



Deliverable 2.1 (V1.0)

Stakeholder Analysis Matrix

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¹ **DATA** = data sets, **DEC** = Websites, patent filings, videos, etc; **DEM** = Demonstrator, pilot, prototype, **ETHICS**; **OTHER**; **R** = Document, report.

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Abbreviations

AFIF	Alternative Fuels Infrastructure Facility
AFIR	Alternative Fuels Infrastructure Regulation
AHP	Analytic Hierarchy Process
AHP-W	Analytic Hierarchy Process – Weighted
AI	Artificial Intelligence
AM	Additive Manufacturing
AMS	Application Management Services
ANP	Analytic Network Process
B2B	Business to Business
BMI	Business Model Innovation
BWM	Best-Worst Method
CE	Circular Economy
CEO	Chief Executive Officer
CINEA	Climate, Infrastructures and Environment Executive Agency
CLSC	Closed-Loop Supply Chain
CNG	Comprehensive Natural Gas
Cobots	Collaborative Robots
CP	Cleaner Production
CSCM	Circular Supply Chain Management
CSI	Clean Shipping Index
DEA	Data Envelopment Analysis
DGRA	Dynamic Grey Relational Analysis
DSR	Design Science Research
EBIT	Earnings Before Interest and Taxes
EBITDA	Earnings Before Interest, Taxes, Depreciation, and Amortization
EC	European Commission
EEA	European Environmental Agency
EFRAG	European Financial Reporting Advisory Group
eFTI	Electronic Freight Transportation Information
EKC	Environmental Kuznets Curve
ENSOS	Environmental and Social Sustainability
ESG	Environmental, Social and Governance
ESI	Environmental Ship Index
ESRS	European Sustainability Reporting Standards

EU	European Union
EV	Electric Vehicle
FBWM	Fuzzy Best-Worst Method
FMEA	Failure Mode and Effects Analysis
FPII	Fuzzy Performance Importance Index
FTENSOSI	Fuzzy Transportation ENSOS Index
GDP	Gross Domestic Product
GHG	Greenhouse gas
GHRM	Green Human Resource Management
GLPI	Green Logistics Performance Index
GR	Government and Regulation
GRI	Global Reporting Initiative
GSCM	Green Supply Chain Management
GVC	Global Value Chains
I4.0	Industry 4.0
IDT	Innovation Diffusion Theory
IEA	International Energy Agency
IoT	Internet of Things
ISO	International Organization for Standardisation
ISSB	International Sustainability Standard Board
KPI	Key Performance Indicator
LCA	Life Cycle Assessment
LED	Light-Emitting Diode
LPBF	Laser Powder Bed Fusion
LS	Logistics Solution
LSI	Logistics Sustainability Index
LSP	Logistics Service Provider
MCDM	Multi-Criteria Decision-Making
M&E	Monitoring and Evaluation
MFA	Material Flow Analysis
MFT	Multimodal Freight Terminal
MSCC	Multinational Supply Chain Cooperation
MSME	Micro, Small, and Medium Enterprises
NFRD	Non-Financial Reporting Directive
NGO	Non-Governmental Organization
OSLMI	Overall Sustainable Logistics Management Maturity Indicator

PI	Physical Internet
PIE	Public-Interest Entities
RAG	Red – Amber – Green
RFID	Radio Frequency Identification
RNN	Recurrent Neural Network
ROE	Return on Investment
RPN	Risk Priority Number
SASB	Sustainability Accounting Standards Board
SCC	Sustainable Supply Chain
SCF	Stakeholder Collaborative Forum
SDG	Sustainable Development Goals
SEM	Structural Equation Modelling
SFA	Sustainability Framework Architecture
SLM	Selective Laser Melting
SLMM	Sustainable Logistics Management Maturity
SLR	Systematic Literature Review
SME	Small and Medium-sized Enterprise
SR	Sustainability Report
SSCM	Sustainable Supply Chain Management
STEEP	Social, Technological, Economic, Environmental and Political
SWARA	Stepwise Weight Assessment Ratio Analysis
TBL	Triple Bottom Line
TCFD	Task Force on Climate-related Financial Disclosures
TEN-T	Trans-European Transport Network
TEU	Twenty-foot Equivalent Unit
ToC	Theory of Change
UN	United Nations
UK	United Kingdom
VFD	Variable Frequency Drive
VSCND	Viable Supply Chain Network Design
WP	Work Package

Publishable Executive Summary

The present report is the Deliverable from Task 2.1 of the ADMIRAL – *Advanced Marketplace for Low Emission and Energy Transportation* project, funded by the European Union under the HORIZON-CL5-2022-D6-02 with Grant Number 101104163. ADMIRAL aims to transform supply chain management in freight transportation by developing a cutting-edge digital marketplace for multimodal logistics. It seeks to shift the focus on indirect emissions, reduce overall emissions in logistics and transportation and enhance transparency throughout the supply chain.

ADMIRAL WP2 – *Sustainable development of logistics & transport* addresses key sustainability issues in the transport and logistics sector such as zero (low) emissions logistics, reduction of energy consumption from fossil fuels in transport and enhancement of collaborative logistics to reach common sustainability goals in the pilots to be implemented in Finland, Lithuania, Portugal-Spain and Slovenia-Croatia. Task 2.1 – *Sustainability Framework for Collaborative, Digital and Green Logistics*, is centred on the identification of the main stakeholders involved in the logistics system and the supply chain, mainly in the Pilots context and the main issues that should be addressed by the sector to solve negative sustainability impacts and provide advancement for local development.

This deliverable, *Stakeholders Analysis Matrix*, represents a cornerstone of ADMIRAL’s vision for transforming European logistics into a collaborative, digital, and green ecosystem. Developed under Task 2.1 – *Sustainability Framework for Collaborative, Digital and Green Logistics*, it provides a strategic foundation for engaging stakeholders and embedding sustainability principles into multimodal transport systems. The report identifies key actors across supply chains, analyses sustainability challenges and long-term strategies at European, national, and local levels, and examines how different dimensions—environmental, social, and governance—are addressed by stakeholders, with a strong emphasis on social equity and inclusiveness.

To achieve these objectives, the methodology combines rigorous research and participatory approaches: a systematic literature review to benchmark sustainability frameworks; design science research and co-creation to develop the ADMIRAL Sustainability Framework Architecture (SFA); qualitative and quantitative analyses of sustainability reports from 23 transport companies; surveys capturing diverse stakeholder perspectives; and focus groups fostering dialogue on barriers, drivers, and opportunities for low-carbon logistics.

The insights generated inform actionable strategies for aligning logistics operations with EU regulatory requirements such as CSRD, GRI, and ISO standards, while promoting innovation and resilience. By mapping priorities and challenges, this report empowers industry leaders to anticipate regulatory shifts, strengthen compliance, and unlock competitive advantages through sustainable practices. Ultimately, Deliverable 2.1 contributes to a multidimensional strategy for the ADMIRAL multimodal marketplace, positioning stakeholders at the forefront of Europe’s transition toward a low-carbon, digitally integrated, and socially responsible logistics sector.

1 Introduction

1.1 Objectives

The present report *Stakeholders analysis matrix* is one result of task 2.1 -Sustainability Framework for Collaborative, Digital and Green Logistics, which integrates ADMIRAL WP2 - Sustainable development of logistics & transport. Following ADMIRAL's project Grant Agreement 101104163, the main goals of task 2.1 are as follows:

- To identify the main stakeholders involved in the logistics systems and the supply chains (mainly in the pilots' contexts) and engage them, by setting up a collaborative framework with stakeholders.
- To identify sustainability challenges of logistics and analyse long-term strategies (European, national and local), sustainability reports, and sustainability related regulation.
- To identify how different sustainability dimensions are treated by stakeholders and partners, the scope of action and their expected contributions, with a special focus on social dimension.
- To contribute to a multidimensional and collaborative strategy to be considered for the development of the multimodal marketplace.

1.2 Methodological Approach

Considering that the ADMIRAL project is a research and innovation action we aimed to respond to the challenge of the EC funding through the European Climate, Infrastructures and Environment Executive Agency (CINEA). Therefore, the research methodology used in Task 2.1 comprises the following:

- a) Systematic literature review (SLR) approach to explore sustainability frameworks and methodologies within the logistics and transport sectors. The objective of the methodological process is to identify and analyse how existing frameworks integrate technological applications with environmental, social, and governance (ESG) dimensions.
- b) The development of the Sustainability Framework Architecture (SFA) follows a design science research (DSR) and participatory co-creation approach. This methodological framework aims to provide the ADMIRAL pilots with a structured yet flexible toolset for identifying sustainability objectives, defining aligned Key Performance Indicators (KPIs), and integrating sustainability principles with digital innovation in logistics.
- c) Qualitative content analysis approach to examine the sustainability reports of twenty-three transport companies participating in the ADMIRAL project pilots (Portugal–Spain, Slovenia–Croatia, Lithuania, and Finland). The analysis relies exclusively on secondary data extracted from publicly available corporate sustainability reports.
- d) Quantitative survey-based research design to gather insights on sustainability objectives, drivers, barriers, innovative practices, and relevant European regulations in the context of green and sustainable logistics. The methodology aims to capture diverse stakeholder perspectives across sectors and geographies, contributing to a comprehensive understanding of current practices and future opportunities for sustainable logistics transformation.
- e) Qualitative focus group methodology to explore the challenges, opportunities, and potential impacts associated with the transition toward a low-carbon and sustainable logistics sector. The focus group serves as a participatory platform for collective reflection among stakeholders, contributing to the co-creation of knowledge and policy-relevant insights within the ADMIRAL project framework.

1.3 Report Structure

This report is structured to provide a comprehensive overview of the ADMIRAL project's approach to sustainability in the logistics sector, integrating stakeholder engagement, regulatory analysis, pilot evaluations, and strategic insights. The structure is as follows:

- **Publishable Executive Summary:** A concise overview of the report's key findings and recommendations, tailored for public dissemination.
- **Chapter 1 – Introduction:** Outlines the objectives, methodological approach, and structure of the report.
- **Chapter 2 – ADMIRAL Sustainability Framework and Stakeholder Engagement:** Presents conceptual approaches to sustainability in logistics, reviews existing frameworks, and introduces the ADMIRAL sustainability architecture and stakeholder engagement strategy.
- **Chapter 3 – Analysis of Relevant EU Regulatory Framework:** Examines key EU regulations and standards relevant to sustainability and freight transport, including eFTI, CSRD, GRI, and ISO standards.
- **Chapter 4 – ADMIRAL Pilots' Sustainability Reporting and Solutions:** Provides insights from pilot projects across different European regions, highlighting sustainability reporting practices and alignment with GRI standards.
- **Chapter 5 – Mapping Key Sustainability Challenges and Priorities:** Uses a stakeholder-driven approach to identify challenges, goals, and barriers in the logistics sector through surveys and focus groups.
- **Chapter 6 – Key Findings from Stakeholders' Perspective:** Synthesizes stakeholder feedback to prioritize sustainability goals and assess pilot performance in terms of equity, accessibility, and environmental justice.
- **Chapter 7 – Conclusions:** Summarizes the main findings and implications for future sustainability efforts in logistics.
- **Chapter 8 – References:** Lists all sources cited throughout the report.
- **Annexes:** Include supplementary materials such as the Stakeholder Collaborative Forum contact form and a list of GRI consolidated standards.

2 ADMIRAL sustainability framework and stakeholder engagement

2.1 Conceptual approaches to address sustainability in logistic sector

Sustainability in logistics and freight transportation is a complex, multidimensional challenge that requires integrating environmental, social and economic considerations into supply chain operations. In the following subchapters there are conducted an in-depth analysis of sustainability in the logistic sector and a review of the sustainability frameworks in the logistics and transport sector which serves as the inspiration and starting point for defining the sustainability framework architecture of the ADMIRAL project.

2.1.1 The importance of sustainability frameworks in the logistics sector

The United Nations (UN) defined sustainability in the *Brundtland Report (1987)* as “meeting the needs of the present without compromising the ability of future generations to meet their own needs”. It was embedded in the 2030 Agenda for Sustainable Development, adopted by all UN Member States in 2015. The European Commission adopts this same principle, framing sustainable development as balancing economic, social, and environmental pillars to ensure present and future well-being (European Commission, 2025b). According to the European Environmental Agency (2025b), sustainability entails the development and preservation of systems that fulfil current human needs without compromising the capacity of future generations to meet their own needs, all within the ecological boundaries of the planet. In this context, the environmental challenges associated with conventional transport and logistics systems have become increasingly urgent. Evidence indicates that over 94% of urban residents are exposed to harmful concentrations of fine particulate matter (PM2.5) (European Environmental Agency, 2025a), while air pollution is estimated to cause more than 1,200 deaths annually among individuals under the age of 18 across EEA member and collaborating countries (European Environmental Agency, 2024). According to the International Energy Agency (International Energy Agency, 2025), the transport sector accounts for about 23% of global energy-related CO₂ emissions, with freight transport (road trucks, shipping, and aviation cargo) responsible for roughly 40% of those emissions. This fact underscores the importance of decarbonising logistics chains. Addressing these multifaceted issues necessitates a strategic, research-driven approach grounded in innovation. In response, **the ADMIRAL project aims to develop collaborative, sustainable, and technologically integrated solutions** that enhance the environmental performance of the logistics and freight sector, thereby reducing its negative impact on natural ecosystems and resources.

The adoption of robust sustainability frameworks also encourages the integration of sustainable practices into core business strategies to enable addressing social and environmental sustainability goals, besides economic efficiency. For example, **frameworks that evaluate green logistics activities, such as eco-driving, route optimization, and environmentally responsible warehousing**, help organizations recognize the benefits of sustainability and the internal and external forces driving its adoption, including regulatory compliance, market demand, and organizational values (Vienažindiene et al., 2021). Furthermore, these frameworks highlight the competencies and collaborative efforts required to maintain high-quality, sustainable logistics services (Centobelli et al., 2020; A. Gupta et al., 2022).

Therefore, **implementing sustainability frameworks can play a crucial role in evaluating and advancing the sustainability performance of logistics companies.** These frameworks provide structured methodologies for evaluating operations across the three pillars of sustainability: economic, environmental, and social dimensions. By providing standardized approaches, they enable consistent measurement, benchmarking, and enhancement of sustainability practices within the logistics sector.

One inspiring example is the **Sustainable Logistics Management Maturity (SLMM) framework**, which facilitates the evaluation of organizational maturity levels in sustainability-related practices in rail, pipeline, road, water, and air freight transport. It enables companies to benchmark their performance, compare practices across organizations, and identify specific areas for targeted improvement in the environmental, social, and governance areas (Werner-Lewandowska & Golinska-Dawson, 2021). For this, each company needs to state its internal capabilities for utilizing logistics solutions (LS) in terms of economic, environmental, and social performance to achieve an overall classification performance. Table 1 presents the logistics tools used in the framework, with special attention (in bold) to the ones that are more relevant to the ADMIRAL project.

Table 1: Logistics solutions used in the SLMM framework

ID LS	Logistics solution
01	Selecting warehouse storage equipment
02	Selecting warehouse material handling equipment
03	Warehouse location
04	Warehouse space calculation
05	5S or 5C, also known as Gemba Kanri
06	Resource planning
07	Task interleaving
08	Using WMS
09	Warehouse maturity scan
10	Warehouse risk assessment
11	How to “green” your warehouse and save energy and CSR
12	Calculating road freight transport charges and rates
13	Transport System Management
14	Transport problems – matching customer demand with supplier capacity
15	Transport audit checklists
16	Calculating emissions in freight transport
17	Vendor assurance of transport logistics service providers
18	Replenishment order quantities
19	Measuring demand variation
20	Periodic review of the inventory of the management system
21	Reorder point inventory management system
22	Economic order quantity
23	Safety stock calculation
24	Vendor-managed inventory
25	Identification and disposal of surplus stock
26	Demand forecasting
27	Supplier relationship
28	Calculating ordering costs
29	Calculating stockholding stocks
30	Performance measures for freight transport
31	Warehouse KPIs
32	Balanced scorecard

ID LS	Logistics solution
33	Activity-based costing and time-driven activity-based costing
34	Supply chain financial ratios and metrics
35	Z-WAVE
36	Cloud

Benchmarking is also a central function of sustainability frameworks, as it allows logistics companies to compare their sustainability performance against industry standards or recognized best practices. Tools such as the **Overall Sustainable Logistics Management Maturity Indicator (OSLMI)** and various **sustainability indices** (Table 2) give assistance to identify performance gaps, prioritize improvement areas, and formulate strategies for implementing green logistics initiatives (A. Gupta & Singh, 2020; Werner-Lewandowska & Golinska-Dawson, 2021). This continuous improvement process is crucial for meeting evolving regulatory requirements, customer expectations, and societal demands.

Table 2: Sustainability indices for freight and logistics companies

Index	Focus	Key features	Use	Source
Fleet Sustainability Index	Emissions from trucking fleets	Provides emissions factors per carrier, using data aligned with International Sustainability Standard Board (ISSB) guidelines.	Enables companies to track and model scope 3 emissions and align with international reporting standards.	(Sustainable Logistics, 2025)
Logistics Sustainability Index (LSI)	General sustainability performance of a company's logistics activities	Calculates a sustainability score using a mixture of quantitative and qualitative criteria, assessing weightings to each criterion.	Goes beyond just CO ₂ emissions, also addressing energy use, infrastructure, and raw materials management.	(The World Bank, 2023)
Environmental Ship Index (ESI) & Clean Shipping Index (CSI)	Maritime sector, including freight shipping lines	ESI is used to rate ships based on the ability to reduce air emissions (SO _x , NO _x , CO ₂). CSI is a holistic, independent, verified ranking addressing various ship environmental impacts	High-scoring vessels benefit from reduced port fees or preferred status	(Rina, 2025)
Green Logistics Performance Index (GLPI)	Benchmark and track environmental sustainability in logistics across European Union countries	Quantifies logistics efficiency, developed by the World Bank, and measures a nation's environmental health and ecosystem vitality	Enables comparison of the relative performance of EU countries in terms of both logistics efficiency and environmental responsibility	(Starostka-Patyk et al., 2024)

Additionally, **index-based and multi-criteria decision-making (MCDM) frameworks** offer systematic tools to assess and enhance environmental and social sustainability initiatives. These approaches help identify both strengths and barriers to progress, which can support strategic planning and operational

improvements (Kumar & A, 2020; Kumar & Anbanandam, 2022a). In the MCDM methodology, identifying and improving attributes is crucial for developing a sustainable freight transport system. Consequently, environmental and social sustainability obstacles are identified using computational values of the **fuzzy performance importance index (FPII)**, measured against a defined threshold level. The attributes found to have poor performance in the Indian freight industry are presented in Table 3.

