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Review

The Port System in Addressing Sustainability Issues—A Systematic Review of Research

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Abstract: The aim of this paper is to analyse the main scientific contributions in the field of sustainable seaports, with a particular focus on passenger seaports and passenger seaports' commitment to sustainability. The focus of this analysis is on the methods used to improve and develop a sustainable seaport. A search of the Web of Science Core Collection that addresses this topic consists of scientific articles published from 2012 to 2022. The articles are divided into seven groups by research area (technical/technological, legal, organisational, economic, social, environmental, and other) and five groups by applied methodology (literature review, theoretical approach, qualitative approach/methods, quantitative approach/methods, and other). The results show that most of the papers were published in the field of the environmental impacts of a sustainable seaport and a sustainable passenger seaport. In addition, most papers used quantitative approach/methods.

Keywords: sustainable seaport; sustainable passenger seaport; scientific publications; Web of Science; review

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1. Introduction

Industries worldwide are facing a new and unprecedented challenge to adapt their operational decisions to a more responsible and sustainable framework. Ports are no exception, as they are fundamental economic ecosystems whose practices have significant environmental and community impacts. Therefore, it is increasingly important to pursue sustainable development in ports, considering the economic, social, and environmental dimensions of sustainability [1]. Environmentally sustainable ports must pay special attention to the port's impact on the environmental future of the surrounding area when achieving their economic and social goals, such as increasing their competitiveness and productivity. This requires the adaptation of logistical operations using innovative technologies that enable and support the management, control, and monitoring of environmental impacts. Regarding all mentioned aspects, this paper provides an overview of innovative technologies and a review of the methods used to improve and develop a sustainable port.

It is also important to note that the International Maritime Organization, (IMO), as a specialised agency of the United Nations, is responsible for global standards for safe, clean, and efficient maritime transport. It plays an important role in the implementation of the 2030 Agenda for Sustainable Development, including the Sustainable Development Goals (SDGs) [2]. The Global Port Sustainability Program considers 17 Sustainable Development Goals as a unique and indivisible orientation for sustainable port development [3]. Considering that port management has a great impact on economic growth, crisis management, environmental protection, and gender equality, ports are at the centre of sustainable development [4]. Following the above, the authors provide an overview of the commitment of the 10 largest European passenger seaports to sustainability and the various SDGs.

The purpose of this paper is to provide an overview of the methods used in articles dealing with sustainable ports and sustainable passenger seaports, with the goal of identifying bases for constructing an assessment model for sustainable port improvements. This review is presented using three approaches: (1) a structured review of the literature examining relevant terms in titles, abstracts, keywords, and scientific articles on sustainable seaports in the Web of Science Core Collection database from 2012 to 2022; (2) a structured review of the literature examining relevant terms in titles, abstracts, keywords, and scientific articles on sustainable passenger seaports in the Web of Science Core Collection database from 2012 to 2022; (3) a detailed review of the annual reports of the 10 largest European passenger seaports.

This review follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [5].

2. Evaluation of Scientific Research on Sustainable Seaports

2.1. Review and Classification of the Research

As the review follows the PRISMA guidelines, the methodology used is presented in the PRISMA flow (Figures 1 and 2).

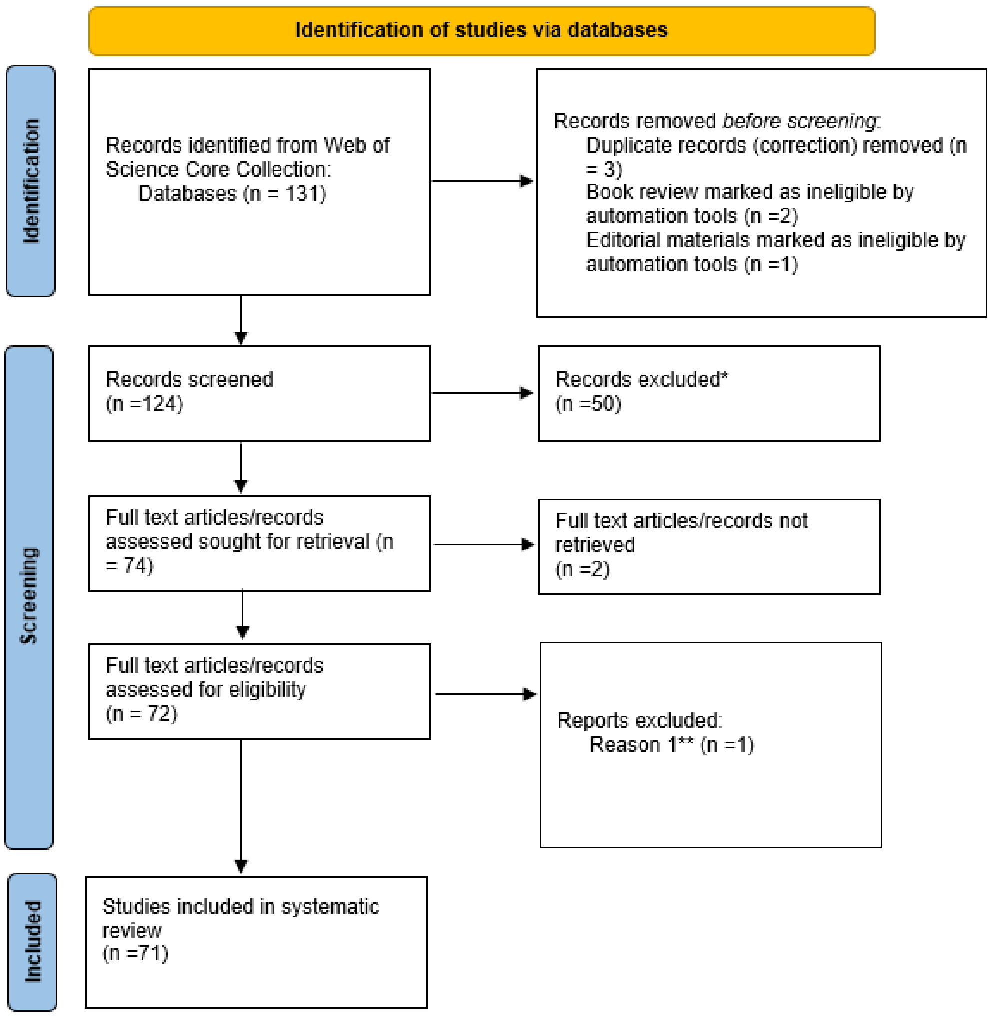

Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) analysis flow, which deals with sustainable ports. * The exclusions correspond to the articles that were removed after reading abstracts. Article does not apply to sustainable ports. ** The exclusions correspond to the articles that were removed after reading full text. Article does not apply to sustainability.

