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Decarbonization technology responsibility to gender equality in the shipping industry: a systematic literature review and new avenues ahead

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Abstract

This study investigates existing literature on decarbonization technology responsibility for sustainable business models in the shipping industry. Specifically, it considers the relationship between responsible innovation from green technology adoption in decarbonization management practices and gender equality to precisely target how decarbonization technology relates to gender mainstreaming, a key element of Sustainable Development Goal 5 in the UN 2030 Agenda. From the institutional theory perspective, this study conducted a systematic review of 114 articles published in the ISI Web of Science and Scopus databases from 1990 to 2022. The results highlight that green technology adoption can support low-carbon practices and gender equality in the shipping industry by contributing to decarbonization technology responsibility, sustainable business models, and responsible innovation. Ultimately, this study suggests that shipping management should provide training and workshops for women on technology adoption in decarbonization operational processes to support gender quality and technological development. It also presents a new conceptual framework and research propositions on significant issues that are currently neglected. The proposed framework may be treated as a decarbonization technology responsibility guideline in shipping management that can reshape the organizational culture to promote gender equality.

Keywords: Responsible innovation, Green technology, Sustainable business models, Decarbonization management practices, Institutional theory, Sustainable Development Goal (SDG) 5

Introduction

Existing literature emphasizes that in the twenty-first century, the world's energy system can address climate change by decarbonizing and reducing carbon dioxide (CO_2) emissions by approximately 50–90% (Loftus et al. 2015). The initial International Maritime Organization (IMO) greenhouse gas (GHG) emissions strategy states that to reduce GHG emissions to approximately 50% and minimize the emission of CO_2 to around 70% by 2050, new green technologies should be introduced. These technologies should be integrated into the entire life cycle of GHG emissions; for example, using Liquefied Natural Gas as a shipping fuel should impact the upstream supply chain and ship bunkering and operations (Balcombe et al. 2019). Hence, the new IMO regulations emphasize that the shipping industry should focus on new and clean technology by implementing decarbonization management practices in the sector (Pomaska and Acciaro 2022). To achieve these goals set by IMO, digital technologies are now attracting increasing attention (Guandalini 2022; Nambisan et al. 2019). The IMO's decarbonization objective has grabbed the attention of shipping companies seeking to design and implement new policies in step with both existing sustainability preferences and their strategic planning (Di Vaio et al. 2021). The shipping industry, the backbone of international trade, is investing more efforts towards sustainability. Green shipping practices are helpful in dealing with cargo working in a sustainable environment, focusing on reducing GHG emissions in shipping activities (Zhou et al. 2023).

In this regard, significant technological changes regarding the responsibilities of decarbonization technology—'decarbonization technology responsibility' (DTR) for short—and decarbonization management practices should be introduced in the sector to restrict CO_2 emissions (Mallouppas and Yfantis 2021). However, the achievement of net-zero emissions in the shipping sector should be considered from the life-cycle perspective, including the shipbuilding industry, which significantly impacts carbon monoxide (CO) and CO_2 emissions during the life cycle of ships (Vakili et al. 2022). In this regard, the shipping sector should adopt decarbonization technologies and related management practices that comply with the current standards of innovation (Pelle and Reber 2015). Likewise, in 2013, some scholars highlighted the need to discuss the relationship between decarbonization technology and education, corporate social responsibility (CSR), public environmental awareness, and government measures (Wong et al. 2013). However, the maritime sector faces economic and technological hurdles regarding adopting voluntary sustainability initiatives (Christodoulou and Cullinane 2021). In this regard, the IMO has suggested that while adopting green technologies may initially involve high costs, it will result in fuel savings in the future, with a payback period between three and ten years. As all external factors help shape organizational activities and generate internal capabilities, social influence always affects organizational actions because organizations are assumed to react promptly to external factors and adopt similar structures, strategies, and procedures (Scott 2005). These external factors force the maritime adoption of new innovative strategies and promote sustainable business models (SBMs) because they are considered complementary foundations for responsible innovation to encourage impactful interventions for business strategies (Calandra et al. 2022).

Existing studies conclude that institutional theory can be used to identify a company's distribution choices. Specifically, this theory can help companies respond to pressures from regulatory authorities by implementing good reporting practices to align with investor desires and the external environment in which they operate (Adams 2013; Lebbadi 2015; Taebi et al. 2014). Notably, the United Nations (UN) 2030 Agenda emphasizes technology's tactical role in improving sustainability. However, scholars have not yet sufficiently considered how the Sustainable Development Goals (SDGs) may be achieved through DTR and related contributions from businesses

(George et al. 2021; Guandalini 2022). Additionally, some scholars suggest that institutional theory encourages gender integration by introducing innovative systems that originate from organizational and managerial changes due to institutional pressure (Di Vaio et al. 2023; Herold et al. 2021; Hew et al. 2020; Kummer et al. 2020). The UN Women Report 2016 states that investments in women's economic empowerment can support both gender equality and national economic growth, as women's economic participation can greatly stabilize national economies. However, women still face insecurity, low-wage jobs, and tough competition in authoritative senior positions. Likewise, the transport sector is also gendered. Particularly, the maritime port and shipping sectors are male-dominated: men hold more technical and skilled positions with higher salaries, while women hold few technical and skilled jobs, such as port operations and cargo handling (Nduna and Sys 2022). Accordingly, women's contributions to meeting climate goals and developing recovery pathways in these sectors are not popularly recognized. Therefore, the visibility of women at all stages of transport policy, planning, implementation, and usage should be encouraged to make transport more responsive to gender equity and national economic development, thus, increasing the sustainability of the sector's development (UN Climate Change Conference UK Report 2021).

