Key ESG factors driving global sustainability in the shipping industry

Neolini Diamantara

University of the Aegean, Department of Shipping, Trade and Transport, Leros, Greece

E-mail: *neolini20@gmail.com

ABSTRACT

Environmental, Social, and Governance (ESG) criteria have become a central mechanism for assessing corporate sustainability, while the United Nations Sustainable Development Goals (SDGs) provide a universal framework for addressing global challenges. Aligning these two frameworks is essential for shipping companies, as unclear prioritization of ESG criteria may lead to ineffective allocation of resources or missed opportunities to generate meaningful sustainability outcomes. This study aims to identify which ESG criteria—and their associated practices—within the commercial shipping sector contribute most significantly to global sustainability by mapping their alignment with relevant SDGs. This qualitative research employs document analysis, drawing from peer-reviewed scientific literature retrieved through Google Scholar and Scopus, as well as professional and industry sources produced by maritime practitioners across ship design, operations, management, crewing, training, classification, finance, and insurance. The documents analyzed include technical standards, guidelines, regulations, policies, reports, and commentary on industry trends. The findings highlight the ESG practices with the strongest contribution to sustainability, offering shipping companies clearer direction for prioritizing actions that deliver the highest global impact.

Keywords: *ESG, SDGs, shipping industry, sustainability, maritime practices.*

ABSTRAK

Kriteria Environmental, Social, and Governance (ESG) kini menjadi acuan utama dalam menilai keberlanjutan perusahaan, sementara Sustainable Development Goals (SDGs) dari Perserikatan Bangsa-Bangsa berfungsi sebagai kerangka global untuk menghadapi berbagai tantangan dunia. Bagi perusahaan pelayaran, menyelaraskan kedua kerangka ini sangat penting. Tanpa penetapan prioritas ESG yang jelas, penggunaan sumber daya dapat menjadi tidak efektif dan peluang untuk menghasilkan dampak keberlanjutan yang berarti bisa terlewatkan. Penelitian ini bertujuan mengidentifikasi kriteria ESG—beserta praktik yang terkait—di sektor pelayaran niaga yang memberikan kontribusi terbesar terhadap keberlanjutan global, dengan memetakan keterkaitannya pada SDGs yang relevan. Penelitian kualitatif ini menggunakan analisis dokumen, mencakup literatur ilmiah terindeks serta sumber profesional dari para pelaku industri maritim, termasuk bidang desain kapal, operasi, manajemen, kepelautan, pelatihan, klasifikasi, keuangan, dan asuransi. Dokumen yang dikaji meliputi standar teknis, pedoman, regulasi, kebijakan, laporan, dan ulasan tren industri. Hasil penelitian menunjukkan praktik ESG yang paling kuat kontribusinya terhadap keberlanjutan, sehingga memberikan arah yang lebih jelas bagi perusahaan pelayaran untuk memprioritaskan tindakan yang memberi dampak global terbesar.

Kata Kunci: *ESG, SDGs, industri pelayaran, keberlanjutan, praktik maritim.*

INTRODUCTION

The concept of sustainable development has undergone significant evolution over the past five decades, particularly as societies recognized that economic progress based solely on industrial expansion may jeopardize environmental integrity and social well-being. This paradigm shift began with the 1972 United Nations Conference on the Human Environment in Stockholm, which established the United Nations Environment Programme (UNEP) and marked the first global consensus on the urgency of addressing environmental degradation [1]. A further milestone emerged in 1987 with the publication of *Our Common Future* (Brundtland Report), which defined sustainable development as "meeting the needs of the present without compromising the ability of future generations to meet their own needs" [2]. The report emphasized the interdependence of environmental conservation, economic resilience, and social inclusion, forming the foundation of modern sustainability discourse.

To provide a coordinated global framework, the United Nations launched the Sustainable Development Goals (SDGs) in 2015. This agenda comprises 17 goals and 169 targets designed to address poverty, inequality, environmental degradation, climate change, and institutional weakness, with a universal implementation timeline extending to 2030 [3]. The complete set of SDGs is illustrated in Figure 1, which highlights the multidimensional scope of sustainability efforts worldwide.

Figure 1. The 17 Sustainable Development Goals (SDGs) by the United Nations.
(Source: United Nations)

Although national governments maintain primary responsibility for implementing the SDGs, the role of private-sector actors has grown increasingly prominent. Well-known economic theorists have debated the extent of corporate responsibility: Friedman argued that a firm's sole obligation is to maximize shareholder profits [4], while Sen contended that corporations also carry ethical and social duties to advance human welfare [5]. The contemporary consensus leans strongly toward Sen's view, aligning with the emerging model of Corporate Social Responsibility (CSR) and, more recently, Environmental, Social, and

Governance (ESG) frameworks.

The shipping industry is strategically positioned within global sustainability efforts. As a sector responsible for approximately 2.7% of global CO_2 emissions, generating nearly one billion tons of greenhouse gases annually [6], maritime transport significantly influences SDG 13 (Climate Action). Simultaneously, with 59% of food cargo transported by sea, the sector indirectly supports SDG 2 (Zero Hunger) and SDG 1 (No Poverty) by ensuring global supply chain stability [7]. However, the industry also contributes to ocean pollution, biodiversity loss, and safety challenges, reinforcing its shared responsibility in advancing SDG 14 (Life Below Water) and SDG 12 (Responsible Consumption and Production).