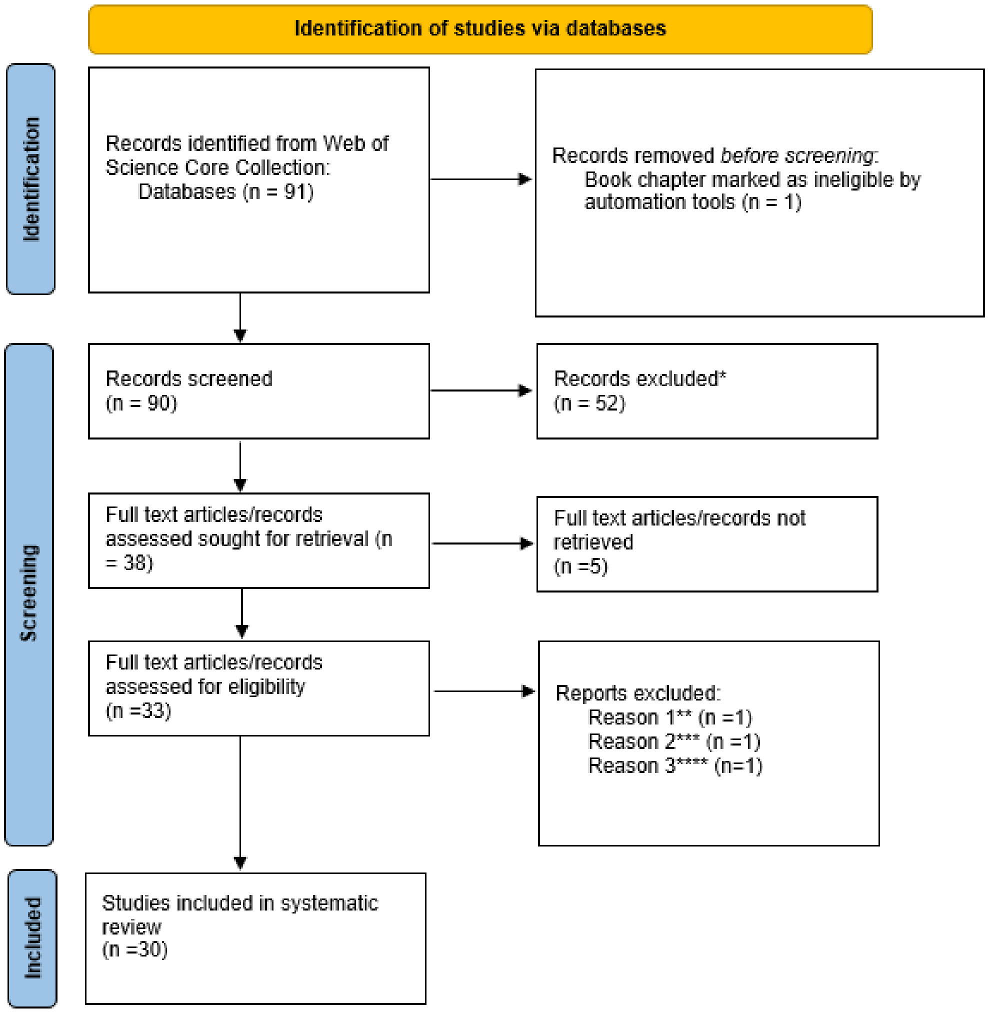

Figure 2. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) analysis flow, which deals with sustainable passenger ports. * The exclusions correspond to the articles that were removed after reading abstracts. Article does not apply to sustainable passenger ports. ** This study does not apply to passenger ports. *** This paper deals with intermodal passenger terminals. **** This paper deals with methodology/calculation for invasive species input.

The number of scientific publications dealing with the topic of sustainable ports/ sustainable seaports/sustainable harbours/sustainable maritime ports has increased in the last decade. This can be illustrated by searching the Web of Science Core Collection (Figure 3). The search is performed using the string Topic, which searches titles, abstracts, author keywords, and keywords plus. Since the focus of this paper is on sustainable seaports and sustainable passenger seaports, the authors' general search for abstracts of publications from 2012 to 2022 (15 March), filtered by Web of Science topic search and publication year, found 74 relevant publications on sustainable seaports and 38 publications on sustainable passenger seaports. Furthermore, some of the papers were eliminated by using automatic (WoS) tools, and some by reading the entire publication. This can be seen in Figures 1 and 2.