Table 3: Environmental and Social sustainability obstacles in Indian freight and logistics companies (Source: Kumar & A, 2020)

Enabler	Dimension	Attribute
Environmental	Internal environmental management practices	Formation of organisational environmental sustainability goals
		Environmental compliance and audit programs
		Environmental performance and monitoring practices
		Publish an annual environmental sustainability report
		Environmental certification of freight carriers
		Environmental management system: ISO 14001
		Green behaviour practices
	External environmental management practices	Coordinated logistics and transportation programs
		A collaborative partnership with other freight transport companies
		Sharing information on greenhouse gas goals
		Sustainability assessment department in logistics companies
	Freight distribution and fleet operations practices	Use of alternative fuels
		Use of less polluting vehicles
	Packaging and freight terminal practices	Energy-efficient freight terminals
Promote the use of green containers		
Green knowledge management practices	Quality of human resources	
	Provide incentives and benefits for green behaviour practices	
Social	Internal human resources	Employment stability
		Occupational health & safety certification
		Continues learning, development, and improvement
		Regular training on traffic and driving practices
	External population	Donation to primary education and community health services
		Promoting cultural diversity in the workplace
		Prevent forced and compulsory labour
		Provide sanitation, drinking water facilities to the workers
	Stakeholder participation	Mutual trust among other transport organisations
		Influence of other transport stakeholders
	Macro social performance	Global presence of the organization
		Provide indigenous rights to stakeholders and workers
		Prevent corruption in their business practices

Besides, **sustainability assessment frameworks support informed decision-making by defining key enablers and barriers to sustainable development**. Factors such as management commitment, regulatory pressure, and customer expectations are frequently identified as critical drivers of the sustainable development of companies (Shoib et al., 2023; Vienažindiene et al., 2021). By categorizing and prioritizing relevant sustainability attributes (e.g., green transportation, waste reduction, and

corporate social responsibility), these frameworks direct organizational focus toward high-impact initiatives (Vienažindiene et al., 2021; Yontar, 2022). This structured approach also improves transparency and facilitates communication with key stakeholders, such as customers, regulatory bodies, and business partners, using consistent and comparable metrics (A. Gupta et al., 2022; A. Gupta & Singh, 2020).

In short, the use of comprehensive sustainability frameworks contributes to the green transition of the logistics sector by establishing a common language and methodology for evaluating sustainability performance, enabling comparability across actors, fostering regulatory compliance, and guiding investment and innovation towards low-carbon, socially inclusive, and resource-efficient practices. They facilitate the identification of research and implementation gaps, promote the dissemination of best practices, and support the development of policies and standards aimed at enhancing sustainability in the logistics industry (Evangelista et al., 2018). By addressing all dimensions of sustainability in an integrated approach, these frameworks ensure that logistics companies not only meet current expectations and regulations but also play an active role in advancing sustainable development objectives.

2.1.2 Review of sustainability frameworks in the logistics & transport sector

A comprehensive literature review was conducted to examine **the current landscape of sustainability frameworks and their associated methodologies within the context of logistics and transport**. This review aimed to understand how various frameworks address the integration of technological applications alongside environmental, social, and governance (ESG) dimensions. The focus was placed on identifying prevailing trends, theoretical underpinnings, and practical implementations that contribute to sustainable practices in the logistics and transport sectors.

The review was conducted using the SCOPUS database, ensuring comprehensive and multidisciplinary coverage of academic publications. A total of 78 documents were retrieved, reflecting a diverse range of perspectives and research approaches. These documents were systematically analysed to highlight how sustainability frameworks are conceptualized and applied, particularly in relation to digital technologies, carbon footprint reduction, social equity, and governance structures within the supply chain and transport ecosystems. After some iterations, the final search query used in SCOPUS is as follows:

```
("Sustainability Framework" OR "Sustainability Approach" OR "Sustainability Model") AND  
("Logistics" OR "Supply Chain" OR "Freight" OR "Intermodal Freight" OR "Freight Transport")  
AND PUBYEAR > 2018 AND PUBYEAR < 2026
```

To improve the analysis of the retrieved literature, the software VOSviewer (version 1.6.20) was used to perform keyword co-occurrence analysis on the 78 selected documents. This tool helped identify key thematic areas by visualizing the frequency and connections of terms used across the publications. Using clustering algorithms, VOSviewer grouped related keywords into distinct clusters, providing a deeper understanding of the conceptual structure and research emphasis within the field of sustainability in logistics and transportation. This visual mapping supported the identification of major topics, emerging trends, and possible research gaps within the reviewed body of literature. Figure 1 presents the relationship between co-occurring keywords extracted from the literature.

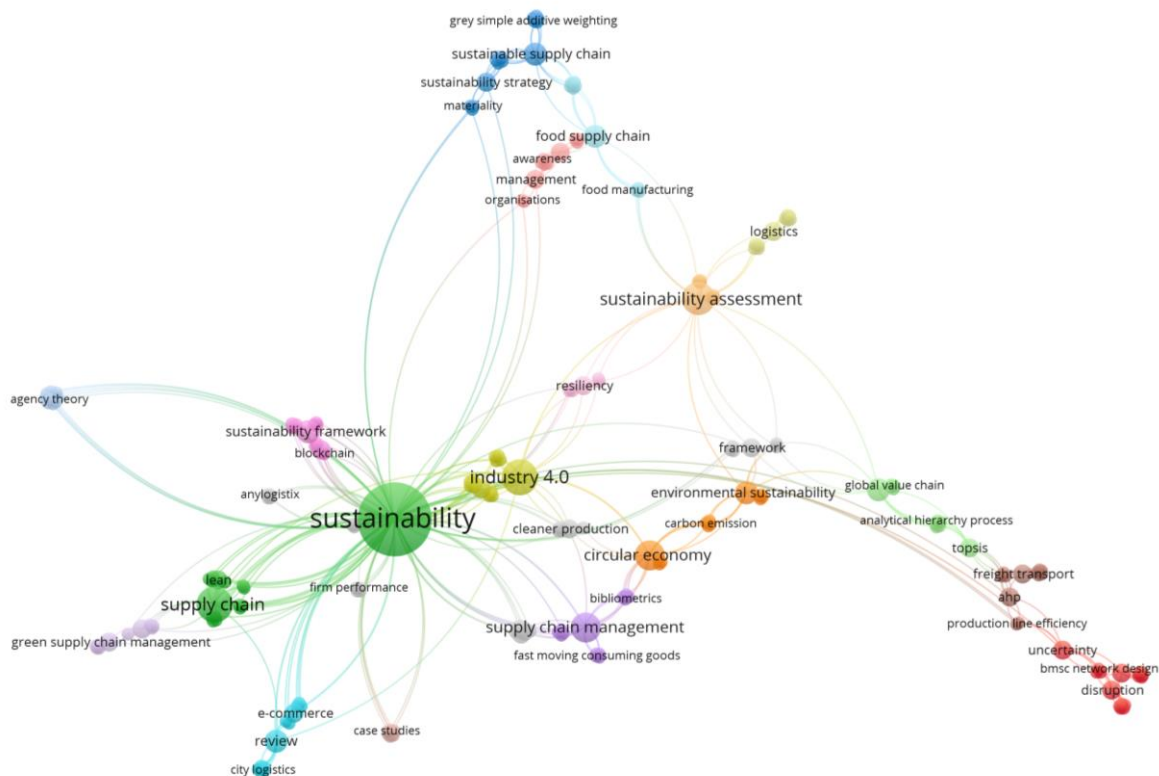


Figure 1: Network visualisation of the keywords co-occurrence links in the 78 papers retrieved

It is possible to identify in Figure 1 that several clusters are formed, each represented by a different colour. The **green cluster** is the most interconnected, orbiting around *sustainability*. It is directly linked to keywords such as *sustainability framework*, *supply chain*, *firm performance*, *blockchain*, *city logistics*, *green supply chain management*, and others. Arrows show a web of interrelations suggesting a strong foundation in holistic and strategic sustainability practices, often enhanced by emerging technologies like *blockchain* and platforms like *AnyLogic*. This cluster **indicates that sustainability initiatives are increasingly being paired with technologies** like blockchain and modelling tools. Practically, this suggests companies can improve supply chain transparency and traceability, optimize logistics operations, and better monitor ESG indicators through tech-enabled frameworks.

The **light blue cluster** focuses on applying sustainability in specific domains, particularly in the *food supply chain*, *manufacturing*, and *organizational management*. The connection to terms like *awareness*, *materiality*, and *grey simple additive weighting* **highlights methodological approaches to decision-making under sustainability strategies**. With its emphasis on methodologies like grey simple additive weighting and organizational awareness, this cluster underscores the value of structured decision-making tools. In practice, these help firms evaluate and rank sustainable alternatives, manage supplier risk, and select greener options in procurement and distribution.

The **light orange cluster**, with a central theme of sustainability assessment, brings attention to frameworks that evaluate sustainability, terms like *resiliency* and *logistics* suggest models are being used **to strengthen supply chain stability and adaptability**. This theme connects to frameworks **assessing supply chain resiliency**. Businesses could apply these insights to develop logistics strategies

that withstand disruptions, such as natural disasters, geopolitical tension, or market volatility, while maintaining sustainability goals.

The **yellow cluster** has a central theme of Industry 4.0 with ties to *cleaner production*; this cluster positions **Industry 4.0 technologies as enablers of environmental efficiency**. The direct connection underlines how advanced manufacturing tools are central to modern sustainable logistics. The link between smart technologies and environmental performance suggests the real potential for integrating IoT, automation, and data analytics into cleaner logistics practices. On the other hand, **the absence of literature addressing Industry 5.0 may reflect the need for more research and innovation in collaboration with the industry and stakeholders**.

The **dark orange cluster** identifies **the circular economy as a stand-alone yet crucial concept**, with *bibliometrics* hinting at a growing academic interest in this domain. Companies might adopt reverse logistics, remanufacturing, or waste valorisation strategies to align with circular economy principles, reducing both costs and environmental impact.

The **red cluster focuses on disruption**. This dynamic cluster involves terms like *uncertainty*, *bmsc network design*, and multi-criteria decision tools like *TOPSIS* and *AHP*. The presence of *freight transport* and *production line efficiency* signals operational risk and resilience planning under disruptive forces. The prominence of tools like *TOPSIS* and *AHP* signals a need for multi-criteria decision-making under uncertainty. Logistics managers can apply these to balance trade-offs among cost, speed, sustainability, and risk in network design or freight mode selection.

The **lilac cluster** refers to the stand-alone concept of **Agency Theory**, which considers that the relationship between the principal and the agent should reflect efficient organization of information and risk-bearing costs (Fiorini et al., 2018). This single-node cluster suggests a niche or conceptual lens that is possibly applied in governance or organizational behaviour analysis within sustainability research. Though isolated, the presence of agency theory hints at governance-focused applications, such as designing incentive structures or aligning stakeholder interests in sustainability initiatives.

Technology-related literature

The integration of Industry 4.0 (I4.0) technologies within supply chains has prompted significant methodological innovation to enhance sustainability outcomes, particularly in logistics. Several studies have adopted diverse approaches to model, assess, and validate the potential of I4.0 tools in transforming traditional logistics systems into greener, more efficient frameworks.

Schilling et al. (2024) present a **conceptual technology-oriented framework** that maps the relationship between digital transformation and sustainable supply chain management (SSCM) into three interconnected domains: **eco-efficiency, eco-durability, and substantial sustainability**. Drawing on a systematic review of 64 peer-reviewed journal articles, the framework highlights how technologies such as the Internet of Things (IoT), artificial intelligence (AI), blockchain, and big data analytics enhance resource optimization, traceability, and ethical sourcing. Eco-efficiency emphasizes waste reduction and lead-time improvements, while eco-durability focuses on circular-economy integration and supply-chain resilience. The domain of substantial sustainability addresses deeper societal and environmental impacts, which remain underexplored. Methodologically, the study combines

frequency and contingency analyses to detect thematic patterns and variable relationships, leading to the development of the three-part framework (i.e., eco-efficiency, eco-durability, and substantial sustainability). The study demonstrates operational and environmental gains in the studies reviewed (73% and 68% of reviewed cases, respectively) and that supply chain practices are increasingly being shaped by both sustainability (e.g., emission reduction, circular economy initiatives) and digital transformation (e.g., data-driven decision-making, end-to-end supply chain visibility).

Fatahi et al. (2020) developed a forward-looking assessment framework for supply chains that combines digital twin simulations with IoT sensor networks. This allows for real-time monitoring of supply chain parameters across corporate, environmental, and social dimensions. The model was empirically validated in the automotive sector, demonstrating a notable reduction in transportation-related emissions by 18% and a 23% decrease in energy usage within warehousing facilities through enhanced inventory management.

Complementing this, Canas et al. (2020) adopted a systematic literature review to map the foundational components of I4.0-driven supply chains. By emphasizing IoT, blockchain technologies, and AI analytics, the study highlighted how blockchain implementation significantly lowered the prevalence of counterfeit goods by 40%, while AI-enhanced demand forecasting reduced overstock waste by 30%, two outcomes with substantial implications for logistics optimization.

Similarly, Jamwal et al. (2021) employed a mixed-methods design, incorporating survey data from over 200 Micro, Small, and Medium Enterprises (MSMEs) along with qualitative case studies. Structural Equation Modelling (SEM) was leveraged to identify causal links between I4.0 adoption and sustainability performance, revealing that IoT-enhanced fleet management yielded a 15% reduction in fuel consumption and that predictive maintenance decreased delivery delays by 28%.

Another notable contribution is found in Gupta et al. (2021), where the researchers propose an integrative framework that enables manufacturing organizations to assess and enhance ethical and sustainable performance by aligning the principles of Industry 4.0 (I4.0), Cleaner Production (CP), and the Circular Economy (CE). This framework articulates a set of 18 prioritized practices (Table 4), derived from a systematic literature review of 85 peer-reviewed articles and refined through expert consultation using the Delphi Method, which reflect the **convergence of digital transformation, resource efficiency, and circularity**. It is stated that Industry 4.0 contributes through technologies like IoT, big data analytics, smart factories, additive manufacturing, and robotics to support traceability, intelligent decision-making, and optimized operations. Cleaner Production promotes proactive environmental strategies such as waste reduction, eco-design, and workforce engagement, while the Circular Economy emphasizes systemic sustainability through reuse, recycling, supply chain traceability, and product life cycle management. To evaluate and prioritize these practices, the study employs the Best-Worst Method (BWM), a robust multi-criteria decision-making tool that quantifies expert preferences via pairwise comparisons. The framework is empirically validated through its application in five manufacturing organizations, where practices related to the Circular Economy, particularly supply chain traceability, reuse and recycling infrastructure, and maintaining a clean environment, emerge as most influential, followed by practices from CP and I4.0. The results from the study uncover the utility of the framework for guiding managerial decisions, assessing sustainability

maturity, and informing both organizational strategy and public policy in promoting sustainable industrial transformation.

Table 4: Practices for ethical and sustainable business development by Gupta et al., 2021

Main criteria/practices	Sub-criteria/practices	Description
Industry 4.0	IoT (Internet of Things)	This involves integrating smart devices with sensors and actuators to capture and transmit real-time data on product returns and waste across the supply chain
	Big data technologies	Big data analytics support sustainability by enabling real-time supply chain insights into energy use, waste, returns, and maintenance
	Smart factory and Cloud manufacturing	Cloud manufacturing in smart factories enables cross-organizational data sharing, enhancing system performance, lowering costs and waste, and boosting flexibility and agility.
	Additive manufacturing and 3-D printing technologies	Additive manufacturing, or 3D printing, builds products layer by layer with minimal waste, unlike traditional subtractive methods, and if scaled, it could substantially lower production costs.
	Robotic systems	Modern robots enhance flexibility, safety, and cost-efficiency by automating production, reducing waste, and creating safer workplaces.
Sustainable and cleaner production	Top management commitment	Management support for green practices drives progress toward sustainability goals and fosters ethical, sustainable business growth.
	Energy and material use	This refers to minimizing the use of water, materials, and energy in production, while increasing reliance on renewable energy sources.
	Natural and clean environment	This refers to minimizing and recycling production waste and by-products, while reducing or eliminating hazardous substances harmful to human health.
	Packaging and design	This refers to designing products for easy disassembly, reuse, or recycling, with eco-friendly, biodegradable packaging that minimizes waste.
	Competency and skilled building of the workforce	This involves training workers and managers on cleaner, sustainable production and building skills in areas like sustainable design, waste reduction, recycling, and product reuse.
	Supply chain collaboration and integration	This involves collaborating with suppliers and vendors through precise information sharing on raw material needs and product returns to minimize waste and maximize reuse and recycling across the supply chain.
Circular economy	Reuse and recycling infrastructure	This refers to having in-house recycling facilities that allow components to be recovered and reused once a product reaches the end of its life.