Hence, from the institutional theory perspective, this study seeks to analyze the literary corpus on DTR for SBMs in the shipping industry. Specifically, this study explores the relationship between responsible innovation from green technology adoption in decarbonization management practices and gender equality to identify the main drivers of Sustainable Development Goal 5 (SDG 5) in shipping business models. To the best of our knowledge, this is the first study to jointly discuss corporate responsibility for decarbonization technology in the shipping industry and to uncover how responsible innovation plays a key role in the business model to achieve SDG 5. Therefore, to align with the existing literature (Larkin et al. 2017; Psaraftis 2019), the following research questions are designed to fill the gap in the literature:

RQ1: What is the role of green technology in decarbonization management practices in responsible SBMs in the shipping industry?
RQ2: How does responsible innovation from decarbonization management practices meet gender equality goals in the shipping industry?
RQ3: What are the current publication trends regarding DTR and gender equality in SBMs of the shipping industry?

To answer these questions, we conducted a systematic literature review (SLR) by collecting data on 114 articles published from 1990 to 2022. We used two trustworthy databases: the ISI Web of Science (WoS) and Scopus. This study may be a milestone because it is the first to investigate the current literature by developing an SLR on DTR regarding SBMs in the maritime sector and discussing the relationship between responsible innovation using green technologies in decarbonization management practices and gender equality. This study further aims to summarise existing research on how decarbonization technology may contribute to SDG 5, based on the existing gendered inequities in the shipping sector. The suggested agenda may serve as a new shipping management standard by which DTR can be applied to reshape organizational culture to promote gender equality.

The remainder of this study is organized as follows. "Theoretical background" section presents the theoretical background of DTR and gender equality. "Methodology" section explains the methodology of this study. "Data analysis and results" section describes the data analysis and results. "Discussion" section discusses the results, implications, and limitations of this study and directions for further research. Finally, "Conclusion" section briefly discusses the conclusions of this study.

Theoretical background

Many scholars have studied green technology, DTR, responsible innovation, SBMs, decarbonization management practices, decarbonization technology, and gender equality, explaining their relationships with the help of diversified theories and case studies of different organizations in the public and private sectors (Inal et al. 2022; MacNeil and Ghosh 2016; Mallouppas and Yfantis 2021; Wojniak 2017). Meanwhile, this study collectively explores the relationships between these factors under the umbrella of institutional theory. As established above, the maritime sector has historically been male-dominant, and women are never encouraged to take on executive positions. The barriers to women's advancement include lower levels of education, fewer technical skills, household problems (i.e. families and children), and lower wage rates among women compared to men in the same job categories. These barriers can be removed or minimized by modifying existing legal and social norms to promote the participation of women in this sector (MacNeil and Ghosh 2016). While women are part of the workforce worldwide, they earn 24% less than men for the same work. To ensure that men and women have equal rights to education, economic opportunities, productive inputs, and an equal chance to become socially and politically active, policies to facilitate broad productivity gains should be geared to ensure inclusive and green development paths (World Bank 2011).

As the maritime sector intends to normalize digitalization, SBMs, and environmental sustainability, there is a growing need to foster gender equality by facilitating women's participation. The maritime sector must address the gender equality gap by encouraging collective efforts among all stakeholders (Nduna and Sys 2022). Through the UN, the international community has been working to decarbonize all sectors of the global economy. Even if the most carbon-efficient method of transportation is considered, GHG emissions from maritime transport are projected to increase if no action is taken for decarbonization. Thus, the maritime sector is pressured to contribute to the necessary GHG emission cuts. Existing literature explores how adopting technology in the shipping sector in step with institutional theory positively impacts organizational change. In contrast, external factors, such as governments, regulatory bodies, and international influences, also structure organizational practices (Lebbadi 2015).

Green technology, decarbonization management practices, and sustainable business models

Today, green technology is necessary to achieve development goals; in this context, information technology governance gives industries the authority to make decisions for their stakeholders. Information technology also makes industries responsible for defining how best to implement their strategies to ensure effective outcomes (Peterson 2006). Meanwhile, to meet the goals of the IMO and to satisfy the external concerns about maritime transport's environmental impacts, maritime sector organizations must prioritize decarbonization technology (Mallouppas and Yfantis 2021). Decarbonizing the maritime sector is essential to reduce GHG emissions in the future by improving engine efficiency or decreasing vessel hull resistance, slowing steaming within specific limits, and better planning vessel voyages (Herdzik 2021). However, shipping companies working to mitigate climate change to meet the IMO's decarbonization targets, such as desulphurization, do not always agree that regulations that force them to adopt renewable resources are the best way forward, especially given the scarcity of low-sulphur fuels (Zis and Cullinane 2020).

