Disclosure of the sustainable development goals in the maritime industry and port sector

Divulgação dos objetivos de desenvolvimento sustentável na indústria marítima e no setor portuário

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Abstract

The maritime industry and port sector are catalysts of economic growth and development of countries. However, they can generate significant environmental and social impacts on marine ecosystems and neighbouring communities. The sustainable development goals (SDGs) proposed by the United Nations (UN) make up the 2030 Agenda and suggest a global sustainable development that needs the collaboration of various stakeholders. In this context, the article aims to identify the SDGs most evidenced in the maritime industry and port sector from a systematic literature review using the tools EndNote, IRaMuTeQ and VOSviewer. The results pointed to SDG 9 Industry, Innovation and Infrastructure, 13 Action against Climate Change and 14 Life on the Water as the most addressed by the studies, highlighting the guidance of the maritime industry and the port sector in contributing to sustainable development based on concern for the marine environment and climate change. It was

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observed that the studies identified the relevance of contributing to the SDGs. On the other hand, the practical applications were not properly described, thus making it difficult to understand the priority actions for an effective contribution to the SDGs.

**Keywords:** Sustainability. Sustainable Development Goals. Maritime Industry. Port Sector.

**Introduction**

The maritime industry is a common means of transporting cargo essential for global sustainability. Therefore, the efficient and strategic management of maritime routes, both from an economic and environmental point of view, has become a central focus for achieving sustainable development goals (SDGs). It is important to highlight that the maritime industry's responsibility regarding the SDGs goes beyond SDG 14, which is directly related to the marine environment. It can also contribute to promoting the health of communities (SDG 3), ensuring decent jobs (SDG 8) and the development of cities and communities (SDG 11) (Kandasamy et al., 2021; Wang et al., 2020).
The ocean is crucial in regulating the global climate, providing natural resources for human use, enabling recreational activities, and facilitating international trade. However, human development, economic growth, and unrestricted access to the oceans have put significant pressure on marine ecosystems due to overfishing, increased resource extraction, and practices harmful to the marine environment (Vega-Muñoz et al., 2021).

Ports are crucial infrastructure for economic development as they serve as gateways for international trade, facilitate cargo handling activities, and offer value-added services such as storage, packaging, and land transport organization. As a component of the maritime industry, ports play a significant role in global trade and commerce (Hossain et al., 2021).

Port activities play a significant role in the economic growth and job creation of developing countries. However, as highlighted by Azarkamand et al. (2020), these operations also produce negative environmental externalities due to the diverse and complex nature of activities involved in the sector. These impacts include noise, soil contamination, waste production, and gas emissions that contribute to atmospheric pollution, potentially harming marine ecosystems and the well-being of local communities.

In 2015, the United Nations adopted a global action plan for sustainable development called the 2030 Agenda. The global proposal contains 17 Sustainable Development Goals. The SDGs call for global action among governments, businesses and civil society organizations to achieve shared and sustainable prosperity (Khaled et al., 2021).

The maritime industry and the port sector play an important role in this context. The study by Wang et al. (2020) identified that sustainable development goals 8, 9, 12 and 14 are considered the most aligned with the core business of the maritime industry, representing its core responsibility with sustainability.

Caliskan (2022) pointed out a lack of studies on port sustainability based on the SDGs, particularly concerning initiatives, activities, and actions implemented in ports to achieve them. Therefore, this study aims to conduct a systematic literature review to identify the most prominent SDGs in the maritime industry and port sector.

**Literature Review**

**2.1 SDGs in the Maritime Industry**

In the study by Di Vaio et al. (2020), the main corporate strategies used by the four leading companies in the cruise and container transport segments about the sustainable development goals (SDGs) were analyzed, investigating how this information is disclosed.
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Based on sustainability reports. As a result, the results revealed the strong commitment of all the companies analyzed to meet the 17 goals. Still, it should be noted that most of the information made available is qualitative, with a low number of goals linked to the SDGs being perceived, as well as a limited supply of performance indicators. That said, the analysis highlighted that the lack of comprehensive monitoring tools could affect data availability and, consequently, the quality of published reports, leading to incomplete disclosures of information to stakeholders.

In the same sense, the research carried out by Balić et al. (2021), which aimed to analyze the commitment of the ten largest shipping companies to the SDGs, identified that nine of them publish sustainability reports and are aligned with the SDGs, highlighting the search for the achievement of the 17 SDGs in the companies' reports Cosco Shipping and Mediterranean Shipping Company. However, Pacific International Lines emphasizes the importance of commitment to sustainable conduct in line with the SDGs. However, it does not comply with what it suggests nor publish the report. According to the survey, the main SDGs associated with the activities of the companies observed are 8, 13 and 14.