Main criteria/practices	Sub-criteria/practices	Description
	End of life determination	This refers to using technologies that accurately determine a product's end of life, allowing valuable components to be recovered for reuse or recycling.
	Supply chain traceability/information	This refers to having access to detailed data on production, consumption, and waste at each supply chain stage, enabling efficient resource use, recycling, and waste reduction.
	Reduction in supply-related risks	Circular economy initiatives promote increased reuse, recycling, and refurbishing of components, reducing reliance on suppliers and minimizing supply chain risks.
	Legal compliance	Government regulations and compliance requirements encourage organizations to adopt circular economy practices by prioritizing recycling, resource reuse, and waste reduction.
	Investment recovery and long-term profits	Adopting circular economy practices increases recycling and material reuse, cuts waste-related losses, and boosts long-term profitability.
	Global standards and sustainability goals	Environmental standards like ISO 14001 and UN sustainability goals encourage organizations to integrate circular economy practices into their value chains to meet environmental targets.

The study by Krishnan et al. (2024) examines how advanced Industry 4.0 technologies support business model innovation (BMI) in pursuit of sustainable supply chains (SCC), focusing specifically on the Indian automotive industry. At its core, it introduces the **'I4.0-enabled BMI for SC Sustainability' framework**, which clearly defines the link between I4.0 tech, flexible business capabilities, and collaborative supply chain practices to boost environmental and operational results. This framework incorporates essential I4.0 technologies, such as the Internet of Things (IoT), cloud computing, additive manufacturing, data analytics, and automation, aligning them with business models based on the principles of dynamic capability theory. It also highlights the strategic importance of collaboration between large manufacturers and small suppliers to facilitate technology adoption and sustainability efforts. The research finds that applying I4.0 technologies improves operational efficiency, creates new value opportunities, and promotes environmentally responsible supply chain practices. Specifically, the study found that **collaboration among supply chain partners is vital, especially in helping smaller, less-equipped suppliers adopt new technologies**. The observed sustainability improvements include lower resource use, more efficient production processes, and better ecological performance of products. Moreover, the study emphasizes that I4.0 technologies strengthen the dynamic capabilities of companies, enabling them to respond more quickly and effectively to market changes and environmental challenges.

The evolving landscape from Industry 4.0 to Industry 5.0 reflects a transformative shift in industrial paradigms, particularly in logistics, manufacturing, and sustainable development. Central to this transition is the reconfiguration of value chains, where automation and technology-centric operations give way to human-centric, collaborative, and sustainable ecosystems. A literature review performed

by Monferdini et al. (2025) underscores the importance of technological enablers such as artificial intelligence, the Internet of Things, and collaborative robotics, while simultaneously highlighting the increasing role of human-machine integration, resilience, and ethical considerations. A systematic analysis of recent advancements reveals that Industry 5.0 fosters personalization, agility, and innovation through co-working models that fuse human creativity with machine precision. Notably, the fusion leads to improved sustainability outcomes, reduced waste, and alignment with circular economy principles.

Costa (2024) further explores the Industry 5.0's contribution to achieving United Nations Sustainable Development Goal 9 (i.e., fostering resilient infrastructure, inclusive industrialization, and innovation), through frameworks, such as the TBL, to produce human-centric, sustainable, and resilient business models, which can promote resilient infrastructure, inclusive industrialization, and innovation. Cases involving Cobots (collaborative robots) and smart factories demonstrate how adaptive supply chains can respond effectively to crises such as the COVID-19 pandemic. However, disparities in global standards and limited empirical research hinder widespread adoption. To mitigate these barriers, strategic recommendations emphasize the need for circular production systems, investment in workforce retraining, and business model innovation.

A hybrid systematic review performed by Ciasullo et al. (2025) also consolidates qualitative and quantitative findings to advocate for integrated approaches that balance economic, social, and environmental priorities. Digital maturity, inclusive workforce strategies, and ecosystem innovation are recognized as cornerstones for sustainable transformation in Industry 5.0. Across these studies, there emerges a consistent call for future research to delve into the interplay between emerging technologies, human values, and metrics of sustainability, ultimately reframing industrial progress in terms of resilience, inclusiveness, and ethical responsibility.

Advanced AI methodologies were further explored by Jamwal et al. (2022) by the application of convolutional and recurrent neural networks (RNN) to smart factory datasets for real-time anomaly detection. This approach achieved a 92% accuracy rate in predicting delivery failures, consequently minimizing emissions, while AI-directed warehouse robots improved energy efficiency by 25% through optimized navigational routines.

In a more field-deployed context, the study performed by Hassan et al. (2023) explores the transformative role of the Internet of Things (IoT) in promoting sustainability within transportation systems in a real-world sustainable transportation fleet (e.g., electric buses, hybrid cars, electric trucks, CNG-powered vans) (Table 5). It introduces a comprehensive **Smart Transportation Framework** that integrates sensor networks, big data analytics, robust communication infrastructure, and intelligent decision-making modules. These components collectively facilitate real-time data collection and processing related to vehicle location, traffic flow, weather conditions, and parking availability. By enabling dynamic interaction between vehicles, infrastructure, and centralized control systems, the framework supports congestion reduction, energy efficiency, and environmentally responsible transportation practices. Furthermore, the study combines the deployment of IoT hardware, such as sensors and RFID tags, with advanced data processing techniques rooted in machine learning and big data analytics. The framework is tested through MATLAB-based simulations and real-world case studies focusing on urban traffic management and smart parking. Key outcomes include significant

reductions in travel time and fuel consumption, enhanced traffic safety through real-time monitoring and collision avoidance, and improved operational efficiency via automated systems.

Table 5: Features of IoT-based green transportation by Hassan et al., 2023

Feature	Description	Benefits
Real-time data collection	Sensors gather live data on vehicles and the environment	Improve traffic flow, quick response
Big data analytics	Multivariate and machine learning analyses	Predictive insights, optimized routing by simultaneously minimizing carbon emissions, operational costs, and maximizing equitable distribution of workload among heterogeneous vehicles in the fleet
Automated parking	Smart allocation and reservation of parking spaces	Reduced congestion, user convenience
Vehicle tracking & location	Accurate monitoring of vehicle positions	Enhanced safety, efficient logistics
VANET communication	Inter-vehicle data exchange	Collision avoidance, traffic updates
Pollution avoidance	Route and mode optimization for lower emissions	Environmental sustainability

Collectively, these studies illustrate a robust and growing body of evidence that underscores the efficacy of I4.0 technologies in promoting logistics sustainability. Through varied yet complementary methodologies, each paper contributes to a nuanced understanding of how digital transformation enables greener and more responsive supply chain systems.

Multidimensional and social sustainability approaches

A systematic literature review was conducted by Truant et al. (2024) to examine how Environmental, Social, and Governance (ESG) principles are applied in supply chain management to inform business strategy. Using bibliometric analysis, the study evaluates recent scholarly work, synthesizes key findings, and identifies areas for future research. A conceptual framework is introduced, highlighting the **importance of transparency, the role of policymakers, and the influence of ESG adoption on supply chain performance**. The research reveals growing academic and industry attention to ESG, particularly around transparency and regulatory impact. ESG integration is shown to affect operational performance and poses both opportunities and challenges.

Additionally, Whitelock (2019) introduces a multidimensional framework for Environmental, Social, and Governance (ESG) sustainability within purchasing, operations, and supply chain management, grounded in stakeholder theory. The framework conceptually maps the relationships among integration practices, ESG initiatives, and key supply chain actors, aiming to align sustainability and financial reporting. It emphasizes **integration as collaborative efforts between individuals and organizations to support ESG implementation**, particularly in firms lacking formal sustainability strategies (Table 6). By addressing limitations in existing models, the framework offers practical

guidance for researchers and practitioners seeking to enhance supply chain performance through strategic ESG integration.

Table 6: Environmental, social, and governance sustainability framework by Whitelock, 2019

Domain	Materials/initiatives
Environmental	Reduce the amount of energy consumed in the process
	Reduce the price/cost of energy consumed in the process
	Reduce the amount of wasted material generated by the process
	Reduce the cost of wasted material generated by the process
	Reduce the amount of non-recyclable packaging materials used by the process
	Reduce the cost of non-recyclable packaging materials used by the process
	Improve product yield in the process
	Reduce the cost of raw materials used in the process
	Reduce the amount of chemicals and toxic solvents used in the process
	Improve air quality by reducing asbestos, mold, radon gas, and the use of volatile organic compounds
Social	Reduce the number of lawsuits for pay imbalances (i.e., employees performing similar work are paid differently, with the differences not being justified by factors like skill, experience, or performance)
	Reduce the cost of lawsuits for pay imbalances
	Reduce the number of injuries
	Reduce the cost of injuries
	Increase opportunities for career advancements
	Increase opportunities for training and skill-building
	Increase the brand equity of the firm in the eyes of community members, customers, employees, and regulators
	Increase the firm's ability to obtain higher prices (rents) than its competitors
	Increase the amount of repeat business gained by the organization
	Increase the amount of new business gained by the organization
Governance	Reduce incentives for employees to behave inappropriately or unlawfully
	Increase member diversity on the board of directors
	Increase the attendance rate of the board members attending the directors' meeting
	Increase the frequency of meetings to recover from poor performance, faster
	Increase stability by managing the orderly succession of board members' teams
	Increase shareholders' interest and board flexibility by separating the CEO and chairman roles
	Increase the quality of board members' skill sets by appointing and retiring members as needed of the company's dictates

Domain	Materials/initiatives
	Increase the frequency of the audit committee meetings to carry out its function of control and risk management
	Increase the company's independence, transparency, and ability to obtain higher prices than its competitors
	Increase the reputational equity of the company in the eyes of customers, employees, investors, and regulators

Moreover, Valinejad et al. (2022) present a **comprehensive framework for managing sustainability-related risks within supply chains**, tailored specifically to the telecommunication sector (Table 7). The study focuses on a three-phase hybrid model that integrates Failure Mode and Effects Analysis (FMEA) and the Fuzzy VIKOR multi-criteria decision-making technique, structured around five dimensions of sustainability: environmental, economic, social, technical, and institutional. The model initiates with the application of FMEA to systematically identify and classify potential risks based on the Risk Priority Number (RPN), calculated by multiplying scores for severity, occurrence, and detection. Risks are then segmented into critical, semi-critical, and normal categories using statistical thresholds. The second phase applies Fuzzy VIKOR to only the critical risks, incorporating additional sustainability-related criteria, such as uncontrollability, complexity, comprehensiveness, and durability, beyond the traditional FMEA scope. Expert judgments are captured using linguistic variables and converted into fuzzy numerical values, allowing the model to rank critical risks with greater nuance and reliability. In the final managerial phase, root causes and consequences of critical risks are analysed, and strategic responses are formulated. The entire process culminates in a detailed risk management report, offering prioritized actions for decision-makers. The study finds that the integration of five sustainability dimensions (i.e., environmental dimension, social dimension, economic dimension, technical dimension, institutional dimension) provided a holistic risk perspective, with approximately 70% of risks falling into the semi-critical category, underscoring the need for proactive mitigation. Ultimately, the research confirms that combining FMEA and Fuzzy VIKOR within a five-dimensional sustainability framework produces a more robust and actionable risk prioritization tool.

Table 7: Structure of the framework presented by Valinejad et al., 2022

Structure of the framework	Description
FMEA phase	Identifies and classifies all potential supply chain risks
	Uses the traditional Risk Priority Number (RPN) method, which multiplies severity, occurrence, and detection scores
	Segregates risks into critical, semi-critical, and normal based on statistical thresholds
Fuzzy VIKOR phase	Applies only to the critical risks identified by FMEA
	Ranks these risks using a multi-criteria decision-making approach that incorporates additional sustainability-related criteria beyond the basic RPN factors
	Utilizes fuzzy logic to handle uncertainty in expert judgements
Managerial phase	Analyses root causes and potential consequences of each critical risk
	Proposes treatment strategies (avoidance, control, transfer, or acceptance)

Structure of the framework	Description
	Compiles a risk management report detailing ranking, causes, consequences, and strategies for each risk

Fernando et al. (2022) propose a **conceptual framework that links sustainable social supply chain practices to firm-level social performance** and empirically validates these connections through statistical analysis of firm-level data (Figure 2). The framework centres on critical practices such as fair labour conditions, ethical sourcing, supplier diversity, and community engagement, positioning them as integral components of socially responsible supply chain management. By operationalizing these practices within the empirical model, the study quantifies their influence on various indicators of social performance, including corporate reputation, employee well-being, and stakeholder trust. The study results demonstrate a significant positive relationship between the adoption of sustainable social supply chain practices and improved social outcomes at the firm level.

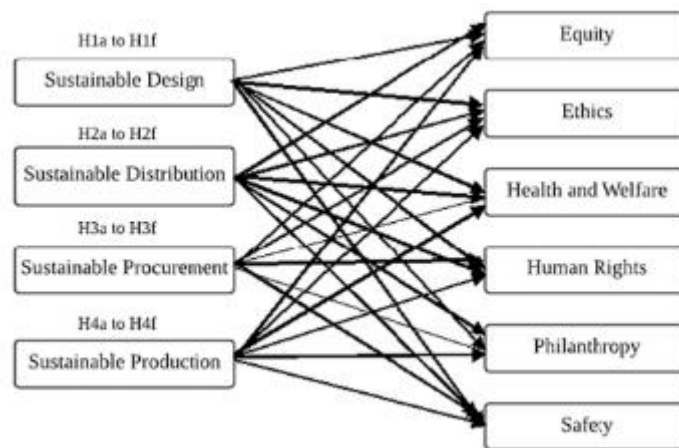


Figure 2: Components of the framework proposed by Fernando et al., 2022

Kumar & Anbanandam (2022b) develop an **integrated multi-criteria decision-making (MCDM) framework for assessing environmental and social sustainability (EnSoS) performance in the freight transportation industry**, utilizing the fuzzy best-worst method (FBWM) and fuzzy logic. The framework, validated through a case study in the Indian freight sector, incorporates two sustainability enablers, nine dimensions, and sixty-three attributes (in bold are the ones of higher importance for ADMIRAL), ten of which are newly introduced, to provide a comprehensive sustainability evaluation (Table 8). FBWM is applied to determine the relative importance of each attribute, while fuzzy logic facilitates performance assessment, resulting in two key indices: the fuzzy transportation EnSoS index (FTEEnSoSI) and the fuzzy performance importance index (FPII). Findings indicate that the Indian freight sector approaches a high sustainability classification, although thirty attributes are identified as barriers to progress. Based on these insights, the study proposes policy interventions to address performance gaps and strengthen the sustainability profile of freight transportation systems.

Table 8: Sustainability enablers used by Kumar & Anbanandam, 2022b

Domain	Dimension	Attribute
Environmental	Internal environmental management practices	Formation of organizational environmental sustainability goals
		Environmental compliance and audit programs
		Environmental performance and monitoring practices
		Publish an annual environmental sustainability report
		Environmental certification of freight carriers
		Environmental management system
		Green behaviour practices
		Support from the top management
	External environmental management practices	Coordinated logistics and transportation programs
		A collaborative partnership with other freight transport companies
		Sharing information on greenhouse gas goals
		Compliance with governmental transport emission law and practice
		Competitive pressure from other transport firms
		Sustainability assessment department in a logistics company
	Freight distribution and fleet operations practices	Use of alternative fuels
		Use of intermodal/multimodal transport for the long haul
		Eco-driving and monitoring driving speed practices
		Avoid empty hauling practices
		Routing techniques to minimize travel distances
		Use of less polluting vehicles
		Sharing a freight vehicle with other transport companies
		Use of long and heavy vehicles
	Packaging and freight terminal practices	Use of recyclable freight vehicles
		Energy-efficient freight terminals
		Efficient land use for the terminal building
		Energy-efficient material handling equipment
		Efficient land use for the terminal building
		Promoting the use of green containers
		Eco-friendly warehouse design
	Green knowledge management practices	Promoting an environmental awareness program for employees
		Quality of organizations' human resources
		Environmental knowledge sharing among freight shippers

Domain	Dimension	Attribute
Social		Employees' green awareness training
		Incentives for green behaviour practices
	Internal human resources practices	Opportunities for equal employment
		Employment stability
		Health and safety practices
		Occupational health and safety certifications
		Continuous learning, development, and improvement
		Nighttime driving hours restrictions
		Adequate claims for workers' death/injury
		Regular monitoring of employee wages
		Regular training on traffic and driving practices
		External population practices
	Reduce the impact of noise on local communities	
	Supporting community projects	
	Training programs for security personnel	
	Provide safety equipment for transport workers	
	Prevention of child labour	
	Promoting cultural diversity in the workplace	
	Prevention of forced labour practices	
	Provide sanitation and drinking water facilities to the workers	
	Stakeholder participation	Develop a mutual trust among other transport organizations
		Deliver reliability for each freight consignment
		Fair employment practices
		Right to vote and political freedom
		Influence of other transport stakeholders
		Freedom of expression
	Macro social performance practices	Global presence of the organization
Provide indigenous rights to stakeholders and workers		
Prevent corruption in business practices		
Adoption of anti-corruption policies and procedures		
Contribute to the national GDP		

Table 8 presents the essential elements for promoting sustainability within the freight and logistics sector. These elements are aligned with the 22 selected key performance indicators (KPIs) under Task 2.4 of the ADMIRAL project and its Deliverable 2.4 (Dais et al. 2025). The scope of the project

encompasses a multifaceted approach to enhancing the sector's sustainability, including: improving environmental performance across freight and logistics enterprises; fostering collaborative engagement among diverse stakeholders throughout the supply chain; promoting the adoption of intermodal and multimodal transport solutions for long-distance haulage; transitioning to low-emission vehicles and transport modes; advancing equal employment opportunities; and facilitating green and technology-oriented training programs for the workforce.

Hossein Shahidzadeh & Shokouhyar (2023) introduce a hybrid multi-criteria decision-making (MCDM) framework to support the development of a **closed-loop sustainability model in reverse logistics**: through integrating the Fuzzy Delphi Method, DEMATEL, and the Analytic Network Process (ANP), the model identifies and analyses critical barriers, causal relationships, and prioritizes sustainability dimensions across economic, environmental, and social pillars. Drawing on the Triple Bottom Line (TBL), circular economy principles, and stakeholder governance, the framework addresses key sustainability metrics, including emissions reduction, cost efficiency, and stakeholder engagement. Empirical analysis highlights major implementation challenges, including insufficient regulatory incentives, technological limitations, and misalignment among stakeholders. Additionally, the study reveals performance trade-offs between environmental and operational outcomes, with environmentally optimized solutions incurring higher costs and cost-focused models reducing social gains. By facilitating visualized Pareto-optimal decision-making, the model improves strategic planning efficiency, achieving 37% faster consensus-building across resource allocation, facility siting, and recovery process design.

