therefore, these two concepts are inter-related. In fact, in any EMS, once the aspects have been identified a set of indicators are required to measure their performance over the time and ensure continual improvement.

In order to assist ports in identifying their Significant Environmental Aspects (SEAs), a tool was developed in the framework of the PERSEUS research project (PERSEUS, 2012). It is called *Tool for the identification and assessment of Environmental Aspects in Ports (TEAP)* (Puig et al, 2015), and it is available online at www.eports.cat/teap. TEAP is connected to the tool presented in this paper, the *Tool for the identification and implementation of Environmental Indicators in Ports (TEIP).* The results of the aspects obtained in TEAP can be taken directly to TEIP for the compilation of indicators. However, if a port has already identified its own SEAs, it can go directly to TEIP.

TEIP tool has been carried out within the EU-funded project PORTOPIA: Port Observatory for Performance Indicator Analysis (2013 – 2017). It aims at developing a Service Cloud where European ports can administer their performance, based on selected performance indicators (PORTOPIA, 2014). In this way, port managers will be able to track the annual variations in the performance of their port and to compare with the average of the sector.

2. Importance of Environmental Performance Indicators

Indicators are increasingly being developed and used as management tools to address environmental issues (e.g. Belfiore, 2003). The use of indicators is strongly recommended due to several reasons:

- To monitor progress and provide a picture of trends and changes over time (Lehane et al., 2002).
- To show not only how an individual authority is performing, but also assess the national and regional benchmark performance (De Leffe et al., 2003).

- To evaluate the effectiveness of policies implemented, by measuring the progress towards environmental targets (e.g. DEFRA, 2003) and to provide a firm basis for future objectives (Dantes, 2003).
- To provide early-warning information, capable of serving as a signal in case the situation is getting worse, indicating risk before serious harm has occurred.
- To know whether the organisation is in compliance with the allowed legal parameters, and to identify risks and assist in the reduction of costs.
- To improve stakeholder relationships and increase confidence of investors, shareholders, banks and insurers (De Leffe et al., 2003).
- To raise public awareness on environmental issues (Gautam and Singh, 2010).

As seen in the previous bullet points, indicators are very useful for assessing environmental information and solving environmental problems. However, they may also have some challenges and limitations. Examples of them are mainly related to the difficulty of some indicators to describe the state of the environment in just some parameters or the limited data availability. In addition, the sensitivity is another parameter to be considered, since some indicators may vary with short-term environmental changes.

However, even considering the foresaid limitations, indicators are key elements of an Environmental Management System (EMS) since they supply quantitative information that allow to verify whether the objective of continual improvement is achieved in an organization (Perotto et al., 2008). There are three main standards widely recognised and implemented among the sector to put in place an EMS: the International Organisation for Standardisation (ISO) 14001 (ISO, 2015), the Eco-Management and Audit Scheme (EMAS) Regulation (EC, 2009) and the Port Environmental Review System (PERS) (ESPO, 2011). The specific information and requirements that these three EMS standards request with regards to indicators were researched and are provided below.

According to the ISO 14001 standard, the organisation should establish and maintain a procedure to monitor and measure the key characteristics of its operations that can have a significant environmental impact and a procedure for periodically evaluate compliance with legal requirements (ISO, 2015). The way to do so is through indicators. ISO 14001 does not provide any specification in terms of examples of indicators or methodologies for their implementation. However, there is one concrete standard, ISO 14031 (ISO, 1999) on environmental performance evaluation and belonging to the ISO 14000 family, which provides examples of indicators to be implemented.

EMAS standard recognises that the reporting of the environmental performance should be on the basis of generic and sector-specific performance indicators (EC, 2009). The standard remarks that EPIs should be developed through information exchange and collaboration between Member States and mentions some characteristics that the indicators should comply, such as giving an accurate evaluation of the port's performance or being understandable and unambiguous (EC, 2009). EMAS protocol lists nine core indicators distributed on six key environmental areas. Although these core indicators are highly recommended for use and report, the standard is flexible and states that if an organisation concludes that some indicators are not relevant to its significant direct environmental aspects, that organisation may not report on those core indicators (EC, 2009).

PERS protocol, the only one specific for ports, also gives importance to the identification of performance indicators, existing one specific clause on this issue. According to PERS (ESPO, 2011), the port should identify from five to ten EPIs relevant to the major environmental aspects and to the policy of the port in order to facilitate monitoring of the environmental performance. The standard provides around 20 examples of environmental indicators likely to be monitored in port areas.

It was observed that the three standards require the use of environmental indicators, including, some of them, examples of indicators that may be adopted by port authorities. However, any standard provides a method on how each port should select its indicators. For this reason, a research was conducted within the EU port sector on the existing methods for identifying indicators, and it is presented in the following section.

3. State of the art on indicators' selection methodologies

This section researches on the already existing methods used for the identification of indicators in ports. The methods that have been found are presented below classified in two groups: the methods that have been developed focussed on the whole port sector; and the methods that are used in individual ports.

a) <u>Port sector's methods</u>

An example of a methodology proposed to obtain a system of indicators in the port sector was found. It is a method that was developed as a result of the research project INDAPORT (2002–2004), which aimed at establishing systems of indicators to implement a sustainable environmental port management (Peris-Mora et al., 2005). The research pathway included the identification of 21 port activities that were applicable to the case study of the Port of Valencia, which were submitted to environmental analysis. Each activity was described through a steps-diagram process, which allowed the identification of inputs and outputs environmental aspects affected by these activities – processes. A cross matrix of aspects and activities permitted the identification of the most relevant impacts from activities. Experts' panel was used in order to find out which were the most significant impacts. Finally, as a result of the described methodology, 17 selected port system indicators were provided. Examples of indicators provided by the INDAPORT project were the 'Total annual greenhouse gas (GHG) emissions' or the 'Total annual water consumption'.

b) <u>Individual ports' methods</u>

A research on the current methodologies used in ports to identify indicators was also carried out. The sample considered 51 EU ports, 39 non-European ports, 13 port operators and 17 marinas. Within the sample of the EU port authorities, the research demonstrated that a large number of ports publish the list of indicators that they use (37 out of 51); however, just a few explained the origin of these indicators (10 out of 51). In all these 10 cases, the sources of the indicators were standardised lists of indicators, such as the ones provided by the Global Reporting Initiative (GRI, 2013) or by the EMAS standard (EC, 2009).

