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Challenging a sustainable port. A case study of Souda port, Chania, Crete

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ABSTRACT

As global maritime trade continues to soar, there is a growing demand for a sustainable balance between economic, social, and environmental performance. Thus, transparent assessment, strengthening the governance and scientific cooperation, as well as developing comprehensive communication are required amongst all interested parties to create realistic plans to meet sustainable development goals. This case study research thoroughly analyzes a Mediterranean port to find challenges and possible solutions to creating a sustainable port. The goal is to provide a methodology for policymakers to develop their future strategies for optimizing sustainable multi-objective design indicators. In addition, it addresses relative purposes for the sustainability of maritime transportation, such as improving energy efficiency, improving the quality of marine waters, and employing green technologies. Initially, key performance indicators were used to solve the multi-objective optimization problem. Then, using Statistical Package for Social Sciences (SPSS) software, the correlation of different criteria about specific demographics was studied. A factor analysis was applied by reducing the variables while maintaining as much information as possible. The methodology provides both quantitative and qualitative tools for policymakers to develop their future strategies to optimize environmental (i.e., new technological tools for reducing/eliminating pollution, recycling), social (i.e., motivations for social participation), and economic (i.e., willingness to pay) sustainability. The results indicated that the responders attributed low scores to road quality, traffic, and waste management but assessed positive indicators such as renewable energy resources, air quality, noise, and dust. Besides, a strong relationship was revealed between gender, age, and educational level with sustainability issues such as social acceptance, environmental awareness, and economic contribution.

1. Introduction

Nowadays, the need for ever-greater transport of goods through maritime trade is the driving force behind optimizing port management and efficiency (Attia, 2016). These new marine transport requirements, due to globalization, have created new port data for their management (Hlali & Hammami, 2018). However, the rapid development of ports has resulted in the degradation of the environment and the rise of social and economic problems (Lam & Yap, 2019). Many international ports are already implementing measures to meet modern needs and requirements. Although the shipping industry is widely regarded as one of the least environmentally detrimental modes of transportation, it faces significant risks due to the scale of shipping and port operations (Peris-Mora et al., 2005). In this context, the need to protect the environment has forced the port industry to adapt its services to enhance competitiveness (Molavi et al., 2019).

In recent years, the change in the European Union (EU) policy and the international community has led to the improvement of ports in all areas efficient and competitive and fully meet the demands of modern trade (Lim et al., 2019). Although implementing integrated sustainable management in ports is extremely important, it is not always feasible to apply it directly but gradually by integrating parameters into each activity to render them viable in social, economic, and environmental sustainability.

Adopting and implementing integrated policies for sustainable development at both European and global levels are becoming imperative. From the second half of the 20th century, the interaction between economic growth, social development, and environmental protection has been evident. The world community has recognized the importance of achieving these three goals in a balanced way to secure a form of long-term development globally, where both present and future generations will enjoy decent living (Zhang & Ravesteijn, 2019). Notwithstanding the burgeoning research, significant weaknesses have been identified that hinder ports' development (Bergqvist & Monios, 2018).

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Research on the marine environment in the context of sustainable development is more relevant than ever, a fact that has attracted the attention of many researchers. However, although researchers and policymakers have focused on quantifying sustainability, a limited number of studies have been conducted on the quality that focuses on the organizational challenges for implementing appropriate measures. To fill this need, this study proposes a methodology for improving port sustainability through specific actions, highlighting parallel the necessity of collaboration of citizens.

Furthermore, many surveys aim to study the perspectives of stakeholders involved in policy and decision-making processes to achieve sustainability goals. The term "stakeholders" might refer to an individual, a group, or an organization affected by the proposed changes, such as shipping companies, store owners, local industry, local organizations, and social and academic institutions such as schools and universities (Kahane Professor et al., 2013). On the contrary, there is a limited number of surveys examining citizens' participation in planning and decision-making. While stakeholders usually represent organized group positions and have a collective interest, citizens are generally considered to be members of local societies who represent individual positions away from financial interests. Table 1. presents some of the advantages and disadvantages of the stakeholders'/citizens' involvement in the decision-making process.

In the present research, an attempt was made to explore citizens' views on the sustainability of the port, examining at the same time the following aspects (social, environmental, and economic). Moreover, it tried to highlight the weaknesses of ports towards zero energy transition as well as the improvement of environmental parameters and provide solutions by proposing measures where resource exploitation, investment direction, and technological development orientation are all harmoniously developed and respectful of human beings' needs (Sifakis & Tsoutsos, 2021). As the EU recognizes that citizen participation in the European Green Deal is critical for policy legitimacy and public support for climate action, our research will try to provide answers as to which indicators are most significant and what measures need to be taken to improve sustainability indicators based on the citizens' opinions. The interaction between port administrators and citizens should be interactive, conversational, and built on trust to enhance public awareness and encourage them to perceive, understand, adapt, and accept the services and systems provided in a future port. Getting the citizens' points of view increases port productivity, boosts citizen participation, and empowers all citizens in the new environment (Spandagos et al., 2022).

Table 1
Advantages and disadvantages of studying stakeholders'/citizens' view.

Stakeholders		Citizens	
Advantages of exploring stakeholders' opinions	Disadvantages to exploring stakeholders' opinions	Advantages of studying citizens' opinions	Disadvantages of studying citizens' opinions
May more effectively represent specific perspectives and interests because of experience and knowledge	Stakeholder selection may not reflect the relative diversity of views	Increase public legitimacy	Limited capabilities for the implementation and limitations of specific suggested solutions
Ability to provide more scientifically documented solutions	The choice of stakeholders can compromise the public legitimacy of a participation process	Increase diversity and pluralism	The large gap in opinions between social groups
They may influence authorities, decision-makers, administrators, and the broader political sector	Strong stakeholders may dominate		

Given the importance of the maritime industry in achieving the Sustainable Development Goals (SDGs), the lack of relevant research on maritime-related topics is notable, as stressed by Sciberras and Silva (2018), stating that no SDGs expressly address the maritime sector. In this context, the survey aims to analyse citizens' perspectives with the primary purpose of providing solutions for the maritime industry with regard to the implementation of the Agenda of the United Nations for SDGs.

The reasons taken into account for the involvement of citizens rather than the stakeholders in this survey were firstly boosting the citizens' views to be taken into account by the relevant bodies; in addition, highlighting that the participation of informed public increases the ability of citizens to deal with current and future problems; also, promoting the participation of citizens as they feel that their opinion is made known and valued and that their community respects them, which in turn is conducive to their more active involvement in decision-making and implementation processes. Based on the citizens' opinions, our research will try to answer which indicators are most significant and what measures need to be taken to improve them. More specifically, the questionnaire was employed to achieve the following research objectives:

- Investigate citizens' level of background information and awareness on sustainable development issues.
- Examine the degree of response/acceptance to the proposed measures for sustainable development of ports by the citizens
- Identify possible problems in implementing the suggested necessary measures and propose potential solutions.