Paybarjay et al. (2024) investigate **how supplier development can be enhanced through sustainability-oriented segmentation**. It introduces an integrative framework that incorporates economic, environmental, and social dimensions into supplier management practices. Departing from conventional approaches, the paper proposes a multi-dimensional segmentation model in which suppliers are evaluated against sustainability indicators in the economic, social and environmental criteria (Table 9). Suppliers are classified using a matrix model based on quantitative variables such as average yearly volume and frequency of site visits. This matrix facilitates the grouping of suppliers into categories like priority, attractive, and auxiliary, with each segment receiving tailored development strategies. In addition, multi-criteria decision-making methods, such as the Best-Worst Method and clustering algorithms, are critically assessed to identify best practices in supplier evaluation. The empirical case study supports the theoretical model by applying the framework to real-world data, where suppliers are sorted into performance tiers across each criterion, resulting in a nine-segment classification that is used to inform management recommendations. For example, priority suppliers benefit from formal agreements, structured reward systems, and the use of intelligent packaging, whereas auxiliary suppliers are managed more flexibly with minimal incentives and ad hoc collection schedules. Therefore, the integration of sustainability dimensions into supplier segmentation enables more precise resource allocation and strategic development. Environmental criteria emerge as central to supplier selection and classification, demonstrating a growing corporate emphasis on reducing ecological impact.

Table 9: Sustainability criteria proposed by Paybarjay, 2024

Domain	Category	Factor	Sub-factor
Economic	Strategic performance	Cost	Low initial price
		Quality	Compliance with the cost analysis system
			Cost reduction activities
			Compliance with sectoral price behaviours
			Conformance quality
			Consistent delivery
			Philosophy of quality
			Prompt response
		Time	Speed of delivery
			Time of product development
			Contract information time
		Flexibility	Product volume changes
			Short set-up time
			Conflict resolution
	Service delivery		
	Innovativeness	New launch of products	
		Using new technology	
	Organizational factors	Culture	Feeling of trust
		Technology	Technological compatibility
			Evaluation of future manufacturing
			Suppliers' speed of development
			Suppliers' design capability
			Technical capability
Current manufacturing facilities/capabilities			
Relationship		Long-term relationship	
		Relations closeness	
	Communication openness		
Environmental	Environmental practices	Pollution control	Remediation
		Pollution prevention	Ending of pipes controls
			Product adaptation
			Process adaptation

Domain	Category	Factor	Sub-factor
		Environmental management system	Establishment of environmental commitment and policy
			Identification of environmental aspects
			Planning for environmental objectives
			Assignment of environmental responsibility
			Checking and evaluating environmental activities
	Environmental performances	Resource consumption	Energy consumption
			Pollution production
			Raw material consumption
			Water consumption
			Producing polluting agents
	Production of toxic products		
	Waste production		
Social	Internal social criteria	Employment practices	Disciplinary and security practices
			Employee contracts
			Equity towards labour sources
			Discrimination
			Flexible working arrangements
			Job opportunities
			Staff rewards
			Research and development
			Career development
			Child labour
			Working hours
			Freedom of association
		Health and safety	Health and safety associations
			Health and safety practice
			Incidents/accidents records
			Hazard and assessment record
			Casualty compensation
		Laborers' occupational health and safety management system	
		External social criteria	Local communities influence
	Education		
	Housing		

Domain	Category	Factor	Sub-factor
			Service infrastructure
			Mobility infrastructure
			Regulatory and public services
			Supporting educational institutions
			Sensory stimuli
			Security
			Cultural properties
			Economic welfare and growth
			Social cohesion
			Social pathology
			Grants and donations
			Supporting community projects
			Corruption
			Fine and punishment for violation of law and regulations
		Contractual stakeholder influence	Purchasing standards
			Partnership screen and standards
			Consumers education
		Other stakeholders influence	Decision influence potential
			Stakeholder empowering
			Collective audience (public)
			Selected audience
			Stakeholder engagement
			Disclosure of information

Senyo et al. (2023) present a transdisciplinary framework for sustainable multi-tier supply chains grounded in the triple bottom line (TBL) concept (i.e., broadening of business performance measurement beyond profit that includes social and environmental dimensions), developed through a systematic review of 64 articles. The framework comprises three interconnected components: the **sustainability conundrum**, which identifies the interplay among environmental (i.e., emissions, energy/water consumption, land use), social (i.e., human rights, labour safety, ethical conduct), and economic challenges (i.e., pricing, cost efficiency and profitability); the realization process, where digital technologies like blockchain, IoT, and AI promote transparency and accountability, strategic initiatives such as governance and supplier development foster multi-tier coordination; and sustainability assessment approaches, offering tools to evaluate TBL performance (Figure 3).

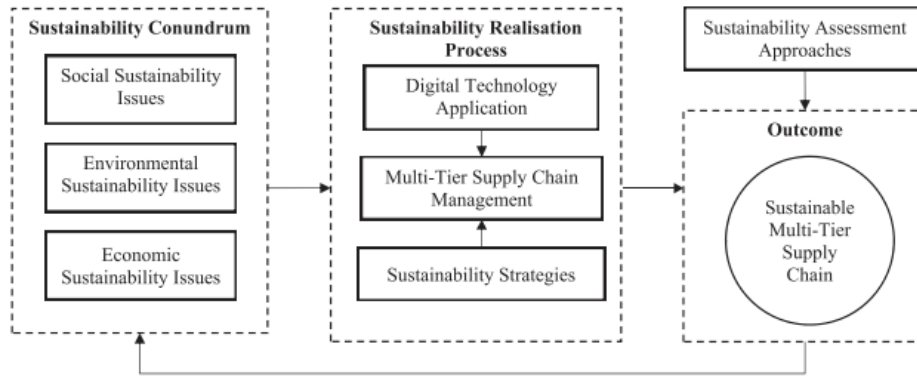


Figure 3: Sustainability multi-tier supply chain framework (Source: Senyo et al., 2023)

Besides, in the context of industrial systems, Njuaem and Ogundare (2023) apply the Triple Bottom Line (TBL) framework to assess the sustainability of globalized mining supply chains. Their model explores how globalization reshapes trade-offs and synergies across economic, environmental, and social dimensions, offering a decision-support tool for sustainable governance in mining operations (Table 10).

Table 10: Globalization effects on sustainability dimensions (Source: Njuaem and Ogundare, 2023)

Dimension	Effects
Economic	Trade
	Competition
	Income
	Economic growth
Social	Security
	Education
	Employment
	Land use
	EHS
	Human rights
Environmental	Air pollution
	Water quality
	Biodegradation
	Transportation

Akbari et al. (2022) present a **multi-criteria framework for the sustainable management** of Scotland’s North Sea fisheries that integrates six dimensions: i) economic growth (i.e., profitability and efficiency, and market stability), ii) social development (i.e., employment and equity, and community well-being), iii) governance structures (i.e., inclusive decision-making, cross jurisdictional coordination, and dynamic policy adjustments), iv) biological conservation (i.e., ecosystem-based targets to protect seafloor habitats, and scientific prioritization), v) environmental impact (i.e., ecosystem protection, and pollution control), and vi) logistical efficiency (i.e., technology adoption, vessel optimization, and supply chain resilience) to address post-Brexit challenges such as stock overexploitation and policy fragmentation. The study uses a mixed-methods approach, including stakeholder engagement and multi-criteria analysis, to identify and prioritize key management objectives. These include reducing marine litter and overexploitation, enhancing vessel efficiency, and establishing inclusive, transparent governance. Results reveal a divergence in priorities between industry stakeholders and scientific

communities, as industry emphasizes economic and social goals like employment and profit, and academia focuses on ecological objectives such as reducing bycatch and minimizing seafloor damage. The framework offers practical guidance for balancing competing priorities in fisheries governance, underscoring the importance of participatory, context-sensitive policymaking.

Telukdarie & Munsamy (2024) present a **comprehensive framework for sustainable business process optimization** that integrates the triple bottom line dimensions: i) economic (i.e., maximizing revenue and minimizing costs), ii) environmental (i.e., reduction of ecological impact from waste and emissions), and iii) social (i.e., enhancement of stakeholder fair labour practices) into a multi-objective modelling approach grounded in Industry 4.0 principles. The framework leverages mathematical techniques, such as weighted sum and Tchebycheff methods, to resolve trade-offs between conflicting objectives, like cost reduction and sustainability enhancement. Stakeholder input is central to the model, with priorities gathered through questionnaires and brainstorming, informing the weighting of goals. Validated through real-world case studies, the framework demonstrates practical benefits including a 21.1% reduction in implementation costs, improved resource allocation across sustainability domains, and Pareto-optimal solutions that balance profit, ecological impact, and social equity. This integrative approach offers a strategic pathway for organizations aiming to embed sustainability in digital transformation initiatives.

Askary et al. (2024) introduce a **multi-objective optimization framework for designing sustainable steel supply chain networks** that integrates economic (i.e., minimizing logistics and production costs), environmental (i.e., environmental impact mitigation), and social (i.e., boosting job creation) objectives under uncertainty. Structured around a three-tier system (i.e., suppliers, steel factories, and downstream manufacturers), the model uses mixed-integer programming to optimize facility location and material flows, incorporates sustainability metrics via multi-criteria decision-making, and employs robust scenario-based optimization to address fluctuating demand. Key features include cost minimization, production efficiency, and site selection based on infrastructure proximity, unemployment reduction, and environmental impact mitigation. Validated through a case study in Iran's steel industry, the framework demonstrates the ability to generate Pareto-optimal solutions and improve resilience, offering practical insights for policymakers aiming to balance profitability with socio-environmental responsibility in heavy industrial contexts.

Lotfi et al. (2024) propose a **Viable Supply Chain Network Design (VSCND) framework** that integrates blockchain technology to enhance transparency and security, two-stage robust optimization, and sustainability metrics to enhance transparency, resilience, and multi-dimensional viability across economic, environmental, and social domains. The framework operates at two decision stages, which are strategic facility location and blockchain deployment, followed by operational transshipment flows, under uncertainty, using advanced optimization techniques such as fix-and-optimize and Lagrange Relaxation to generate scalable, Pareto-efficient solutions. Notably, the incorporation of blockchain mitigates supply chain disruptions while embedding environmental considerations within cost and performance objectives. Case analysis reveals modest cost reductions (0.99%) and superior algorithmic performance, underscoring the framework's potential for resilient, transparent, and sustainable supply chain design.

Besides, Zhang et al. (2023) adopt a **stakeholder-institutional framework** to examine how governance mechanisms **within Global Value Chains (GVCs)** interact with local institutional contexts to influence supplier compliance with social sustainability practices. Through a survey of 356 manufacturers across South Asia, the study identifies factors like customer demands, organizational commitment, and stakeholder pressure as key drivers of adoption, finding that collaboration-based GVC governance models outperform transactional ones. In parallel, Primadasa et al. (2023) propose a barriers model framework to evaluate obstacles such as governance, labour rights, and cultural preservation in palm oil supply chains, emphasizing the dominance of governance-related barriers and the prioritization of economic goals over social initiatives (Table 11). Both frameworks converge on the insight that **aligning supply chain governance strategies with local institutional realities and fostering multi-stakeholder collaboration are essential for advancing social sustainability in global and emerging market contexts.**

Table 11: Features of the barriers Model Framework by Primadasa et al., 2023

Features of the framework	Description
Identification of barriers	Identification of distinct obstacles to social sustainability within the supply chain
ISM Model structure	The identified barriers are structured using the Interpretative Structural Modelling (ISM) approach, which organizes the barriers into a multi-level hierarchy
Clustering	The barriers are grouped into clusters and arranged across hierarchical levels, illustrating their interrelationships and the cascading effects of overcoming certain barriers before others

Moreover, Marzouk & Sabbah (2021) present a hybrid decision-making framework, “**AHP-TOPSIS Social Sustainability Approach for Selecting Supplier in Construction Supply Chain**”, that systematically integrates social sustainability criteria into supplier selection within construction projects in Egypt. Centred on three core components, the framework first identifies 17 sub-criteria across the social dimension (Table 12). Using the Analytic Hierarchy Process (AHP), it assigns weighted priorities to each criterion through pairwise comparisons, while the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) ranks suppliers based on their proximity to an ideal sustainability benchmark. Supported by field data from suppliers and refined through sensitivity analysis, the framework demonstrates effectiveness in emphasizing human rights and safety systems as dominant factors. Empirical application not only improved decision accuracy by 27% compared to single-method models but also reduced supply chain disruptions by 34%, showcasing the framework’s capability to balance quantitative and qualitative metrics for ethical, efficient, and socially responsible procurement.

Table 12: Sub-criteria selected by Marzouk & Sabbah (2021) for the framework

Sustainability dimension	Sub-criteria	Definition
Social	Rights of stakeholders	The capability of suppliers with respect to regulations and contractual relationships with the contractor
	Safety practices	Related to the safety and labour health of workers
	Contract labour	Engaging individuals or businesses for specific tasks or projects through a contractual agreement, rather than as traditional employment
	National origin	Non-discrimination in national origin
	Wages	Salary of employees according to their position
	Stakeholder relation	Strategies of the suppliers, the relations with a contractor, such as long-term relationships
	Ethnic	No regional discrimination
	Annual number of accidents	Accident rate – fatal accidents
	Colour	Non-discrimination in colour
	Occupational health and safety management system	Conducting code to meet the health and safety requirements, such as OHSAS18001
	Technical training of employees	Support for educational and job training programs
	Child labour	Working by children under 18 years is dangerous to their physical and mental health, and also prevents school attendance
	Working hours	Number of hours worked per week
	Social management commitment	Establishment of a social commitment team or department to manage and control social activities
	Social code of conduct	Conducting code to meet the social sustainability requirements
	Donation for a sustainable project	Funds donated for sustainability projects
Gender diversity	Female-to-male ratio	

Zhang & Chen (2023) propose a **conceptual framework that integrates stakeholder and institutional perspectives to analyse supplier adoption of social sustainability practices within Global Value Chains (GVCs)**. The framework examines how governance models employed by international buyers interact with local regulatory environments, cultural norms, and stakeholder pressures, including customers, internal management, and NGOs, to influence supplier compliance. By surveying 579 apparel and footwear manufacturers across five South Asian countries and combining survey results with secondary institutional analysis, the study reveals that governance effectiveness is contingent upon institutional alignment: collaborative models such as long-term partnerships and capacity-building strategies outperform compliance-driven approaches when adapted to local contexts. The research underscores the primacy of labour regulations, enforcement capacity, and organizational

culture in shaping supplier responses, offering empirical evidence that global governance strategies must be tailored to national institutional realities to achieve sustained social sustainability outcomes.

Sustainability approaches, frameworks for resilience and uncertainty, and Life Cycle Assessments (LCA)

The literature on sustainability frameworks also reflects a growing academic and practical interest in embedding sustainability frameworks across sectors such as maritime transport, mining supply chains, urban logistics, and port planning, with a focus on sustainability approaches, resilience for addressing a wider range of uncertainties, and Life Cycle Assessment (LCA). Both sustainability and LCA (analytical tool) address a systems approach, through focusing on interdependencies and rejecting siloed analysis.

Wu et al. (2020) investigate the integration of eco-centric perspectives in port planning, proposing a conceptual evolution from sustainable to eco-port and ultimately **green port strategies**. The **holistic framework for sustainable port planning** proposed by the authors incorporates four main elements: i) eco-centric perspective (i.e., prioritizes the intrinsic value of ecosystems in port areas, advocating for the protection and restoration of natural habitats affected by port activities); ii) multi-dimensional sustainability (i.e., integrates environmental, social, and economic dimensions, but with a stronger emphasis on ecological integrity compared to conventional models); iii) stakeholder engagement (i.e., encourages the involvement of diverse stakeholders in the planning process to ensure that ecological concerns are adequately addressed); iv) ecosystem services approach (i.e., recognizes and quantifies the ecosystem services provided by marine and coastal environments, such as water purification, habitat provision, and recreation, and incorporates these values into decision-making).

Urban logistics is also transforming, as shown in the systematic review by [Mohri et al. \(2023\)](#), which synthesizes the literature on crowdshipping. The authors categorize findings across environmental, operational, and social dimensions, concluding that crowdshipping, particularly in joint delivery models, can enhance delivery efficiency and reduce emissions. Crowdshipping systems that combine crowdshippers and dedicated drivers can achieve up to 33% savings in total delivery costs compared to traditional van-based delivery models. In addition, this model can reduce vehicle miles travelled and emissions, especially when leveraging existing passenger trips for parcel delivery.

Nogueira et al. (2024) undertake another comprehensive literature review to explore how **environmental sustainability is conceptualized and implemented in business-to-customer B2C e-commerce last-mile deliveries**. The study highlights various strategic approaches, from using alternative, eco-friendly delivery vehicles and route optimization techniques to incorporating consumer behaviour in encouraging greener choices. Although the review protocol lacks detailed methodological disclosure, it successfully organizes existing knowledge into thematic pillars and identifies important research gaps. Findings indicate that, despite customer preference for low-cost, fast delivery, there is a segment of consumers willing to choose more sustainable options if they receive appropriate incentives or transparent information. The paper ultimately supports the development of integrated frameworks that consider not only environmental and economic concerns but also social aspects of sustainability, emphasizing the need for further empirical research, especially into consumer decision-making and innovative logistics technologies.