To measure and enhance corporate sustainability performance, shipping companies increasingly adopt ESG indicators, covering emissions, fuel efficiency, waste management, crew welfare, safety standards, anti-corruption mechanisms, and governance transparency. The regulatory pressure has intensified with the introduction of the Corporate Sustainability Reporting Directive (CSRD) in the European Union, which mandates ESG reporting for thousands of companies, including major maritime operators [8].

However, despite their common sustainability orientation, ESG indicators and SDG targets are not naturally aligned. SDG indicators were originally designed for national monitoring rather than corporate evaluation, making them insufficiently tailored to business operations. Consequently, shipping companies often lack clarity on:
a) which ESG criteria most effectively contribute to the SDGs,
b) which sustainability practices deliver the greatest global impact, and
c) how to prioritize operational strategies accordingly.

To address this gap, recent research has attempted to identify SDGs considered most critical by experts, students, and general populations. A synthesis of five studies revealed that SDGs 2, 13, 6, 3, 4, and 1 consistently rank as the highest global priorities. These findings are summarized in Table 1, which integrates cross-study data to form a consolidated prioritization framework.

Table 1. The six most important SDGs based on synthesis of five independent studies.

Rank	SDG	Description
1	SDG 2	Zero Hunger
2	SDG 13	Climate Action
3	SDG 6	Clean Water and Sanitation
4	SDG 3	Good Health and Well-being
5	SDG 4	Quality Education
6	SDG 1	No Poverty

In the context of maritime sustainability, these SDGs provide a strategic lens to evaluate ESG practices. For example, environmental criteria such as emissions reduction are strongly aligned with SDG 13, while social criteria such as crew welfare contribute to SDGs 3 and 4. Governance criteria such as anti-corruption measures support SDG 16, which underpins institutional integrity.

Given the shipping industry's environmental footprint, global supply-chain role, and regulatory exposure, identifying high-impact ESG criteria and mapping them to SDG targets is essential. This research therefore aims to:

1. Identify the ESG criteria most relevant to commercial shipping.
2. Map their alignment with SDG targets using a structured scoring methodology.
3. Determine which ESG-linked maritime practices contribute most significantly to global sustainability.

By constructing an ESG–SDG alignment matrix specific to the maritime sector, this study offers shipping companies a practical framework to prioritize sustainability actions with the highest potential for global impact.

LITERATURE REVIEW

Evolution of Sustainability and the Global SDG Framework

The discourse on sustainability has progressed through several historical phases, beginning with the environmental awakening of the early 1970s. The 1972 Stockholm Conference marked the first coordinated global recognition that economic growth must be reconciled with environmental protection, resulting in the establishment of the United Nations Environment Programme (UNEP) as a global authority for environmental governance [9]. The 1987 Brundtland Report further shaped sustainability thinking by proposing an integrated model of development that balances environmental integrity, economic progress, and social equity [10]. This three-pillar model—now embedded within most global sustainability frameworks—was later reflected in multiple international environmental agreements, including the Kyoto Protocol (1997) and the Paris Agreement (2015), both designed to mitigate climate change [11].

In 2015, the United Nations introduced the Sustainable Development Goals (SDGs) as a universal and holistic framework comprising 17 goals and 169 targets, designed to guide global sustainability efforts across environmental, social, and economic domains [12]. Unlike the Millennium Development Goals (MDGs), which focused mainly on developing countries, the SDGs require active participation from all nations and industries. Importantly, they call for partnerships among governments, private-sector actors, and civil society, emphasizing collective responsibility.

Table 2. The three pillars of sustainability and their connection to SDGs.

Pillar	SDGs
Environmental	6, 7, 12, 13, 14, 15
Social	1, 2, 3, 4, 5, 8, 10, 11, 16
Economic & Governance	8, 9, 16, 17

This multidimensional integration demonstrates that sustainability extends beyond environmental protection to encompass inclusive social development, economic productivity, and strong governance institutions.

The ESG Framework and Its Integration into Corporate Sustainability

While SDGs operate as global policy objectives, industries and corporations require a more operational tool to measure their sustainability performance. The Environmental, Social, and Governance (ESG) framework emerged to fill this gap and is now widely adopted by companies, investors, and regulators. ESG serves as a standardized mechanism for assessing a company's environmental impact, social responsibility, and governance quality.

Environmental Dimension

Environmental ESG metrics typically include:

- greenhouse gas (GHG) emissions (Scope 1–3),
- energy and fuel consumption,
- renewable energy adoption,
- waste management and circularity practices,
- water usage and discharge quality,
- biodiversity and ecosystem protection.

These indicators are particularly relevant to industries with high energy demands and pollution footprints, such as shipping.

Social Dimension

Social indicators reflect how companies interact with their workforce and communities, covering topics such as:

- occupational safety,
- crew welfare and mental health (critical in maritime operations),
- gender equality and diversity,
- human rights,
- labor conditions and fair compensation,
- access to education and upskilling.

Governance Dimension

Governance indicators assess leadership integrity and ethical corporate behavior, including:

- board composition and independence,
- transparency in decision-making,
- anti-corruption and anti-bribery mechanisms,
- compliance with international regulations,
- accountability structures.