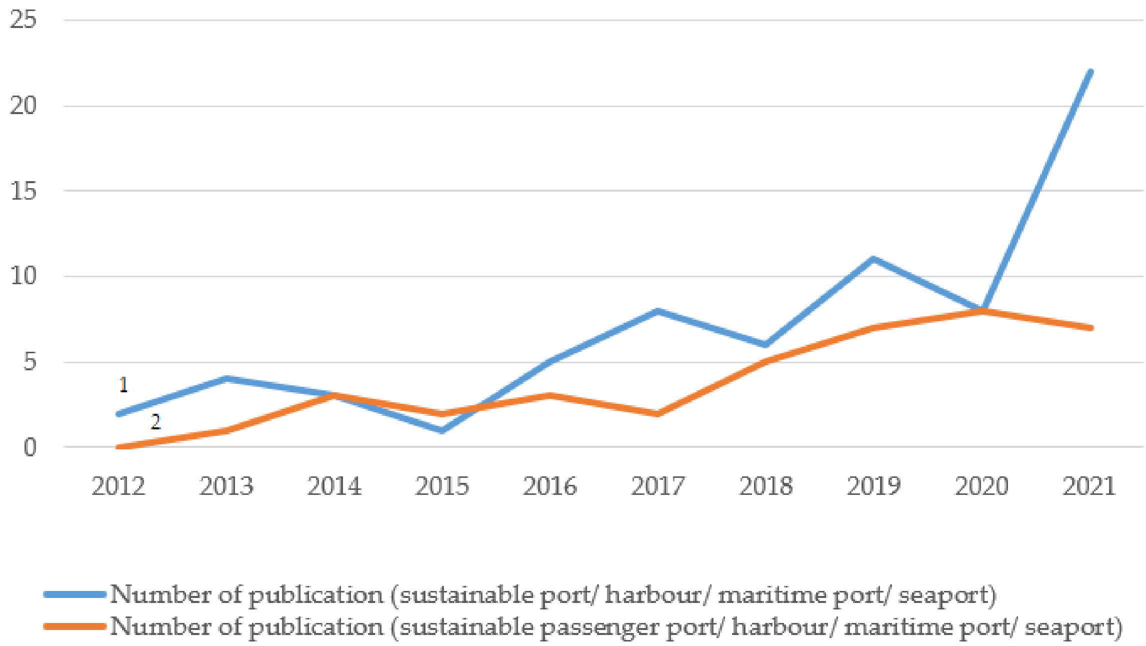

Figure 3. Comparison of studies of sustainable ports and sustainable passenger ports during 2012–2021, found on Web of Science on 15 March, using Topic search: (1) (TS = ("sustainable port *" or "sustainable maritime port *" or "sustainable harbour *" or "sustainable seaport *"); (2) TS = ("sustainable passenger port *" or "sustainable passenger maritime port *" or "sustainable passenger harbour *" or "sustainable passenger seaport *").

The articles are classified according to the research area, the geographical position of the port, and the methodology used. Regarding the research area, each article is divided into seven proposed groups: technical–technological, legal, organisational, environmental, economic, social, and other.

Since the aim of this paper is to give an overview of the methods used so far for the purpose of the sustainable development of seaports, the authors grouped the used methods into one of the five proposed categories: literature review, theoretical approach, qualitative approach/methods, quantitative approach/methods, and other (Table 1). Some of the articles used a combination of methods and, therefore, the authors grouped them into more categories. The theoretical approach category includes various methods such as systematised strategies, comparative analyses, framework for the selection measures, an overview of existing documents, and different elaboration of information. The qualitative approach/methods category consists of various questionnaires and interviews. For example, port executives' structured deep interviews, e-mail questionnaires and interviews with managers, analytic hierarchy process methodology, and online questionnaire using the DRIP score benchmarking model. Various quantitative approaches/methods are used in the papers, such as a multi-objective mixed robust possibilistic flexible programming (MOMRPFP) model, numerical analyses, exploratory factor analysis and one-way ANOVA, dispersion and maximum distribution methods, Kalman filter, regression analysis, indicator selection, Kolmogorov–Smirnov test, Environmental Performance Indicators, data normalisation methods, calculation of ship engine exhaust emissions, network construction, dispersal analysis, graph theory, environmental and economic analysis, analytic hierarchy process, eco-efficiency indicators, a derivation of the procedure used to calculate the Port Sustainability Synthetic Index, THPD model, network analytics, method of complex network, synchrosimulation model, AutoCAD, Excel, and a mixed integer linear programming model. The category "other" denotes the papers that could not be classified into any of the six categories (optimal systems configuration, analysing and assessing, simulating, predicting, and evaluating the degree of effects generated, and carbon footprint (CF) methodology).

Since the focus of this work is on sustainable passenger ports, the published work for the passenger port sector has been considered separately, and the results obtained are presented in Table 2. The proposed methodology in terms of the distribution of papers by research group and their use is the same as in Table 1. Only one article, "A methodological approach for environmental characterization of ports" [6], is included in both tables.

Table 1. Overview of publications that deal with sustainable seaports.

Authors	Origin/Seaport	Research Area Group	Methodology Proposed/Used
Tai, HH; Chang, YH [7]	Seven international commercial ports in Taiwan (Kaohsiung, Keelung, Taichung, Taipei, Hualien, Anping, and Suao)	environmental	quantitative
Lee, Y; Song, H; Jeong, S [8]	Busan New Port	environmental/legal/ technical–technological	qualitative
Chapapria, VE; Peris, JS [9]	Valencia Port	technical–technological/ environmental	theoretical and quantitative
Jaafar, HS; Abd Aziz, ML; Ahmad, MR; Faisol, N [10]	Ports in the southern region of Malaysia	technical–technological/social/other	qualitative
Liu, JG; Kong, YD; Li, SJ; Wu, JJ [11]	China, 21 port cities (Shanghai, Ningbo, Shenzhen, Guangzhou, Qingdao, Tianjin, Xiamen, Dalian, Yingkou, Lianyungang, Rizhao, Foshan, Dongguan, Fuzhou, Nanjing, Yantai, Tangshan, Quanzhou, Zhuhai, Haikou, and Jiaxing)	economic/social/environmental/ technical–technological	quantitative
Cavalli, L; Lizzi, G; Guerrieri, L; Querci, A; De Bari, F; Barbieri, G; Ferrini, S; Di Meglio, R; Cardone, R; Tardo, A; Pagano, P; Tesei, A; Lattuca, D [1]	Port of Livorno	technical–technological	theoretical and quantitative
De Martino, M [12]		economic/social/organisation	theoretical
Roh, S; Thai, VV; Jang, H; Yeo, GT [13]	Korea	economic/social/environmental	literature review and qualitative
Argyriou, I; Sifakis, N; Tsoutsos, T [14]	Port of Souda	social	qualitative
Meyer, C; Gerlitz, L; Philipp, R; Paulauskas, V [15]	Small- and medium-sized ports (SMSPs) in the Baltic Sea Region (BSR)	technical–technological/environmental	qualitative
Othman, MK; Rahman, NSFA; Ismail, A; Saharuddin, AH [16]	Malaysian ports	organisational	theoretical
Barreiro-Gen, M; Lozano, R; Temel, M; Carpenter, A [17]	EU ports	social	qualitative
Gan, M; Li, DD; Wang, JW; Zhang, JK; Huang, QL [18]	Chinese ports	environmental/legal	quantitative
Iris, C; Lam, JSL [19]		environmental/organisational/economic	quantitative
Shankar, S; Punia, S; Singh, SP; Dong, JX [20]		other	quantitative
Gerlitz, L; Meyer, C [21]	Small- and Medium-Sized Ports in the TEN-T Network	organisational/economic/social/other	theoretical
AlRukaibi, F [22]	Port of Shuwaikh	organisational/social/environmental/other	quantitative
Hossain, T; Adams, M; Walker, TR [23]	Thirty-six seaports were selected from North America (NA), Europe (EU), and Asia Pacific (AP)	legal/organisational/other	theoretical and quantitative
Kong, YD; Liu, JG [24]	China (Hong Kong, Guangzhou, Shanghai, Ningbo, Tianjin, Shenzhen, Qingdao, Dalian, Xiamen)	technical–technological/ social/environmental/economic	quantitative
Holler, L [25]	Port of Kirkenes	economic/environmental	theoretical
Gu, YM; Loh, HS; Yap, WY [26]	China, India	economic/social	theoretical
Wang, CX; Haralambides, H; Zhang, L [27]	Shanghai, Guangzhou, Shenzhen, Tianjin, Ningbo, Qingdao, Dalian, Xiamen, Yantai, Fuzhou, Quanzhou, Haikou, Sanya, Zhanjiang, and Shantou	environmental/economic/social/ technical–technological	quantitative