The questionnaire in our study was designed around 31 questions deemed sufficient for the research objectives. In addition, these questions were prepared in a clear and straightforward manner using the following type of questions: (a) multiple-choice questions, in which respondents were given a set of options to choose from, and (b) scaling or ranking questions, in which respondents were given the option of ranking the available answers on a scale using a given range of values (namely, in our case, the Likert scale). The particular questionnaire was distributed to 500 citizens (Appendix 1). Key Performance Indicators (KPIs) were initially used to analyze the results. Then, with the use of the Likert method, the question criteria were evaluated. Moreover, using the SPSS, the correlation between the different criteria on specific demographics was studied. Finally, a factor analysis method was applied by reducing the variables while maintaining as much information as possible.

The paper is structured as follows: in the next section, a comprehensive overview of the port sustainability concept focusing on problems, actions, and results are analyzed. The methodology is presented in Section 3. The survey results are summarized and interpreted in Section 4. Section 5 provides proposed measures. Conclusions and future research agenda are provided in the last section.

2. Literature review

The concept of "sustainability" is widespread. It is applied with the main aim of improving the current situation, where the exploitation of resources (environmental), the direction of investments (economic), the orientation of technological development (technical), and institutional change (socially) develop harmoniously and with respect both human needs and the environment (Ashrafi et al., 2019). In general, improving sustainability can lead to a better holistic image of the port.

In addition, the concept of the green port, as mentioned in this study, has aroused the interest of academics, especially marine economists, engineers, social scientists, and others with an interdisciplinary background. However, the barrier found while conducting a bibliographic

search on the issue of green ports is the lack of a universally acknowledged definition of what a green port policy is and what it entails. Its broad definition allows different port authorities to include a series of tasks in their environmental goals. For the purposes of this paper, it was decided to use the definition of the green port as "an environmentally friendly and sustainably developed port, which meets all environmental requirements" (Satir & Doğan-Sağlamtimur, 2018). Insular small and medium ports are strongly depended on local communities to be upgraded by using mainly public financing. The local motivation could be, not only economic, but also environmental based on the approach "think locally, act globally". As a result, their local approach is critical for their sustainable planning.

Many ports have adopted various environmental, social, and economic criteria to study and analyze various aspects of sustainability (Argyriou et al., 2022). These criteria mainly provide citizens with an overview of the port situation, particularly indicating their strengths and weaknesses (Hossain et al., 2021).

To ensure that hazardous consequences are minimized, the shipping industry's activities are dictated by International and national regulations. The European Green Deal (EGD) agenda, announced by the European Commission in 2019, established a strategy for addressing climate change and environmental challenges, as well as transforming the EU into a fair and prosperous society with a modern, resource-efficient, and competitive economy that is decoupled from resource use (European Commission, 2019). Moreover, the European Union adopted the European Climate Law in 2021, which establishes a framework for assessing progress toward the goal of net-zero emissions by 2050 and intends to guarantee that all sectors of business and society contribute to that objective (Janota et al., 2022). Furthermore, the European Commission introduced 'Fit for 55′ in July 2021, a comprehensive package of legislative actions addressing climate, energy, land use, transportation, and taxation to ensure that EU policies are consistent with the EU's climate targets. Some of these projects are particularly relevant to the Blue Economy (Köhl et al., 2021).

The adoption of the Agenda of United Nations (UN) for Sustainable Development and the ratification of the 17 Sustainable Development Goals (SDGs) by all UN Member States in September 2015 is considered a milestone for the international community. For the first time, a consensus has been reached between developed and developing countries for achieving universal sustainable goals (Bennich et al., 2020; Cetrulo et al., 2020). Together with the Paris Agreement on Climate Change, the 2030 Agenda provides a road map for a better future and a global framework for international collaboration on sustainable development in its economic, social, environmental, and governance elements. Continuous SDGs progress is critical for demonstrating the EU's commitment to and leadership in sustainable development. Therefore, our research highlights the strengths and weaknesses of a port in various sections and proposes solutions to improve the environmentally-related SDGs. More specifically, our research focuses on promoting and further developing mainly SDGs 7 (Affordable and Clean Energy) and 11 (Sustainable cities and communities).

Climate change and other human acts that harm the environment on land and at sea require citizens' active participation and rapid intervention. Changes in residents' and customers' attitudes toward more sustainable standards can be achieved through education, awareness-raising, environmental monitoring, and reporting, all of which significantly strengthen the economy. Consumer habits, attitudes, and lifestyles that can be changed through education can help the financial assessment (Glavič, 2020).

Several methodologies have been identified in the literature to increase competitiveness and improve customer service to enhance port sustainability. Puig et al. (2014) proposed a method using European Performance Indicators (EPIs) to assess port authorities' environmental performance and monitor progress toward continuous improvement. They suggest that port authorities demonstrate compliance and continuous improvement through scientific data and measurement tools. Furthermore, one additional tool is European Resources Planning (ERP) (Chadhar & Daneshgar, 2018), where the majority of researchers found that ERP systems are urgent to strengthen the economy (Sislian & Jaegler, 2020).

Yeo et al. (2015) investigated the relationship between port service quality and customer satisfaction at Korean container ports. This research showed that providing a high-quality port service is significant to consumer satisfaction.

Ha et al. (2017) posed the question, "How to design a Port Performance Measurement (PPM)» framework as a diagnostic instrument to aid decision-makers in analyzing port performance?". The suggested PPM framework's goal was to identify the most critical Port Performance Indicators (PPIs) for each group of port citizens and create an effective performance evaluation tool.

Through interviews with experts representing the port authorities and important stakeholders at Port Canaveral, Kodzi et al. (2021) aimed to create a framework through which a current cruise port may include multiple stakeholder interests to realize its attractiveness. Dimitrovski et al. (2021) investigated stakeholder perspectives on the sustainability of coastal and marine tourism in cross-border zones of the Nordic coastal area using a mixed-method approach. The findings add to existing knowledge by considering the perspectives of cruise tourists (individual) and destination marketers and policymakers (organizational).

Taking into account existing research, a gap that can be filled is that activities and sustainability measures are primarily focused on environmental issues, such as pollution (Acciaro et al., 2014; Alamoush et al., 2021). Another gap that our research aims to fill is that although researchers have used several methodologies to help port decision-makers propose tools and technologies based on stakeholders' preferences for a transition towards sustainability, there is not a wide range of studies based on citizens' preferences. Given the pressure on ports to maintain sustainable performance, including their role in sustainable development, and the aforementioned academic and practical gaps, this study aims to provide a framework that will guide port designers in integrating sustainable ports into sustainable development.

Academically, the study incorporates advancements in port sustainability, including categorizing findings (actions and measures), developing a conceptual framework that establishes new relationships and perspectives on the subject, and proposing a methodology to investigate sustainable port actions further. From a practical standpoint, the study's findings are a comprehensive instrument that guides port professionals and policymakers about various actions and sustainability measures. As a result, they may assess their progress, determine whether they are viable, and determine how to improve their implementation.