In the non-EU port authorities, the results were less encouraging. Although 26 ports published the list of indicators, only one port provided the source (GRI guidelines) and the resulting indicators. With regards to port operators, 38.5% of them provided the list of indicators and 30.8% the source, being this the list of recommended indicators by GRI and EMAS. In terms of marinas, there was a higher percentage (47%) of ports that published both the indicators and the source, being the EMAS standard (EC, 2009) the source of all marinas.

In any case, neither in EU ports nor in non-EU ports, any example was found having a methodology for identifying indicators.

4. The need for TEIP

In the previous sections of this paper, the benefits and importance for identifying environmental indicators have been detailed. Several reasons have been provided which demonstrate that they are key elements of the whole environmental management of a port. As mentioned before, ISO 14001, EMAS and PERS specifications determine that indicators should be used to assess the environmental performance. However, since each organisation has its own characteristics and distinctive features, the standards do not establish a common methodology for their identification and assessment. Some examples of EPIs are provided by the standards, although the final decision relies on each individual port, in accordance with their significant aspects.

In the research of the existing methodologies in the sector, only one procedure was found explaining how to create a system of indicators. In addition, the research demonstrated that this procedure is currently no longer used by ports. The research on individual ports made evidence that a wide range of ports use EPIs, but just a few explained the reason for using that set of indicators.

In addition, the *European Port Industry Sustainability Report 2016* revealed that 66% of the respondent ports have identified environmental indicators to monitor trends in environmental performance (ESPO, 2016). Nevertheless, when ports were asked to name the environmental indicators used, the responses provided almost 100 different indicators. This wide range of indicators means that although ports are becoming increasingly aware of the benefits of using environmental indicators, there is not a common approach as to which indicators adopt. If ports are not using a procedure to identify indicators, it may well be that the selected indicators are not the most appropriate.

These reasons have contributed to identify the need for the creation of a common method that assists ports in identifying indicators in a more reliable manner. As mentioned before, even if each port is different, having a standard methodology that can provide specific results for each port is desirable to mutual advantage of sector and individual ports. As a consequence, an interactive tool has been created aiming at proving a set of performance indicators especially selected for the port user and which is based on the Significant Environmental Aspects (SEAs) of the port, as well as other port characteristics. The method has been developed specifically for the port sector and it is valid and publicly available for any port authority, including sea ports and inland ports. The development of the tool is explained in the following section.

5. Development of the TEIP tool

The steps followed for the development of the TEIP tool are schematised in figure 1 and explained in the paragraphs below:

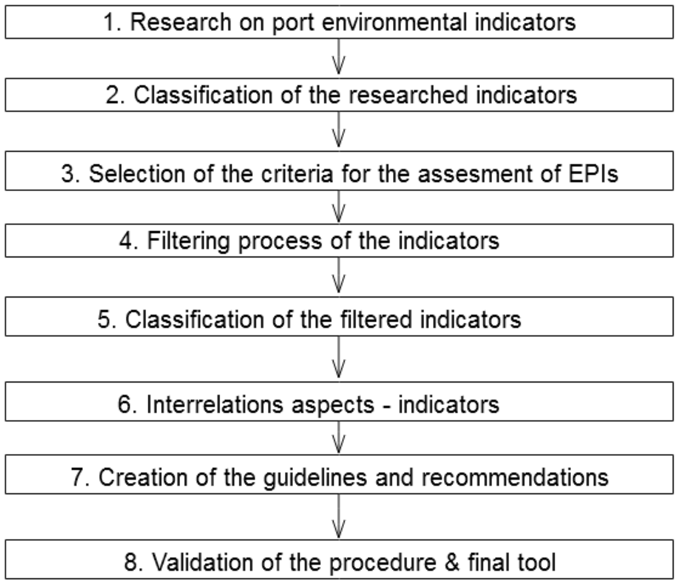


Figure 1: Steps carried out for the development of TEAP

5.1. Research on port environmental indicators

An extensive research was carried out in order to identify and compile a very broad inventory of EPIs that are being used and reported in the industrial sector, with especial emphasis to the port sector. A vast list of references was researched and each single new indicator that was identified was considered for the study, gathering a total number of 1279 indicators. However, after analysing all of them, a final inventory of 648 indicators was obtained, excluding repetitions. It may be considered as the largest compilation of environmental indicators for the port sector that is known. Eleven different sources of information were used (including the outcomes of research projects or the results of the ESPO Environmental Questionnaire), obtaining in each one the number of EPIs provided in table 1, listed in descending order.

Table 1: Sources of information used for the identification of indicators

Sources	Total number
PPRISM project	311
Port environmental reports	282
Research studies	135
Legislation	115
EMS standards	98
ESPO Questionnaire	95
Self-Diagnosis Method (SDM)	65
Port organisations	61
EPI ECOPORTS project	56
Global Reporting Initiative (GRI)	44

INDAPORT project	17

5.2. Classification of the researched indicators

The inventory of 648 environmental indicators was classified under nine categories of indicators. On one hand, it was seen that most of the indicators could fit in the seven categories of environmental aspects that were previously defined in the development of the TEAP tool (Puig et al, 2015). These categories of environmental aspects were identified after a deep research on the existing environmental aspects in ports. The research included ports' websites, ports' environmental or annual reports, and EMS reports (involving mostly PERS and EMAS Declarations) of port authorities and terminal operators. On the other hand, it was seen that there were two types of indicators that did not fit to any of those seven categories. For this reason, two more groups were created: the environmental management and the port development indicators. As a result of that, all the indicators were classified accordingly to the nine established categories, as shown in table 2.