Table 1. *Cont.*

Taljaard, S; Slinger, JH; Arabi, S; Weerts, SP; Vreugdenhil, H [28]	South African ports	environmental	theoretical
Zhao, CP; Li, R; Wang, YC; Yu, H; Gong, Y [29]	Gulf ports	environmental/other	quantitative
Paulauskas, V; Filina-Dawidowicz, L; Paulauskas, D [30]	Klaipeda port	environmental/other/social	quantitative
Mankowska, M; Kotowska, I; Plucinski, M [31]	Port of Szczecin	technical–technological/ legal/organisational	theoretical
Moeis, AO; Desriani, F; Destyanto, AR; Zagloel, TY; Hidayatno, A; Sutrisno, A [32]	Tanjung Priok Port	legal/environmental	theoretical and quantitative
Sinha, D; Chowdhury, SR [33]	Indian ports	legal/environmental/ technical–technological/other	quantitative
Wu, XF; Zhang, LP; Yang, HC [34]		environmental	literature review
Huang, YX; Yip, TL; Liang, C [35]	Tianjin Port	economic/legal/environmental	quantitative
Huda, LN; Sulastri, R [36]	Belawan Port	economic/environmental	quantitative
Zhao, YF; Zhu, QH; Kou, Y; Lun, EN [37]	Ports in the Pearl River Delta region in China	legal/environmental	quantitative
de Boer, WP; Slinger, JH; Kangeri, AKW; Vreugdenhil, HSI; Taneja, P; Addo, KA; Vellinga, T [38]	Tema Port	technical–technological/ economic/environmental/social	theoretical
Casazza, M; Lega, M; Jannelli, E; Minutillo, M; Jaffe, D; Severino, V; Ulgiati, S [39]		technical–technological/environmental	theoretical
Lawer, ET; Herbeck, J; Flitner, M [40]	Ports in Europe and West Africa Tema (Ghana), Lagos (Nigeria), Abidjan (Côte d'Ivoire) in West Africa, and the twin ports of Bremen/ Bremerhaven (Germany)	environmental/social	qualitative
Tijan, E; Agatic, A; Jovic, M; Aksentijevic, S [41]		economic/environmental/social	theoretical and literature review
Bjerkan, KY; Seter, H [42]		environmental/other	theoretical and literature review
de Boer, W; Mao, YJ; Hagenaars, G; de Vries, S; Slinger, J; Vellinga, T [43]	Ports in Africa	technical–technological/environmental	theoretical
Lozano, R; Fobbe, L; Carpenter, A; Sammalisto, K [44]	Port of Gävle	economic	theoretical and literature review
Muangpan, T; Suthiwartnarueput, K [45]	Thailand	economic	quantitative
Tsao, YC; Thanh, VV [46]		economic/social/environmental	quantitative
Nunes, RAO; Alvim-Ferraz, MCM; Martins, FG; Sousa, SIV [47]	Ports in Portugal (Leixões, Setúbal, Sines, and Viana do Castelo)	environmental/social	quantitative
Wu, XF; Zhang, LP; Dong, YW [48]	Xiamen Harbor	social/environmental/economic	theoretical
Kotowska, I; Mankowska, M; Plucinski, M [49]	Antwerp, Rotterdam, Hamburg, and the Marseilles–Fos port complex	environmental/economic/legal	theoretical
Li, KX; Park, TJ; Lee, PTW; McLaughlin, H; Shi, WM [50]	Busan, Gwangyang, and Incheon	technical–technological	quantitative
Ignaccolo, M; Inturri, G; Le Pira, M [51]		social/organisation	theoretical
Jonathan, CEY; Kader, SBA [52]	Port of Tanjung Pelepas	environmental/legal/technical–technological	quantitative
Wang, W; Chen, JJ; Liu, Q; Guo, ZX [53]	China	technical–technological/environmental/economic	quantitative
Yigit, K; Acarkan, B [54]	Brazil, United Kingdom, Turkey, India, and Japan	technical–technological	quantitative
Schipper, CA; Vreugdenhil, H; de Jong, MPC [55]		legal/environmental/social/economic	quantitative
To, NT; Kato, T [56]	Haiphong port, Vietnam	environmental/social	qualitative
Nebot, N; Rosa-Jimenez, C; Ninot, RP; Perea-Medina, B [57]	Spanish Mediterranean ports	environmental/ technical–technological/social	theoretical
Bandyopadhyay, R; Kaplan, PO; Araujo, R; Dodder, R; Smith, ER [58]	SAD	environmental/economic	theoretical
Neisingh, WWJ; Taneja, P; Vellinga, T; Verlaan, JG [59]	Bay of Havana in Cuba	organisational	theoretical
Lazaroiu, C; Roscia, M [60]	Port of Naples	environmental	theoretical