2.1. Social sustainability

Social sustainability invokes decisions and projects that promote the overall improvement of society (Olakitan Atanda, 2019). The philosophy for the common good and social responsibility actions is today the most comprehensive strategy that can guarantee long-term economic viability and, at the same time, prosperity for society. The realization that there can be no survival and success, expressed only through economic figures, has changed society's expectations radically. Any work is judged based on financial results and social and environmental criteria (Dobre et al., 2015).

2.2. Environmental sustainability

As mentioned above, ports play a crucial role in national and international transport networks. Therefore, it is evident that the indirectly and directly related functions and activities cause various complex environmental issues (Lim et al., 2019). The environmental dimension needs to promote actions for environmental management (Lam & Li, 2019). More specifically, it calls for efforts to reduce emissions, promote environmentally-friendly technology and renewable energy sources,

and sustain initiatives for achieving environmental sustainability (Chel & Kaushik, 2018).

2.3. Economic sustainability

European seaports are vital for the economy, as many goods are exported or imported into the European Union. Economic sustainability seeks to meet the needs of people in a way that preserves the natural resources and environment for future generations (Nikčević, 2019).

2.4. Proposed measures

According to the literature, proposed measures for improving sustainable indicators are mentioned in Tables 2-4.

3. Methodology

3.1 Case study description

The port of Souda (Chania-Crete) is a European one located at a significant position in the network of Mediterranean Sea routes. The location and geomorphology of the port render it of supreme strategic importance and rank it among the top in the Mediterranean. In addition, it is the primary cargo and passenger line between Western Crete and the rest of Greece. In recent years, it has been continually developing as a crossroad of the most crucial sea routes contributing decisively to the commercial, tourism, and economic development of the Prefecture of Chania as thousands of passengers, vehicles, and all kinds of goods (agricultural, livestock, etc.) are transported daily through it. Moreover, it has been established as an imperative destination for cruise ships carrying thousands of tourists annually. Finally, the port is characterized as an area of particular military interest due to the military port facilities (Naval Base of Crete, NATO Naval Base).

Unfortunately, however, the current condition of the port does not match its utility significance.

Its current outdated situation and the lack of proper port technological equipment make it necessary to upgrade it. The upgrade should aim to smooth integration of the port in the surrounding area through various activities that will be the main lever for developing the wider region. In this way, new perspectives and jobs will be created in a particularly unfavourable situation for the region's economic data.

3.2. Sampling

The profile of the sample taken through random sampling (500 individuals) is identified in Table 5. The data collection process took place for approximately-three months (early February to late April 2019). The selected categories and subcategories of citizens are listed below as the exact number of participants per subcategory.

Demographic data were used to examine the perspectives in several categories such as age, educational level, and gender. Specifically, the research examines the relationships between age and environmental concern, environmental values, attitudes towards environmental behaviors, environmental awareness, environmental knowledge, environmental motivations as well as environmental intentions. Furthermore, it investigates sustainable perceptions in relation to education and occupation, with the aim of determining greater incentives for groups that present with weak sustainability perceptions. Other demographic data was utilized to check the research's shortcomings, such as the high number of replies from permanent residents as opposed to tourists. This is consistent with the fact conducted during winter and the winter months when visitor traffic was low.

3.3. Mathematical tools and models

3.3.1. Mathematical tools

The nature of the research was quantitative and qualitative, exploiting a specially designed questionnaire. The questions sought to cover indicators referring to society, the environment, and the economy. More precisely, the questionnaire consisted of four different parts. The first three sections were focused on assessing social, environmental, and economic sustainability, while the fourth looked solely at demographics. The research instrument used to study the questionnaire was the Likert scale.

3.4. Mathematical models

3.4.1. Key Performance Indicators (KPI)

To ensure the priorities of public and social interventions to create a sustainable port, we first assessed the society's attitudes towards various problems so that the planned actions are compatible with the local framework and citizens' perceptions. The port quality assessment focused on three factors directly affecting the civilians' lives (social, environmental, and financial) carried out using a methodology based on the creation/determination of KPIs (Schipper et al., 2017). The indicators provide quantitative information on the existing port condition and the willingness and interest of the society in the new measures/actions to be taken to develop a green port.

Each indicator, referring to a specific variable, X_i, is calculated by the following equation.

$$KPI_{X_i} = \frac{\sum weight_j * frequency_j}{100 * \text{total number of answers for } X_i}$$

Studying one of these KPIs, Table 6 analytically depicts the number of answers for the question of the social assessment "Can the creation of sustainable port bring about positive results?", namely X_1, about the gender [Male (M), Female (F)].

The particular indicator (of X_1 w.r.t Male) is calculated as follows:

Table 2
Measures to increase the social indicators.

Factors	Ways	Actions	Results	Bibliography
Social elements	Social participation	• The right to information • Present the need for sustainability	• Train people so that they can substantiate their objections and propose alternative solutions. • Contribute to better environmental decision-making, facilitate complex problem solving, safeguard the legitimacy of the process, and foster citizens' environmental awareness	(Meadowcroft, 2004)
	Motivations	• Lower port charges • Reduced cost of tickets based on sustainability goals	Willingness for participation/contribution	(Marbuah, 2019)
	Social development	New businesses due to increased passenger numbers	Better social conditions	(Nyenno & Nitsenko, 2017)
Information policy	Education	Information	• Safety and security in new jobs • Benefits and disadvantages of sustainable growth	(Pauw et al., 2015)

Table 3
Measures to improve the environmental indicators.

Factors	Measures	Ports of implementation (Case studies)	Cost	Bibliography
Air quality	Replacement of obsolete technology cars/ trucks	Barcelona (Spain), Koper (Slovenia)	Medium-High	(Bjerkan & Seter, 2019)
	Cold ironing	Antwerp (Belgium), Hamburg (Germany)	High	(Zis, 2019); (Bouman et al., 2017)
	Reducing port dues	Los Angeles/ Long Beach (USA) / Rotterdam (Netherlands)	No	(Winnes et al., 2015)
	Monitoring	Potland (USA), Antwerp (Belgium)	Low	(Toscano & Murena, 2019); (Olukanni et al., 2018)
	Solar power	Rotterdam (Netherland), Valencia (Spain)	Medium-High	(Bouman et al., 2017)
	Wind power	Mostyn (UK), Oostende (Belgium)	High	(Brabant et al., 2011)
	Reduced ship speed	Los Angeles/Long Beach (USA)	No	(Gusti & Semin, 2018), (Bouman et al., 2017)
	Electric cars	Port of Barcelona (Spain), New York and New Jersey (USA)	Medium	(Norsworthy & Craft, 2013)
Noise	Electric cars	Barcelona (Spain),	Medium	(Maffei & Masullo, 2014)
	Monitoring	Vancouver (Canada)	Low	(Kirichenko et al., 2017)
	Noise walls and barriers, i.e., Planting trees as a barrier	Vancouver (Canada)	Low-Medium	(Merchant, 2019)
Dust	Box-type handling of bulk material	Ust-Luga Sea Trade (Russia)	Low-Medium	(Kirichenko et al., 2017)
	Wind-dust screens	Murmansk (Russia)	Low-Medium	(Kirichenko et al., 2017)
	Smart Lighting	Long Beach Container Terminal in Los Angeles, CA	Low-Medium	(Sdoukopoulos et al., 2019)
	Support via ICT systems	Antwerp (Belgium)	Low	(Kotowska & Kubowicz, 2019)
Waste management	Recycling	Helsinki, Igoumenitsa (Greece)	Low-Medium	(Beza et al., 2014)

Table 4
Measures to improve the economic indicators.