Global standards supporting ESG performance include:

- the Global Reporting Initiative (GRI),
- the Sustainability Accounting Standards Board (SASB),
- the Task Force on Climate-Related Financial Disclosures (TCFD),
- and the EU's Corporate Sustainability Reporting Directive (CSRD) [13].

The CSRD is particularly transformative for the maritime sector, mandating ESG disclosure from 2024 onward and requiring companies to align operations with the EU Taxonomy for climate mitigation [14].

ESG Practices and Challenges in the Global Shipping Industry
Environmental Pressures in Maritime Transport

Shipping is responsible for nearly 3% of global CO_2 emissions, equal to the emissions of major industrialized nations [16]. Environmental challenges include:

- GHG emissions from bunker fuel combustion,
- sulfur and nitrogen oxide emissions (SOx, NOx),

- ballast water pollution and bioinvasion,
- marine litter and waste discharges,
- oil spills and chemical leaks,
- underwater noise pollution affecting marine life.

Social Challenges and Crew Welfare

The COVID-19 pandemic exposed severe vulnerabilities in seafarer welfare, including prolonged onboard confinement, limited medical access, and mental health strain. Issues such as harassment, gender inequality, and limited career progression for women remain persistent challenges, with women constituting only **1.2% of global seafarers** [17].

Governance and Compliance Risks

The maritime sector faces high governance risks related to:

- corruption in port-state inspections,
- falsification of waste logs,
- illegal discharge practices,
- money laundering within maritime logistics [18].

To address these risks, shipping companies increasingly adopt stronger governance structures, whistleblowing mechanisms, external audits, and transparent reporting.

Table 3. Key ESG criteria most prevalent in shipping companies.

Pillar	ESG Criteria	Key Maritime Examples
Environmental	Emissions; Fuel Efficiency; Renewable Energy; Waste & Water Management; Biodiversity	Scrubbers, alternative fuels, cold ironing, ballast water treatment
Social	Seafarer Welfare; Safety; Diversity; Training	Mental health programs, safety drills, equal opportunity policies
Governance	Transparency; Anti-Corruption; Board Diversity	Whistleblowing systems, independent audits

Global Prioritization of SDGs: Insights from Research and Global Surveys

A growing body of research seeks to identify the SDGs considered most critical to achieving global sustainability. Five independent studies, spanning experts, students, and global public respondents, provide consistent patterns:

Expert-Based Prioritization

Yang et al. (2020) found that sustainability experts prioritize SDG 2 (Zero Hunger), SDG 6 (Clean Water), and SDG 1 (No Poverty), indicating the primacy of basic human needs [19].

Student & Academic Prioritization

Kleespies & Dierkes (2022) reported that environmental science students place SDG 13 (Climate Action) at the top, followed by SDG 6 and SDG 3 (Good Health) [20].

Public Perception Surveys

Lampert & Papadongonas (2018) and the World Economic Forum (2019) found public

opinion strongly favors SDG 2, SDG 6, and SDG 3, revealing concerns over hunger, water access, and health [21-22].

Cross-Cultural Sustainability Priorities

Schlange et al. (2020) observed that younger and highly educated populations prioritize SDG 13, SDG 15, SDG 12, and SDG 6 as the most urgent goals [23]. Synthesis across the five studies shows consistent agreement on six SDGs: SDG 2, SDG 13, SDG 6, SDG 3, SDG 4, SDG 1. These represent foundational human needs and critical environmental challenges.

The Importance of ESG–SDG Alignment for Shipping

Despite the availability of ESG frameworks and SDG goals, the two systems are not automatically synchronized. SDGs are global policy targets with government-level metrics, while ESG indicators are operational and business-oriented. As a result:

- Shipping companies may focus on low-impact SDGs for branding purposes ("SDG washing").
- High-impact practices may be overlooked if not tied directly to ESG reporting.
- Investors increasingly demand SDG-linked ESG performance.
- Regulators require documented alignment between corporate sustainability actions and national climate goals.

Table 4. Detailed framework of ESG–SDG alignment process.

Stage	Sub-Category	Elements / Activities	Purpose	Relevance to SDGs
Inputs	ESG Indicators	Emissions, Waste Management, Water Management, Seafarer Welfare, Governance	Provide a structured baseline for sustainability assessment	Indicators correspond to multiple SDGs (6, 7, 8, 12, 13, 14, 16)
	Data Sources	ESG reports, IMO regulations, SDG targets, ESG ratings, sustainability disclosures	Ensure validity and alignment with international standards	Supports transparency for SDG alignment
	Organizational Context	Shipping operations, vessel type, energy use, workforce profile	Tailor ESG relevance to maritime activities	Links operational impact to sustainability goals
Alignment Process	Mapping	Match ESG indicators with **40 SDG sub-targets**	Identify direct + indirect SDG linkages	Ensures comprehensive multi-goal alignment
	Prioritization	Apply **SDG priority weighting** (SDG2,	Enhance focus on globally	Reflects urgency and global impact