Table 2: Categories of the researched indicators

Category	Total number
Emissions to air	66
Discharges to water / sediments	83
Emissions to soil	17
Resource consumption	93
Waste production	65
Noise	22
Effects on biodiversity	43
Environmental management	238
Port development	21

5.3. Selection of criteria for the assessment of EPIs

Since a large number of indicators were obtained, almost 650 different EPIs, it was found necessary to filter this large set to a shorter list, more suitable to be potentially applied in port areas. In order to carry out this filtering process in a methodological way, each indicator was assessed through a set of criteria. Then, the indicators that complied with more criteria were selected and the ones that obtained a poor performance were rejected.

In order to establish the set of criteria, a literature review was conducted on already existing criteria. A total number of 11 different sources were consulted. The nature of these sources was very broad, including scientific articles (Dale and Beyeler, 2001; Peris - Mora et al., 2005; Donnelly et al., 2007); reports from governments (EC, 1998 and Ministry for the Environment of New Zealand, 1999) and from public institutions (EEA, 2005; and UNEP, 2003); reports generated by other agencies (OECD, 1993; and

Verfaillie and Bidwell, 2000); on-line publications (Jakobsen, 2008) and even the results of an investigation carried out in the framework of an environmental management course (De Leffe et al., 2003).

From this 11 sources, a set of 84 different names of criteria used to assess performance indicators was obtained. By analysing them, it was found that although some of them were written differently, the concept and the meaning was the same or, at least, similar. For this reason, the criteria that had the same purpose were grouped under the same name. This process allowed the reduction from the 84 criteria identified in the sources until the final number of 11 criteria. These criteria were applied in two phases, since the criteria of the first filter were considered to be more generic and applicable to all indicators, and the criteria of the second filter were considered to be more specific. In this case, a previous research on the indicators' characteristics was needed. Table 3 shows the criteria applied in the first and second filter.

Table 3: List of criteria applied in the first and second filter

First filter	Second filter
1. Reliable	1. Cost effective
2. Understandable	2. Legislative priority
3. Useful	3. Sensitive
4. Comparable	4. Clearly defined method
5. Broadly accepted	5. Easy to monitor
	6. Significant

5.4. Filtering process of the indicators

The filtering process consisted of three steps: i) the first filter, ii) a regrouping of the indicators and iii) the second filter of the indicators.

The first filter consisted of analysing the complete broad list of indicators that were compiled. The evaluation of the indicators against the five criteria was carried out by three researchers, with the objective of applying the filter in a contrasted way. These researchers were coordinated by a supervisor, who ensured that they had the same understanding of the criteria and punctuation. Several internal meetings were held during the filtering process with this purpose.

As shown in the example of table 4, if the indicator met a criterion, it was coloured with a green dot and if it did not comply, with a red dot. It was considered that an indicator was accepted by an evaluator when the result of the division between the accomplished criteria (green dot) and the total number of evaluated criteria was higher than 0.5. In other words, since in this first filter all the five criteria were applied, the indicators that met three or more criteria were accepted. A green tick (✓) indicates that the evaluator accepted this indicator, and a red cross (✗) that the indicator did not pass the first filter. All those indicators that were selected by at least two of the three evaluators were accepted. If there was only one green tick or any of them, then it was rejected.

Table 4: Example of the first filter assessment

Indicators	Criteria (E2)					Evaluator			Is it Accepted?
	1	2	3	4	5	1	2	3	
Total annual port waste sent to	🔴	🟢	🔴	🟢	🔴	✗	✗	✗	No

controlled landfill									
Total annual port waste stored in situ	red	green	red	green	red	✗	✗	✓	No
Existence of separate containers for the collection of port wastes	green	green	green	green	green	✓	✓	✓	Yes
Frequency of cleaning the port area	red	green	green	green	red	✓	✓	✗	Yes

In this way, a first list of selected indicators was obtained. From the total number of 648 indicators, 354 were accepted through the first filter and 294 were rejected.

The indicators that passed the first filter were regrouped. In some cases, there were some indicators that were normalized against different references, and they were unified in one more generic indicator. For instance, the indicators 'Electricity consumption per cargo handled' and 'Electricity consumption per number of employees' were regrouped into a generic indicator called 'Total annual electricity consumption'. In other cases, there were some indicators very similar, or that the response of one already implied the response of the other indicator. The regrouping process eliminated 109 indicators from the compilation list and reduced it from 354 (first filter) to 245 indicators.

The second filtering process of indicators consisted of six criteria that evaluated individually the indicators that remained after the first and the regrouping process. In many cases, it was necessary to conduct a previous research on the indicators in order to determine if they fulfilled a particular criterion. In the same way as in the first filter, it was considered that an indicator was accepted when it met more than half of the criteria; in other words, the ratio between the accepted criteria and all the evaluated criteria had to be over 50%. In this second filter there was a major difference compared to the first one, because the total number of criteria evaluated was not always the same. This is due to the fact that not always all criteria were applicable to all the indicators due to their different nature. In this case, a grey dot was allocated (see example of table 5). For example, the criterion 4 (clearly defined method) was not applicable to the indicator "annual amount of recovered rainwater" since there is no a scientifically based method to calculate this indicator. It was also possible that, for certain indicators, not enough information was available to assess a specific criterion and the blue dot was established. In both cases, these criteria were not summed up in the total number of criteria assessed.

Table 5: Example of the second filter assessment

Indicators	**Criteria**						**Is it Accepted?**
	1	**2**	**3**	**4**	**5**	**6**	
Biological Oxygen Demand (BOD)	green	green	green	green	red	green	✓
Annual amount of recovered rainwater	blue	green	green	grey	green	red	✓
Percentage of the port area that has a system for the collection and treatment of rainwater	blue	red	green	grey	red	red	✗

Due to the complexity of this method and the fact that it was necessary to find more specific information for each indicator, this process was done by one researcher, instead of three as in the first filter. A total number of 72 indicators were rejected in this second filter. As a result, the initial number of 245 indicators was reduced to a list of 173.

Figure 2 summarizes the three main steps followed to filter the indicators and mentions the total number of indicators that resulted after the application of each filtering process.