Atnafu Gelagay et al. (2024) contribute to the discourse by interrogating the link between **Green Human Resource Management (GHRM)** and **Green Supply Chain Management (GSCM)**. The study performs a systematic literature review that synthesizes 30 peer-reviewed articles published between 2016 and 2023, the majority of which adopt quantitative, survey-based methodologies. The review conceptualizes GHRM through five dimensions: **green recruitment (i.e., implementation of eco-friendly measures to minimize the environmental impact of recruitment activities and attracting candidates who are aligned with the organization’s commitment to sustainability), selection, training and development, performance management, and reward systems**, while GSCM is broken down into internal (e.g., eco-design, internal environmental management) and external (e.g., green procurement – purchase of products and services that reduced environmental impact, supplier and customer collaboration) domains. The authors find that GHRM positively influences GSCM by cultivating environmentally responsible behaviours among employees and enhancing overall organizational performance across environmental, economic, and social axes.

Koilo (2019) examines sustainability in maritime transport through an empirical lens, validating the Environmental Kuznets Curve (EKC) hypothesis in Norway. The study finds an inverted U-shaped relationship between GDP growth and CO₂ emissions, suggesting that economic maturity may lead to environmental improvements. It also reveals the sector’s sensitivity to oil price fluctuations (i.e., a 1% increase in oil prices leads to a 0.26% decrease in the value added by ocean transport) and highlights the role of innovation and policy in decoupling emissions from growth (i.e., improvements in energy efficiency and technological advancements in the shipping industry have contributed to reduce environmental impacts, particularly through the adoption of renewable energy and efficiency standards).

In the context of additive manufacturing (AM), Feldmann et al. (2019) propose a **sustainability-oriented supply chain alignment strategy that incorporates LCA** to assess the environmental performance of metal-based AM technologies, particularly selective laser melting (SLM) and laser powder bed fusion (LPBF). The LCA framework delineates system boundaries from raw material sourcing to product end-of-life, capturing energy consumption, material flows, and emissions across each stage (Table 13). Comparative analyses with conventional manufacturing methods reveal that AM can reduce environmental impacts by up to 37%, particularly when lightweight design and process optimization are applied. However, the study also identifies electricity consumption and powder preparation as major environmental hotspots. These challenges can be mitigated through renewable energy integration, improved equipment utilization, and closed-loop material flows that reduce transportation emissions and support localized production.

Table 13: AM green benefits and risks across the six stages in the life cycle by Feldmann et al., 2019

LCA stage and AM green benefits	AM green risks
Procurement: fewer direct raw materials, fewer deliveries, less reliance on air freight, reduced fuel consumption, and emissions	More dispersed production cells can increase delivery frequencies, increasing emissions and fuel consumption
Production: reduced materials needed, less internal transport, lower energy use through parts designed to use less material, and fewer parts	Increased waste from finishing operations and emissions during the printing process, especially as materials are heated

LCA stage and AM green benefits	AM green risks
Distribution: reduced fuel consumption and emissions due to shorter transport distances, reduced weight, reduced air freight, and lower transport of obsolete inventory	Higher frequency of small transport volumes from many small suppliers or private printers can increase fuel consumption and emissions
Use or consumption: lighter weight reduces fuel consumption and emissions for parts in some contexts	Consumption of more products and resources than necessary (throw-away culture)
Maintenance or repair: spare parts made using a pull rather than push supply chain, reducing costs through local, on-demand production	Share of replacement deliveries increases compared to repairs due to limited accessibility for repairs
Disposal or recycling: since the amount of material used in AM is less than in subtractive manufacturing processes, turning or milling, there is less material to dispose of	Recycling of some materials is not yet possible, and disposal of two or more materials that are fused in the primary process is difficult. Further, some raw materials are toxic

A similar application of LCA is found in the work of Marmolejo Saucedo et al. (2019), who examine the structural dynamics of logistics networks through a sustainability lens. Their methodology **combines classical network optimization with LCA** to evaluate environmental burdens associated with logistics infrastructure and operations. By mapping nodes, links, and flows, and quantifying impacts such as GHG emissions and resource use, the study enables scenario-based comparisons of alternative network configurations. The findings highlight the trade-offs between economic efficiency and environmental performance, demonstrating that LCA-informed logistics planning can lead to more sustainable network designs, particularly when cross-docking strategies are employed to minimize environmental impact.

In the steel sector, Toletini and Di Maria (2023) present a case study that integrates **Material Flow Analysis (MFA) with LCA** to assess the environmental sustainability of circular steel products. Their framework compares conventional and circular production systems, using mass-based indicators to evaluate resource efficiency through narrowing, slowing, and closing material loops. The LCA component assesses environmental impacts across the product life cycle, accounting for functionality, lifetime, and material quality. Interestingly, the study reveals that circular interventions do not inherently lead to lower environmental impacts; in some cases, initial assessments show higher burdens due to factors such as energy mix and transportation. Nonetheless, optimization strategies, such as increasing secondary material use and improving energy sources, can enhance the environmental performance of circular steel products. The integration of MFA and LCA thus provides a holistic perspective that supports more robust sustainability assessments and informed decision-making in circular economy strategies.

Alarcón et al. (2023) conduct a systematic literature review of **LCA applications in electric mobility**, focusing on road freight logistics. Their review synthesizes findings from 119 peer-reviewed studies, highlighting the environmental, economic, and operational impacts of electric freight vehicles across their life cycles. The analysis confirms that electric vehicles (EVs) offer substantial reductions in urban emissions compared to diesel counterparts, particularly when powered by renewable energy. Key determinants of environmental performance include battery production, electricity sourcing, vehicle design, and usage patterns. However, the review also identifies significant methodological gaps in

current LCA studies, particularly concerning battery end-of-life, infrastructure impacts, and integration with smart logistics systems. The authors call for more comprehensive LCA models and improved data on real-world freight operations to better capture the sustainability potential of electric mobility.

In addition, the integration of circular economy (CE) principles into supply chains and sustainability strategies has gained significant traction across diverse contexts, from industrialized systems to developing economies. In a broader theoretical context, Garcia-Buendia et al. (2024) conduct a systematic literature review of circular supply chain management (CSCM), offering a comprehensive synthesis of emerging themes and assessment models. Through bibliometric and thematic analysis, the study identifies key constructs such as resource loops, closed-loop systems, reverse logistics, and stakeholder integration. The review reports a paradigmatic shift from linear to circular supply chain models, emphasizing the growing importance of digitalization, collaborative governance, and policy alignment. The authors defend the development of integrated assessment frameworks capable of capturing the multidimensional nature of circularity, highlighting current gaps in measurement and implementation.

Focusing on the Global South, Ofori (2025) examines the practical realities of the circular economy using Ghana as a case study. The study applies an environmental sustainability framework and a qualitative case study methodology, combining interviews, field observations, and secondary data analysis. It finds that while CE practices, such as recycling and reuse, hold considerable promise for improving environmental outcomes, their implementation is hindered by infrastructural deficits, weak policy enforcement, financial limitations, and low public awareness. **The research calls for the development of context-sensitive frameworks and supportive policy instruments to facilitate CE transitions in developing countries**, particularly through the integration of closed-loop supply chain (CLSC) principles and stakeholder engagement.

The growing complexity and volatility of global supply chains have intensified **the need for frameworks that integrate resilience and uncertainty management with sustainability**. Sadeghi et al. (2021) propose a robust scenario-based stochastic programming model for sustainable and resilient supply chain network design (Table 14). Their framework explicitly incorporates supplier disruption probabilities to simulate real-world uncertainties (Figure 4). The model is multi-objective, balancing cost minimization with the maximization of social and environmental performance. Using the ϵ -constraint method and solved via GAMS software, the model demonstrates that supply chains can maintain strong average performance across a range of disruption scenarios. This work underscores the value of integrating resilience and sustainability objectives into supply chain architecture to enhance adaptability and robustness.

Table 14: Key elements from the framework developed by Sadeghi et al., 2021

Element	Description
Resilience	The model incorporates the probability of supplier disruptions, allowing the supply chain to adapt and recover from various disruptive events
Sustainability	The framework evaluates suppliers based on economic cost, social responsibility, and environmental impact (i.e., precalculated metrics involving emissions data, resource use, waste management), ensuring a holistic approach to supply chain management

Element	Description
Multi-objective optimization	The model simultaneously addresses three main objectives: minimizing total costs, maximizing social scores of suppliers, and maximizing environmental scores of suppliers

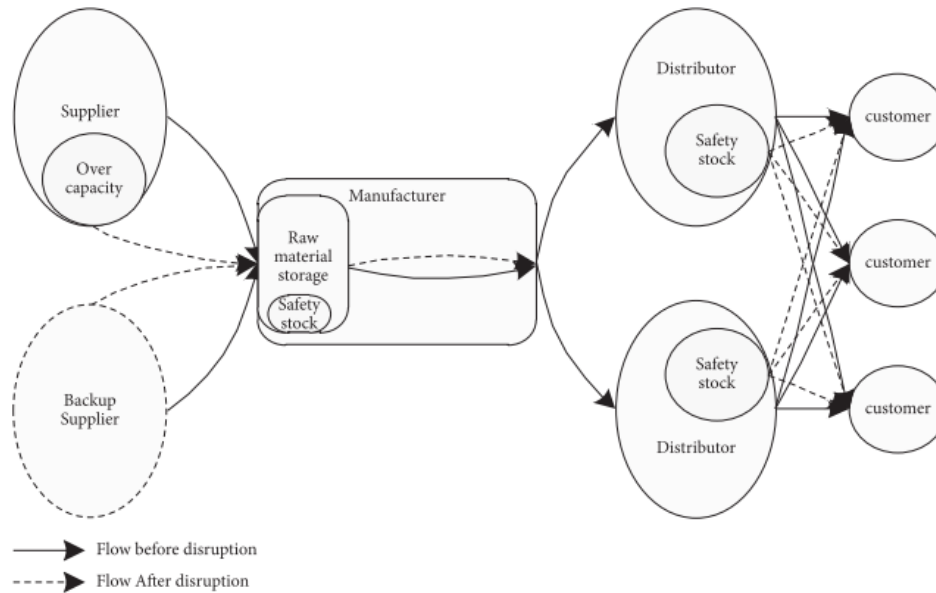


Figure 4: The supply chain network flow before and after disruptions (Source: Sadeghi et al., 2021)

In a complementary vein, Kaur et al. (2022) explore the role of **customer engagement** as a resilience enabler within sustainable supply chain management (SSCM). Grounded in stakeholder theory, their framework emphasizes both economic and non-economic performance during disruptions such as the COVID-19 pandemic. The study employs a hybrid methodology combining Stepwise Weight Assessment Ratio Analysis (SWARA) and rough set theory to rank key enablers. Agility, collaboration, and information sharing emerge as the most critical factors, enabling rapid response and continuity under uncertainty.

Salehi et al. (2022) focus on the bioenergy sector in Iran, presenting an optimization-based model for designing resilient and sustainable biomass supply chains. Their approach integrates stochastic elements to address demand uncertainty and supply disruptions. The model reveals that jointly **optimizing for resilience and sustainability yields a more robust network** capable of maintaining operations in the supply chain sector despite fluctuations and shocks, thereby reinforcing the importance of dual-objective planning in renewable energy logistics (Table 15).

Table 15: Optimization methodology proposed for biomass supply chains by Salehi et al., 2022

Element	Description
Problem definition and objective setting	Clearly define the scope (e.g., supply, storage, logistics, conversion, and delivery stages) and set the objectives (such as cost minimization, profit maximization, emission reduction, or resilience enhancement)
Parameter and data collection	Gather data on biomass feedstock availability (including seasonality and geography), transportation options, facility capacities, costs, and demand profiles. Identify

Element	Description
	sources and likelihood of uncertainties (e.g., weather-driven supply chain changes, market demand, facility disruptions)
Formulation of an optimized model	A mixed-integer linear programming (MILP) model is developed to design the supply chain network that maximizes profit. The objective function on profit maximization, balancing revenue from bioenergy products against the costs of supply chain operations
Addressing uncertainty and disruptions	Embed uncertainties (e.g., biomass yield, disruptions due to climate or facility failure) in the model using stochastic programming, scenario analysis, or robust optimization methods. Thus, the model incorporates a robust optimization approach to handle demand uncertainty, ensuring that supply chain decisions remain effective under different demand scenarios. Then, a sensitivity analysis is conducted to understand the impact of residual capacity on disruption effects
Solution method	The model is implemented and solved using GAMS software. This computational approach enables solving the MILP efficiently and allows testing various scenarios for validation

In the oil and gas supply chain sector, Babaei et al. (2024) develop a decision-support framework to evaluate blockchain adoption strategies under uncertainty. Using Data Envelopment Analysis (DEA), the model assesses cost, profit, and income efficiency across deterministic and non-deterministic scenarios. The findings highlight that strategy effectiveness varies with uncertainty conditions, and that trade-offs between efficiency, sustainability, and resilience must be carefully navigated. This framework offers nuanced insights for supply chain managers seeking robust digital transformation pathways.

Junaidi et al. (2024) take a strategic perspective on uncertainty management, examining how sustainable practices contribute to customer loyalty in uncertain supply chain environments (Figure 5). Although the methodology is less explicitly defined, the study emphasizes **the role of proactive risk management and sustainability in fostering long-term business resilience**. The findings suggest that trust, awareness, and literacy are key mediators in sustaining customer relationships amid volatility.

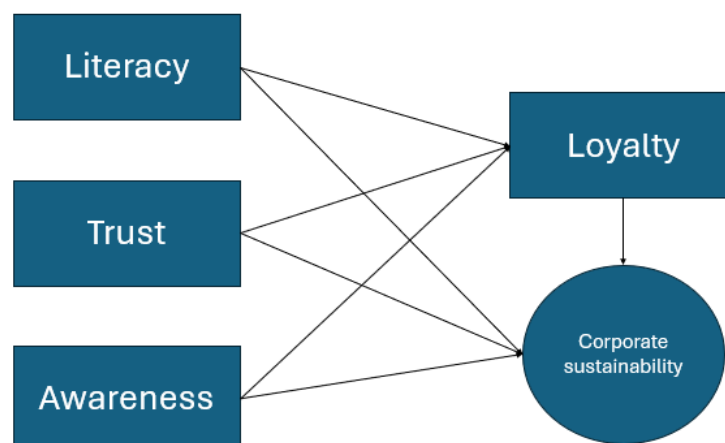


Figure 5: Conceptual model of the framework proposed by Junaidi et al., 2024

Parkouhi et al. (2025) introduce a hybrid Best-Worst Method (BWM) (i.e., used for determining the weights of various criteria by capturing expert preferences efficiently and consistently) and the

Dynamic Grey Relational Analysis (DGRA) (i.e., applied to handle dynamic and uncertain data, enabling robust ranking of ports or scenarios based on their performance over time) to **assess port resilience and sustainability**. Their model identifies and ranks critical attributes, with flexibility emerging as the most important resilience factor (i.e., allows the model to capture temporal variations in performance, making it highly effective for segmenting and analysing the changing resilience of ports, and is a measurable criterion by experts related to other resilience-related criteria - BMW) and pollutant emissions as a key sustainability concern (i.e., pollutants are assessed within the hybrid BWM-DGRA models as one of several sustainability criteria, and are evaluated by experts to measure its importance compared to other environmental factors). The segmentation model enables targeted improvement strategies, offering a structured pathway for enhancing port operations under uncertainty. Table 16 presents the authors’ suggestions for improving resilience and sustainability in ports.

Table 16: Improvements for resilience and sustainability in ports by Parkouhi et al., 2025

Dimension	Suggestion
Sustainability	Purchasing modern loading and unloading equipment and machinery to expedite cargo handling and transfer
	Enhancing advertising and marketing operations regarding capabilities at both domestic and international levels
	Developing and strengthening infrastructure and transport routes, such as railways, to establish direct connections to other ports, highways, and airports, to reduce operational costs, increase efficiency, and boost the port’s capacity to handle larger volumes of cargo
	Providing more support and attention to encourage, attract, and support both foreign and domestic investments
	Maximizing the use of current capabilities and the high capacity of the port for cargo handling, unloading, and loading operations
	Using automated loading and unloading systems, including cranes and automated equipment, to increase loading and unloading speed, reduce operational costs, minimize vessel downtime, enhance port productivity, reduce human errors, and improve safety, also enables 24-hour operations, which can reduce vessel turnaround time
	Enhancing fuel quality, including the use of low-sulphur fuels with improved environmental standards, applies to all port operations, including loading equipment and ships
	Implementing unnecessary stop restrictions, including setting limits to reduce unnecessary emissions, and controlling equipment and vehicle downtime
	Training and skill development for employees, including organizing training courses to enhance their technical and professional skills, aiming to increase their knowledge management capabilities and improve career opportunities
Resilience	Using alternative routing in case a port in the network becomes inactive or experiences infrastructure issues, leveraging other ports in the network as substitutes to continue the transport process with minimal delay
	Strengthening coordination systems among transit-related organizations (customs, clients, etc.)
	Collecting and processing port operation data, developing intelligent data analysis programs, utilizing machine learning models to identify relationships between modules, providing

Dimension	Suggestion
	managers with a more comprehensive view, and enabling accurate predictions before and after disruptions
	Increase safety by implementing strict procedures to ensure safety in the handling of hazardous materials, providing safety equipment, and conducting training sessions and workshops to raise safety awareness among employees, particularly for ports located within cities
	Strengthening critical cyber infrastructure, including maintaining wide-area networks for daily port operations and addressing vulnerabilities to various cyberattacks that could severely impact port databases, transport systems, navigation, and management
	Utilizing modern and robust information systems for loading and unloading reporting to prevent any disruptions, stoppages, or delays

Focusing on last-mile deliveries, Bellahirich et al. (2024) present an **innovative multi-capital framework** that transcends the traditional Triple Bottom Line (TBL) by integrating various dimensions of sustainability, such as natural (environmental), economic (financial, stakeholder, and human), and social (relational) capitals. The authors develop tailored **Key Performance Indicators (KPIs) aligned with SMART criteria (specific, measurable, acceptable, realistic, and timely)** through a rigorous process combining literature analysis with stakeholder consultation (Table 17). The four-step methodology includes **contextual analysis, data collection from literature and company interviews, indicator computation using formalized equations, and a final performance assessment**. Applied to a Tunisian last-mile delivery start-up, the framework reveals strong human and social capital indicators, highlighting stakeholder engagement and digital presence, while underperforming in environmental and financial aspects, such as CO₂ emissions, fuel use, water footprint, and a benefit-cost (BC) ratio of 0.66 (i.e., the net annual benefit of the year divided by the cost for assets of the year). The authors recommend strategic interventions, including seasonal vehicle reduction, GPS-based route optimization, hybrid vehicle adoption, and partnerships with recycling initiatives.