		13, 6, 3, 4, 1 highest)	significant sustainability areas	
	Scoring	Assess indicator strength based on SDG coverage & depth	Quantifies contribution of each ESG component	Supports evidence-based decision making
	Cross-Impact Evaluation	Identify overlaps, synergies, and trade-offs	Prevent contradictory sustainability actions	Aligns ESG initiatives with holistic SDG outcomes
Outputs	High-Impact ESG Criteria	Environmental: Emissions, Energy Efficiency, Waste/Water; Social: Welfare; Governance: Anti-corruption	Highlight ESG areas with the strongest sustainability leverage	Directly contributes to prioritized SDGs
	Strategic Priorities	Emission reduction pathways, welfare programs, governance strengthening	Guide corporate sustainability strategy	Ensures high-impact SDG contributions
	SDG Contribution Map	Primary outputs aligned with SDG **2, 13, 6, 3, 4, 1**	Show final contribution to global sustainability agenda	Demonstrates strategic alignment & impact

ESG–SDG alignment is therefore indispensable for strategic planning, regulatory compliance, financing access, and global sustainability reporting.

RESEARCH METHODOLOGY

Research Approach

This study adopts an exploratory qualitative approach supported by an extensive document analysis method, which is widely recognized for examining complex conceptual frameworks such as ESG criteria and their alignment with the Sustainable Development Goals (SDGs). Document analysis enables the systematic interpretation, comparison, and synthesis of both academic literature and professional records, making it appropriate for research contexts where knowledge is dispersed across regulatory documents, corporate sustainability reports, and scholarly publications. According to Bowen [24], document analysis is a robust methodological choice when the research problem requires the integration of multiple textual sources to construct a coherent analytical framework. This applies directly to ESG–SDG alignment, where sustainability principles, maritime regulations, and corporate practices

coexist across diverse forms of documentation.

In this study, the qualitative approach is grounded in the assumption that ESG criteria cannot be meaningfully evaluated solely through quantitative indicators, especially within the maritime sector, where environmental, social, and governance impacts interact in non-linear and multidimensional ways. The methodology therefore prioritizes interpretive depth, thematic integration, and conceptual mapping over numerical generalization. This allows the research to uncover relationships between ESG practices and SDG outcomes that may not be explicitly stated but are embedded within regulatory texts, industry reports, and academic discourse [25-26].

Data Sources and Document Corpus
Scientific Sources

The scientific corpus draws from peer-reviewed journal articles, books, book chapters, and conference proceedings sourced primarily from Scopus, ScienceDirect, SpringerLink, and Taylor & Francis. These sources offer theoretical grounding, empirical insights, and methodological precedents for assessing sustainability frameworks, mapping corporate impacts on SDGs, and evaluating maritime environmental performance. The selected publications span from 2010 to 2024, ensuring the inclusion of the most recent developments in sustainability science, energy transition models, maritime decarbonization, and ESG reporting frameworks.

The scientific literature provides conceptual clarity on topics such as global SDG prioritization [19], climate mitigation strategies [16], capital market reactions to ESG performance [15], and the theoretical evolution of sustainability [10]–[12]. These insights are essential for contextualizing the role of ESG within the broader sustainable development agenda and for establishing the analytical foundation required for mapping ESG criteria to SDGs.

Professional Maritime Documents

The professional documentation includes regulatory texts, technical standards, audit guidelines, classification society rules, corporate sustainability reports, and sector-wide assessments produced by organizations such as the International Maritime Organization (IMO), Sustainability Accounting Standards Board (SASB), DNV, Lloyd's Register, ABS, and major commercial shipping companies (e.g., Maersk, MSC, Evergreen, Danaos). These documents were selected because they capture operational realities, technical constraints, regulatory requirements, and emerging industry trends.

The dataset includes ESG disclosures, GHG reduction pathways, energy efficiency guidelines, seafarer welfare assessments, anti-corruption frameworks, and environmental compliance monitoring systems. These sources serve as empirical anchors for determining how ESG criteria manifest in real-world maritime operations and how they implicitly or explicitly relate to SDG targets.

Table 5. Overview of document corpus used in the analysis.

Document Category	Source	Purpose	Examples
Scientific Literature	Scopus, ScienceDirect,	Provide theories, frameworks, empirical	Decarbonization studies, SDG

	T&F	results	prioritization, ESG theory
Regulatory & Technical Standards	IMO, DNV, ABS	Establish legal & operational sustainability requirements	MARPOL rules, EEXI guidelines, ESG audit standards
Corporate Sustainability Reports	Shipping companies	Show practical ESG implementation	Maersk ESG Report, Danaos Sustainability Report
Policy & Global Surveys	UN, WEF, Ipsos	Identify global sustainability priorities	SDG 2015 Framework, Global SDG Perception Survey

Analytical Framework and Coding Procedures

The analytical framework consists of four sequential analytical layers, each designed to convert documentary evidence into a structured ESG–SDG alignment model.

Layer 1: Identification and Categorization of ESG Criteria

The first layer involves the extraction and classification of ESG indicators specific to the maritime sector. Using the techniques of open, axial, and selective coding as described by Saldaña [28], the study identified twelve ESG criteria across three pillars: environmental (six indicators), social (four indicators), and governance (two indicators). This classification is supported by SASB Maritime Standards, IMO environmental regulations, and recurring thematic elements in corporate ESG disclosures.