In the analysis raised by Kitada et al. (2017), endorsed by an online questionnaire carried out by participants of the International Conference on Maritime Energy Management, it was concluded that the future of research in maritime energy management needs more practical examples, use of multidisciplinary approaches and initiatives aligned with compliance of SDGs 7, 13 and 14, pointing out the indispensability of applying mechanisms that reduce the existing gap between developed and developing countries.

In a similar approach, Poland (2020) discussed the future of research in the maritime sector, where he argued about the multidisciplinarity of the theme and the relevance of the convergence of debates related to the 17 SDGs, defined by the United Nations (UN). The study pointed out that SDGs 6, 7, 9, 11, 12, 13 and 14 should be highlighted more in future studies, focusing on the last SDG and intensifying scientific research on the marine environment.

Concerning SDG 16, Knapp et al. (2021) analyzed the effect of corruption on the quality of vessel safety. The conclusions showed that Port States with a higher corruption perception index (CPI) are less likely to detain ships, Flag States located in countries associated with a higher CPI tend to have a more significant number of serious incidents, and countries with a more excellent perception of corruption have a higher degree of underreporting of serious incidents. The study also showed the strengthening of the fight against corruption, with training and applying the code of good conduct for control inspectors...
in the maritime industry, intensifying the establishment of accountability structures and consequently expanding efforts in favour of SDG 16.

From the perspective of Ahmad et al. (2020) on the impact perceived by the marine environment due to the rapid development of Marinas, it was found that the environmental dimension is one of the most critical factors for developing a green marina. The research was a case study carried out at the company Duyong Marina & Resort, based on interviews with specialists, and pointed out that the main incentives should be related to reducing the carbon footprint (zero carbon policy) and updating the facilities, with a focus on a future green marina, contributing to SDG 14. The research highlighted the existing orientation, by the management of the enterprise, in contributing to sustainable development based on the objectives of the 2030 Agenda.

Likewise, Bank et al. (2021) discussed the proposal to create a Global Plastic Pollution Observation System (SGOP), where the main objective was to support the formulation of governance policies based on monitoring methods and techniques, with the aim of characterizing and quantifying plastics in the environment. The authors noted that the system would provide periodic assessments and identify priority actions to mitigate the risks associated with plastic pollution. Thus, with the implementation of public policies to reduce this problem, it is possible to cooperate with the SDGs, such as SDG 14, oriented towards contributing to a more sustainable marine environment.

With regard to understanding the relevance of marine spaces, Wang and Wang (2020) elucidated several floating solutions as constructors of a new approach to coastal urban development, with the aim of encouraging the blue economy, reducing the impacts of coastal land pressures, allowing for the expansion of territories and align them with the SDGs. The researchers also highlighted that the floating solutions addressed contribute to SDG 6, 7, 9, 11, 13, 14 and 15.

In line with the perception of previous authors, encouraging methods aimed at growth based on sustainable practices, Kandasamy et al. (2021) evaluated the environmental and economic benefits related to a new sea route in the Indian subcontinent. The analysis measured environmental indices and their impacts on the cost in two ways, the original, with circumnavigation around Sri Lanka and the alternative route, the Sethu Samudram Canal Project (PCSS). It was found that the alternative route presented better results, such as a reduction of up to 21% in CO2, a reduction in the cost and time of travel and, therefore, obtaining green logistics. In this sense, investments in a logistics infrastructure can result in the evolution of a sustainable maritime ecosystem, combating climate change (SDG 13) and promoting efficient strategies for managing marine resources (SDG 14).
Addressing the challenges perceived by the cruise industry during and after the COVID pandemic, Eskafi et al. (2022) proposed strategies linked to the SDGs to face the observed consequences. Based on a systematic literature review, adaptive actions were identified and proposed with a focus on supporting decision-making by policymakers and managers. The research described how actions aligned with the SDGs enhance sustainability in the cruise industry, acting as drivers of the post-pandemic sector. The results pointed to the contribution of the various SDGs descriptively, highlighting SDGs 3, 4 and 17.