Table 1. *Cont.*

Papaefthimiou, S; Sitzimis, I; Andriosopoulos, K [6]	Hong Kong, Kaohsiung, Shanghai, New York, Los Angeles, Seattle, Long Beach, Oakland, Rotterdam, Piraeus, Aberdeen, Copenhagen, Antwerp, Koge, Elsinore, Bergen	economic/environmental/social	quantitative
Hou, LJ; Geerlings, H [61]	Port of Shanghai	environmental/legal	quantitative, qualitative, and theoretical
Schulte, F; Gonzalez-Ramirez, RG; Ascencio, LM; Voss, S [62]	Latin America and the Caribbean (Santos, Brazil; Manzanillo, Mexico; Callao, Peru; Guayaquil, Ecuador; Buenos Aires, Argentina; Valparaíso, Chile; Buenaventura, Colombia)	organisation	qualitative
Roh, S; Thai, VV; Wong, YD [63]	Vietnamese ports	organisation/social/economic/environmental	literature review and qualitative
Tseng, PH; Pilcher, N [64]	Taiwan's three main ports: Kaohsiung, Keelung, and Taichung	environmental	quantitative
Zhou, Y; Wang, WY; Song, XQ; Guo, ZJ [65]		technical-technological	quantitative
Bauk, S; Sekularac-Ivosevic, S; Jolic, N [66]	The Adriatic, Aegean, and Black Sea ports	social/economic	quantitative
Puig, M; Wooldridge, C; Darbra, RM [67]		environmental	quantitative
Hiranandani, V [68]	Port of Long Beach (USA), Port of Rotterdam Authority (The Netherlands), Sydney Ports Corporation (Australia), and Transnet Limited, which owns and manages South African ports	organisation	theoretical
Pavlic, B; Cepak, F; Sucic, B; Peckaj, M; Kandus, B [69]	Port of Koper	technical–technological/economic/environmental	theoretical
Morel, G; Lima, FR; Martell-Flores, H; Hissel, F [70]		technical–technological/organisational/social/environmental	theoretical
Daamen, TA; Vries, I [71]	European port cities: Marseilles, Barcelona, Hamburg, and Rotterdam	legal	theoretical
Lirn, TC; Wu, YCJ; Chen, YMJ [72]	China, Hong Kong, and Taiwan	environmental	qualitative
Onwuegbuchunam, DE [73]	Nigeria	organisation/social	quantitative
Hartman, BC; Clott, CB [74]		environmental	quantitative
De Langen, PW; Van Den Berg, R; Willeumier, A [75]	Port of Rotterdam	legal/other	theoretical and qualitative

Table 2. Overview of publications that deal with sustainable passenger seaports.

Authors	Origin/Seaport	Research Area Group	Methodology Proposed/Used
Andrade, MJ; Costa, JP; Jimenez-Morales, E [76]	European tourist city ports	economic/social/technical–technological	literature review, quantitative and theoretical
Gil-Lopez, T; Verdu-Vazquez, A [77]	Spanish ports	technical–technological/environmental	quantitative
Sifakis, N; Tsoutsos, T [78]		other	literature review
Lapko, A; Hacia, E; Wieczorek, R [79]	Port of Świnoujście	environmental/social	quantitative
Yehia, W; Kamar, L; Hassan, MA; Moustafa, MM [80]	The Suez Canal at Port Said City, Egypt	environmental/economic	quantitative
Ignaccolo, M; Inturri, G; Giuffrida, N; Torrisi, V [81]	/	environmental/legal	theoretical
Mangano, S; Ugolini, GM [82]	Italian ports (Civitavecchia, Venice, Naples, Genoa, Savona, Livorno, Palermo, Bari, La Spezia, Cagliari, Messina)	social	theoretical and quantitative
Liu, YH; Dong, EW; Li, SQ; Jie, XW [83]	Southern China	social/economic	literature review, quantitative and qualitative
Paiano, A; Crovella, T; Lagioia, G [84]	Italian ports	environmental	other
Mortensen, L; Kornov, L; Lyhne, I; Raakjaer, J [85]	Port of Aalborg	environmental/legal	theoretical