The extended narrative coding enabled the identification of conceptual relationships among emissions control, energy efficiency, waste management, seafarer welfare, crew training, diversity, governance transparency, and anti-corruption mechanisms. These indicators collectively form the operational ESG framework that the study uses for subsequent SDG mapping.

Layer 2: Mapping ESG Criteria to SDG Sub-targets

The second analytical layer applies the content-matching technique, which involves systematically comparing the semantic content of ESG indicators with 40 corporate-relevant SDG sub-targets. This process draws upon thematic correspondence, reference matching, and interpretive linking approaches that have been used in prior cross-sectoral sustainability studies [20-21, 27].

Through iterative refinement, the mapping process generated a multidimensional matrix showing which SDGs and sub-targets each ESG criterion influences. Environmental criteria were found to connect strongly with SDG 6, 7, 12, 13, 14, and 15; social indicators aligned with SDG 1, 2, 3, 4, 5, 8, 10, 11, and 16; and governance indicators aligned with SDG 8, 9, 16, and 17.

*Layer 3: SDG Impact Scoring and Priority Weighting*

To determine which ESG criteria contribute most significantly to global sustainability, the study developed a three-component scoring system. The scoring evaluates:

1. SDG sub-target coverage, indicating the breadth of impact;
2. SDG count, showing how many goals each ESG criterion supports; and
3. SDG priority weighting, based on five global studies identifying SDG 2, 13, 6, 3, 4, and 1 as the highest-impact goals for human and environmental well-being [19-20, 23].

The weighted scoring system ensures that ESG criteria contributing to high-priority SDGs receive proportionally greater recognition, thus aligning maritime sustainability actions with global needs.

Flowchart of the Analytical Process
Figure 2. ESG–SDG analytical procedure flowchart.
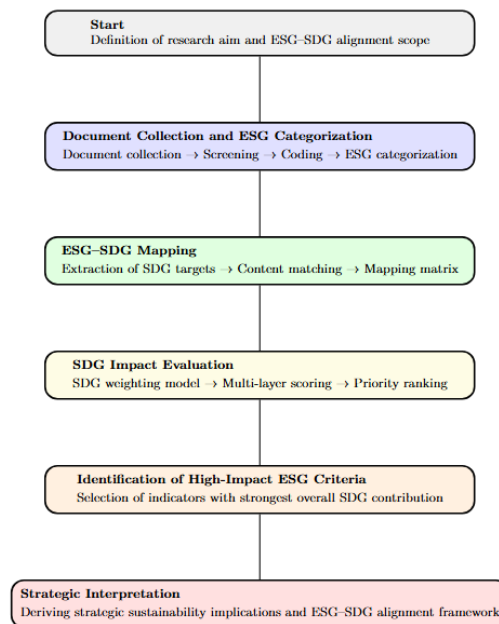
Trustworthiness, Validity, and Triangulation

Ensuring methodological rigor is essential for qualitative analysis of this scope. Trustworthiness is achieved through:

1. **Triangulation:** Cross-verification between scientific literature, regulatory documents, and corporate sustainability reports ensures that findings are not dependent on a single perspective [29].
2. **Convergence Validation:** The ESG–SDG mappings were tested against internal coherence between matrices and external coherence with documented practices from shipping companies and industry associations.
3. **Auditability:** All analytical steps were logged, coded systematically, and subjected to iterative review to ensure that interpretations were grounded in data.

Methodological Limitations

The methodology has intrinsic limitations. The reliance on document analysis means that interpretations are bound by what organizations choose to disclose publicly. Furthermore, quantitative validation—such as emissions measurements or welfare performance metrics—is beyond the scope of this study. Differences across ship types, fleet sizes, and geopolitical

regulatory environments also introduce heterogeneity that cannot be fully captured within a conceptual ESG–SDG mapping exercise. Nevertheless, the approach is well suited for constructing a strategic sustainability framework whose purpose is exploratory and analytical rather than predictive.

RESEARCH RESULTS AND DISCUSSIONS

This section presents the findings generated from the document analysis and the ESG–SDG mapping framework. The discussion evaluates the strategic relevance of each ESG criterion, the magnitude of its contribution to SDG outcomes, and the broader implications for the maritime industry. The results are organized into thematic subsections that reflect the sequence of analytical procedures: (1) identification of ESG criteria; (2) mapping to SDG sub-targets; (3) multi-layer scoring and prioritization; and (4) strategic interpretation of the findings.

Identification of ESG Criteria in the Maritime Sector

The first major result of this study is the identification of twelve ESG criteria specific to the maritime sector. These criteria emerged through iterative coding of scientific literature, IMO conventions, SASB Maritime Standards, and sustainability reports from global shipping companies including Maersk, Danaos, Evergreen, MSC, and others. The identification process revealed that ESG indicators in shipping are distributed unevenly across the three main pillars:

Environmental (*6 criteria*)
1. Greenhouse gas (GHG) emissions
2. Fuel and energy efficiency
3. Use of renewable or low-carbon alternative fuels
4. Waste management (solid, hazardous, and operational waste)
5. Water and ballast management
6. Biodiversity and marine ecosystem protection

Social (*4 criteria*)
1. Seafarer welfare, mental health, and crew well-being
2. Safety management and accident prevention
3. Diversity, inclusiveness, and equal opportunity
4. Training, skills development, and maritime education

Governance (*2 criteria*)
1. Transparency, reporting integrity, and internal oversight
2. Anti-corruption, legal compliance, and ethical conduct

Compared with ESG frameworks from other transport sectors, maritime ESG frameworks are environmentally concentrated, reflecting the inherently global and ocean-dependent nature of shipping. This finding is consistent with prior research showing that shipping's externalities—air pollution, carbon emissions, underwater noise, and risk of marine contamination—exceed those of most other transport modes [16, 34]. In addition, the presence of only two governance criteria underscores a strategic weakness: governance practices in shipping remain narrower in scope compared to industries with long-established transparency mechanisms.