Analyzing the same study area of the previous research, Di Vaio et al. (2022) investigated, through the sustainability reports of Carnival Corporation, Royal Caribbean Group, Mediterranean Shipping Company Cruise and Norwegian Cruise Line, published from 2015 to 2019, the role of digital technologies for sustainable waste management, to comply with the 2030 Agenda guidelines. The results highlighted the growing commitment of cruise companies to reduce their environmental impact, meeting the SDGs with investments in digital technologies. The study also identified the best practices that should be applied on board ships as facilitators of cruise sustainability and, consequently, the achievement of the SDGs, highlighting the practices used to achieve SDGs 3, 6, 12, 13 and 14.

### 2.2 SDGs in the Port Sector

In the survey carried out by Cerreta et al. (2020a), the Circular City Model (CCM) approach and a multidimensional and multiscalar decision support system were used as a methodological basis to select the most appropriate indicators to assess the sustainable transition in the port city of Naples, located in southern Italy. The objective was to analyze the probable impacts resulting from the transformations related to the port-city relationship and the existing correlation between the indicators related to the MCC and the Sustainable Development Goals (SDGs). The note guided the choice of 16 indicators for the environmental dimension, 17 for the economic and 26 for sociocultural, also emphasizing that the choice of indicators is linked to achieving the SDGs.

Still referring to the same authors cited above and using the same city as a case study, Naples (Italy), they carried out another study involving the representativeness of the use of Circular Economy (CE) principles within the scope of sustainable objectives, aiming to implement an MCC based on SDG 9, 11 and 12, as well as the European Maritime Spatial Planning Directive 2014/89. For this, an approach based on mixed evaluation methods and an analysis of hard and soft knowledge domains were expressed and measured by a set of sustainability indicators linked to the SDGs. The authors concluded that the main contribution...
is based on three alternatives of sustainable projects for the city in question, strengthening the development of a scenario aligned with CE and, therefore, with sustainability principles.

Regarding the transparency and effectiveness of Corporate Social Responsibility (CSR) disclosure in the port sector, Michalska-Szajer et al. (2021) carried out a comparative analysis on ecological and social responsibility between Polish ports and the ports of Antwerp (Belgium) and Hamburg (Germany), used as a reference. The objective was to study how Polish ports contribute to sustainable development, based on the objectives of the 2030 Agenda, and identify gaps, thus providing insights for the administrators of these ports. Thus, the researchers concluded that the management of Polish ports is socially responsible, contemplating the three areas of CSR (economic, social and environmental). However, the form of disclosure and the amount of information related to sustainable measures in the analyzed reports are insufficient and unclear when compared with the information obtained in the reports from the ports in Belgium and Germany.

Aligned with the methodology and understanding of previous authors, Fedorenko and Khmeleva (2021) examined the challenges and opportunities that can be understood and taken advantage of by the Port of Vladivostok (Russia), based on the outstanding experience of the Port of Antwerp (Belgium) in accordance with a sustainable development operationalized through the SDGs. The authors suggested the application of the model used by the Belgian port, focused on the three parameters (economic, social and environmental), unlike the model present in the Russian port, where only the economic and social dimensions are significantly contemplated in the port management. They also highlighted the pertinence of defining the SDGs that are the highest priority for the reality of the observed port and presenting projects based on sustainable initiatives, thus developing an integrated system of efficient coastal management.

Examining guidelines for inclusive port development, Jansen et al. (2018) developed exploratory research with the purpose of ascertaining the necessary conditions for this purpose in the Port of Tanjung Carat in Indonesia. As a methodology, a case study and an action-research approach were used, combining qualitative data extracted from interviews, field visits and surveys carried out with the main interested parties (stakeholders). The conclusion explained the concept of “partnership space” as a condition for a balanced advance, where social inclusion and port development are aligned. Therefore, the study also stressed the essentiality of the social parameter in the port sector and highlighted its compliance with the SDGs.

Also carried out in the previous research, Al Amien et al. (2020) used an Indonesian port as a case study. The researchers studied the effect perceived by the development of the
new Port of Mafa in relation to five of the 17 UN goals, namely: 1, 2, 8, 9 and 14, identifying its contribution to the sustainable growth of the region. The study pointed out the main sustainable guidelines connected to port development by comparing the Indonesian port model and the best port practices applied by the Port of Gothenburg (Sweden). The results highlighted that the project contributes positively to SDG 1, 2, 8 and 9. However, it negatively impacts SDG 14.