In this line, it shows that after the indicators' research the total number of different indicators was 648. After the application of the first filter this number was reduced to 354, the regrouping process reduced it to 245 and the application of the second filter reduced to a final list of 173 indicators.

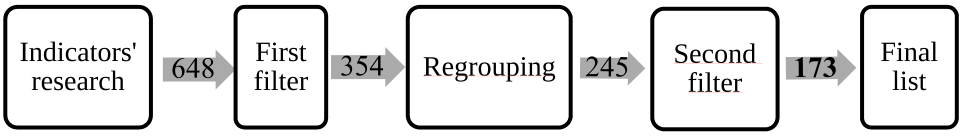


Figure 2: Number of indicators resulting after each filtering process

5.5. Classification of the filtered indicators

The list of 173 indicators was analysed in order to develop the TEIP tool and it was found out that there were both quantitative and qualitative indicators. On one hand, the *quantitative* indicators (fig 3) were clearly identified as the output indicators of the tool (e.g. the number of environmental objectives defined). On the other hand, by analysing the qualitative indicators, it was found that some of them involved questions which were useful to demonstrate existence or inexistence of a specific environmental topic (e.g. 'Has the port defined objectives for environmental improvement?'). As a consequence, those indicators were considered all together in the category of *questions* which would provide additional information to identify the most suitable KPIs selection. In addition, other qualitative indicators that were considered to be not so appropriate as indicator were suggested as *recommendations* to port authorities (e.g. 'Does the port have quantitative objectives?').

Finally, as a result of the suggestions provided by the TEIP reviewers, two indicators were *rejected* and therefore not included in the final list of TEIP indicators (e.g. 'Total annual paper consumption'). According to this, the final 171 indicators were categorized in the four groups provided in figure 3.

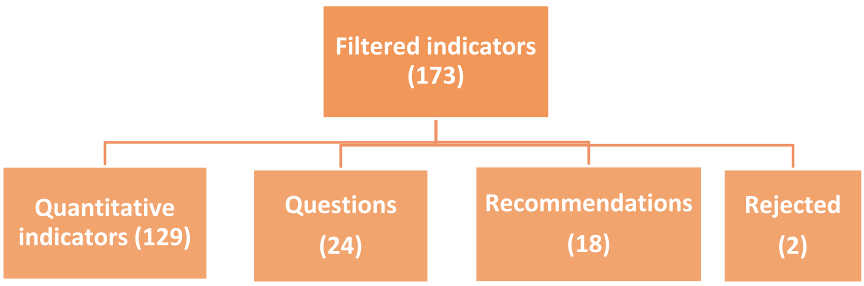


Figure 3: Classification of the filtered indicators

5.6. Interrelations aspects - indicators

The TEIP tool selects the indicators based on the Significant Environmental Aspects of the port. In other words, when an aspect is considered significant, its related indicators are suggested for monitoring. It may be that the port already knows its significant aspects, or they may be obtained through the application of the TEAP tool (Puig et al, 2015). Table 6 shows an example of the interactions between the aspect *Emissions of combustion gases* and the related quantitative indicators (highlighted in green). This aspect has some questions related highlighted in yellow and depending on the answer ('if yes' or 'if no'), further indicators and recommendations (highlighted in blue) are provided.

Table 6: Indicators and recommendation related with emissions of combustion gases

<table>
<tr><td>Aspect</td><td colspan="2">Emissions of combustion gases</td></tr>
<tr><td>Related indicators</td><td colspan="2">- Carbon monoxide (CO) (G.1.1)
- Nitrogen oxides (NO_x) (G.1.2)
- Sulphur dioxide (SO_2) (G.1.3)</td></tr>
<tr><td rowspan="2">Does the port measure or estimate its Carbon Footprint?</td><td>If YES:</td><td>- Total annual Carbon Footprint by scope (G.1.4)
- Frequency of monitoring the Carbon Footprint in the port area (G.1.5)
- Percentage of each energy source contributing to the Carbon Footprint (G.1.6)
- Percentage of annual change in the Carbon Footprint (G.1.7)</td></tr>
<tr><td>If NO:</td><td>- Carbon Footprint Recommendation (R.1.1)</td></tr>
<tr><td rowspan="2">Does the port differentiate dues for 'Greener' vessels?</td><td>If YES:</td><td>-- (no related indicators)</td></tr>
<tr><td>If NO:</td><td>- Differentiate dues for 'Greener' vessels recommendation (R.1.2)</td></tr>
</table>

TEIP tool compiles all the indicators that are obtained directly from the aspects that are significant for the port, and the indicators and recommendations obtained as a result of the questions that have been asked to the user. These indicators are gathered internally by the tool and they are displayed and provided in the last step. In addition, a set of guidelines for the implementation of the indicators (e.g. G.1.4 in table 6) and some recommendations (e.g. R.1.1 in table 6) are also provided.

5.7. Creation of the guidelines and recommendations

For each one of the 129 quantitative indicators, a guideline on how to implement properly this indicator was created. In addition, 18 recommendations also were developed. Indicators' guidelines and recommendations are attached as PDFs in the final step of the tool, where the list of final indicators and recommendations are provided. Table 7 shows an example of a guideline for the indicator *Percentage of annual change in the Carbon Footprint.*

Table 7: Example of a guideline for the application of indicators

<table>
<tr><td>Indicator's name</td><td colspan="3">Percentage of annual change in the Carbon Footprint</td></tr>
<tr><td>Category</td><td>Emissions to air</td><td>Indicator's code</td><td>G.1.7</td></tr>
<tr><td>Sub category</td><td colspan="3">Emissions of combustion gases</td></tr>
</table>

Definition	This indicator expresses the annual variation in the emissions of the port's Greenhouse Gas (GHG). In order to calculate this variation, the annual CO_2e emissions (see Guideline G.1.4 for more information) are required. To carry out the calculation, the following formula may be used: $\% \, variation = \frac{t \, CO_2e \, current \, year - t \, CO_2e \, previous \, year}{t \, CO_2e \, previous \, year} \cdot 100$ A positive percentage means an increase on the emissions and a negative percentage, a decrease.
Importance	The annual variation of the GHG emissions is useful for setting targets for reducing the Carbon Footprint of the port.
Units	Percentage
Frequency	Annually
Level of effort	Intermediate level: the information required by the indicator is not very complex, but it requires certain research to be obtained.