Ways	Results	Bibliography
Lower municipal taxes for residents	Willingness to pay/ contribute	(Cohen, 2019)
• Funding by government • EU projects	Increase competitiveness	(Malinauskaite et al., 2017)
Informing citizens about the advantages and disadvantages (e.g., aesthetic image) of new investments	Reduce expenses such as energy and water consumption	(Pauw et al., 2015)

Table 5
Profile of the sample.

		% of responses
Sex	Male	76.6
	Female	23.4
Age	15–24	9.6
	25–39	32.6
	40–64	53.4
	>64	4.4
Job	Public/State employee	26.6
	Private employee	26.6
	Unemployed	5.2
	Freelancer	27.2
	Housewife	0.6
	Retired	7.0
	Student	6.8
Level of education	Junior High School (JHS)	3.2
	High School (HS)	26.8
	Bachelor's degree (BD)	49.4
	Master Degree (MSc)	15.6
	Doctor of Philosophy degree (PhD)	5.0
Residency	Permanent	85.6
	Non -permanent	14.4
Frequency of port visits	Up to 2 times	37.8
	2–4 times	26.6
	> 4 times	35.6
Reasons of visit	Personal	75.4
	Professional	24.6

$$KPI_{X_i(M)} = \frac{\sum weight_j * frequency_j}{100 * \text{total number of answers for } X_i} = 13*0 + 21*25 + 62*50 + 179*75 + 108*100)/38300 = 0.73$$

X_1 refers to questions 1 and M: Male.

Similarly, the indicator of X_1 w.r.t Female is equal to:

$$KPI_{X_1(F)} = (3*0 + 5*25 + 18*50 + 53*75 + 38*100)/11700 = 0.75$$

To get a KPI for X_1 for the gender (namely $KPI_{X_1(G)}$), the following results were normalised. These weights are compatible with the gender distribution in Greece's last official census population (Table 7).

So, finally, the KPI for the X_1 (gender) is equal to:

$$KPI_{X_1(G)} = 0.49*0.73 + 0.51*0.75 = 0.74$$

The same method is applied to evaluate KPIs for each of the variables of the social, environmental and economic section w.r.t demographical data. (Table 8).

Finally, the KPI for the social assessment related to gender is calculated as the average of the KPIs of the variables of the social part w.r.t the gender: $KPI_{(S)}$=0.63.

Based on the above calculations, the environmental and economic assessment for the gender is$KPI_{(EC)}$ = 0.46 and$KPI_{(ENV)}$ = 0.69, respectively.

3.4.2. Software Package for the Social Sciences (SPSS)

In sustainability monitoring, multilevel statistical techniques play an increased role as tools to assess and assist the policymakers of the port. The main objective is to identify the most critical factors influencing the deterioration of natural ecosystems. The statistical analysis of the data obtained (questionnaire responses) was conducted using the SPSS v. 25.0 statistical packages.

3.4.3. Factor Analysis

Another step in our statistical analysis was the exploratory factor analysis aimed to reduce the dimension of the data and identify any latent variables (main factors) characterizing them (Maskey et al., 2018). Factor analysis for each of the three parts of the questionnaire (social, environmental, and economic) was employed. Such factors

Table 6
KPI computation for the question X_1 w.r.t Gender.

		Not at all	A little	Little	Much/A lot	Very much	Total	KPI
Weight X_1		0	25	50	75	100		
Can the creation of a sustainable port bring about positive results?	M	13	21	62	179	108	383	0.73
	F	3	5	18	53	38	117	0.75
	T	16	26	80	232	146	500	0.73

Table 7
Gender and age distribution of the population of Greece (census 2011).

		Number of Citizens	Percentage
Sex	Male	5.303.223	49
	Female	5.513.063	51

determine the basic structure of the correlations of a set of variables and create a subset of interrelated variables. The specific factors represent the dimensions of the data, while at the same time, the variables that compose them by definition show significant correlations between them. In practice, it is a data reduction technique with the ultimate goal of finding the existence of common factors between a group of variables. This tool was utilized in our research to cluster different criteria and identify the port's primary issues. With this process, the main problems could be identified and targeted solutions proposed.

4. Results

4.1. Based on KPI

4.1.1. Social assessment

The social network should be the key priority to accomplish the parallel and balanced development of the three sustainability pillars. In this context, the research aims to answer how citizens would be satisfied with creating a sustainable port and suggest possible solutions to ensure maximum responsiveness. The survey results showed that citizens expressed high satisfaction with developing a green port (63.8 %). More specifically, they expressed positive opinions about creating new jobs (63.6 %) and better working conditions (58.6 %). On the other hand, they assessed the section as very low concerning the public's information about the advantages/disadvantages of sustainable development variables (90 % not sufficient).

4.1.2. Environmental assessment

The citizens assessed all indicators relating to the port's environmental footprint as relatively low, indicating that its picture is not satisfactory from an environmental point of view and that measures are needed to improve it. The sample granted the environmental indexes low (air pollution (31.4 %), noise (27 %), and dust (22.8 %). The primary environmental problems of this port, like the ones of major international ports, are sea pollution (37.1 %), waste management (50.6 %), road quality (75.4 %), and traffic (66 %). A significant source of pollution is the ships (31.4 %), the adjacent military port facilities (29.6 %), and the traffic (22.4 %). Another element highlighted by the environmental assessment survey is the endorsement of specific types of renewable energy sources by citizens, such as solar (54.6 %), wind (47.9 %), tidal (41.8 %), and biofuels (37.3 %).

The results showed that all indicators relating to the low environmental footprint of the port of Souda were granted very low by citizens, indicating that the situation is not satisfactory and measures are needed for improvement. The assessment of environmental indicators, particularly in Section I of the questionnaire, suggests that port managers must take immediate action. This can be done with properly planned activities based on good practices from other ports. In the case of section II, it is observed that the sources of pollution (facilities, vehicles, ships) have almost the same environmental impact. Another element highlighted by the environmental assessment survey in section III is endorsing specific types of renewable energy sources by citizens, such as wind and solar. This is explained by the plentiful sunshine and the strong area winds. On the other hand, the choice of wave energy does not find suitable ground, and other studies have been done in Greece as this solution does not thrive for all regions.