Addressing the issue of sustainability performance in the port sector, MacNeil et al. (2021) analyzed the sustainable initiatives most used by Port Authorities of Canada (APCs), proposing a specific framework for each port based on the Global Reporting Initiative (GRI) disclosures, which are directly aligned with the achievement of SDG targets. The article pointed out that only 14 goals out of the 36 most relevant of the 17 objectives are present in Canadian port management. Using an alternative methodology based on GRI standards aims to improve sustainability practices and make sustainable port performance more meaningful.

In accordance with the subject discussed above, Taneja et al. (2021) presented a methodology to evaluate and quantify the performance of sustainability in port infrastructure, using a quay wall in the Port of Rotterdam (Holland) as the object of study. Thus, based on a systematic literature review, the authors identified the main themes related to sustainability and port infrastructure, making it possible to develop a systematic framework aimed at managing the main practices and goals aimed at sustainable development. In this context, the priority topic addressed was “atmospheric pollutants”. The selected performance measure was Greenhouse Gases (GHG) and the quantification tool Dubocalc. The results showed that the use of the framework allows the organization to address and evaluate the numerous dimensions of sustainability, thus collaborating with the SDGs, highlighting objectives number 9 and 13.

Contributing to the previous analysis, Nitsenko et al. (2017) developed a monitoring tool based on quality indicators for the port sector to monitor the impact of its sustainable development at the macroeconomic level. The researchers highlighted the need to invest in a reliable and quality infrastructure to underpin the economic and social development relevant to the sector, as well as to intensify the process of inclusive and sustainable industrialization by 2030 and to expand access to information technology in developing countries. The study concluded that these proposals are based on the objectives proposed by the 2030 Sustainable Development Agenda, emphasizing objective 9.

With an emphasis on measuring Environmental Performance in Ports (DAP), Vega-Muñoz et al. (2021) followed a scientometric meta-analytical methodology to review the various scientifically documented methods on how to measure environmental performance in...
ports, port companies or port authorities, extracting the corpus for analysis from the Web of Science Core Collection database. In this sense, the scientometric search initially identified 36 papers, after the screening process carried out by the PICOS tool (Population, Interventions, Comparators, Outcomes and Study), 10 articles met the necessary eligibility criteria. The results presented a set of environmental performance indicators and associated them with the sustainable development goals, highlighting SDGs 11, 13 and 14.

In line with the topic discussed above, the analysis carried out by Cavalli et al. (2021), which aimed to measure the economic, social and financial performance resulting from the use of 5G networks and the advancement of digital transformations in port dynamics, presented a pilot technology project aimed at designing new models of port management, operational planning and implementation of sustainable port development policies, observing the Port of Livorno (Italy) as an object of study. The research was defined by the authors as an instrument to enhance technological advances in port competitiveness and to identify how the “Port of the Future” can contribute to achieving the objectives intended by the 2030 Agenda. The port sector contributes more significantly to SDGs 4, 8, 9, 11, 12, 13, 14 and 17.

With regard to sustainable logistical development in the port sector, D’Amico et al. (2021) carried out a systematic literature review on the most recurrent topics on sustainable smart logistics initiatives in port cities to develop a multidimensional structure capable of integrating the predominant facilitating factors, domains and goals, using research carried out in some cities, for example, Hamburg, Singapore and Amsterdam. The review conclusively pointed out that sustainable logistics initiatives have the potential to increase economic, environmental, social and technological flows, as well as enhance stakeholder engagement and awareness. With this, as part of the goals present in the proposed structure, it is possible to contribute to SDGs 3, 8, 9, 11, 12, 14 and 15.

Analyzing the challenges to achieving sustainable development goals in the Port of Klang (Malaysia), Beleya et al. (2020) investigated the relationship between the dependent variable: solving the challenges to achieve the SDGs and the independent variables: technology, financing, and human capital and supplier, based on a qualitative approach. The authors concluded that all the independent variables strongly interfere in the process of sustainable development of the Malaysian port, evidencing the technological advance as an effective tool in the search for better productivity and reduction of waste, as well as the investment in financing by the government, aimed at resolving identified gaps. The study also attested that SDG 6, 7, 8, 9, 13, 14 and 15 have a strong connection with the research carried out.
In the study by Varese et al. (2022), a conceptual framework was developed, with the aim of investigating state of the art related to the assessment of environmental sustainability in dry ports, boosting the development of future research in this area. Through a systematic literature review, this conceptual framework was proposed. The results pointed to the scarcity of research that addresses the environmental aspects of dry ports, little involvement of stakeholders and the absence of debate on the SDGs. The review concluded that sustainability in dry ports cooperates with SDGs 3, 8, 9, 12 and 13.