Table 17: KPIs and associated units by Bellahirich et al., 2024

Domain	KPI theme	Metric
Environmental	Potential of global warming (GWP)	Kg of CO ₂ eq
	Fossil fuel depletion (FDEP)	Kg oil-eq/tonne-km
	Potential of acidification (AP)	Kg SO ₂ eq
	Water scarcity footprint (WSF)	m ³ H ₂ O eq
	Waste to landfill (WL)	Tone/year, %
Economic	Benefit-cost ratio (BC)	n/a
	Company's earnings per share (EPS)	TDN
	Degree of satisfaction with information sharing among stakeholders	n/a
	Labor productivity (LP)	TND/h

Domain	KPI theme	Metric
Social	Number of deliveries per customer	n/a
	Number of followers on social media	n/a

Building on this, González-Romero et al. (2024) advocate a participatory, **stakeholder-driven approach to designing sustainable last-mile systems**. Drawing on a systematic review of 169 scholarly articles, the framework synthesizes best practices and taxonomizes challenges and opportunities in last-mile logistics from the perspectives of stakeholders such as logistics firms, public authorities, retailers, and consumers. The methodology centres on qualitative analysis, mapping stakeholder influence and interests, and identifying KPIs rooted in real-world measurability and relevance (Table 18). The framework emphasizes contextual specificity and urges collaborative governance models to address sustainability holistically. Its primary contribution lies in structuring complex stakeholder dynamics and offering a roadmap for operationalizing sustainability within varied urban and logistical contexts.

Table 18: Sustainability KPIs identified by González-Romero et al., 2024

Domain	KPI
Environmental	Pollutant emissions (CO ₂ , NO _x , greenhouse gases)
	Particulate emissions (PM _{2.5})
	Resource management
	Congestion
	Visual impact
	Weather adaptability
	Climate change
	Global warming
	Habitat loss
	Noise pollution
	Economic
Profits and savings	
Level of service	
Operational capabilities	
Risk management	
Social	Accidents
	Safety and security
	Quality of life
	Infrastructure deterioration
	Vibrations
	Night-time disruptions
	Accessibility and mobility
	Working conditions
	Health (public and workers)
	Information security and transparency
	Acceptance
	Equality
Legislation and green policies	

In addition, Beck et al. (2025) introduce a **cause-and-effect chain framework** grounded in the EU DECARBOMILE project. It diverges from supply-side logistics by adopting a customer-centric approach and incorporating principles from the data economy (e.g., data valorisation, stakeholder-centric data use, objective criteria for decision-making, demand-driven data insights). Anchored in the Physical Internet (PI) and Theory of Change (ToC), this framework maps interventions to targeted sustainability outcomes, ensuring alignment between stakeholder challenges and practical solutions. The mixed-methods research design includes literature review, participatory field studies across Spain, Belgium, the UK, and France, and stakeholder workshops that validate and prioritize key interventions (Table 19). A decision-support tool operationalizes this framework, enabling scenario analyses and intervention mapping based on systemic impact. Results highlight the effectiveness of combining supply and demand sustainability measures, such as low-emission vehicles, smart routing, and urban consolidation centres, and validate the framework through pilot implementations that enhanced urban logistics and stakeholder coordination.

Table 19: Sustainable features identified by Beck et al., 2025

	Domain	Intervention/Features
Offer	Environmental	Systemic viability
	Social	Safety
		Working conditions
	Economic	Profit
Productivity		
Demand	Environmental	Systemic viability
	Social	Customer geography
		Sale's capillarity dependence
	Economic	Operational capabilities
Economic nature		

Focusing on the maritime sector, Hossain et al. (2021) present a comprehensive assessment of sustainability initiatives across global seaports, with particular emphasis on the environmental, social, and economic dimensions, especially in developing countries and the Global South. Environmentally, the study examines the impacts of port operations, particularly passenger terminals, on water quality, waste management, and ecosystem health, highlighting the role of international frameworks such as ISO 14001, EcoPorts, and the Port Environmental Review System in promoting environmental stewardship. Socially, it evaluates port-related employment, community engagement, cultural heritage preservation, and the influence of port development on urban populations, emphasizing the need for inclusive governance and stakeholder participation. Economically, the research analyses port growth, efficiency in maritime logistics, integration into global supply chains, and the adoption of sustainability reporting standards like GRI, SASB, and the UN Global Compact to enhance transparency and competitiveness. The study employs a holistic conceptual framework that integrates these dimensions through 78 indicators, supported by DPSIR and causal loop methodologies, and applies tools such as the Fuzzy Analytical Hierarchy Process and content analysis of Brazilian port reports. Findings reveal a strong emphasis on environmental concerns in existing literature, while also highlighting the importance of balancing ecological protection with economic development and social equity. The paper identifies four key pillars, such as environmental management, socio-cultural dynamics, governance, and economic development, as essential for sustainable port strategies, and

advocates for innovative technologies and integrated planning to achieve long-term sustainability goals. Table 20 presents the multidimensional indicators presented in the research.

Table 20: Multidimensional indicators for port sustainability proposed by Hossain et al., 2021

Domain	Description
Environmental management	Focus on reducing the environmental impacts of seaports, including pollution control, resource efficiency, and ecosystem preservation
	Use of standardized environmental management systems and certifications, for example, ISO 14001 and EcoPorts tools
Economic development	Emphasizes sustainable economic growth driven by increased port volumes, logistics efficiency, and enhanced economic activities linked to ports such as fisheries, tourism, and trade
	Integration of economic indicators aligning with the socio-economic welfare of the port city and its stakeholders
Social and socio-cultural dimensions	addresses social equity, community engagement, employment opportunities, and protection of cultural heritage around port areas
	Focus on the interaction between the port and the city, including livelihood and quality of life
Governance and politics	Encompasses institutional strength, stakeholder coordination, policies, legal frameworks, and participatory governance necessary for sustainable port management
	Deals with contractual, regulatory, and operational frameworks influencing port development
Technical and innovation components	Includes adoption of innovative technologies and management practices for sustainability, such as operational adaptations to minimize emissions and energy use
	Incorporates technological solutions as enablers for environmental and economic objectives

Following this subject, Dovbischuk (2021) examines sustainable firm performance among Logistics Service Providers (LSPs) within the maritime supply chain, proposing a **theory-based framework that draws on Contingency Theory, Innovation Diffusion Theory (IDT), and Resource Advantage Theory** (Table 21). Contingency Theory underscores the influence of environmental uncertainty on supply chain collaboration, while IDT explains how sustainability practices are shared and institutionalized across supply networks. Resource Advantage Theory emphasizes how cooperative relationships yield unique capabilities that enhance competitive positioning. Building on these theoretical foundations, the paper presents a five-stage model describing how LSPs diffuse sustainable practices to their partners, from initial engagement to outcome confirmation. Empirical data were collected through a survey of 215 Chinese cold chain suppliers exporting to developed markets and analysed using Structural Equation Modelling. The results show that sustainable practices implemented by LSPs significantly strengthen multinational supply chain cooperation (MSCC), which in turn drives improvements in sustainable production and competitive advantage. These findings highlight the importance of embedding economic, environmental, and social sustainability into the core of LSP operations as a driver of resilience and long-term success.

Table 21: Integrated Theory-based model in maritime logistics

Theory	Role in the model	Maritime logistics application
Contingency theory	Aligns strategies with the external environment	Adapting to regulatory and market changes
Innovation diffusion	Explains the adoption of new practices/technologies	Spread of sustainability and digital tools
Resource advantage	Highlights unique resource-based advantages	Leveraging IT, infrastructure, and partnership

To investigate customer loyalty in the maritime transport sector, Eileen Justavilo-Castillo et al. (2022) focused on how relational variables and perceptions of sustainable practices contribute to customer segmentation. By integrating concepts such as logistics value, long-term orientation, and relationship quality, the study **categorizes B2B clients based on their relational (logistics value, satisfaction, and long-term orientation) and sustainability orientations**. Survey data from 122 firms are analysed using Multiple Correspondence Analysis and cluster techniques to identify three distinct customer groups: those with high, medium, and low levels of engagement. The analysis reveals that loyalty drivers vary substantially across segments, with highly engaged customers prioritizing both relationship strength and sustainability efforts, while less engaged customers show more transactional preferences. Segment membership correlates with company characteristics such as size and experience, providing actionable insights for service providers aiming to enhance customer retention. The study concludes that **aligning relational strategies with visible sustainability commitments can significantly influence loyalty and competitive differentiation in maritime logistics**.

Taking into consideration the road freight transport, Lalendle et al. (2021) developed a **monitoring and evaluation (M&E) framework designed specifically for road freight transporters in South Africa** that can be applicable in other developing countries. Recognizing that existing models often fall short in encompassing all three pillars of sustainability (i.e., economic, social, and environmental), this framework adopts a holistic perspective rooted in sector-specific goals and processes. It structures sustainability performance around strategic objectives such as safety, cost efficiency, and stakeholder collaboration, and maps corresponding inputs, including safety management protocols, community engagement, and socio-environmental initiatives. Outputs are quantified through KPIs like reduced accident rates, improved driver behaviour, frequency of stakeholder meetings, and outcomes of corporate social responsibility efforts (Table 22). The incorporation of key performance indicators (e.g., carbon tax contributions, community outreach frequency) ensures accountability across the three pillars. Employing a mixed-methods approach that leverages both qualitative insights and quantitative benchmarking, the framework provides organizations with a robust tool to track sustainability metrics, assess operational progress, and evaluate policy impacts over time. Notably, the framework supports iterative improvement by enabling year-on-year monitoring and targeted interventions in the road freight sector.

Table 22: KPIs used in the sustainability framework for road freight transport proposed by Lalendle et al., 2021

Pillars of sustainability	KPIs	Description
Economic	Operational costs	Measures such as costs per tonne-kilometre and fuel efficiency
	Maintenance costs	Frequency and cost of vehicle maintenance
	Productivity	Load factor, delivery times, and on-time deliveries
Environmental	GHG emissions	Total CO ₂ emissions per vehicle or per tonne-kilometre
	Energy efficiency	Fuel consumption per trip or per tonne-kilometre; use of alternative fuels
	Adoption of advanced technology	Use of low-emission vehicles, route optimization software, and telematics
	Waste management	Recycling rates, waste generated from operations
	Air and noise pollution	Emissions of NO _x , SO _x , particulate matter, and noise levels
Social	Safety	Number of road accidents, fatalities, and injuries involving freight vehicles
	Labor rights	Compliance with labor standards, driver working conditions, and training
	Stakeholder engagement	Frequency and quality of stakeholder meetings, community impact assessments
	Corporate social responsibility	Investments in local communities, health, and education initiatives

Kumar et al. (2019) address decision-making in the siting of multimodal freight terminals (MFTs), proposing a **sustainability-focused location selection framework rooted in the STEEP (Social, Technological, Economic, Environmental, Political) model**. This multidimensional approach ensures that freight terminal planning goes beyond traditional economic feasibility to incorporate broader socio-political and environmental considerations. The framework evaluates social factors such as community accessibility and potential societal disruption; technological aspects including infrastructure readiness and modal connectivity; economic dimensions such as cost-effectiveness and regional development potential; environmental indicators like emissions profiles and ecological footprint; and political variables encompassing regulatory support and alignment with strategic policy objectives. The methodology centres on Multi-Criteria Decision-Making (MCDM), integrating both qualitative judgments and quantitative scoring to compare and rank potential MFT sites. Criteria and sub-criteria are derived through literature reviews and expert consultations, and real-world data is utilized to demonstrate the framework’s practical viability. The results indicate that applying the STEEP lens enhances the transparency and robustness of terminal site evaluations, offering policymakers and logistics planners a systematic tool to make balanced decisions that reflect a nuanced understanding of sustainability trade-offs.

Sharma et al. (2023) propose a generalized quantitative framework for sustainability assessment that integrates environmental, economic, and social indicators to support multi-criteria decision-making. The environmental indicators include greenhouse gas emissions, energy efficiency, and resource consumption; economic indicators encompass cost-effectiveness, return on investment, and lifecycle costs; and social indicators reflect employment generation, social equity, and public acceptance. These indicators are normalized, weighted based on expert input, and aggregated into a unified sustainability score using a novel antinorm-based function (Figure 6). The framework accommodates data uncertainty through interval-scale inputs and applies sensitivity analysis to test the robustness of rankings against variations in criteria weights. Demonstrated through case studies on electricity generation systems in Portugal, biodiesel feedstock selection, and negative emission technologies, the framework effectively identifies the most sustainable alternatives across diverse contexts.

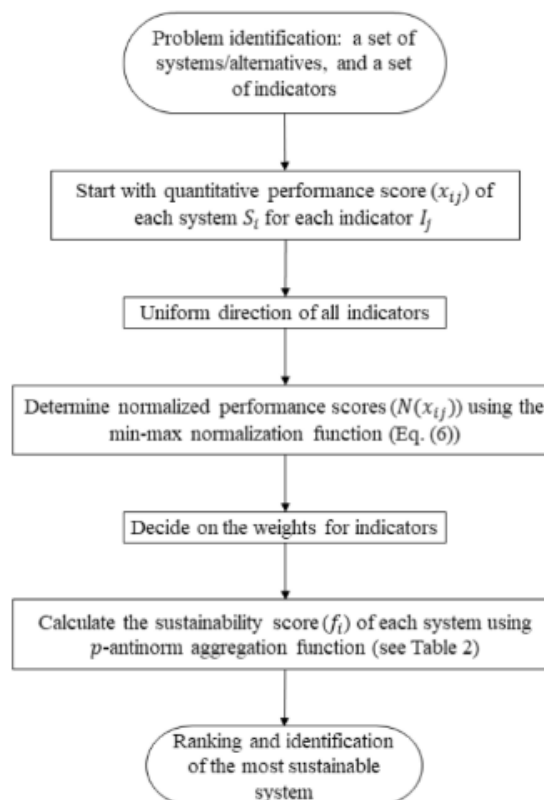


Figure 6: Proposed framework for sustainability assessment by Sharma et al., 2023

A complementary perspective is offered by Kosasih et al. (2023), whose study proposes an **integrated conceptual model that combines lean and green practices to enhance sustainable supply chain performance**, especially within small and medium-sized enterprises (SMEs). Building on a comprehensive literature synthesis, the model explores the interplay of lean and green strategies through the lens of the triple bottom line. It posits seven hypotheses that examine direct, mediated, and moderated relationships among lean processes, environmental initiatives, and sustainability outcomes. Key enablers identified include leadership commitment, organizational culture transformation, and institutional factors such as policy support and financial capacity. Practical tools linked to the model include traditional lean techniques (e.g., Kaizen, 5S – workplace organization to improve efficiency, safety, and quality, waste reduction) and green instruments (e.g., ISO 14001, life

cycle assessment, and the 3Rs approach). Supply chain performance is measured using SCOR-based indicators spanning cost, quality, time, flexibility, and innovation dimensions. The findings suggest that strategic integration of lean and green practices not only improves operational efficiency but also yields substantial environmental and social benefits. Furthermore, the study emphasizes the critical role of contextual conditions, especially collaborative synergy and technology advancement, in shaping the strength of these sustainability linkages.

Besides, Bhérier-Breton et al. (2025) assess the **usability of product-level sustainability frameworks** within agri-food supply chains by evaluating the Food System Sustainable framework and the Sustainable Nutrition Security framework. The study develops a set of usability criteria, including data quality, ease of use, transparency, and analytical relevance. Using a waterfall selection strategy, it applies both frameworks to seven representative Norwegian food products, encompassing dairy, vegetables, grains, and meats. Findings indicate that while both frameworks provide broad sustainability insights at the social and environmental level, their practical application is constrained by limitations in data granularity and usability, especially for non-specialist users. A key trade-off emerges between comprehensive analysis and user accessibility: frameworks offering richer insights often demand greater data and technical sophistication. Additionally, the frameworks struggle to delineate product-specific social and ethical impacts, reflecting broader challenges in operationalizing social sustainability at the micro level.

Focusing on frameworks that operationalize lean principles, address constraints in developing economies, and leverage digital innovation for resource optimization, Gargalo et al. (2021) introduce **the SustainSC-VSM methodology, an extension of traditional Value Stream Mapping designed to integrate sustainability metrics into supply chain analysis** (Figure 7). By incorporating both qualitative and quantitative indicators (i.e., material value added, energy cost, total inventory level cost, entity inventory cost, backorder, lead time factor, operational lead time factor, inventory turns, service level quantity factor, service level time factor, ok-pats, overall throughout effectiveness, volume flexibility, time flexibility, carbon emission, waste factor, sustainable energy, labour equity, fatal accident rate, corruption, variability of lead time, bullwhip effect) across the economic, environmental, and social domains, the approach enables systematic bottleneck identification through a five-step process: mapping the supply chain, decomposing paths using graph theory, calculating sustainability indicators, pinpointing inefficiencies, and redesigning future state value streams (Table 23). Applied in a real industrial setting, the methodology demonstrated its capacity to generate actionable improvements, allowing managers to quantify sustainability performance and initiate continuous improvement initiatives across diverse industry contexts.