Table 2. *Cont.*

Wondirad, A [86]		social/economic	literature review
Perea-Medina, B; Rosa-Jimenez, C; Andrade, MJ [87]	Mediterranean ports	technical–technological/environmental	quantitative
Santos, M; Radicchi, E; Zagnoli, P [88]	Port of Lisbon and port of Livorno	economic/environmental/social	quantitative and qualitative
Gamez, MAF; Serrano, JRS; Gil, AC; Ruiz, AJC [89]	The port of Malaga	social	literature review, quantitative and qualitative
Ruiz-Guerra, I; Molina-Moreno, V; Cortes-Garcia, FJ; Nunez-Cacho, P [90]	Port of Barcelona	environmental/social	quantitative
Kishchenko, K; De Roeck, M; Salens, M; Van Maroey, C [91]	Port of Antwerp	technical–technological/environmental	theoretical
Urbanyi-Popiolek, I [92]	Baltic Sea Region (Copenhagen, Helsinki, Gdansk, Gdynia, Mariehamn, Rostock, St. Petersburg, Stockholm, Tallinn, Turku)	technical–technological/environmental/legal	theoretical
Wilewska-Bien, M; Anderberg, S [93]	Baltic Sea ports	environmental	qualitative
Sakib, N; Appiotti, F; Magni, F; Maragno, D; Innocenti, A; Gissi, E; Musco, F [94]	Mediterranean ports	technical–technological/environmental/legal	quantitative
Rosa-Jimenez, C; Perea-Medina, B; Andrade, MJ; Nebot, N [95]	183 ports in the Mediterranean and the Black Sea	technical–technological	theoretical and quantitative
Grindlay, AL; Martinez-Hornos, S [96]	Port of Malaga	technical–technological	other
Iannello, A; Bertagna, S; Pozzetto, D; Toneatti, L; Zamarini, R; Bucci, V [97]		technical–technological/environmental	other
Manginas, V; Manoli, S; Nathanail, E [98]	Port of Volos	economic/legal/organisational	qualitative and quantitative
Papaefthimiou, S; Sitzimis, I; Andriosopoulos, K [60]	Hong Kong, Kaohsiung, Shanghai, New York, Los Angeles, Seattle, Long Beach, Oakland, Rotterdam, Piraeus, Aberdeen, Copenhagen, Antwerp, Koge, Elsinore, Bergen	economic/environmental/social	quantitative
Laxe, FG; Bermudez, FM; Palmero, FM; Novo-Corti, I [99]	Spanish ports	economic/environmental	quantitative
Bianucci, M; Merlino, S; Ferrando, M; Baruzzo, L [100]	La Spezia Harbor	technical–technological/environmental	other
Thurau, B; Seekamp, E; Carver, AD; Lee, JG [101]	Panama Canal	economic	qualitative and quantitative
Sotaniehha, M; Peric, A; Scholl, B [102]	Port of Piraeus	technical–technological/other	theoretical
Urbanyi-Popiolek, I [103]	City of Gdynia	technical–technological/economic/social/environmental	quantitative and qualitative
Dundovic, C; Juric, M; Kovacic, M [104]	Port of Split	technical–technological/economic/social/environmental	theoretical

Most studies have examined environmental effects (66 of them). The most frequently studied environmental impacts are development, sustainability, exhaust emissions, port waste, energy efficiency, tourist mobility, air quality, and cruise industry impacts. Moreover, 34 articles are classified into the technical–technological group, while the combination of environmental and technical–technological is studied in 25 articles. The legal component is usually studied in combination with other impacts (technical–technological, organisational, environmental, economic, and others). The social component is usually studied in combination with environmental and economic impacts. There are 12 papers in the "other" category (Figure 4). These papers address various issues relevant to this area but may also be directly related to other impacts.

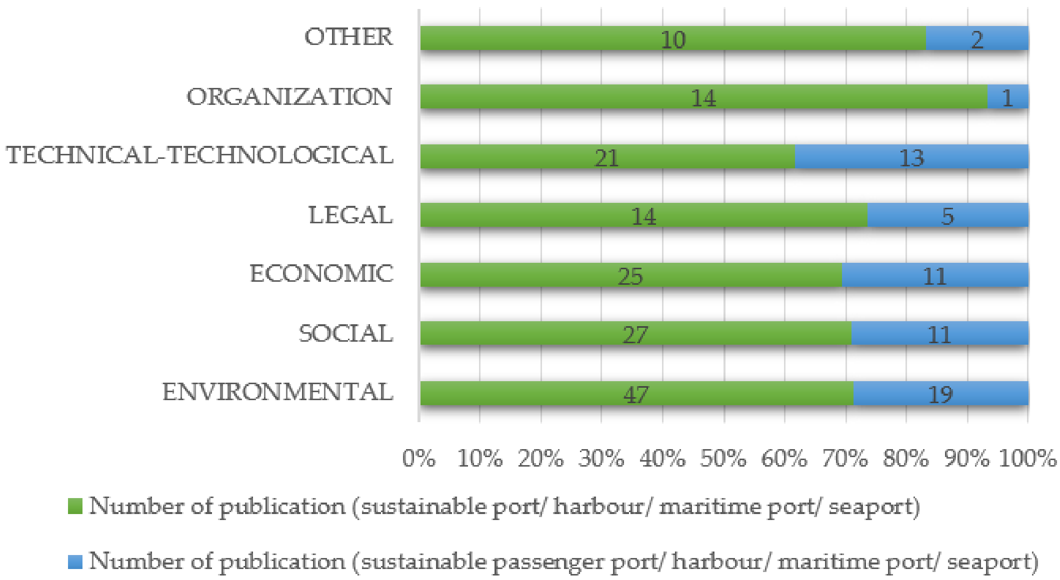

Figure 4. Relation of the total number of filtered publications and research area group in the period 2012–2022.

Looking at the geographical distribution of the research including sustainable passenger seaports, it can be concluded that the majority of the research refers to the European area, while the geographical distribution of the research including sustainable seaports covers a wider territory.

2.2. Overview of the Methods Used

A structured review of the literature on sustainable seaports and sustainable passenger seaports reveals that most of the papers are classified in the quantitative approach/methods category, with 41% of the total number of papers. Moreover, 31% of the papers fall into the theoretical approach category, while only 16% of the papers fall into the qualitative approach/methods category (Figure 5). In the structured review of the literature on sustainable seaports, no paper was placed in the "other" category. In the structured review of the literature on passenger seaports, four papers were placed in the mentioned category.