Lima and Souza (2022) analyze how climate change is addressed by port planning policies, coastal management and climate adaptation in Brazil, using the state of Santa Catarina as a case study. Based on an exploratory analysis of public policies and document analysis, the scope of SDG 13 was verified, where all goals were adapted to the port context. The survey showed that at the national level, the country has a robust policy for adapting to climate change with the National Adaptation Plan. On the other hand, the incentive to include and prepare Brazilian port management to face climate risks is insufficient, mainly due to the high costs of financing adaptation.

Discussing the theme of maritime business models, sustainability and digitization of operational processes at the ship-port interface, Del Giudice et al. (2022) investigated the role of digitization in reducing the environmental impact of maritime and port activities aimed at meeting the 2030 Agenda and the SDGs. The study concluded that digitization at the port interface allows creating a link between the goals of SDGs 7 and 13, operating as a link for the unification of sustainable practices. The authors pointed out that the SDGs should be integrated into the strategic plans of maritime organizations, generating sustainable business models based on innovative technologies.

MacNeil et al. (2022) analyzed interactions between relevant SDG targets for the Canadian port sector and Green Marine Environmental Program (GMEP) performance indicators. The results showed that not all SDGs are relevant to the Canadian port scenario, with 12 of the 17 SDGs included in the analyzed program and of the 36 goals belonging to these 12 SDGs, only 14 are directly linked to the GMEP.

Evaluating the direction of sustainability disclosures of European ports in relation to the SDGs, Caliskan (2022) developed a framework of sustainability initiatives related to the port sector, focusing on contributing to the SDGs. The study correlated the best practices of European ports to all 17 SDGs, highlighting that the port industry has the potential to significantly collaborate with SDGs 8, 9, 11, 12, 13 and 17.

Idris (2022) discussed sustainable policies and initiatives based on the 2030 Agenda used by the port sector in Asian countries. SDG 17 was approached as a mechanism for
strenthening the sustainable development of the analyzed countries. The survey highlighted that the investigated ports have sustainable guidelines in their national policies, but the planning of sustainable port management is still ineffective. The study’s results highlighted the relevance of expanding the focus beyond environmental sustainability, seeking to cover all parameters of sustainable development and thus corroborate with the SDGs.

In the research by Argyriou et al. (2022), a methodology was proposed to support policymakers in building sustainable strategies, based on the study of the Port of Souda (Chania-Crete), with a focus on examining the challenges and possible solutions for the development of a port sustainable. The study explored the citizens' perception of the sustainability of the analyzed port, highlighting the leading indicators aligned with a positive sustainable performance. The results showed that respondents believe more investments should be directed towards reducing marine pollution and efficient waste management. The survey highlighted the focus on meeting SDGs 7 and 11.

Addressing the existing barriers to achieving the SDGs in the Sri Lankan maritime sector, Katuwawala and Bandara (2022) identified, from interviews with port managers in the country, the reasons for the disparity between global standards of port sustainability and national practices. The study concluded that inefficient policies, structural, managerial and market restrictions and the absence of a standardized global port structure directed towards the SDGs are significant barriers to fulfilling the 2030 Agenda.

Methodology

This research used a systematic literature review based on a qualitative analysis of the data intermediated by content analysis. Its result was based on the similarity analysis derived from the IRaMuTeQ software. One of the premises was to conduct a systematic literature review applying the same methodological parameters (Porte & Trindade, 2021; Porte et al., 2022).

The database was obtained from the Web of Science and Scopus platforms, with the insertion of the keywords “Sustainable Development Goals” and “ports” or “SDG” and “ports” in the topic field for the period from 2017 to 2022. This time interval was chosen because the 2030 Agenda, which comprises the Sustainable Development Goals, was approved on September 25, 2015. Therefore, it was decided to use the studies published from 2017 to 2022, making up a cycle of 5 years. The year 2023 was excluded because it is ongoing.

In the Web of Science database, the filter was applied by selecting papers and reviewing articles. Thus, the system provided a result of 55 articles. In the Scopus database,
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Then, they were transferred to the Endnote system so that the first content analysis process could be carried out to select only the articles that addressed the SDG theme and ports in their content. With this objective, the articles were analyzed individually, verifying if the theme was contemplated in the studies. Therefore, it was observed that in some surveys, the term “port” comprised the nomenclature of cities and not the actual meaning intended for this review, as well as, in other surveys belonging to the sample obtained, the word “SDG” was only included in the summary or conclusions. Most of the time, it was not related to the ports.