4.1.3. Economic assessment

Investment is essential for enhancing the port industry. The survey examined economic evaluation factors such as investments in various environmental fields, the degree of involvement of public/private partnerships, and citizens' willingness to contribute financially to creating a sustainable port. The results revealed that several investment initiatives are needed in various areas of concern, such as traffic (75.8 %), road quality (78.8 %), sea pollution (75.2 %), and waste management (81.6 %). Additionally, many respondents believe that a public authority should make these investments with the support of shipping companies (Fig. 1). In other words, most residents believe that if not entirely, at least to a greater extent, port investment projects should be done and funded by the public, assuming that port management is public. However, some private sector participation should also be considered due to the high cost.

Another significant result revealed by the survey is the neutrality of citizens to contribute financially to the creation of a green port (71 %). However, as neutrality is not conducive to any development, one objective of the survey was to suggest ways of re-sharing people's attitude approaches.

An illustrative analysis of these results is presented in the following radar charts demonstrating the values of the various KPIs about gender and age (Figs. 2-4) and KPIs for each pillar of sustainability (Fig. 5). The last figure demonstrates that the social parameter granted first, the environmental parameter second, and the economy last in creating a green port.

Table 8
KPIs related to gender and age.

	Gender			Age				
	M	F	normalization	15–24	25–39	40–64	>64	normalization
Social Average	0.61	0.64	$KPI_{X_1(S)} = 0.63$	0.62	0.61	0.63	0.58	0.61
Environment Average	0.45	0.46	$KPI_{(EC)} = 0.46$	0.50	0.46	0.44	0.42	0.45
Economic Average	0.69	0.70	$KPI_{(ENV)} = 0.69$	0.71	0.70	0.69	0.64	0.68

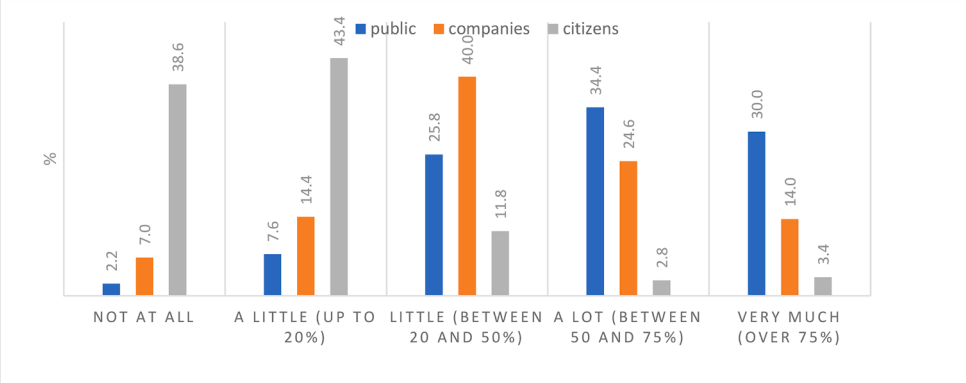

Fig. 1. Financial contributors to the creation of a sustainable port.

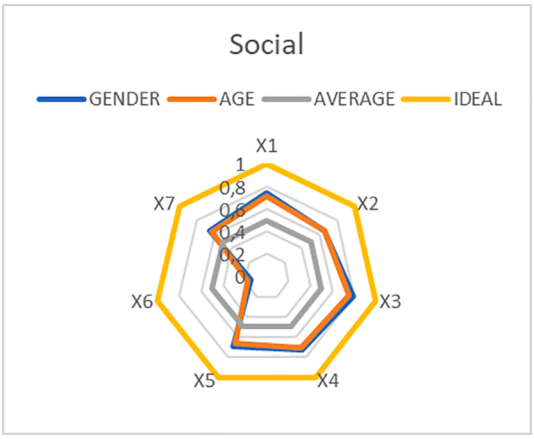

Fig. 2. Social assessment KPIs.

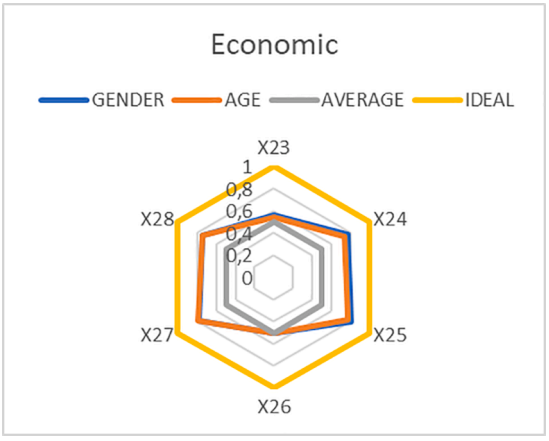

Fig. 3. Economic assessment KPIs.

4.2. Based on correlations

4.2.1. Gender

According to the literature, women are more concerned about environmental degradation (Collantes et al., 2018) and more committed to environmentally friendly behaviours such as recycling than men.

It is evident that women are more inclined toward developing a sustainable port, which coincides with the bibliography above (Table 9). Regarding the financial sector, women want to invest more money to deal with various forms of pollution while men want to invest more money in traffic issues. This can probably be explained because most professionals working at the port are men (i.e., truck/bus/taxi drivers, dockers, etc.).

4.2.2. Age

Another demographic data that is of importance and seems to be correlated (statistically significant) with some social, economic, and environmental variables is age (Wiernik et al., 2013). The labour force group (ages 18–64) considers that creating a sustainable port will have a positive impact. The study of these elements is essential as it outlines the trends of the working population, which are crucial parameters in developing a future strategy. Another element that becomes clear from the results is the correlation between age and social, environmental, and economic variables. These variables are assessed lower as the respondents' age increases (Table 10).

4.2.3. Level of education

Didham & Ofei-Manu, (2015) believes that education is the crucial element that facilitates social-economic and environmental development with sustainability. The literature has widely recorded the positive relationship between education level and environmental awareness (Hermann & Bossle, 2020). People with higher education are more concerned about the environment and more inclined to adopt environmental attitudes. Learning and teaching for environmental sustainability must occur not only in schools and higher education but across the system (formal, non-formal, and informal) and at all levels to reach its full potential (from early childhood to adulthood into older age). In this context, the European Commission has proposed an Environmental Sustainability Education Recommendation for students of all ages and levels of education, in accordance with the EU Biodiversity Strategy and the Communication on the European Education Area (European Commission, 2022). This effort is a step towards assisting EU countries in developing more robust policies for environmental sustainability, climate education, biodiversity, and other relevant issues through collaboration. Moreover, marine environmental protection has been deemed a top priority on the IMO's work agenda (Ampah et al., 2021). For more than two decades, the IMO has tried to ensure that both developing and developed countries have access to high-quality maritime education.

In Table 11, the coefficient for the following variables, such as positive results, creation of new jobs, better working conditions, and budget to be spent on sea pollution, are evaluated regarding education level.