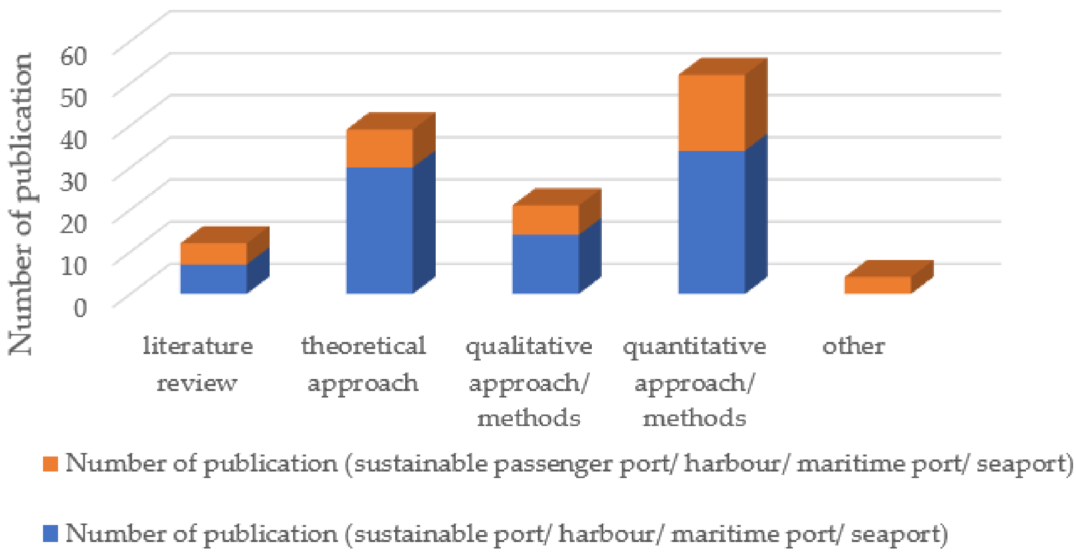

Figure 5. Relation of the total number of filtered publications and applied methods in the period 2012–2022.

Comparing the literature review on sustainable seaports and the literature review on sustainable passenger seaports, it is noticeable that most of the papers in both reviews are categorised under the quantitative approach/methods group (Figure 5). When reviewing the methods and approaches used, it is clear that some of the methods are repeated in both reviews. For example, the analytic hierarchy process (AHP) method was used in three papers. The authors of [72], in their paper “Green performance criteria for sustainable ports in Asia”, use the AHP technique and an importance and performance analysis (IPA) model to assess the overall green performance of the three largest Asian seaports and provide port authorities with clear strategies to improve their environmental performance. In their paper, “Enhancing sustainable mobility: A business model for the Port of Volos”, the authors of [98] processed the data using a modified version of the AHP to determine the importance of specific port functions and services.

The Adriatic, Aegean, and Black Sea ports, sharing unique marketing features and target markets, have been analysed by the authors of [66], with the aim of being mutually positioned. The ports considered have similar goals: to achieve a higher level of competitiveness and to attract a larger number of customers based on superior port selection criteria. These circumstances were studied using different quantitative and qualitative criteria by applying the appropriate, well-known, and structured quantitative PROMETHEE and AHP methods.

The majority of the methods used in both studies that fall into the category of qualitative approach/methods are interviews, questionnaires, and surveys.

Considering that the auxiliary objective is to identify the methods used in articles dealing with passenger seaports, it is important to note the following. In reviewing the literature that addresses sustainable passenger seaports, seven papers were categorised as qualitative approaches/methods. It was interesting to note that two papers used the interview method [83,88], two used the questionnaire/surveys method [89,101], and three papers used a combination of interviews and questionnaires/surveys [93,98,103].

The authors used various quantitative approaches/methods to process the data obtained through questionnaires, surveys, or interviews. The authors used cluster analysis in the article “Should Cruise Ports Market Ecotourism? A Comparative Analysis of Passenger Spending Expectations within the Panama Canal Watershed” [101]. The paper “Enhancing sustainable mobility: a business model for the Port of Volos” [98] deals with the investigation of the possibility of introducing a public–private partnership (PPP) in the Port of Volos and finally presents the development of an appropriate business model. This research involved interviews with key staff of the Volos Port Authority and local travel and port agents, as well as the completion of questionnaires by a random sample of 100 passengers during afternoon hours. The interviews focused mainly on the operations of the Port Authority, while the questionnaires targeted the port infrastructure, the services offered, and the passengers’ satisfaction with these factors. The data collected were analysed using a modified version of the AHP to determine the importance of specific port functions and services. In the article “Cruise Passengers’ Intention and Sustainable Management of Cruise Destinations” [89], the authors processed the obtained data using statistical tests adjusted to metric variables (average, standard deviation).

It is also important to point out the article [83], “Cruise Tourism for Sustainability: An Exploration of Value Chain in Shenzhen Shekou Port”, where a quantitative method was applied first (online text analysis using Rost Content Mining 6 software to analyse 2552 Ctrip travel networks) and then another study was conducted through face-to-face interviews.

It is evident that most of the studies in the qualitative approach/methods category use surveys, questionnaires, and interviews to investigate the port’s commitment to sustainability.

2.3. European Passenger Seaports' Commitment to Sustainability

Sustainable development is the primary global objective of port authorities to maintain and improve their economic activity and attractiveness [105]. Seaports, as the main hub of maritime transport, should also base their operations on principles or aspects of sustainability: the economic principle (efficient provision of seaport services), the environmental principle (efficient use of natural resources, reduction of pollutant emissions and paper consumption), and the social principle (welfare of seaport employees and stakeholders) [40].

The third approach involves the idea of verifying passenger seaports' commitment to sustainability through their actual work, i.e., by analysing their reports on sustainability (Table 3). Analysing the annual reports for the five-year period (2017 to 2021) of the top 10 European passenger seaports—the Port of Dover, Helsinki, Messina, Tallinn, Reggio di Calabria, Piraeus, Calais, Stockholm, Napoli, and Paloukia Salaminas—their commitment to sustainability and different SDGs was observed. To identify the top 10 ports by the number of passengers, the average (2018, 2019, and 2020) number of passengers that embarked and disembarked at each port was calculated using EUROSTAT data [106].

Table 3. Commitment to sustainability among the top 10 European passenger seaports.

Top Ten Passenger Ports	Origin	2021	2020	2019	2018	2017
Port of Dover	United Kingdom	–	+	+	+	+
Port of Messina	Italy	–	–	–	–	–
Port of Helsinki	Finland	+	+	+	+	+
Port of Reggio di Calabria	Italy	–	–	–	–	–
Port of Tallinn	Estonia	+	+	+	+	+
Port of Piraeus	Greece	–	+	+	+	–
Port of Napoli	Italy	–	–	–	–	–
Port of Calais	France	–	–	–	–	–
Port of Paloukia Salaminas	Greece	–	–	–	–	–
Port of Perama	Greece	–	–	–	–	–

The Port of Dover is committed to ensuring the best possible protection of the environment within its jurisdiction, consistent with its mission and the aim of sustainable development [107]. They demonstrate their business through six of the United Nations Sustainable Development Goals: Affordable and clean energy (SDG 7), Decent work and economic growth (SDG 8), Industry, innovation and infrastructure (SDG 9), Sustainable cities and communities (SDG 11), Responsible consumption and production (SDG 12), and Climate action (SDG 13) [108].