Duplicate articles and those irrelevant to the study theme were also excluded. After this analysis, 85 studies were excluded from the sample, resulting in a final total of 32 articles that were again analyzed and classified according to the context of the study.

Objectives were extracted from all articles, in addition to some cataloguing criteria with the type of SDG found in the studies, with the purpose of being catalogued and formatted to create a single textual corpus to be analyzed in IRaMuTeQ. After inserting the corpus, an attempt was made to generate the dendrogram of the classes. However, it was not possible to obtain the same due to the heterogeneity of the writing of the objectives associated with the sample size and the number of existing SDGs (17). Therefore, the use of the software turned to the discussion of the results.

Thus, the review was carried out based on the 32 papers. Their results were evaluated and discussed based on the analysis of the results obtained by the IRaMuTeQ and VOSviewer software.

Results and Discussions

The research addressed in the review highlighted the commitment of the maritime industry and the port sector to link their activities to the SDGs. Still, it is imperative to highlight that in most of the analyzed studies, the practical applications related to the SDGs were not properly described, thus making it challenging to understand priority actions for an effective contribution to the SDGs.

In the studies related to the maritime industry, studies that addressed the efforts of maritime transport companies to contribute to the 17 SDGs and the publication of sustainability reports stand out as an attempt to encourage the transparency of actions towards stakeholders. Thus, these surveys identified a small number of companies that set targets and
performance indicators for monitoring and measuring sustainable actions aimed at the SDGs. The best-defined, quantified and controlled positions are directed to the environmental parameter due to the robust legal framework. In contrast, from the social perspective, most companies only mention financial support to social programs, not highlighting strategic plans and mechanisms for promoting social inclusion, emphasizing the qualitative vector of information.

It was possible to observe that despite the intense orientation towards the fulfilment of the SDGs, it is necessary to carry out effective training and constructive debates with the stakeholders of the observed organizations, aiming to improve knowledge and sustainable applications, as well as to encourage effective actions in support of the SDGs and reduce simple compliance with legislation.

Still addressing research pertaining to the maritime industry, there is the presence of analyses that examined the multidisciplinary nature of maritime research and the versatility of the maritime industry in achieving the 17 SDGs and not just SDG 14, directed at marine spaces. Likewise, surveys discussing subjects such as: combating corruption and investments in logistics infrastructure in the maritime industry were presented as guides in contributing to the SDGs.

The proposed mechanisms to reduce this problem were identified in the study on the perceived effect of corruption on vessel safety. Still, the metrics and procedures that should be used for this control were not shown in detail. Already approaching the theme of investments in logistics infrastructure, it was possible to verify from the analysis of the study the environmental and economic benefits derived from the proposal of the new alternative maritime route. However, limitations were also perceived, some of them: being the associated religious values of the region and the possible oil spill in the marine reserve of the Gulf of Mannar Marine National Park.

In research related to the port sector, there was a significant number of analyses using comparative methods, with a focus on applying the most effective techniques found (benchmarking) in the case studies in question, as an example: the survey that presented a comparative analysis of disclosure of Corporate Social Responsibility (CSR) between Polish and European ports, where some parameters, contemplated in the reports of European ports, were proposed to be implemented by the management of Polish ports, namely: greater detailing of pro-environmental and pro-social actions to stakeholders, the inclusion of Global Reporting Initiative (GRI) tables in CSR reports, external audits of reports and the publication of more comprehensive reports, involving all sectors and activities of the port complex and not just those carried out by the port authority. With the application of these measures, the
reliability of CSR reports is enhanced, due to the standardization of information, sustainably promoting Polish ports.

From the perspective of measuring port performance, the study that evaluated the economic, environmental and social impacts of the use of 5G networks described the potentially benefited port processes, namely: storage, land and sea transport and port control and operation activities and port terminals. However, externalities arising from these applications were not evaluated, for example, the possibility of replacing employees with machines in certain port activities, generating a reduction in jobs, as well as the potential increase in Greenhouse Gas (GHG) emissions influenced by the rebound effect, derived from the increased efficiency of activities and flows of navigation operations. In this sense, research using quantitative data is necessary for this analysis.