The tier of decarbonization can be described in terms of innovation, institutions, infrastructure, and investment. Every dimension has two different parts: actions for reducing short-term emissions and long-term impacts. Following this detailed procedure and designing decadal goals and inducements can identify important factors for national and international climate policies. Advanced business models are necessary to follow these policies, achieve green technology goals based on decarbonization, and realize sustainable development (Rockstrom et al. 2017). From a broader perspective, DTR in SBMs in the shipping industry should consider the industry's links with the shipbuilding industry. It should involve a trans-disciplinary approach beyond energy efficiency (Vakili et al. 2022). Decarbonization technology in management processes is linked to how advancements in ship technology can help to mitigate climate change and digitize handling operations at the ship–port interface (Del Giudice et al. 2022). Over the last decade, several studies have been done on SBMs, considered key drivers of sustainability in organizations. Notably, the sustainable business model extends existing understandings of CSR by incorporating environmental performance into the concept of business value. In terms of the three dimensions of sustainability, a sustainable business model can be defined as 'A business model for sustainability [that] helps describe, analyze, manage, and communicate (1) a company's sustainable value proposition to its customers, and all other stakeholders, (2) how it creates and delivers this value, (3) and how it captures economic value while maintaining or regenerating natural, social, and economic capital beyond its organizational boundaries' (Schaltegger et al. 2016). SBMs may be categorized as a subcategory of normative business models by situating them as a set of norms rooted in business models in step with an institutionalization procedure. Sustainability can be viewed as a set of values that can resolve many social issues (Randles and Laasch 2016).

Responsible innovation, decarbonization management practices, and gender equality under the lens of institutional theory

Responsible innovation supports institutional theory and emphasizes how organizations uphold their own values and policies in their technical development (Taebi et al. 2014). Furthermore, several studies have concluded that responsible innovation is related to the effects of CSR and the external forces that influence a company's decision-making processes. For example, a company may act out against market and regulatory pressures (Herold et al. 2021; Neumeier 2017). Today, the globalization and shipping sector has promoted world trade by helping nations towards sustainable growth and providing them with the best job opportunities to improve their living standards. Specifically, for sustainable development, the sector highly stresses the involvement of digitalization and decarbonization management practices to reduce social and political pressures regarding CO_2 emissions (Agarwala et al. 2021). Decarbonization is a process of adopting such management practices that are helpful to reduce GHG emissions by placing any sector to limit its global temperature (EERE 2023).

In his 2019 Methanol fuel from CO_2 ($MeFCO_2$) Project, Sanchez introduced the concept of 'Ds' based on five fundamental pillars to cope with this dilemma. The process comprises the following stages: the most important to shift from an existing system to a low-carbon system is the switch in focus to alternative fuels, renewable energy resources, and energy storage devices. Users can be authorized to use data and analytics and operate as power-generating systems. While it will be difficult to achieve a low-carbon system, digitization can support the development of such an energy system. Gender equality is also essential in efficiently shifting from an existing system to a low-carbon economy. The cheerful addition of women to the shipping sector will lead to greater diversity and expand the endowment's puddle to address this issue (Cazzola 2018).

Science and technology enable us to understand natural phenomena and control processes occurring in the world. Therefore, it is important to focus on existing and upcoming technological innovations as well as the perspectives of scientists behind such developments (Wojniak 2017). Gender equality is one of the most important drivers of responsible innovation. Accordingly, to ensure that technological developments meet the needs and expectations of modern society, we have to prioritize solutions to gendered imbalances. As suggested above, gender inequality can be observed today in gendered leadership and authoritative position disparities. A key step in ensuring gender equality in research institutions is creating a non-discriminatory workplace environment that ensures equity across different positions, especially positions of authority (Wojniak 2017).

Decarbonization technology responsibility and gender equality for sustainable business models in the shipping industry

The UN and affiliated agencies emphasize the need to empower women, who play a vital role in the national economy. In response, the World Maritime University (WMU), founded by the IMO, designed specific policies to encourage women to contribute to the shipping industry (Lares 2017). As noted above, while the world is moving towards the DTR, women are rarely positioned as technology experts in maritime shipping and port labour (Nduna et al. 2021). Nduna and Sys (2022) highlighted that the social pillar is a key enabling factor for smart ports. Business models for improving human capital wealth in the maritime labour force must be more inclusive. An analysis conducted by the same scholars showed that little progress had been made in terms of gender in both shipping and ports and, moreover, that women currently play a more significant role in ports than in shipping. A study by Nduna and Sys (2022) on a sample of ports suggested that the female workforce is predominantly employed in specific functional roles, such as management, administrative, and corporate positions, while women are still underrepresented in cargo handling and other kinds of operations (technical, marine, and engineering). Their analysis also highlights that female labour is concentrated in families with executive and management jobs. Therefore, the process of decarbonization still seems to be disconnected from the social dimension of sustainability. Specifically, from several perspectives, women are not often involved in emerging technologies; this gendered gap limits society (Di Vaio et al. 2023; Thylin and Duarte 2019). Although the maritime sector is working toward gender equity, gendered imbalances continue to characterize the maritime workforce. Meanwhile, the sector is increasingly concerned about adopting next-generation technologies; however, its information technology fields remain male-dominated. From this perspective, materialistic actions and decisions are essential (Nduna and Sys 2022).