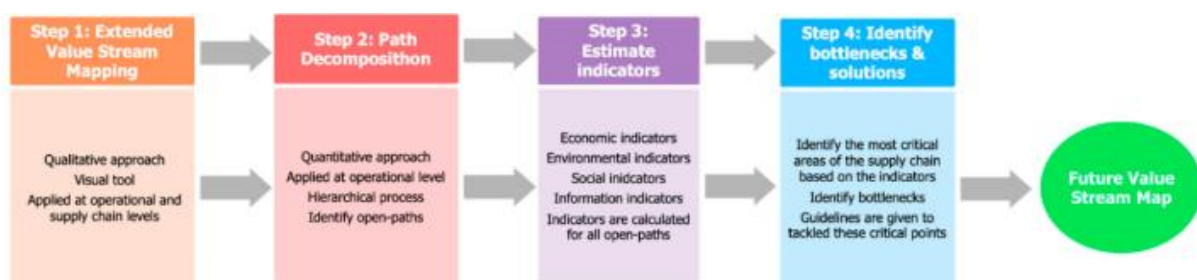


Figure 7: Stepwise process for the SustainSC-VSM methodology (Source: Gargalo et al., 2021)

Table 23: Indicators proposed in the SustainSC-VSM methodology by Gargalo et al., 2021

Indicator	Description	Unit
Material value added	Value added in the supply chain per path	Euro
Energy cost	The cost of energy consumption per path	Euro
Total inventory level cost	The cost of the inventory per path	Euro
Entity inventory cost	The percentage of the cost that represents each entity	Ratio
Backorder	The total value of lost sales per path	Euro
Lead time factor	The total lead time per path	Time
Operational lead time factor	The percentage of time that represents each entity	Ratio
Inventory turns	The inventory that takes longer to empty per path	Time
Service level quantity factor	The accomplishment of the delivered quantity per path	Ratio
Service level time factor	The accomplishment of the delivered time per path	Ratio
OK-parts	The quality of the delivered product per path	Percentage
Overall throughput effectiveness	Comparing actual to maximum attainable productivity	Percentage
Volume flexibility	The capacity to adapt to volume demand changes per path	Ratio
Time flexibility	The capacity to adapt to time demand changes per path	Ratio
Carbon emission	The CO ₂ emissions into the environment per path	Tons CO ₂
Waste factor	The disposal of waste material per path	Ratio
Sustainable energy	The ratio of renewable energy used per path	Percentage
Labor equity	The distribution of employee compensation per path	Ratio
Fatal accident rate	Statistical method that reports the number of incidents per path	Inc/(Em*Time)
Corruption	The total number of lawsuits per path	Lawsuits
Variability of lead time	The variability of the Lead Time Factor per path	Time
Bullwhip effect	The demand variation of the first entity per path	Ratio

Building on this operational foundation, Moyo et al. (2024) focus on sustainability challenges in food supply chains within developing economies, using Malawi's banana sector as a case study. A tailored sustainability model is constructed to address issues commonly faced by SMEs, including high product wastage and limited resources. The framework emphasizes six core dimensions, such as awareness, collaboration, efficiency, governance, knowledge sharing, and resilience, as critical to advancing supply chain sustainability. The study combines literature review, interviews, field observations, and surveys of 353 participants across three districts to generate a robust empirical base. Using simulation modelling structured through Design Science Research, the study evaluates the impact of reorganizing

supply chain processes. Results show notable improvements in shelf-life, lead times, product quality, throughput, and waste reduction. The findings highlight the necessity of context-sensitive models in enhancing supply chain performance in developing regions and provide valuable managerial insights related to strategic planning, risk mitigation, and stakeholder engagement.

Moreover, Erdos et al. (2023) shift the focus to digital innovation in warehouse management, presenting a **sustainability-driven framework for SAP Application Management Services (AMS)**. In this study, sustainability is pursued through the integration of machine learning into support functions within SAP Extended Warehouse Management systems. The proposed approach utilizes AI-based ticket classification to automate support processes, reduce human error, and improve the allocation of organizational resources. A series of machine learning algorithms, including Logistic Regression, Decision Tree, Random Forest, Support Vector Machine, and Neural Networks, are applied to real-world SAP ticket data to identify the most effective solution. After comparative analysis, the optimal model is embedded within the AMS workflow and evaluated on its ability to streamline operations. Results show substantial improvements in resource efficiency, workload reduction, and support quality, thereby enhancing both sustainability performance and customer satisfaction. The study demonstrates that AI-enhanced, non-cloud-based solutions can have a measurable impact on IT service sustainability, linking digital transformation directly to broader supply chain resilience goals.

Exploring more contemporary perspectives on organisational sustainability, offering a macro-level overview of how institutions engage with sustainability Lozano (2023a) presents a systemic and holistic **framework for evaluating how organisations engage with and impact sustainability**, emphasizing the interconnectedness between internal processes and external outcomes (Figure 8). Internal engagement refers to how various organisational system elements, such as research and innovation, management and strategy, operations and production, products and services, and procurement and supply chain, participate in sustainability efforts. Each element is assessed for its level of engagement, recognizing that different parts of the organisation may contribute in distinct ways. The framework highlights that these internal efforts are not isolated but dynamically influence the external impacts an organisation has on broader sustainability dimensions. The external outcomes are evaluated across four key dimensions: economic, environmental, social, and time (Figure 9). The time dimension considers how impacts unfold over short, medium, and long-term periods. The framework uses structured assessments, often through surveys or data collection, to measure both the degree of engagement and the resulting impact of each organisational element. These assessments allow for comparisons within and between organisations, helping to identify areas of strength, weakness, or disconnect.

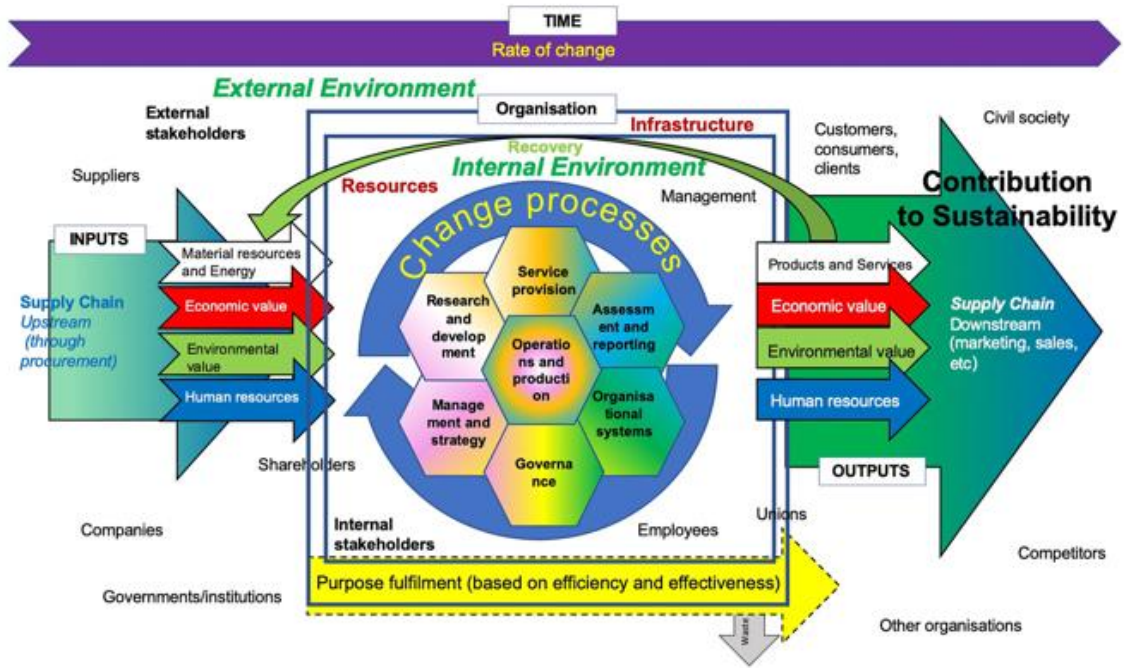


Figure 8: Organizational sustainability framework by Lozano, 2023

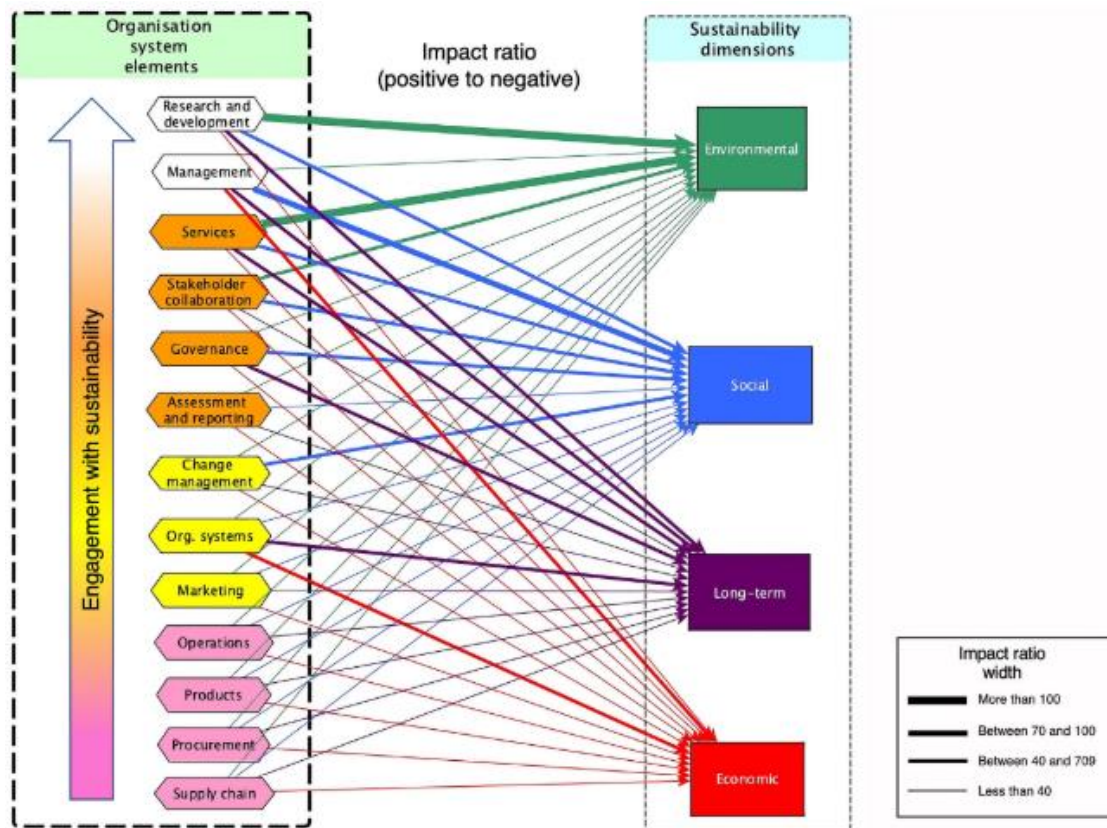


Figure 9: Organizational system elements engagement and impact on sustainability framework (Source: Lozano, 2023)

The logistics sector in retail was the focus of the research performed by Karthikeyan et al. (2023) that adopted a qualitative, multi-case study methodology based on industry data spanning 2018 to 2021. Guided by the **Triple Bottom Line and Life Cycle Sustainability Assessment frameworks**, the study showed how smart shelving reduced transport-related waste due to overstocking by 33% and how the use of drones in last-mile delivery cut urban logistics emissions by 45%.

Extending this analysis into supply chain dynamics, Forslund et al. (2022) apply agency theory to analyse how sustainability is managed across the transport supply chain tiers. Through an in-depth case study involving a shipper, a third-party logistics provider, and a carrier, the research highlights how varying levels of collaboration and asymmetrical information flows influence sustainability integration. Each dyadic relationship reveals distinct collaboration modes, shaped by actors' roles, contractual structures, and degrees of transparency. The study identifies several systemic challenges, including shippers' limited understanding of downstream logistics contexts, the prevalence of underdeveloped contracts that lack sustainability clauses, and the marginalisation of actors at the tail end of the supply chain, such as hauliers. This “silencing” effect exacerbates information asymmetries and weakens compliance with sustainability norms.

Building on Lozano's Organizational Sustainability Framework (2023b), a sustainability framework for logistics supply chain decarbonisation and collaboration should place stakeholders at the centre, surrounded by interconnected components: strategic vision, governance, environmental performance, social equity, economic viability, collaboration mechanisms, innovation & digitalisation, and temporal continuity (time dimension):

- **Stakeholders at the Centre**
 - **Why:** Logistics chains are multi-tiered and interdependent. Shippers, carriers, regulators, technology providers, employees, customers, and communities all influence decarbonisation outcomes.
 - **Role:** Stakeholders co-create goals, share data, and align incentives. Without stakeholder buy-in, decarbonisation strategies remain fragmented.
- **Strategic Vision & Purpose**
 - Anchored in the **Triple Bottom Line (TBL)** but extended to include **time** (Lozano's fourth dimension).
 - Defines long-term decarbonisation targets (e.g., net-zero by 2050) and aligns them with EU Green Deal, Fit for 55, and corporate ESG commitments.
- **Governance & Accountability**
 - Clear **roles, responsibilities, and reporting structures** across the supply chain.
 - Integration with **ESRS, GRI, ISSB** standards to ensure transparency.
 - Mechanisms for **shared accountability** in collaborative logistics projects (e.g., green freight corridors).

- **Environmental Performance**
 - **Core decarbonisation levers:** modal shift (road → rail/water), fleet electrification, sustainable fuels, energy-efficient warehousing.
 - **Measurement tools:** Life Cycle Assessment (LCA), carbon accounting, Scope 3 emissions tracking.
 - **Indicators:** CO₂ per tonne-km, energy intensity, renewable energy share.
- **Social Equity & Inclusion**
 - Ensures that decarbonisation strategies do not disadvantage workers, SMEs, or vulnerable groups.
 - Promotes **fair labour practices, safety, and accessibility** in logistics operations.
 - Links to **just transition principles** in EU policy.
- **Economic Viability**
 - Balances decarbonisation with **cost efficiency and competitiveness**.
 - Encourages **green investment, carbon pricing integration, and collaborative cost-sharing models**.
 - Recognises that sustainable logistics must remain financially resilient.
- **Collaboration & Partnerships**
 - Multi-actor collaboration across **public–private partnerships, industry alliances, and research networks**.
 - Shared platforms for **data exchange, benchmarking, and joint innovation** (e.g., digital freight platforms, eFTI regulation).
 - Encourages **trust-building and co-creation** of decarbonisation roadmaps.
- **Innovation & Digitalisation**
 - Deployment of **AI, IoT, blockchain, and digital twins** to optimise freight flows and reduce emissions.
 - Supports **real-time monitoring, predictive analytics, and interoperability** across logistics actors.
 - Digitalisation is both a decarbonisation enabler and a collaboration catalyst.
- **Temporal Dimension (Time)**
 - Lozano (2023) stresses **time as a fourth sustainability dimension**.
 - Logistics frameworks must integrate **short-, medium-, and long-term horizons**:

- Short-term: operational efficiency (fuel savings, load optimisation).
- Medium-term: technology adoption (EVs, hydrogen trucks).
- Long-term: systemic transformation (circular logistics, regenerative supply chains).

2.2 The ADMIRAL sustainability framework architecture

Based on the inputs from the previous analysis and review, it has been defined a Sustainability Framework Architecture (SFA) with the aim of providing ADMIRAL pilots with different components or tools designed to:

- Identify the main sustainability objectives for each pilot.
- Define Key Performance Indicators (KPIs) aligned with these objectives.
- Integrate sustainability principles with digital innovation in logistics.

The Sustainability and collaborative framework architecture (SFA) illustrated in Figure 10 highlights a collaborative and iterative approach for defining sustainability priorities within the ADMIRAL pilots. The framework integrates strategic guidance, regulatory drivers, stakeholder's needs, and sustainability constraints, all converging in the Stakeholder Collaborative Forum (SCF), which acts as the central coordination hub. The framework is composed of interconnected components that enable continuous collaboration and refinement:

Strategic and Tactical Layer

At the top of the architecture, the strategic and tactical layer provides the policy direction and long-term vision that guide sustainability ambitions. This layer ensures alignment with global, European, national and regional policy frameworks, translating broad goals -such as decarbonisation, low-emission logistics, and energy efficiency -into actionable insights for pilot design and evaluation.

Requirements: Regulations and Standards

The second layer gathers the regulatory and standard-base requirements that shape the sustainability agenda of the pilots. These include European directives, international standards, and other compliance obligation relevant to ADMIRAL. In the figure, these requirements feed directly into the SCF, ensuring that stakeholders discussions and decisions remain anchored in formal regulatory expectations.

Sustainability constraints

On the right side, the framework identifies the key sustainability constraints that influence the feasibility of green and digital logistics solutions. These include:

- Economic aspects such as investment needs, operational benefits, cost reduction, return on investment, ...
- Environmental aspects including energy efficiency, climate considerations, air pollution, resource consumption, ...
- Social aspects such as labour conditions, human rights, societal expectations, product responsibility, ...

Additionally, there are other practical limitations to achieving green, digital and sustainable logistics solutions -including technological maturity, infrastructure availability, standardization issues, technical knowledge, regulatory barriers, etc. These constraints are identified and assessed collaboratively via the SCF through participatory tools such as workshops, surveys, and expert panels.

Stakeholders Collaborative Forum

The **Stakeholders Collaborative Forum (SCF)** is the central hub of the architecture. It facilitates **continuous engagement, dialogue, and co-creation among the main stakeholder groups across the ADMIRAL pilots** (detailed description in Chapter 2.3). It is directly connected to three supporting components – Stakeholders’ Needs, Requirements, and Constraints -ensuring that sustainability actions and decisions are grounded in a collaborative, evidence-based process. The SCF fosters continuous dialogue and co-creation, enabling a coordinated understanding of the role of regulation and sustainability, collective identification of stakeholder needs and priorities, and harmonisation of pilot’s sustainability goals. It synthesises inputs from all components -regulatory requirements, constraints, and strategic vision- to support decision-making and iterative improvement.

Outputs: Priorities and Pilots’ Sustainability Goals

The bottom layer of the figure shows how the SCF translates the interactive process into concrete outcomes:

- Shared understanding of the role of regulation and sustainability,
- Consolidated stakeholders’ needs and priorities, and
- Definition of the pilots’ sustainability goals.

These outputs ensure that sustainability actions are co-developed, evidence-based, and aligned with both external requirements and the operational reality of the pilots.