5.8. Validation of the procedure & final tool

A comprehensive validation of the TEIP tool was carried out. The on-line link of the tool was sent to a broad list of port professionals and stakeholders in order to gain their feedback and opinion about the format and content of the tool. In addition, an on-line webinar was undertaken, where the development of the tool was explained and a case study of a port was presented. Around 20 port-related professionals participated in the webinar. The feedback obtained from the reviewers was highly considered and much appreciated in order to improve the quality of the tool. Most of the comments and proposed amendments were accepted and, therefore a final updated version of the tool was developed. Table 8 lists some examples of the feedback obtained and whether the action was accepted (✓**)** or rejected (×).

Table 8: Feedback obtained and actions taken

Feedback	Action taken
Mention that the aspects make reference to the whole port area	✓
List the final indicators and recommendations by categories and in bullet points	✓
Delete the recommendation *Existence of facilities for the treatment and cleaning of the dredged sediments*	✓
Provide the definition of the aspects, in line with TEAP tool	✓
Provide the opportunity to introduce new aspects	✓
Add sections (equivalences and best practices) in the guidelines' template	✓
Modify the name of some indicators	✓
Include the issue underwater noise	×
Include the issue ballast water	×

6. TEIP application

This section shows the interface of the tool, from the point of view of the user. Initially, the introduction presents the several steps that compose the TEIP tool. The time to complete the tool is estimated in 20 minutes, and the confidentiality is ensured.

The first page when entering to www.eports.cat/teip is the TEIP introduction. In figure 4 the different steps of the tool are briefly explained.

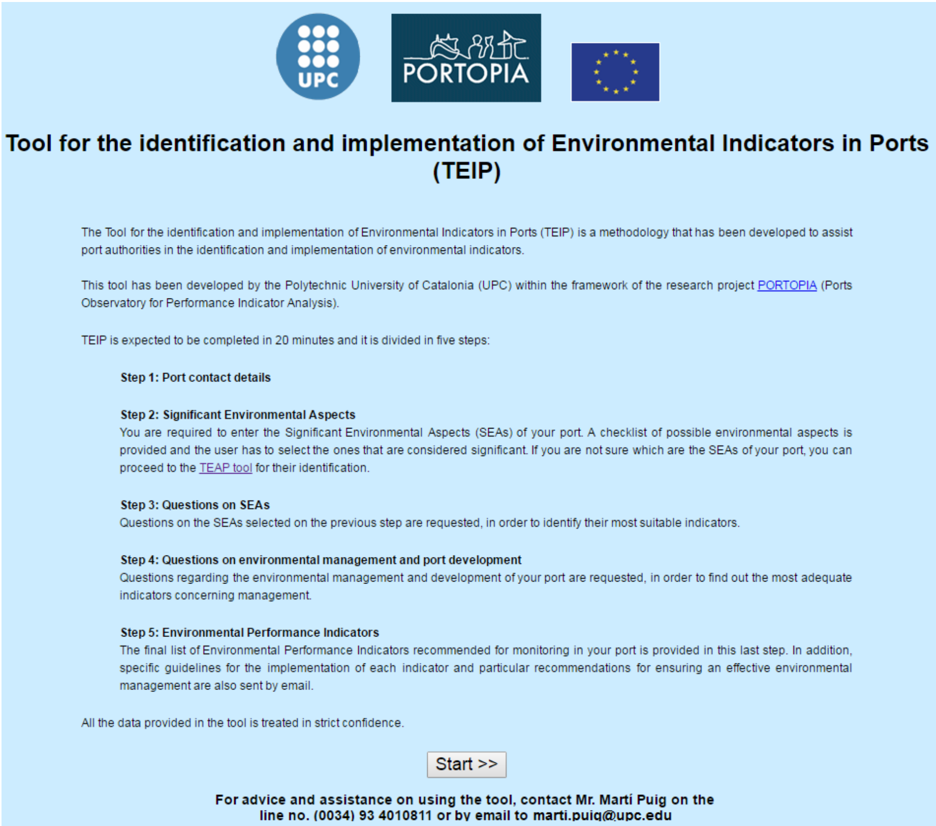


Figure 4: Final screenshot of the TEIP introduction

Step 1 requires the contact details of the respondent. It contains the name and country of the port, and the name, position and email of the respondent. A screenshot of this section is showed in figure 5.

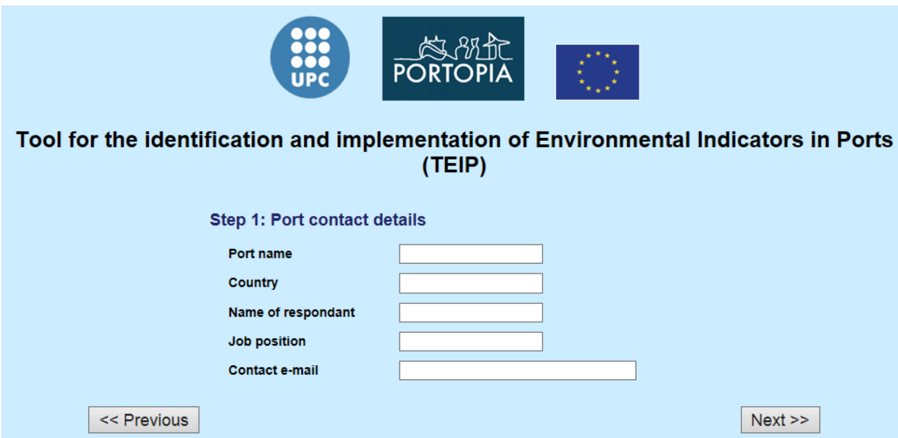


Figure 5: Final screenshot of TEIP Step 1: Port contact details

In the Step 2, the respondent has to select the aspects that are considered significant in his/her port. If the port has used the TEAP tool to identify significant aspects, then the user does not have to enter the SEAs, since they are already considered by the system. Figure 6 shows the interface of the step 2. The definition of each aspect is provided in the symbol *i* and there is a blank space to add further aspects, if it is the case.