The shipping industry needs to address all the environmental and social issues. Adopting digitalization and green technologies helps the shipping sector minimize its emission level but only with effective business models (Bohnsack et al. 2014). Moreover, digitalization and decarbonization technologies can be used to incorporate SBMs to create long term value for the shipping sector (Foss and Saebi 2018; Del Giudice et al. 2022). SBMs aim to explore the businesses' positive and negative social impacts. In this regard, gender balance and equity in workplaces is important to consider. The participation of women in administrative as well as regulatory actions can assist the shipping sector toward the successful implementation of designed SBMs (Gartzia 2021). Furthermore, for sustainable economic growth, the participation of women in technology can also help reduce GHG emissions (ILO 2019).

The shipping sector has to integrate DTR and a sustainable business model to realize its low-carbon goals. However, some barriers, including the absence of efficient policies, the governing framework, little market encouragement, lengthy investment prospects, conferred interests of ship owners and operators, technical uncertainty, complications in solutions, lack of R&D investment, hidden costs, and limited access to capital, make this relationship more complex. On June 8, 2022, the United Nations Conference on Trade and Development (UNCTAD) Transport and Trade Facilitation Newsletter stated that the maritime industry is facing severe environmental pressures, composed of numerous value chains that require the efforts of all stakeholders. These value chains are deeply caught up in decarbonization because they include the marine fuel, shipbuilding, and maritime operations value chains.

The report further states that green technology is necessary to achieve decarbonization targets and to run the shipping industry effectively while meeting low-carbon targets. This process of adopting green technology is necessary for SBMs. The important factor across the three value chains is the provision of alternate fuel at a market-friendly price. As its output, this action can determine shipbuilding, including design, engine quality, and operations. Green power-to-X technologies are preferred to support decarbonization, which refers to technologies used to produce green fuel and operation control by utilizing collaborative platforms for energy-efficient maritime operations (Fig. 1).

Methodology

This study was conducted using an SLR. This methodology allows us to systematize previous studies on the issues introduced in this study and identify the linkages between different approaches scholars adopt on DTR and gender equality in the shipping industry.

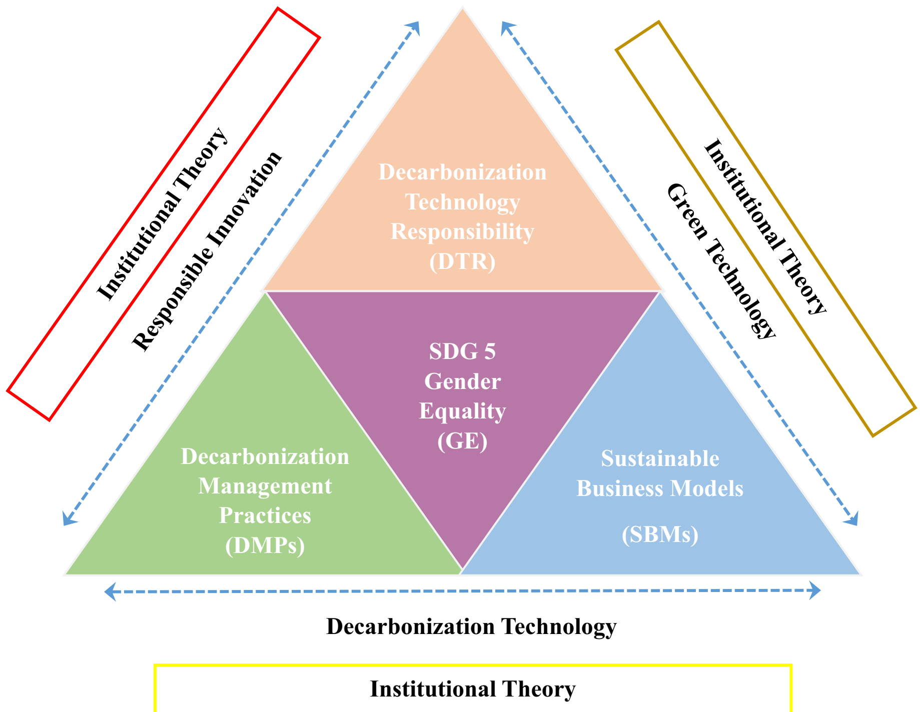

Fig. 1 Theoretical framework on DTR for gender equality through decarbonization management practices and SBMs

The literature review opens up future research possibilities by identifying emerging trends and exploring intellectual domains in the research field (Lim et al. 2022). However, the issues introduced in this study are still under investigation. The SLR allowed us to find the main answers to the three research questions and refine other areas for future research on the issues discussed in this study (Arrigo et al. 2022).

Adopting SLR as a methodology summarises the specific areas in which research is still required (Snyder 2019). This SLR is based on the methodology designed by Tranfield et al. (2003), and is composed of a three-step framework comprising data collection, analysis, and reporting. Based on standard procedures, the selection process of articles depended on the reliable databases of Scopus (launched by Elsevier in 2004) and WoS (invented by Eugene Garfield and his Institute for Scientific Information), covering the timeframe from 1990 to 2022. These databases include references, abstracts, and summaries (Fink 2010; Randhawa et al. 2016) as well as the h-index of the documents to ensure the quality of books and journals (Hirsch 2005). Both databases are regularly maintained and are considered credible sources of efficient academic knowledge worldwide. The most well-known journals that publish on decarbonization, gender equality, and shipping include *Sustainability, Energy, Environment & Sustainability, Journal of Marine Science & Engineering, International Journal of Transport Economics, Journal of Cleaner Production, Ocean and Coastal Management, Transactions on Maritime Science, Australian Journal of Maritime & Ocean Affairs, Maritime Transport and Regional Sustainability, Maritime Policy and Management.* The authors performed content analysis to remove duplicate research articles on the same topic. Figure 2, the PRISMA flow