Citizens with a lower level of education (JHS) have rated social variables lower. Social development is directly linked to education and culture. A starting point for its effective implementation is the change in values, attitudes, mentalities, and perceptions of life, both individually and collectively. However, this is a multidimensional issue. The approach requires reforms in all levels of the education system, which means changes in peoples' beliefs, stances, mentalities, and reactions towards all issues. Concerning the correlation of the financial variables

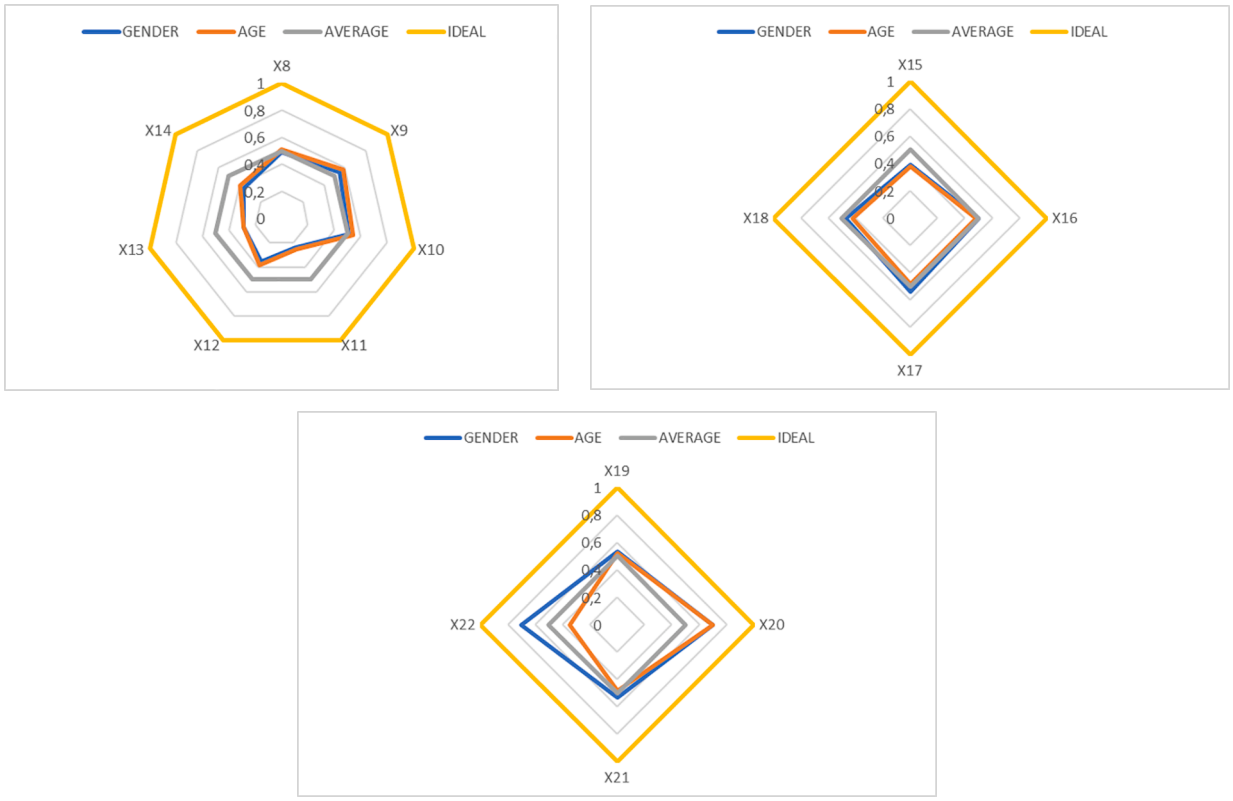

Fig. 4. **a.** Environmental quality indexes **b.** Environmental problems **c.** RES endorsement.

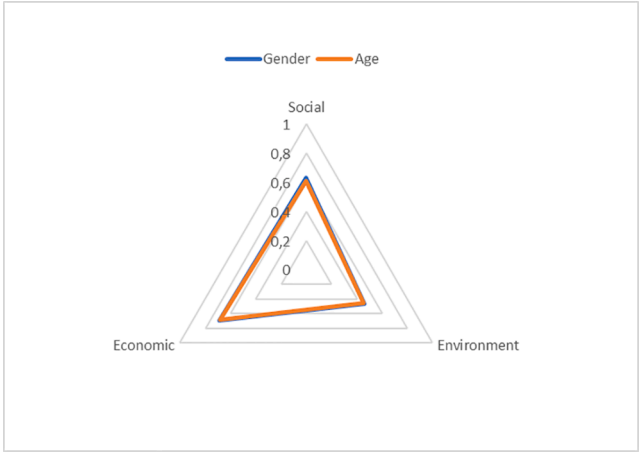

Fig. 5. KPI values per sustainability pillar/part.

Table 9
Chi-square tests w.r.t. gender.

Environmental				
	men (%) (%)	Women (%)	xˆ2	p-value
air quality	15.9	30.0	15.593	0.004
dust	19.6	33.3	13.721	0.008
waste management	47.2	61.6	10.502	0.033
sea pollution	43.7	58.2	15.895	0.007
Social				
prosperity of area	70.5	85.5	20.028	0.000
Economic				
budget spend on pollution	36.8	48.7	19.811	0.008
traffic/parking spaces	77. 3	70.9	10.359	0.035

Table 10
Chi-square tests w.r.t. age.

	Age					
Social	15–24 (%)	25–39 (%)	40–64 (%)	>=65 (%)	xˆ2	p-value
positive results	14.6	23.9	36.3	13.6	25.104	0.014
better working conditions	20.8	28.2	31.8	4.5	21.459	0.044
Economic (budget spent on)						
air pollution	29.2	12.3	10.5	9.1	23.343	0.025
sea pollution	50.0	41.7	31.1	27.3	32.106	0.006
waste management	54.2	48.5	39.7	22.7	26.917	0.008
Environmental						
traffic pollution	20.8	28.2	36.3	36.4	27.951	0.006
ships' pollution	16.7	11.0	7.9	4.5	28.710	0.005
tracks/ vehicles pollution vehicles	14.6	9.8	6.7	4.5	22.057	0.037

(e.g., budget to be spent on sea pollution) with the level of educational background, it can conclude that the participants of the survey with a low educational experience (JHS graduates) gave a lower grading to these variables as opposed to the ones of a higher academic background. It is also noticed that there are no significant variations of the statistical analysis results among the respondents of higher education level (e.g., High school graduates to PhD holders).

4.3. *Based on factor analysis*

For the requirements of the analysis, certain indexes had to be computed we had such as (a) the Keiser Meyer Olkin (KMO) index, which assesses the adequacy of the sample taken (Rossoni et al., 2016) and must be at least 0.50 to proceed to factor analysis (b) Bartlett's index, which assesses whether the relevance/correlation between

Table 11
Chi-square tests and KPIs w.r.t. level of education.