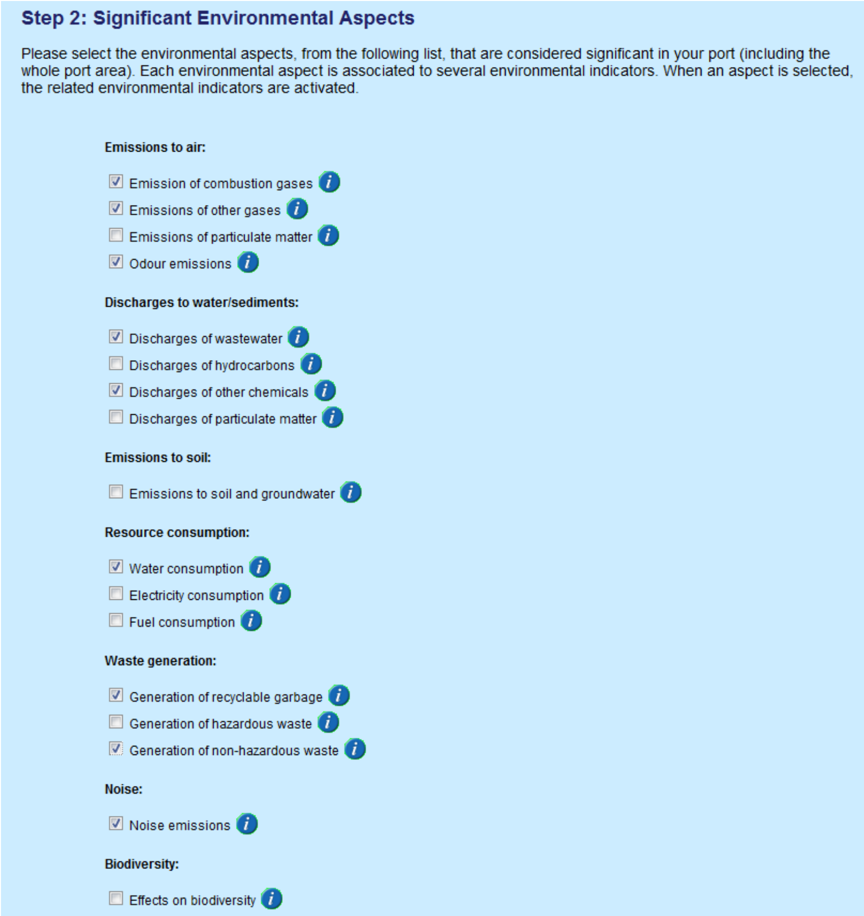


Figure 6: Final screenshot of TEIP Step 2: Significant Environmental Aspects

Step 3 is composed of a set of questions concerning some significant aspects that require more detail. For those aspects that the tool has enough information, it is not needed to answer further questions. As it can be seen in figure 7, the environmental aspect is mentioned and under it there is/are the related question(s). All the questions are Yes/No responses.

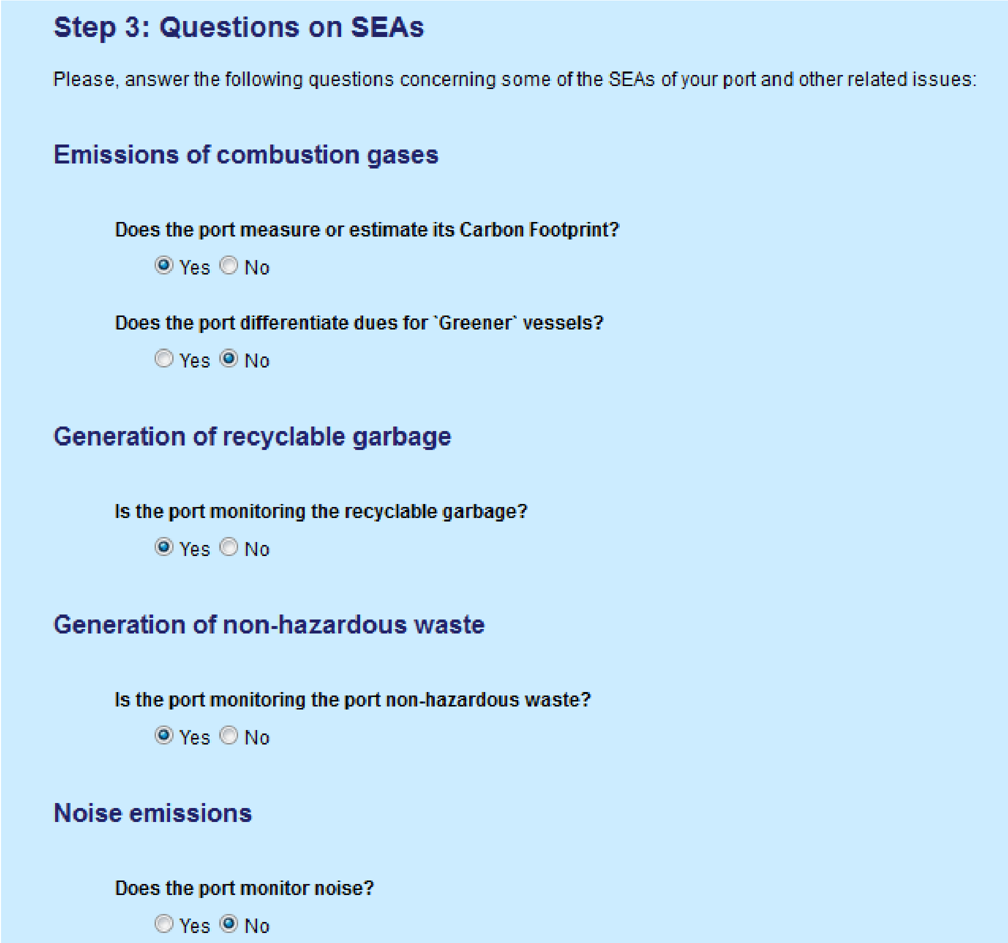
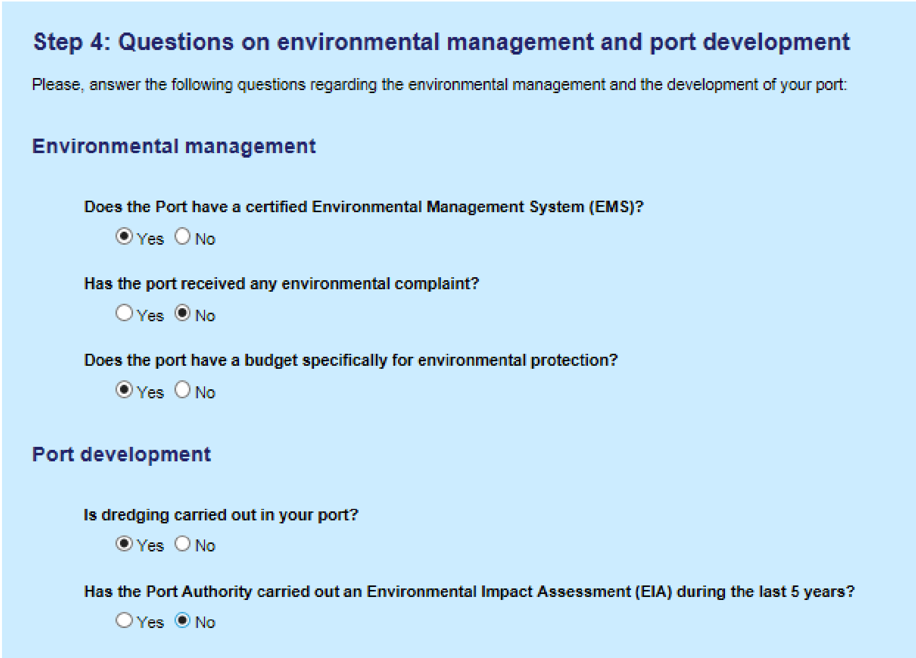