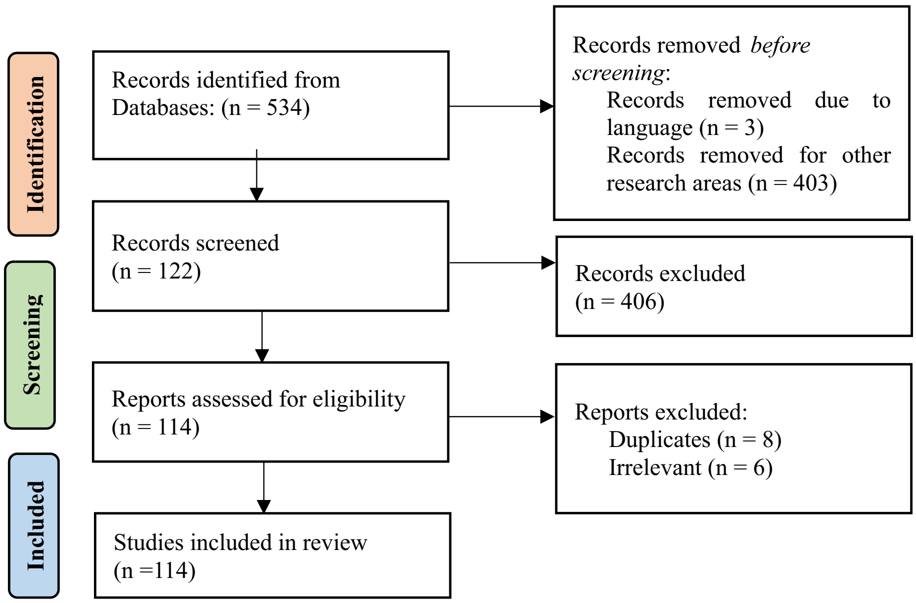

Fig. 2 Research design and methodology

chart, depicts the approach used for data collection and represents the reporting of all the phases of SLR regarding the information on relevant data identification, screening, and inclusion (Page et al. 2021).

In the first phase, two reliable databases, Scopus and WoS, were used to capture the main research developments in the desired field. A combination of specific keywords was used in the multiple searches. These keywords included decarbonizing, shipping, sustainable business models, green technology, institutional theory, responsible innovation, gender, gender equality, GE, sustainability, decarbonization, sustainable business model, green innovation, female, gender, and maritime. The search was explicitly based on the title, abstract, or keywords. Only articles, book chapters, conference proceedings, and reviews were selected for the analysis with these words in their titles, abstracts, or keywords. The five search strings were designed for Scopus, as well as for WoS, based on keywords to grab the related data:

Category 1: Decarboni* AND Shipping AND Sustainable AND Business AND Model*
Category 2: Decarboni* AND Green Technology AND Shipping
Category 3: Decarboni* AND Institutional Theory AND Sustainability
Category 4: Gender AND Decarbo*
Category 5: Decarboni* AND Responsible Innovation

A total of 534 articles were retrieved, of which 419 were from Scopus and 115 from WoS. In the second stage, the authors read the retrieved documents' abstracts to ensure the research papers' accuracy. In the third step of the screening, 412 articles were excluded because they were irrelevant and not in English. After removing duplicates, a total of 114 articles remained, which were all included in our analysis. A summary of the selected articles is provided in Additional file 1: Appendix A.

Data analysis and results

This section summarises the results of our study after a comprehensive review of 114 research articles related to DTR for SBMs. These studies discuss the relationship between the adoption of responsible innovation from green technology in decarbonization management practices and gender equality. In detail, this study focuses on works related to how decarbonization technology relates to gender mainstreaming and, thus, SDG 5. In response to RQ1: What is the role of green technology in decarbonization management practices in responsible SBMs in the shipping industry? This study found that SBMs are the key factor in the shipping industry's shift from its existing system to a system based on green technology and decarbonization management practices; however, the study also revealed that the sector's decarbonization and its ability to meet carbon emission goals require the implementation of laws and practices (Christodoulou et al. 2021; Inal et al. 2022; Reuter 2022; Sachs et al. 2019). Digital transformation explores the path for successful strategy building, planning and implementation of business models. Moreover, green and digital technologies are essential for the shipping sector to run their functions according to responsible management practices (Del Giudice et al. 2022). In this regard, with the help of institutional theory, the emergence of SBMs is reliable to bring innovation in the sector and embed the economic, social and environmental issues to create long-term value even for stakeholders (Evans et al. 2017). Notably, internal and external factors influence the shipping sector, and geographical locations impact sustainability. Specifically, digitalization and new technologies are essential for maintaining SBMs to achieve the SDGs. In this regard, the sector is actively promoting green technology and responsible innovation adoption—today and in the future, its growth depends on technological infrastructure (Del Giudice et al. 2022).