Mapping ESG Criteria to SDG Sub-targets
Mapping Overview

The second core result is a detailed ESG–SDG mapping that connects each of the twelve ESG criteria to 40 SDG sub-targets established in the document set. The mapping shows that shipping companies influence a significantly broader portion of the SDG agenda than commonly assumed. A systematic semantic analysis revealed:

Table 6. ESG pillar contributions to sdg coverage and thematic areas.

ESG Pillar	SDGs Reached	Number of Sub-targets	Dominant Themes
Environmental	10	22	Climate mitigation, ocean health, resource efficiency
Social	7	13	Well-being, equity, safety, education
Governance	4	5	Institutional integrity, partnership, compliance

Environmental indicators are deeply embedded in goals concerning water quality (SDG 6), energy transition (SDG 7), production efficiency (SDG 12), climate mitigation (SDG 13), marine ecosystem protection (SDG 14), and terrestrial ecosystem health (SDG 15). Social indicators contribute substantially to SDG 1 (poverty reduction), SDG 2 (food security), SDG 3 (health), SDG 4 (education), SDG 5 (gender equality), SDG 8 (decent work), SDG 10 (reduced inequality), and SDG 16 (peace and justice).

Governance indicators, although few, connect with SDG 8, SDG 9, SDG 16, and SDG 17, reinforcing the importance of transparency, institutional trust, and international cooperation in maritime operations. This finding aligns with UN Global Compact guidance, which stresses that the maritime sector's governance structures function as "foundational enablers" of sustainability but do not directly generate measurable environmental or social outcomes [34].

Detailed Mapping of ESG–SDG Relationships

To illustrate the depth of relationship between ESG criteria and SDG targets, the study constructed a multi-level mapping matrix (extract below):

Table 7. Extract of ESG–SDG mapping matrix.

ESG Criterion	Strong SDG Linkages	Supporting SDG Evidence
Emissions	SDG 7, 12, 13	Core driver of energy transition and climate mitigation
Fuel Efficiency	SDG 7, 9, 12	Enhances resource efficiency and industrial innovation
Waste Management	SDG 6, 12, 14	Prevents ocean pollution and supports circular economy
Water Management	SDG 6, 14	Supports clean water and marine ecosystem protection
Biodiversity	SDG 14, 15	Prevents habitat loss and marine degradation

Seafarer Welfare	SDG 3, 8	Protects mental and physical health of maritime workers
Training	SDG 4, 8, 10	Enhances lifelong learning and reduces inequality
Governance	SDG 16, 17	Strengthens transparency and international partnerships

This mapping reveals that environmental indicators are not merely compliance-based but are transformative in their potential SDG contribution.

Multi-layer Scoring and Prioritization
Scoring Overview

The third key result is a multi-layer scoring model that evaluates ESG criteria through three dimensions:
1. SDG sub-target coverage
2. Number of SDGs influenced
3. Weighted priority score reflecting global SDG importance (Highest global priorities: SDG 2, 13, 6, 3, 4, 1 [19–23])

Table 8. Results of impact scoring.

ESG Criterion	Total Score	Impact Category
Emissions Reduction	28	**High Impact**
Energy Efficiency	25	**High Impact**
Waste Management	23	**High Impact**
Water Management	21	**High Impact**
Seafarer Welfare	20	**High Impact**
Training & Upskilling	16	Medium
Safety	14	Medium
Diversity & Inclusion	12	Medium
Transparency	10	Medium
Anti-corruption	8	Low

Environmental criteria dominate the impact hierarchy because they strongly affect SDG 13 (Climate Action), one of the most globally prioritized SDGs.

Why Emissions, Energy Efficiency, and Waste Management Score Highest

These three indicators consistently demonstrate multi-SDG influence:
- Emissions affects climate, energy, industry, ecosystems, and global atmospheric health.
- Energy efficiency links to industrial innovation (SDG 9), climate mitigation (SDG 13), and sustainable energy (SDG 7).
- Waste and water management influence marine ecosystems and freshwater quality—crucial for shipping corridors and port communities.

These findings validate maritime decarbonization as the most strategically important sustainability challenge worldwide.