	JHS	HS	BD	MSc	PhD	x^2	p-value
Social							
Positive results	6.3 %	30.6 %	25 %	35.9 %	40 %	34.417	0.023
New jobs	18.8 %	38.1 %	39.4 %	32.15 %	32 %	32.754	0.036
Inform public	12.5 %	1.5 %	0.9 %	3.8 %	4 %	31.902	0.044
Economic							
The budget for sea pollution	18.8 %	41 %	34.3 %	41 %	32 %	46.806	0.05
KPIs per education level							
Positive results	0.53	0.76	0.72	0.77	0.74		
New jobs	0.55	0.74	0.74	0.69	0.71		
Better working conditions	0.7	0.81	0.86	0.82	0.82		
Waste management	0.23	0.37	0.38	0.34	0.5		

variables allows the application of the factor analysis and should be significant, i.e., its p-value must be less than 0.05 (DiStefano et al., 2009) and (c) the determinant index, testing for multicollinearity and singularity of the variables and that should be>0.00001(Elmousalami, 2019). Table 12 illustrates these indexes for each of the three parts of the questionnaire.

The results from factor analysis made it possible to group the variables, reducing the volume of data while retaining most of the information. Table 13 gives a short understanding per factor. In addition, Table 14 shows each variable's degree of correlation (loadings) with the (respective) factor. What can be noted is that most of the loadings are above 0.5 and, in many cases, above 0.7, which indicates a strong correlation between a variable and a factor. The variable contributes significantly to its interpretation. The research shows that the social assessment is related to two factors (Y_1, Y_2), the environmental with four (Y_3-Y_6) and the economic with three (Y_7-Y_9), respectively. Studying the results for each of the three areas of sustainability separately, it can be observed that social evaluation consists of two factors (Y_1: Sustainable port social parameters, Y_2: Public information). The first factor, Y_1, consists of five variables (four of which with a load of>0.5), indicating the importance placed by society on shaping the port sustainability projects. The second factor (Y_2) includes two variables related to environmental education and how the public is informed. As far as environmental assessment is concerned, the results have highlighted four factors (Y_3: Environmental indicators assessment criteria (Pollutant), Y_4: Renewable Energy Sources contribution, Y_5: Pollution sources impact criteria assessment, Y_6: Environmental indicators assessment criteria (traffic)). The results showed that factor Y_3 consists of four variables that focus on the evaluation of environmental problems and, at the same time, highlight the degree of gravity for each of the issues. It is, therefore, stated that the citizens are highlighting air pollution, noise, and dust pollution as serious environmental problems. Factor Y_4 consists of four variables that demonstrate the willingness of citizens to use specific forms of renewable energy sources by indicating their preference for the use of wind and solar energy. Factor Y_5 expresses citizens' views on pollution patterns and includes three variables with an almost similar contribution weight. Factor Y_6 involves two parameters by examining the road network. In the case of economic evaluation, the results highlighted three factors (Y_7: Budget allotment criteria (Environmental indicators), Y_8: Budget allotment criteria (Traffic), and Y_9: Financial involvement parties). Factor Y_7 expresses the citizens' willingness to invest money to reduce the environmental impact in different sectors. The results have shown that citizens want more money to be invested in counteracting marine pollution as well as in successful waste management. Factor Y_8 describes the willingness of citizens to invest in improving the road network and consists of two variables. The results showed that both variables carry almost the same weight. Finally, factor Y_9 shows the degree of participation in the road network. It can be concluded that the results highlighted the importance of citizen participation, which confirms the need to carry out our research.

Table 12
Factor analysis indexes per part.

	Social	Environment	Economic
KMO	0.783	0.785	0.673
	0	0	0
Determinant	0.297	0.016	0.137

Table 13
Interpretation of factors.

Factor	Factor's name	Description of the factor
Y1	Sustainable port social parameters	Describes several crucial social network characteristics influencing citizen approval of a sustainable port.
Y2	Public information	Examines the importance of environmental education and public information on the benefits/risks inherent in creating a sustainable port.
Y3	Environmental indicators assessment criteria (Pollutant)	Investigates the attitudes of citizens towards environmental problems such as water pollution, air pollution, noise, etc
Y4	Renewable Energy Sources contribution	Focuses on examining and exploiting RES as one of the policies that will contribute to energy (in) dependence and tackle environmental problems. According to the citizens ' opinion, various types of RES are being considered to determine the most appropriate.
Y5	Pollution sources impact criteria assessment	Records citizens' attitudes towards various pollution sources to prioritize viable solutions.
Y6	Environmental indicators assessment criteria (traffic)	The current status of urban pollution resulting from transportation issues highlighted at various levels is examined (infrastructure shortages, transport system operation).
Y7	Budget allotment criteria (Environmental indicators)	Explores the relationship between environmental performance and financial performance. An attempt is made to study the extent to which investments (environmentally friendly) are necessary and where the investment should focus on having a sustainable policy.
Y8	Budget allotment criteria (Traffic)	Explores the extent to which traffic and network quality investment is needed to improve the transportation network's efficiency (people and goods).
Y9	Financial involvement parties	Investigates the relationship between the public / private sector as to the degree of involvement in financial investment to create a sustainable port. In addition, it explores citizens' willingness to make a financial contribution to creating a sustainable port.

5. Conclusions and recommendations

As the development needs of the port continue to grow within the framework of the competition, the port facilities are called upon to address the growing challenges that arise effectively. Supporting ports' shifting functions demands a holistic perspective of ports that considers all aspects and roles, as well as port-specific demands and capabilities. Because of this diversity, the European port system is more resilient, and the optimum method for optimizing and supporting each ecosystem will be unique to each port. A local sustainability plan involves community participation (known as a bottom-up approach) to maximize the possibilities of a successful outcome. The primary reason is that only residents

Table 14
Factors and loadings.

Social	Factor			
	Y_1			Y_2
positive results	0.438			
accepted by the local	0.642			
social prosperity	0.829			
new jobs	0.753			
better working conditions	0.731			
sufficient information				0.832
seminars, info materials				−0.516
Environment	Factor			
	Y_3	Y_4	Y_5	Y_6
noise assessment	0,794			
air quality assessment	0.848			
dust assessment	0.846			
ship pollution	0.560			
road quality				0.855
traffic				0.82
civilian facilities pollution			0.786	
military facilities potion			0.850	
ships pollution			0.785	
wind contribution		0.805		
solar contribution		0.774		
tidal contribution		0.770		
biofuels contribution		0.591		
Economic	Factor			
	Y_7		Y_8	Y_9
air pollution	0.76			
sea pollution	0.841			
waste management	0.795			
noise	0.604			
road quality			0.889	
traffic, parking space			0.877	
Public content.				0.561
Shipping co.				0.693
civilians				0.688

have a close connection to the place and the local expertise required to produce location-based solutions. Based on the above, the study's goal was to learn more about what drives ports' decisions today, how ports will adapt and navigate through this changing world, and what is needed to optimize this process so that ports in Europe can continue to be a catalyst for sustainable, innovative, and resilient growth. More specifically, it investigated citizens' level of background information and awareness on sustainable development issues, examined the degree of response/acceptance to the proposed measures for sustainable development of ports by the citizens, identified possible problems in implementing the suggested necessary measures and proposed potential solutions.