Concerning our RQ2: How does responsible innovation from decarbonization management practices meet gender equality goals in the shipping industry? The results highlighted that responsible innovation proposes providing the best possible solutions for implementing emerging decarbonization technologies (Brezet and Silvester 2004). Institutional innovation promotes gender equality by fostering social values (Inhetveen 1999). Several studies have highlighted the issue of gender imbalances in the maritime sector. They also emphasized that while women increasingly join the workforce, they are still greatly underrepresented in this sector (Kim et al. 2019; Kitada et al. 2019; Ku et al. 2017). Inadequate attention has been given to the social aspect of gender equality, despite the fact that it is vital for sustainability (Barreiro-Gen et al. 2021). Because women remain underrepresented in shipping, there is room for further investigation. Many benefits are associated with women's empowerment in this sector, such as improved performance and career development (Nduna and Sys 2022). Institutional theory is necessary to jump from the existing system to a low-carbon system, and it is only possible in the maritime industry when green technology is adopted in decarbonization management practices with the equal participation of women (MacNeil and Ghosh 2016; Thylin and Duarte 2019; Wojniak 2017).

In response to RQ3: What are the current publication trends regarding DTR and gender equality in SBMs of the shipping industry? Our SLR covers the period from 1990 to the present. Still, it is noticed in the dataset that the research started in this area from 1999 by focusing institutional innovation on promoting gender equality. Later on, from

2000 to 2005, the publication percentage was about 1% regarding women in technology to improve climate change policy. Then this research area was again pushed back and less focused, but in the year 2016, an increase can be seen in the publication trend by exploring the areas of low carbon future for shipping, renewable energy, gender imbalance in the maritime industry, shipping in changing climates, decarbonization of international shipping industry, sustainable shipping, business model innovation for sustainability, responsible research and innovation. These topics were highlighted after UN 2030 Agenda and Paris Agreement. Still, the literature lacks evidence related to DTR for SBMs, specifically responsible innovation for green technology adoption to promote gender equality under the umbrella of institutional theory. The gender imbalance can adversely affect the implementation of successful SBMs towards GHG emissions (ILO 2019). Our results revealed that existing literature had not used institutional theory to touch on the relationships between these factors in the maritime sector; therefore, the implementation of internal and external forces is necessary to remove these barriers to decarbonization management practices while adopting green technology to promote gender equality (UN Climate Change Conference UK 2021; Wojniak 2017).

Discussion

The UN 2030 Agenda covers the environmental, economic, and social aspects under high consideration for the sustainable shipping industry (Zhou et al. 2023). The decarbonization practices adopted by the shipping sector are the priority of this industry. In this regard, the results of our study explored that the decarbonization of the maritime sector is possible only by shifting it towards green and decarbonization technology (Roussanoglou 2023).

The UN introduced three tools under Kyoto Protocol to meet the requirements of GHG emissions that are also cost-effective: (1) emission trading—which will be helpful to achieve environmental objectives with the allocation of emission allowances; (2) joint implementation—this will help the sector to join with other parties to earn emission reduction; (3) clean development mechanism—in which GHG emission reduction projects are considered to be started in developing countries (ESCAP 2021). Carbon capture can also be used as one of the best technology that can help to neutralize the global impacts of climate change. The advancement in carbon capture technologies is actively continuing, focusing on modifying the present onboard shipping systems (Roussanoglou 2023).

Notably, the shipping sector reacts very slowly to technological innovations. Instead of taking prompt action, it uses a wait-and-see approach and tries to make better decisions based on the experience of organizations that have already adopted technological innovations (Wu et al. 2022). As the maritime sector causes about 940M tons of CO_2 yearly, strict technical measures are required to accomplish the vision of the decarbonization shipping sector as soon as possible. To decarbonize the shipping sector, institutional policies greatly impact the sector's technology adoption and related measures (ESCAP 2021). The IMO has a vision to minimize the global shipping GHG emissions by at least 40% by 2030 and 70% by 2050. This objective alerts the shipping sector to actively involve themselves in GHG emissions reduction measures (Helmi 2023). For this purpose, IMO, European Union and the national levels highly recommend the evaluation and implementation of policies and regulations (Dong et al. 2022).

At the same time, some studies discuss gender imbalances in the sector. However, the current study highlighted that no attention has yet been given to how the maritime sector may promote gender equality under the lens of institutional theory while adopting decarbonization technology. Institutional theory primarily focuses on procedures that emphasize specific social structures accepted by society and suggests social behaviours that may help organizations better operate in the market (Acciaro 2013). Thus, in this modern era, the research focus is shifting to how to give women opportunities to participate in different management processes, such as advanced technological skills, responsible innovation, and SBMs. New decarbonization technologies can support women's participation in the sector by operating a fair system (Di Vaio et al. 2023). In this regard, IMO is also making efforts to support women's representation by enhancing their contributions as stakeholders and introducing technical training and skills for women. Green technology and decarbonization technology adoption and implementation in the shipping sector are essential for the sector's operations and SBMs. Therefore, there is a dire need for institutional theory to analyze and investigate responsible innovation adoption and its implementation in organizational culture; institutional theory pressures the sector to practice responsible innovation by creating demand for green and decarbonizing technologies. This shift emphasizes the need to implement rules and regulations in organizational culture and information systems (Lebbadi 2015).