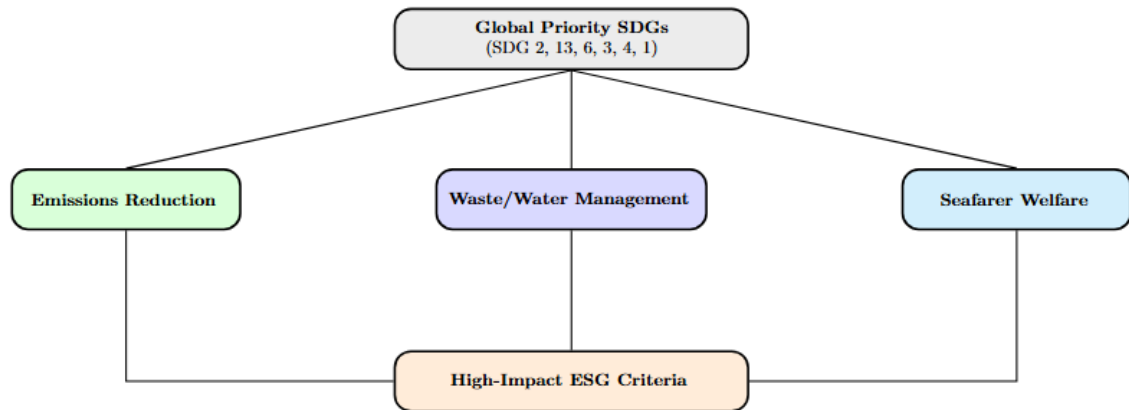**Integrated Analysis of High-Impact ESG Clusters**

Figure 3. High-impact ESG–SDG relationship cluster.

This cluster underscores that environmental measures and crew welfare anchor the sustainability transformation of the maritime industry.

Discussion

Environmental Factors as Dominant Drivers of SDG Impact

The results affirm that environmental indicators generate the most significant global sustainability impact. This conclusion is consistent with long-standing research showing that maritime transportation is responsible for approximately 3% of global CO_2 emissions—more than all domestic aviation combined [16]. Moreover, emissions directly influence four of the most globally prioritized SDGs (SDG 2, 13, 6, and 3), demonstrating their central strategic importance. Waste and water management also achieved high-impact scores due to direct correlations with SDG 6 and SDG 14—both foundational to ocean health.

Social Sustainability as an Underestimated Maritime Priority

While environmental pressures dominate public attention, social sustainability emerges as a strong contributor to SDG alignment—especially in seafarer welfare, which intersects with SDG 3 (Good Health) and SDG 8 (Decent Work). The COVID-19 pandemic exposed severe vulnerabilities: crew confinement, mental health strain, and excessive contract extensions. These factors underscore welfare as a strategic—and not merely ethical—priority for the global maritime workforce.

Governance: Low Direct Impact but High Strategic Influence

Governance scores lower because its direct SDG connections are fewer, but the implications are profound. Governance enhances:

- accountability,
- transparency,
- compliance integrity,
- investor trust, and

- international regulatory credibility.

Thus, governance acts as a force multiplier: it strengthens the effectiveness of environmental and social initiatives even if its SDG linkages are fewer.

Strategic Implications for Maritime Sustainability

The results have four strategic implications:

1. Decarbonization should remain the core sustainability investment priority—aligned with global regulatory pressures and SDG urgency.
2. Crew welfare reforms must be institutionalized, not episodic or reactive.
3. Waste and water management improvements offer rapid-return sustainability gains, especially for shipping companies operating in ecologically sensitive regions.
4. Governance modernization is needed to support the credibility of ESG reporting and avoid "SDG washing."

Summary of Key Findings

The study demonstrates that:

- Environmental indicators form the backbone of maritime sustainability impact.
- Social indicators, particularly seafarer welfare, play a critical but underrecognized role.
- Governance indicators remain essential enablers of long-term sustainability.
- The ESG–SDG alignment framework provides a strong analytical tool for identifying impact-driven priorities.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

This study provides an integrated analytical framework that links maritime ESG criteria with the Sustainable Development Goals (SDGs), revealing the most influential dimensions of sustainability within the global shipping industry. Through systematic document analysis, thematic coding, and multi-layer ESG–SDG mapping, the research identifies twelve ESG criteria and evaluates their relative contributions to forty SDG sub-targets. The results demonstrate that environmental indicators—particularly emissions reduction, energy efficiency, and waste–water management—exert the strongest influence on global sustainability outcomes due to their direct connections with high-priority SDGs such as SDG 13 (Climate Action), SDG 6 (Clean Water), and SDG 2 (Zero Hunger). In parallel, social indicators, especially those related to seafarer welfare, emerge as crucial drivers of SDG achievement, reinforcing the importance of safeguarding the physical and psychological well-being of maritime workers. Governance indicators, while less directly linked to SDG targets, serve as essential enablers that reinforce accountability, transparency, and ethical implementation of sustainability initiatives.

Overall, the findings highlight that the shipping industry possesses a multidimensional capacity to contribute to global sustainability beyond carbon mitigation alone. The ESG–SDG alignment framework developed in this study provides a strategic lens through which shipping companies, regulators, and investors can prioritize actions that deliver the greatest systemic impact. By identifying the ESG criteria that produce the deepest SDG contributions, this research assists the maritime sector in shifting from compliance-driven reporting to high-impact sustainability planning. The study concludes that a balanced integration of environmental

innovation, human-centered social policies, and strengthened governance mechanisms forms the core foundation of an effective sustainability strategy for the maritime industry.