The Port of Helsinki reports on the achievement of its responsibility and sustainable development goals as part of its annual reporting. The port achieved its 2021 responsibility targets well: its focus on society's security of supply was highlighted and its carbon neutrality programme proceeded as planned. The key aspects of the port's responsibility management model are financial, social, and environmental responsibility. Objectives and decisions are considered from a financial, social, and ethical perspective, taking into account company stakeholders [109].

Tallinna Sadam consistently strives to reduce the negative impacts of its business and activities on the environment [110]. Through its activities, Tallinna Sadam contributes to the achievement of Estonia's goal of climate neutrality, as well as to the implementation of the European Green Deal and the Sustainable Development Goals of the UN [111].

Piraeus Port Authority supports the United Nations 2030 Agenda, which sets out 17 Sustainable Development Goals for 2030. Its aim is to actively contribute to the achievement of these goals by promoting the well-being and safety of the population, protecting the environment, and fighting poverty. Priority is given to achieving goals directly related to the activities and challenges of the transport sector, as shown in the Corporate Responsibility and Sustainable Development Report for 2020 [112].

The port of Calais has published the latest environmental report of 2014, available on its website. However, the website emphasises its strategic objectives: ensuring the satisfaction of its customers, operators and users; protecting the health and ensuring the safety of property and people; preserving the environment and the way of life of all; ensuring attractiveness; supporting initiative and innovation; ensuring development and well-being to enhance collective performance; adopting ethical, responsible, and civic behaviour. In addition, the port organises its Sustainable Development Action Plan around 10 themes that can be linked to the SDGs. For example,

- *Promoting the reduction of air emissions;*
- *Preserving water quality;*
- *Promoting the integration of the sites of Boulogne-sur-Mer and Calais in their urban areas;*
- *Maintaining ecological continuum and balance;*
- *Treating and recycling all waste;*
- *Fighting against discrimination;*
- *Ensuring satisfactory working, health, and safety conditions;*
- *Promoting personal development, skills acquisition, and development;*
- *Constituting a port community of goals and means* [113].

Reviewing the annual reports, including the financial and sustainability reports, on the top 10 passenger seaports, it can be concluded that all passenger seaports do not have available reports on their websites in the period 2017–2021. Furthermore, this analysis shows that some ports included Sustainable Development Goals in their reports (only some of the goals).

3. Discussion and Conclusions

Considering the importance of sustainable development in all fields, the main purpose of this paper was to provide an overview of the research area and applied methodology dealing with sustainable seaports and sustainable passenger seaports. The authors extracted 74 relevant publications on sustainable seaports and 38 publications on sustainable passenger seaports.

The article "Role of sustainability in global seaports" [22] examines the relationships between the existing sustainability of seaports and the current discussion on sustainability. Thirty-six seaports from North America (NA), Europe (EU), and the Asia Pacific (AP) region were selected for analysis. Considering the top 10 European ports, only the port of Helsinki was included in this research.

The main objective of the paper titled "A methodological approach for environmental [60] characterization of ports" is to propose a collective methodology for port assessment, based on the combination of available economic data and information on environmental and social parameters. The study included 16 ports, of which only one (Piraeus) was included in this study. Moreover, the paper "The Port of Piraeus: Industrial Zone or Urban Continuity" [102] includes the port of Piraeus and its relation to the surrounding urban pattern.

The paper "Challenges for European Tourist-City-Ports: Strategies for a Sustainable Coexistence in the Cruise Post-COVID Context" [76] proposes five different strategies that contribute to a sustainable coexistence between tourist ports and their cities. In this research, the port of Naples was included.

In their study, the authors of [82] explore the potential of diversifying shore excursions offered by cruise lines to reduce pressure on popular destinations. The ports of Messina, Naples, and Calabria were included in the study.

In the research "Managing sustainable practices in cruise tourism: the assessment of carbon footprint and waste of water and beverage packaging", the authors [84] present an analysis of the carbon dioxide emissions and waste associated with water and beverage packaging. In this research, the port of Naples was included.

A total of 101 papers were included in the literature review, without filtering according to geographic area. Only six papers dealt with the ports listed as the top 10 passenger seaports in Europe. This indicates insufficient research on European seaports in the context of sustainable development. This can be added to the unavailability of data and annual reports from the European seaports.

Regarding the visibility of the sustainability commitment of the top 10 passenger seaports, it can be concluded that most of them had room for improvement in the years observed. Moreover, they should include more sustainable development goals, if necessary.

According to the methodology applied, each article was classified into the five proposed groups: literature review, theoretical approach, qualitative approach/methods, quantitative approach/methods, and other. Some of the articles used a combination of methods, so they were classified by the authors into more categories (usually three). Comparing the literature review on sustainable seaports and the literature review on sustainable passenger seaports, it is noticeable that most of the papers in both reviews were categorised as quantitative approach/methods. Most of the methods used in both studies that fell into the qualitative approach/methods category were interviews, questionnaires, and surveys.

The main contribution of this paper is a summary of the most commonly used tools/methods to evaluate the current sustainable measures of passenger seaports.

The limitations of this research may arise from the number of people reviewing the papers [114], as well as different interpretations of the terms or keywords sought. Some papers addressing this topic may not have been included because they were not published in WoS, or the search was conducted using only the keywords "sustainable seaport" and "sustainable passenger seaport".

The existing literature identified in this paper will serve as the basis for a deeper analysis of the methods/ways in which the elements that contribute to sustainability in passenger seaports can be determined. Future research can incorporate these findings to create an assessment model for sustainable port improvements. It is necessary to identify all elements of the passenger seaport (economic, social, environmental, legal, technical, technological, organisational, and others) that influence sustainable port development. It is also important to assign a numerical value to all elements of the passenger seaport.

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