The World Bank Group states that women in the transport sector face problems getting jobs and climbing the ladder in this sector because it is a male-dominated sector. Along these lines, men hold most of the high-level positions in the sector, causing a wide wage gap between both genders. Moreover, the literature elaborates that opportunities for women in the sector are limited due to women having relatively poor access to information, lower levels of education, less technical skills, and some financial issues (Namukombo 2016). The Women's International Shipping and Trading Association (WISTA) is an international networking organization aimed at supporting women at the managerial level in the maritime, trading, and logistics sectors. The WISTA was granted a consultative status with the IMO in 2018. The WISTA's work supports economic growth by giving women opportunities to participate in the economy. However, further support is still required to facilitate gender equality in the maritime sector. Because this is the first study to broadly address these issues using institutional theory in the modern era, there is still room for more research to be done on green technology and decarbonization technology adoption in different contexts and diversified business scopes.

Academic implications

By reviewing current literature, the study sheds light on the existing gap by linking DTR, SBMs, and gender equality together on a single platform. The relationship between DTR, SBMs, green technology, and decarbonization technology adoption regarding gender equality is relatively underexplored, especially in developing countries. This study's insights provide suggestions for how to adopt advanced green technology and decarbonization technology in the interest of gender equality and SBMs to improve the long-term value of the shipping industry. The current study acts as a helping tool for scholars to focus on this serious issue by incorporating stakeholder theory and/or resource-based theory. There is great stress from legal and regulatory bodies on shipping industry regarding their environmental and social impacts. The institutional approach helps the shipping industry to design its strategies and to plan its business activities compatible with institutional pressures to get better achievements. Moreover, the study helps future scholars to stress the participation of women in this sector as women are not highly encouraged to participate in the shipping sector due to the assumption that they are technically less skilled than men. Therefore, to better understand the issue represented in our findings, the current study may be treated as an initial step in developing best practices for implementing green and decarbonization technologies to promote gender equality. Moreover, the focus should also be on promoting gender equality to support SBMs in the sector in response to external and internal factors.

Managerial implications

The proposed framework may be used to develop management guidelines for the responsible adoption of new decarbonization technology in ways that reshape organizational culture to promote gender equality. Furthermore, using artificial intelligence as a digital technology and business strategy can help executives adopt these new technologies with greater awareness of the opportunities, challenges, and benefits that artificial intelligence may bring to their shipping organizations. Moreover, managers should incorporate such policies to support their use of green and decarbonization technologies in the interest of gender equality. They also should ensure that the DTR implements and maintains SBMs in the shipping sector. Last, management should introduce training and workshops for women to promote gender equality while facilitating green technology adoption in decarbonization management practices.

Policy recommendations

Policymakers and higher authorities should promote gender equality by adopting new decarbonization technology and responsible innovation and provide females with equal opportunities by minimizing the barriers they face in the shipping sector. As suggested above, training and workshops should be a part of the industry to improve gender equality. Moreover, women should be equally represented in executive positions in the maritime sector.

Limitations of the study

This study has several limitations. First, both databases—Scopus and WoS—are updated daily, which causes fluctuations in the amount of data collected. Second, the accuracy of the data retrieved on each day is questionable. Third, the research areas were specified while retrieving the data from the databases. Finally, the search strings were based on the literature of our study; therefore, there is a possibility that other keywords may appear in future research.

Avenues for future research and recommendations

This study provides recommendations and suggestions to other authors, journal editors, and reviewers on green technology and decarbonization technology adoption for gender equality in the shipping sector and the implementation of DTR in SBMs through new digital technology. Based on the current SLR, this field was found underexplored. Therefore, the results of this study can be treated as an initial step for further research in this area. Hence, in Fig. 3, the main constructs are identified by clearly stating the propositions in the existing literature on SLR (Snyder 2019).

Shipping is an essential tool for promoting the global economy but on the same side, this sector is causing high GHG emissions, which are expected to increase by up to 50% by 2050 (Monios 2022). Therefore, the institutions regularize the sector by introducing them to novel decarbonization practices concepts with green technology adoption (Moshiul et al. 2023). The following proposition is developed based on the previous studies reviewed in SLR on green technology for decarbonization management practices in responsible SBMs. As for future research, it is essential to ensure the implementation of policies and strategies related to adopting green and decarbonization technology.

Proposition P1 *The link between green technology and decarbonization technology adoption for decarbonization management practices can be facilitated by implementing policies.*

Additionally, scholars have shed light on this issue in suggesting that SBMs play a vital role in the maritime sector's adoption of green technology to incorporate decarbonization management practices by ensuring the implementation of rules and regulations in responsible SBMs (Christodoulou et al. 2021; Sachs et al. 2019). Adopting new technologies in ports can increase the efficiency of management practices (Del Giudice et al. 2022). Moreover, Del Giudice et al. (2022) stressed that new digital technologies allow the sector to reduce GHG emissions by encouraging change in existing business models. Based on this, the following proposition is proposed:

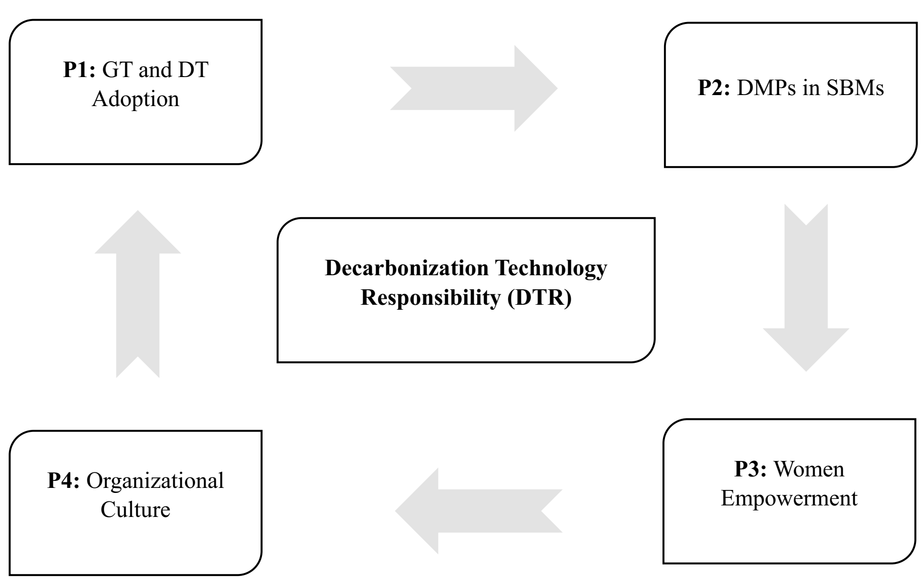

Fig. 3 A conceptual framework of DTR for green technology adoption in SBMs to promote gender equality in shipping sector

Proposition P2 *The link between decarbonization management practices in responsible SBMs is moderated by green technology and decarbonization technology adoption by implementing policies.*

Based on the existing literature targeting gender equality for decarbonization management practices in the shipping sector, the following proposition was developed. There are many barriers to gender equality in the maritime sector, especially in developing countries. Even though gender equality is always a common topic of discussion, it still faces consensus (Kobayashi and Eweje 2021). To align with the needs of stakeholders and pressures from institutional regulations, the shipping sector is trying to identify new entry points for women to explore the gender-climate nexus (Franziska et al. 2023).

Proposition P3 *Women should be empowered to enjoy equal job opportunities in the shipping sector.*

The following proposition was developed based on the existing literature on institutional theory in the shipping sector. Existing literature explores the fact that institutional theory can be a helpful tool for investigating the barriers faced by the shipping sector by incorporating special initiatives to respond to institutional pressures (Kobayashi and Eweje 2021). Gender gaps are always considered barriers to effectively mitigating GHG emissions. The policies and the strategies regarding women's involvement in the sector should be encompassed as allowed and suggested by regulatory bodies to participate in low-carbon transitions effectively (Franziska et al. 2023).

Proposition P4 *Organizational culture should be maintained and flexible towards institutional theory to promote gender equality.*

In future research, this study can be helpful to survey-based research to explore these propositions. Further research can apply other theoretical models on different sectors with specified digital technologies to meet SDG 5; it can investigate it in more depth with the help of empirical analysis. Furthermore, on a theoretical basis, other theories, i.e. stakeholder theory and/or resource-based theory, can be used to investigate the factor that may influence digital technology adoption and decarbonization management practices in SBMs.

Conclusion

This study found that adopting green technology is essential to reduce GHG emissions in the shipping sector. Specifically, this study found that existing literature explores six main strategies in the maritime sector: CO_2 reduction, cost optimization, adoption of renewable energy resources, smart technology adoption, the regulatory landscape of greening seaports, and the adoption of the most suitable guidelines for green seaports (Alzahrani et al. 2021). This study further highlights that adopting green technology can be crucial to gender equality in the shipping sector. This study reveals that the sector should support women in attaining authoritative positions to avoid gender-based risks. To meet decarbonization goals, the shipping sector should encourage women to participate in digitalization. In this regard, the IMO is also promoting gender equality by offering training and workshops to enable women to enhance their representation in the sector so that they can take on administrative positions. In 2019, the IMO Assembly approved a resolution to achieve gender equality and ensure a barrier-free environment for women in the coming years throughout the maritime sector.

Meanwhile, the WISTA, an international networking organization, supports the IMO's Strategic Plan to promote gender equality and empower women. Ultimately, women should be provided with a peaceful work environment where they do not face the risk of gender violence and harassment. In sum, this study explores how the male-dominated shipping sector may introduce and maintain SBMs to meet SDG 5 of the UN 2030 Agenda specifically by implementing DTR.

Abbreviations

CO	Carbon monoxide
CO2	Carbon dioxide
CSR	Corporate social responsibility
DTR	Decarbonization technology responsibility
GHG	Greenhouse gas
IMO	International Maritime Organization
MeFCO2	Methanol fuel from CO_2
SBMs	Sustainable business models
SDG 5	Sustainable development goal 5
SDGs	Sustainable development goals
SLR	Systematic literature review
UN	United Nation
UNCTAD	United Nations Conference on Trade and Development
WISTA	Women's International Shipping and Trading Association
WMU	World Maritime University
WoS	ISI Web of Science

Supplementary Information

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Additional file 1. Appendix – I. Supplementary Table.

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Author contributions

ADV conceptualized the study, developed methodology, supervised the study, acquired funding, wrote—original draft, and wrote—reviewed and edited the study. AZ handled the data collection, developed methodology and results, wrote—original draft, and wrote—reviewed and edited the study. DB-L validated the results and discussion, wrote-reviewed and edited the study. AG investigated new conceptual framework and wrote-reviewed and edited the study. All authors read and approved the final manuscript.

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Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Competing interests

The authors declare that they have no competing interests.

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