Recommendations

Based on the findings, several key recommendations can guide the maritime industry toward stronger ESG–SDG alignment. First, shipping companies should prioritize decarbonization efforts, including alternative fuels, energy-efficient technologies, and emissions reduction programs, as these actions consistently deliver the highest sustainability impact. Second, companies must enhance seafarer welfare and safety, particularly through improved mental health support, better working conditions, and expanded training opportunities, which directly strengthen SDG outcomes related to health, decent work, and equality. Third, improvements in waste and water management—including stricter MARPOL compliance, advanced treatment systems, and circular resource practices—should be accelerated to protect marine ecosystems. Fourth, firms should reinforce governance and transparency, adopting credible ESG reporting standards and strong anti-corruption measures to ensure accountability and trust. Finally, industry bodies and regulators are encouraged to adopt ESG–SDG alignment frameworks as part of sustainability benchmarking, enabling more consistent evaluation and strategic planning across the maritime sector.

REFERENCE

[1] Al-Enazi, A., Okonkwo, E. C., Bicer, Y., & Al-Ansari, T. (2021). A review of cleaner alternative fuels for maritime transportation. *Energy Reports, 7*, 1962–1985.

[2] United Nations Environment Programme. (1972). *Declaration of the United Nations Conference on the Human Environment (Stockholm Declaration).* UNEP.

[3] World Commission on Environment and Development. (1987). *Our common future.* Oxford University Press: Oxford, United Kingdom.

[4] Bodansky, D. (2021). The Paris Climate Agreement: A new hope? *Environmental Policy and Law, 51*(1), 34–42.

[5] United Nations. (2015). *Transforming our world: The 2030 agenda for sustainable development.* United Nations.

[6] Sustainability Accounting Standards Board. (2017). *Marine transportation sustainability standards.* SASB.

[7] World Maritime Academy. (2024). *CSRD and sustainability reporting in maritime industries.* World Maritime Academy.

[8] Whelan, T., Kronthal-Sacco, R., & Case, K. (2021). *ESG and financial performance: Uncovering the relationship by aggregating evidence.* NYU Stern Center for Sustainable Business.

[9] Lindstad, H., Eskeland, G., Rialland, A., & Valland, A. (2021). Strategies and measures for reducing maritime GHG emissions. *Energy, 227*, Article 120000.

[10] BIMCO, & International Chamber of Shipping. (2021). *Seafarer workforce report.* BIMCO & ICS.

[11] International Institute for Human Rights and Business. (2023). *Corruption and governance risks in the maritime sector.* IHRB.

[12] Yang, C., Matthews, R., & Wohlfart, E. (2020). Prioritizing SDGs: A survey of global sustainability experts. *Sustainability, 12*(8), Article 3141.

[13] Kleespies, M., & Dierkes, M. (2022). University students' priorities for sustainable development goals. *International Journal of Sustainability in Higher Education, 23*(5), 1034–1054.

[14] Lampert, M., & Papadongonas, P. (2018). *SDG prioritization in the public consciousness: A global opinion study.* UNSDG Research Papers.

[15] World Economic Forum, & Ipsos. (2019). *Global citizens' perceptions of sustainable development goals.* WEF.

[16] Schlange, L. E., Rüeger, D., & Schmutz, S. (2020). Global and regional priorities of SDGs across demographics. *Journal of Global Responsibility, 11*(4), 381–400.

[17] Bowen, G. A. (2009). Document analysis as a qualitative research method. *Qualitative Research Journal, 9*(2), 27–40.

[18] Bryman, A. (2016). *Social research methods* (5th ed.). Oxford University Press: Oxford, United Kingdom.

[19] Atkinson, P., & Coffey, A. (2011). Analysing documentary realities. In N. K. Denzin & Y. S. Lincoln (Eds.), *The SAGE handbook of qualitative research* (pp. 77–92). SAGE Publications: Thousand Oaks, California, United States.

[20] Saldaña, J. (2020). *The coding manual for qualitative researchers* (4th ed.). SAGE Publications: Thousand Oaks, California, United States.

[21] Denzin, N. K. (2012). Triangulation in qualitative research. *Journal of Mixed Methods Research, 6*(2), 80–88.

[22] UN Global Compact. (2022). *SDG corporate alignment guidelines.* UNGC.

[23] International Maritime Organization. (Various years). *Conventions, codes, and guidelines on environmental protection and GHG reduction (e.g., MARPOL, EEXI, CII).* IMO Publishing.

[24] Maersk. (2022). *Sustainability report.* A.P. Moller–Maersk Group.

[25] Danaos Corporation. (2023). *ESG & sustainability report.* Danaos Shipping.

[26] Hellenic Chamber of Shipping. (2021). *Maritime sustainability and SDG alignment report.* Hellenic Chamber of Shipping.

[27] Evergreen Marine. (2023). *Corporate social responsibility report.* Evergreen Group.

[28] MSC Mediterranean Shipping Company. (2023). *Sustainability highlights report.* MSC Group.

[29] Lloyd's Register. (2020). *Maritime decarbonisation pathway report.* Lloyd's Register.

[30] DNV GL. (2020). *Energy transition outlook: Maritime forecast.* DNV.

[31] American Bureau of Shipping. (2021). *Sustainability and compliance framework for maritime operators.* ABS.

[32] UNCTAD. (2022). *Review of maritime transport 2022.* United Nations Conference on Trade and Development.