The proposed methodology (KPI, SPSS, Factor analysis) tried to highlight any weaknesses in the operation of a major port with the broader aim of offering solutions to optimize its sustainability. The results showed that traffic and waste management are the areas with the most significant weaknesses. These weaknesses significantly degrade the environment, threatening at the same time and human health. In addition, the results showed that the infrastructure and energy sectors (e.g., RES) could significantly improve the quality of life and the environment, as there are significant opportunities that can be turned into capabilities. Furthermore, the data analysis did not show substantial differences in the responses between men and women. The greater awareness of women explains a slight differentiation that is evident in the environmental issues compared with men. Another transparent element was the correlation of age with the environmental and economic variables. These variables are assessed lower as the respondent's age increases.

Moreover, a key measure to increase environmental concerns is to keep the citizens informed on environmental issues to ensure their participation and take their views into account for the future port design. It should be noted that developing a comprehensive plan requires the cooperation of many different scientific disciplines. Building a framework to support interdisciplinary interactions and integrate sustainability goals into the research and development process will benefit green growth. The interactions will be able to create technologies that simultaneously minimize the impact on the environment, economy, and society by drawing on combined know-how in the chemical sciences, engineering, environmental health, social sciences, public policy, and business.

After conducting the analysis and interpretation of the results, specific measures were proposed for sustainability issues to improve. The proposed actions can only be considered general guidelines on which it is deemed that a plan must be drawn up after analyzing the current situation.

This methodology serves to support government policymakers and developers in implementing reforms to build a sustainable port system. The research aims, therefore, to levelize solutions to the maritime industry for the alignment of the objectives of the European Green Agreement and the relative 7 and 11 SDGs. More specifically, through citizens' response analysis, it proposes empowering solutions for the most efficient energy planning and resolving of issues regarding port green energy management and active participation of involved parties.

The impact of this study in the case of other ports is multi-faceted. Firstly, this study presents vital concepts such as creating a green sustainable port. Moreover, the methodology is proposed, which reveals the involvement of citizens in finding problems and solutions for any ports. In practice, our study provides a comprehensive assessment of various sustainability criteria of port facilities to achieve sustainable development goals. The research findings point to any overlooked improvements and require more collective effort. The proposed methodology also serves as a self-assessment tool for an individual port facility in relation to its current stage of sustainable development. It creates implications for future SBG implementation strategies. It can be said that with the support and guidance of our research, as well as a collaborative approach between ports and city authorities, there is a great window of opportunity to make improvements that will benefit ports, local communities, and the environment.

Future research may focus on the views exclusively of port managers and policy managers. The study focused on specific groups of citizens gives extra weight due to their expertise and experience. Further future research may explore any incentives, funding, and technology development. In addition, the effectiveness of the proposed measures to reshape the attitude of respondents should be considered in a future research effort.

Some limitations to our methodology are essential to acknowledge. The present survey was conducted in the winter of 2019, noting the absence of responses from tourists who have different criteria from local passengers (permanent residents) of other periods. The research results cannot be generalized as they examined only a specific period. Another limitation of our study is the higher percentage of men's responses than women's. The lower percentage of women's responses is estimated to the current tradition related to a man-driven society in port activities based on historically "heavy" jobs in port, such as truck drives, crane operators, and dock workers, etc. The research included also womens' answers, which, as usually, showed a more environmentally-oriented viewpoint compared to men.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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The authors want to thank all the participants who willingly contributed to collecting data and making this research possible.

Appendix A. Survey questions

Social Questions		Can the creation of a sustainable port bring about positive results?	X_1
		Do you think creating a sustainable port will be accepted by the local society?	X_2
		Will the creation of a sustainable port be conducive to the social prosperity of the area?	X_3
		Will a sustainable port contribute to the creation of new job positions?	X_4
		Will the creation of a sustainable port secure better working conditions?	X_5
		Do you consider people's information on the advantages and disadvantages of sustainable development to be sufficient?	X_6
		Do you believe that educative seminars and informative action materials can facilitate your better understanding of the port functions and their effects on the quality of the environment?	X_7
Environmental Questions	SECTION 1	How do you assess the condition of the port of Souda in relation to the following environmental indicators [noise]?	X_8
		How do you assess the condition of the port of Souda in relation to the following environmental indicators [Air quality]?	X_9
		How do you assess the condition of the port of Souda in relation to the following environmental indicators [dust]?	X_{10}
		How do you assess the condition of the port of Souda in relation to the following environmental indicators [Quality of road network]?	X_{11}
		How do you assess the condition of the port of Souda in relation to the following environmental indicators [Waste Management]?	X_{12}
		How do you assess the condition of the port of Souda in relation to the following environmental indicators [traffic]?	X_{13}
		How do you assess the condition of the port of Souda in relation to the following environmental indicators [Sea pollution]?	X_{14}
	SECTION 2	In your opinion, what is the degree of pollution impact on the environment port of Souda for each of the following sources of pollution [civilian port facilities]?	X_{15}
		What is the degree of pollution impact on the environment port of Souda for each of the following sources of pollution [military port facilities]?	X_{16}
		What is the degree of pollution impact on the environment port of Souda for each of the following sources of pollution [ships]?	X_{17}
		What is the degree of pollution impact on the environment port of Souda for each of the following sources of pollution [vehicles, trucks]?	X_{18}
	SECTION 3	Do you think that the following form of renewable sources can contribute to the optimization of the environmental indicators in the port of Souda [Wind]?	X_{19}
		Do you think that the following form of renewable sources can contribute to the optimization of the environmental indicators in the port of Souda [Solar]?	X_{20}
		Do you think that the following form of renewable sources can contribute to the optimization of the environmental indicators in the port of Souda [Tidal]?	X_{21}
		Do you think that the following form of renewable sources can contribute to the optimization of the environmental indicators in the port of Souda [Biofuels]?	X_{22}
Economical Questions		To what degree should a budget be spent on the following categories to improve the respective environmental indicators [Air pollution]?	X_{23}
		To what degree should a budget be spent on the following categories to improve the respective environmental indicators [Sea pollution]?	X_{24}
		To what degree should a budget be spent on the following categories to improve the respective environmental indicators [waste management]?	X_{25}
		To what degree should a budget be spent on the following categories to improve the respective environmental indicators [noise]?	X_{26}
		To what degree should a budget be spent on the following categories to improve the respective environmental indicators [Quality of road]?	X_{27}
		To what degree should a budget be spent on the following categories to improve the respective environmental indicators [traffic, parking space]?	X_{28}
		What should the degree of financial involvement of public services/parties be in creating a sustainable port?	X_{29}
		What should the degree of financial involvement of shipping companies be in creating a sustainable port?	X_{30}
		In your opinion, what should civilians' degree of financial involvement be in creating a sustainable port?	X_{31}

Demographic data.

Age	15–24	Gender		Level of education	JHS	Reasons of visits	
	25–39		Male		HS		Personal
	40–64				BD		
	>65		Female		MSc		Professional
					PhD		

Job	Public/State employee	Frequency of port visits	Up to 2 times
	Private employee		
	Unemployed		2–4 times
	Freelancer		
	Housewife		> 4 times
	Retired		
	Student		

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