It was observed in the surveys carried out in 2022 the direction to contribute to the formulation of policies and the decision-making of port managers, based on analyzes that proposed in detail sustainable practices linked to the SDGs. As an example, the study that addressed the sustainable mechanisms used by the leading European ports and highlighted their links to each SDG as a way of disseminating the best practices used by these ports, considered as reference parameters and thereby providing sustainable port management guidance for stakeholders, collaborating with the 2030 Agenda.

Regarding the research objectives analyzed in contributing to the SDGs, the IRaMuTeQ software was used to obtain the similarity analysis referring to the main SDGs addressed in the literature review (figure 1).

Thus, based on the similarity analysis, the most observed SDGs in the review were: 14, 13 and 9, with SDGs 14 and 13 addressed in 15 studies and SDG 9 in 12. The sustainable development goals appeared with the following frequency SDG 11 (10), SDG 12 (8), SDG 8 (8), SDG 7 (7), SDG 6 (5), SDG 3 (4), SDG 15 (4) and SDG 17 (3) in the papers analyzed.
SDGs 1, 2, 4, 5, 10 and 16 are not represented in the image because they were mentioned in less than three searches, so the software does not consider them in the results. The general SDG comprises the group of nine investigated articles that comprehensively discussed the scope of the 17 SDGs but, for the most part, did not directly and expressively specify how this purpose was achieved nor the metrics used.

Regarding SDG 14, several studies have comprehensively addressed the topic (Ahmad et al., 2020; Al Amien et al., 2020; Balić et al., 2021; Bank et al., 2021; Beleya et al., 2020; Cavalli et al., 2021; D’Amico et al., 2021; Di Vaio et al., 2022; Kandasamy et al., 2021; Kitada et al., 2017; MacNeil et al., 2022; Poland, 2020; Varese et al., 2022; Vega-Muñoz et al., 2021; Wang & Wang, 2020). Only six papers highlighted direct applications related to SDG 14, as in Ahmad et al. (2020), in which the environmental dimension was identified as a key factor in developing a green marina. The survey highlighted the use, by the analyzed company, of mechanisms for reducing the carbon footprint, waste management and pollution control of the water around the marina. Bank et al. (2021) proposed the plastic pollution observation system to identify critical points of pollution (facilities, cities, roads and ports) in marine environments and other types of ecosystems, enabling reliable monitoring and encouraging the formulation of public policies based on this evidence.

Likewise, Poland (2020) highlighted the value of stimulating ocean stakeholders (scientific community, public policymakers, companies and civil society) in promoting scientific knowledge that can underpin the sustainable conservation of marine resources. Wang and Wang (2020), where large-scale floating breakwaters have been proposed to protect coastal assets from strong waves in an environmentally sustainable way, ensuring that undersea habitat fragmentation is minimized.

In Di Vaio et al. (2022), the companies studied installed advanced wastewater purification and ballast water treatment systems to clean wastewater by mechanical filtration, using ultraviolet light and chemical treatment before being returned to the sea. MacNeil et al. (2022) highlighted that SDG 14 was one of those identified as priorities for achievement by Canadian port authorities, being directly linked to the spill prevention indicator, which aims to reduce spills and leaks of pollutants into the environment.

Recent studies deal with SDG 13 (Balić et al., 2021; Beleya et al., 2020; Caliskan, 2022; Cavalli et al., 2021; Del Giudice et al., 2022; Di Vaio et al., 2022; Kandasamy et al., 2021; Kitada et al., 2017; Lima & Souza, 2022; MacNeil et al., 2022; Poland, 2020; Taneja et al., 2021; Varese et al., 2022; Vega-Muñoz et al., 2021; Wang & Wang, 2020). It is essential to point out that most of these studies belong to the group of articles related to SDG 14, differing only from four.
Caliskan (2022), where energy transition, balanced modal division, circular economy and digitization were identified as the instruments used by European ports to achieve SDG 13. Lima and Souza (2022) adopted all targets belonging to SDG 13 in the Brazilian port sector for document evaluation of public policies. As well as Del Giudice et al. (2022) addressed the issue of digitization in port business models, emphasizing the strengthening of SDGs 13 and 7. And Taneja et al. (2021) highlighted using renewable energy, temporary drainage systems, electrified transport and machinery and hydrogen as dredging fuel for GHG reduction and contribution to SDG 13.