Figure 7: Final screenshot of TEIP Step 3: Questions on SEAs

The Step 4 comprehends a set of questions on environmental management and port development. It is asked in a separate step since they do not correspond to any SEA of the TEAP tool. All the questions are Yes/No responses. Depending on the answer, additional questions are displayed. For example, although it is not shown in figure 8, if the respondent selects ‘No’ in the first question of EMS, further questions on the EMS elements (e.g. environmental policy, objectives, monitoring plan) appear.



Step 4: Questions on environmental management and port development

Please, answer the following questions regarding the environmental management and the development of your port:

Environmental management

Does the Port have a certified Environmental Management System (EMS)?

(•) Yes ( ) No

Has the port received any environmental complaint?

( ) Yes (•) No

Does the port have a budget specifically for environmental protection?

(•) Yes ( ) No

Port development

Is dredging carried out in your port?

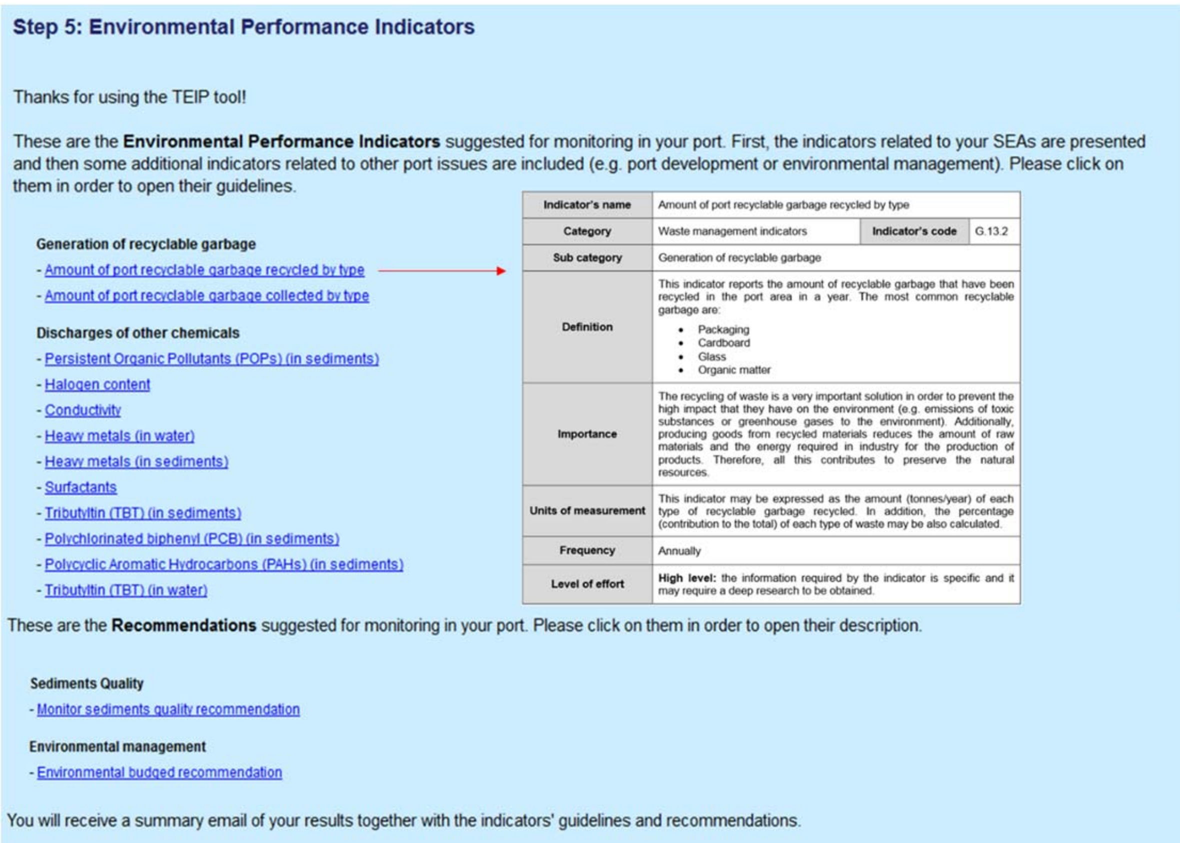
(•) Yes ( ) No

Has the Port Authority carried out an Environmental Impact Assessment (EIA) during the last 5 years?