Regarding SDG 9 (Al Amien et al., 2020; Beleya et al., 2020; Caliskan, 2022; Cavalli et al., 2021; Cerreta et al., 2020b; D’Amico et al., 2021; MacNeil et al. al., 2022; Nitsenko et al., 2017; Poland, 2020; Taneja et al., 2021; Varese et al., 2022; Wang and Wang, 2020) discussed the theme, only the groups mentioned above studies by Cerreta et al. (2020b) and Nitsenko et al. (2017). The latter stressed that for an effective contribution to SDG 9 it is necessary to propose a business model based on a quality infrastructure that supports economic development and investment in research and innovation in developing countries.

With the focus on analyzing the existing relationships between the SDGs addressed in the articles belonging to the review, the VOSviewer software was used, where the main connections between the SDGs were identified (figure 2).

![Fig. 2. Connections between SDGs](image)

It is observed that SDG 14, 13 and 9 have a greater number of connections. SDG 14 has the highest number of relationships (62), not connecting only with SDG 10 and 16, based on the surveys analyzed. SDG 13, however, has 59 connections and is unrelated to SDGs 1,
2, 10 and 16. SDG 9 has the same connections as SDG 13 and is unrelated, like SDG 14, to SDG 10 and 16.

SDG 10 was not addressed in any article in the sample, and SDG 16 is unrelated to the other SDGs, appearing only in the study by Knapp et al. (2021). The articles belonging to the general SDG comprehensively approach the theme, with no connection with the SDG specifically.

Thus, it is evident that SDGs 14, 13 and 9, in addition to having more significant connections with the other SDGs, are still related. Some studies contribute simultaneously to the three (Beleya et al., 2020; Cavalli et al., 2021; MacNeil et al., 2022; Poland, 2020; Wang & Wang, 2020).

Given the above, research involving the maritime industry and the port sector with a focus on the SDGs influenced almost all 17 SDGs, except SDG 10, which was not identified in any of the 32 studies in the sample. In this way, the expansion of efforts aimed at the sustainability of the various sectors related to marine spaces demonstrates the commitment to the 2030 Agenda, enabling the strengthening of studies addressing this theme, such as environmental performance measurements, verification of corporate transparency with stakeholders (non-financial reports), literature reviews and practical applications based on the SDGs.

Thus, analyzing the Brazilian context in the field of studies aimed at port sustainability based on the SDGs, there was only one survey within the criteria used for this review. The country stands out for having promising geographical parameters for the production of wind and solar energy, as well as for green hydrogen (H2V), configuring itself as a differential for the decarbonization of sectors with high CO2 production, as is the case of the port sector. Brazil can become a significant global exporter of H2V. Therefore, the commitment to the best sustainable practices based on the SDGs becomes essential for achieving this possible milestone.

Conclusions

This study aimed to identify the SDGs most evidenced by studies developed in the maritime industry and the port sector, based on a systematic literature review. In the study, it was possible to highlight the sustainable solutions proposed to reduce their impacts. The review highlighted the commitment of the sectors analyzed to the SDGs. However, most of these were little mentioned in the notes checked, showing the scarcity of research on the subject.

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It was observed that the studies recognized the importance of contributing to the SDGs. Still, most of them did not indicate the achieved goals related to the SDGs, making it difficult to assess the effectiveness of sustainable practices. It is necessary to adapt better and explain the goals to enable effective comparison of the results of the studies found.

The non-mandatory publication and standardization of sustainability reports make it difficult to compare the sustainable practices developed in each company, as well as the analysis of the SDGs contemplated in the reports.

The use of international models such as the Global Reporting Initiative (GRI) would serve as a reference for the publication of non-financial reports, as observed in the ports of Antwerp (Belgium) and Hamburg (Germany). In this sense, the standardization of reports would contribute to effective transparency with stakeholders and would facilitate benchmarking among companies belonging to the maritime industry and the port sector worldwide.

For future research, it is suggested to carry out surveys based on quantitative data that allow an authentic understanding of how sustainable actions are linked to the SDGs in the environments studied, as well as analyses that explain the commitment of the maritime industry and the port sector to the social parameter, elucidating the impacts produced in local communities and correlating them to the specific SDGs.

In addition, research is important that points out the role of stakeholders as collaborators for the fulfilment of the 2030 Agenda, in the identification of priority SDGs and in the formulation and application of viable sustainable mechanisms in each context studied, these being some of the gaps identified in the study.

In view of the above, SDGs 9, 13 and 14 were highlighted for the analyzed sectors, pointing out gaps identified in the findings, performing critical analyses on them and proposing future research that may cover poorly elucidated themes. Sustainability based on the SDGs must be the central focus of scientific research, as its interdisciplinarity allows it to be understood in different areas of knowledge.

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Referências


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