( ) Yes (•) No

Figure 8: Final screenshot of TEIP Step 4: Questions on management and development

Finally, as shown in figure 9, the last step presents all the indicators that resulted recommended for monitoring in the port. The user can click over the indicators or recommendations in order to obtain their respective guidelines. The indicators are listed separately from the list of recommendations, and they are presented classified by categories of aspects.



Step 5: Environmental Performance Indicators

Thanks for using the TEIP tool!

These are the **Environmental Performance Indicators** suggested for monitoring in your port. First, the indicators related to your SEAs are presented and then some additional indicators related to other port issues are included (e.g. port development or environmental management). Please click on them in order to open their guidelines.

Generation of recyclable garbage

- Amount of port recyclable garbage recycled by type
- Amount of port recyclable garbage collected by type

Discharges of other chemicals

- Persistent Organic Pollutants (POPs) (in sediments)
- Halogen content
- Conductivity
- Heavy metals (in water)
- Heavy metals (in sediments)
- Surfactants
- Tributyltin (TBT) (in sediments)
- Polychlorinated biphenyl (PCB) (in sediments)
- Polycyclic Aromatic Hydrocarbons (PAHs) (in sediments)
- Tributyltin (TBT) (in water)

Indicator's name	Amount of port recyclable garbage recycled by type		
Category	Waste management indicators	**Indicator's code**	G.13.2
Sub category	Generation of recyclable garbage		
Definition	This indicator reports the amount of recyclable garbage that have been recycled in the port area in a year. The most common recyclable garbage are: • Packaging • Cardboard • Glass • Organic matter		
Importance	The recycling of waste is a very important solution in order to prevent the high impact that they have on the environment (e.g. emissions of toxic substances or greenhouse gases to the environment). Additionally, producing goods from recycled materials reduces the amount of raw materials and the energy required in industry for the production of products. Therefore, all this contributes to preserve the natural resources.		
Units of measurement	This indicator may be expressed as the amount (tonnes/year) of each type of recyclable garbage recycled. In addition, the percentage (contribution to the total) of each type of waste may be also calculated.		
Frequency	Annually		
Level of effort	**High level:** the information required by the indicator is specific and it may require a deep research to be obtained.		

These are the **Recommendations** suggested for monitoring in your port. Please click on them in order to open their description.

Sediments Quality

- Monitor sediments quality recommendation

Environmental management

- Environmental budged recommendation

You will receive a summary email of your results together with the indicators' guidelines and recommendations.

Figure 9: Selected final screenshot of TEIP Step 5: Environmental Performance Indicators

7. Conclusions

The paper has demonstrated that Environmental Performance Indicators are a key element for ensuring environmental protection and sustainable development since they provide organisations with real and updated data and information of their environmental performance. The three major standards for the achievement of an Environmental Management System within the port sector, ISO 14001, EMAS and PERS, recognise the importance of using indicators and encourage organisations to establish a method to periodically evaluate the performance through indicators. Some examples of indicators are provided by these standards, for instance, EMAS provides a list of nine core indicators. However, they do not define any specific procedure.

Another interesting issue studied in this paper was the existing methods for the identification of indicators. The research demonstrated that there is a small number of procedures developed aiming at obtaining a system of indicators. The level of implementation of these methods among ports was studied, and it was found that they are not currently in place among the sector.

Based on the aforementioned reasons, it was detected that a new methodology, available to all European ports was needed, to be broadly implemented among ports, so that they are able to identify their most adequate indicators with a scientific procedure behind it. Through the existing techniques and on the considerations from the EMS standards, a new methodology was developed: the Tool for the identification and implementation of Environmental Indicators in Ports (TEIP).

To develop the tool, firstly an inventory of existing environmental indicators in ports was created. Research on the Global Reporting Initiative (GRI) guidelines, outcomes of research projects and studies, information from ESPO environmental reviews, pieces of legislation, port environmental reports, and EMS standards contributed to the identification of almost 650 indicators that are in use in ports. All the proposed indicators are real (existing), which proves that they are in place and take part in the daily environmental management. The broad variety of indicators also demonstrates the diversity of the sector in terms of needs, activities, responsibilities and priorities.

Since a large number of EPIs was compiled, it was required to reduce the extensive list of indicators to a shorter list, more appropriate to be implemented in ports. The filtering process consisted of three main steps: a first filter against a set of five criteria, a regrouping process, and a second filter against of six criteria. The criteria were established through a research of several different sources containing examples of criteria used. The indicators that complied with more criteria were selected and the ones that obtained a poor performance were rejected. After evaluating all the indicators, a total number of 171 indicators were selected to be incorporated into the TEIP tool.

This tool was developed using as a basis the aspects that were considered significant for the port. The interrelations between aspects and indicators were created. In TEIP, the list of significant aspects of the port may be obtained from two ways: as a result of applying the TEAP tool or by introducing the aspects manually. Some indicators are obtained straightaway when the aspect is selected as significant and other indicators are activated after answering a set of related questions. In any case, the user receives a set of indicators suggested for monitoring in the port, along with a guideline for its implementation. A set of recommendations are also provided. The tool suffered a process of validation from sector stakeholders, which provided the opportunity to update and improve it.

This method is applicable to all types of ports (e.g. seaport, inland port), no matter their country, geographical location, size or commercial profile since it provides specific results for each one. This method assists port managers in identifying the EPIs of their own port area in a user-friendly, practicable and time-effective manner. This will help ports to have the suitable tools to measure their environmental performance, gather valuable elements for decision-making and to enhance their environmental performance in order to achieve a sustainable development. In addition, the adoption and application of TEIP have the potential to enhance further the exchange of knowledge and experience throughout the sector and with its wide range of stakeholders.

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