The SFA promotes a **continuous, collaborative process**. Insights from needs, constraints, and requirements components converge in the SCF, which synthesis this information to guide pilot’s sustainability strategies. Rather than imposing a top-down mandate, the architecture **fosters a dynamic, iterative approach** driven by stakeholder collaboration across sustainability, regulatory and technological domains.

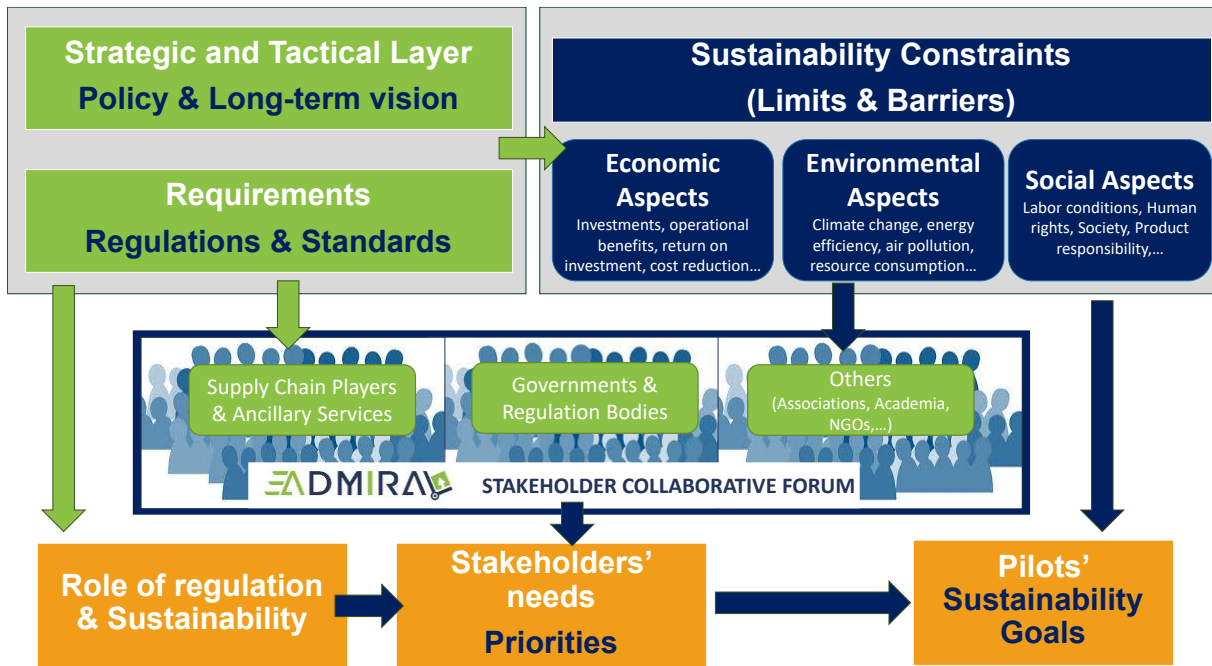


Figure 10: Sustainability Framework Architecture (SFA) for ADMIRAL pilots

2.3 ADMIRAL Stakeholders' mapping and engagement: ADMIRAL Stakeholders Collaborative Forum

The initial step in establishing the Stakeholders Collaborative Forum is **the systematic identification and categorization of stakeholders relevant to the ADMIRAL project**. This process focuses on mapping organizations that are either directly connected to pilot activities or gave a potential interest as future users of the ADMIRAL marketplace and related solutions. Building on this, the ADMIRAL project introduces a consolidated frameworks comprising three main groups, each with specialized relevance to logistics and sustainability. The primary stakeholders are Supply Chain Players with specialized relevance to logistics and sustainability. All the groups demonstrate distinct capabilities and responsibilities in advancing sustainable logistics practices. Reflecting the project's four-dimensional perspective on sustainability—environmental, economic, social, and governance—Table 24 summarizes the selected stakeholder categories and outlines their respective roles in driving sustainability-related actions. This classification has been developed by partners within the ADMIRAL project to ensure a comprehensive and structured approach to stakeholder engagement, nevertheless the categorization will be applied in any other project or case study.

Table 24: ADMIRAL Stakeholders categorization and the primary role in logistics

MAIN GROUP	Stakeholder Main category	Stakeholder Subcategory	Role in ADMIRAL and sustainability competences
SUPPLY CHAIN PLAYERS (SC)	Cargo Owner	<ul style="list-style-type: none"> • Agriculture, forestry and fishing • Mining and quarrying • Manufacturing • Construction • Wholesale and retail trade, repair of motor vehicles • Accommodation and food service activities • Chemical and other dangerous materials • Other 	Produces or owns goods and initiates logistics operations to transport them through the supply chain, playing a key role in defining transport demand and sustainability targets.
	Transport operator		Provides multimodal transportation services (road, rail, air, sea, or inland waterways), ensuring the efficient, safe, and low-emission movement of goods.
	Freight forwarder and/or Custom broker		Coordinates multimodal shipments, handles documentation, and manages customs clearance processes. Their role is essential for optimizing transit times, reducing administrative barriers, and ensuring smooth cross-border flows.
	Infrastructure manager or operator	<ul style="list-style-type: none"> • Port authority • Dry port • Multimodal platform • Berth service provider • Railroad infrastructure manager • Road infrastructure manager • Other 	These actors manage and maintain the physical infrastructure that enables efficient, reliable, and integrates multimodal transport services.
	Energy supplier		Provides fuel and energy for logistics operations, supporting the transition toward low-carbon and renewable energy solutions in transport and warehousing.
	Technology provider, IT, software company, platform provider, etc.		Develops and implements technological and digital tools and solutions — such as IoT systems, automation, and real-time tracking — to improve visibility, optimization, and environmental performance across logistics networks.
	Financial institution		Offers financing, investment, insurance, and risk management services that underpin logistics infrastructure and operations.
	Consultancy firm		Provides strategic, operational, and regulatory expertise aimed at improving logistics performance, competitiveness, and sustainability.

MAIN GROUP	Stakeholder Main category	Stakeholder Subcategory	Role in ADMIRAL and sustainability competences
	Other		Covers any additional entities contributing to logistics performance, innovation, or value-added services within the supply chain ecosystem.
GOVERNMENT AND REGULATION BODIES (GR)	European Institution (Commission, Parliament, EU agency, etc.)		Define and enforce EU policies, legislation, and strategic frameworks supporting sustainable, efficient, and integrated logistics systems. They also manage funding programmes and initiatives that enhance multimodal connectivity across Europe.
	EU national governments		Implement and enforce EU logistics and transport policies, manage national infrastructure investments, and define country-specific strategies aligned with European priorities.
	Regional or local government		Plan and manage regional logistics infrastructure, promoting sustainable urban freight solutions and last-mile delivery optimization.
	Market and/or competition regulator		Ensure transparency, fair competition, and compliance with EU competition law within logistics and transport markets.
	Standardization and certification body		Develop and harmonize standards related to logistics safety, interoperability, and quality assurance.
	Custom office		Control cross-border goods movement, ensuring compliance with customs and trade regulations while facilitating legitimate international trade.
	Border authority and/or health authority		Oversee the inspection of imported and exported goods, ensuring compliance with sanitary, phytosanitary, and security requirements.
	Cities authorities		Manage urban logistics operations, regulate freight traffic, and promote sustainable and efficient last-mile delivery systems.
OTHERS (OT)	Transportation/Logistics Association		Represent the interests of logistics operators, promote collaboration among industry players, and contribute to knowledge transfer and policy dialogue.
	Cargo owner association		Represent shippers, defending their interests and promoting fair, efficient, and sustainable logistics solutions.
	Research and Academia		Contribute to innovation, policy development, and data-driven decision-making through research on logistics systems, digitalization, and sustainability.
	Think Tank		Provide strategic analyses and evidence-based recommendations to improve logistics policy and governance frameworks.
	Consultancy firm		Support both public and private stakeholders through specialized services in logistics

MAIN GROUP	Stakeholder Main category	Stakeholder Subcategory	Role in ADMIRAL and sustainability competences
			planning, process optimization, digital transition, and sustainability assessment.
	Trade Union		Represent the logistics and transport workforce, advocating for fair labour conditions, safety, and skills development.
	Media		Disseminate knowledge, best practices, and sectoral trends, fostering awareness of the logistics sector's contribution to the economy and sustainability.
	Consumer Association		Advocate for consumer rights, promoting transparency, reliability, and quality in delivery and logistics services.
	Chamber of commerce		Facilitate trade, support logistics innovation, and promote collaboration among businesses and logistics stakeholders.
	EU fora		Encourage cross-sectoral dialogue and cooperation between logistics stakeholders at the European level, often within EU-funded initiatives.
	Customers Association		Represent logistics service users, emphasizing service quality, transparency, and sustainability performance.
	NGOs		Promote social responsibility, environmental protection, and ethical practices across logistics and transport chains.
	Other		Include all additional entities that contribute to innovation, governance, or sustainability within the European logistics ecosystem.

The stakeholders mapping at pilot level has been carried out using a matrix in which each of the identified stakeholders is categorized based on the categorization in Table 24 and the following four main attributes based on a Low, Medium, High scale:

- *Power*: The stakeholder's ability to influence actions/decisions
- *Legitimacy*: The stakeholder possession of legal/moral/presumed claims within the pilot (e.g., the Port and stakeholders are in a contractual relationship)
- *Urgency*: The stakeholder's demand for urgent/priority action
- *Proximity*: The stakeholder proximity (spatial relationship) to the Pilot area and hinterland (e.g., multimodal green corridors).

The four ADMIRAL pilots identified stakeholders by main categories and categorized based on the four main attributes. As an example, the Finnish pilot stakeholder's matrix categorization is included in the following Table 25.

Table 25: Example from Finnish pilot stakeholders matrix categorization

Stakeholders identification	POWER The stakeholder's ability to influence actions/decisions	LEGITIMACY The stakeholder possession of legal/moral/presumed claims (e.g., the Port and stakeholder are in a contractual relationship)	URGENCY The stakeholder's demand for urgent/priority action	PROXIMITY The stakeholder proximity (spatial relationship) to the Pilot area and hinterland (e.g., multimodal green corridor)
Cargo Owners				
Stora Enso*	High	High	High	High
UPM Kymmene*	High	High	High	High
Metsä Group	High	High	High	Medium
Kotka Mills	High	High	High	High
Finnish Fibreboard	Medium	High	Medium	Low
Pankakoski	Medium	High	Medium	Low
RoRo-Port				
Steveco (Hietanen Ro-Ro operations)	High	High	High	High
Logistics (operators, brokers, forwarding agents)				
Steveco Logistics	High	Medium	High	High
Bruhn Spedition	Low	Medium	Medium	Medium
Spedition Services	Low	Medium	Low	Low
Rhenus	Low	Medium	Low	Low
Moonway	Low	Medium	Low	Low
Sea-Load	Low	Medium	Low	Low
Shipping lines				
Finnlines*	High	High	High	High
Transfennica	High	High	High	High
Wagenborg	High	High	High	Medium
Shipping Agents				
C&C Port Agency	Medium	Medium	High	High
Authorities				
HaminaKotka Port Authority	Medium	High	Medium	High
Rail Transport Operator				
VR Cargo	Medium	Low	High	High
Sectorial Associations				
Finnish Port Operators Association	Medium	Low	Low	Low
Finnish Freight Forwarding and Logistics Association	Low	Low	Low	Low

* STEVECO owners

The stakeholders mapped by the ADMIRAL pilots represent the main target audience to participate in the Stakeholder Collaborative Forum (SCF), as they are likely to have a direct interest in the project's outcomes. The ADMIRAL project partners aim to actively engage these stakeholders in the forum. Nevertheless, the SCF is not limited to project partners or directly mapped stakeholders – it was open to any organization or individual involved or interested in the greening of supply chains. This includes, but is not limited to, cargo owners, logistics service providers, infrastructure managers and operators, energy providers, governments, regulation bodies and academia.

To join the Stakeholder Collaborative Forum, a registration form was created on the SurveyMonkey platform. See Annex 1 – Stakeholder Collaborative Forum Contact Form. The form allowed institutions or companies to register institutions/companies as a member of the ADMIRAL Stakeholders Collaborative Forum.

As of June 2025, the SCF consisted of the following 57 companies and 81 contact persons. The following Figures 11 and 12 summarize the composition of 57 stakeholders by country and enterprise size. Most stakeholders come from Portugal (23%), Spain (19%), Finland (18%) and Slovenia (12%). In terms of

enterprise size, 37% represents large enterprise with 250 or more employees, while micro enterprises with fewer than 10 employees account for 26%.

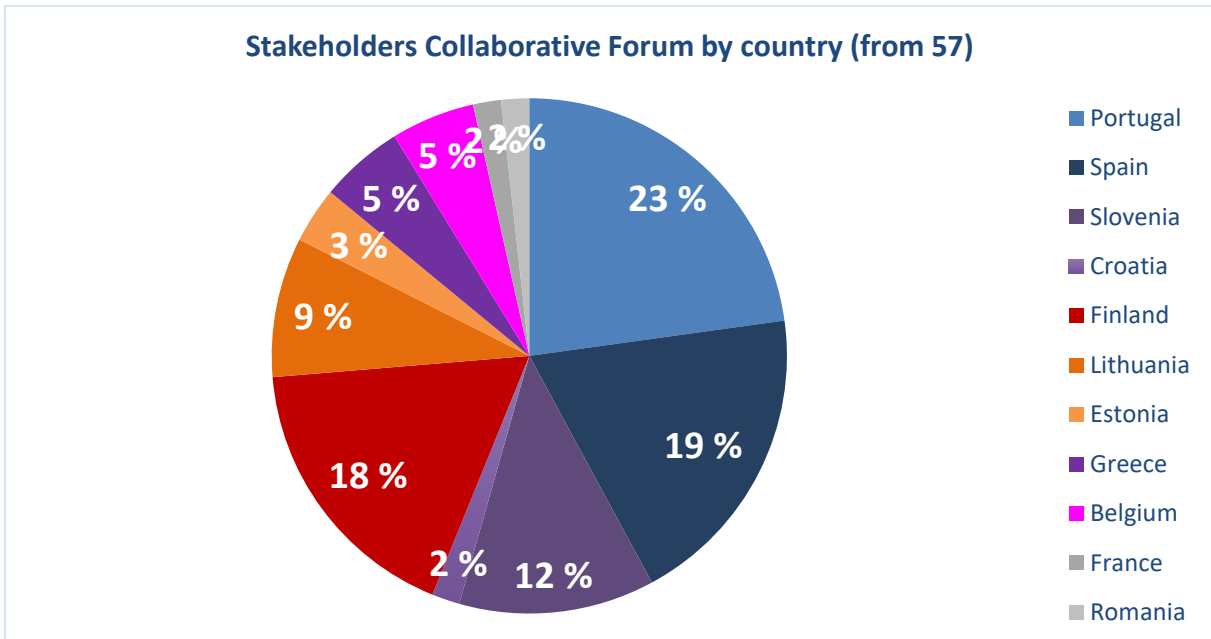


Figure 11: Stakeholders Collaborative Forum by country

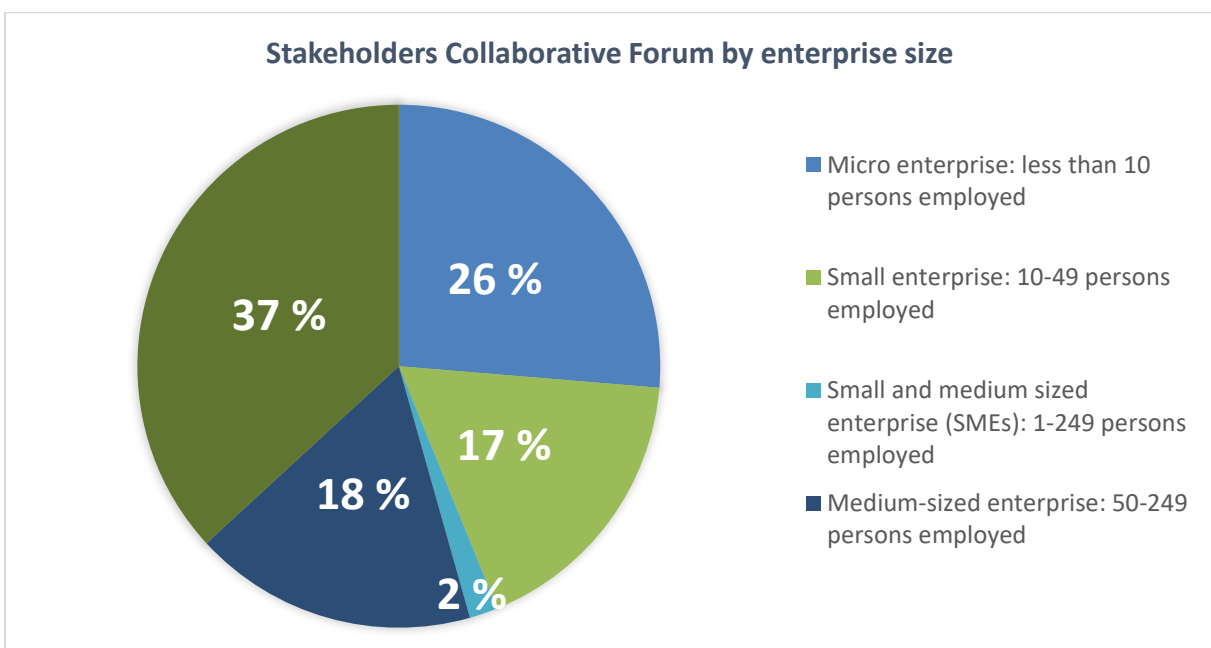


Figure 12: Stakeholders Collaborative Forum by company size

The ADMIRAL SCF comprises a diverse set of actors categorized into three main groups as shown in Figure 13, the majority of stakeholders belong to Supply Chain and Ancillary Services (60%), followed by Others (30%), and Government and Regulation Bodies (10%).

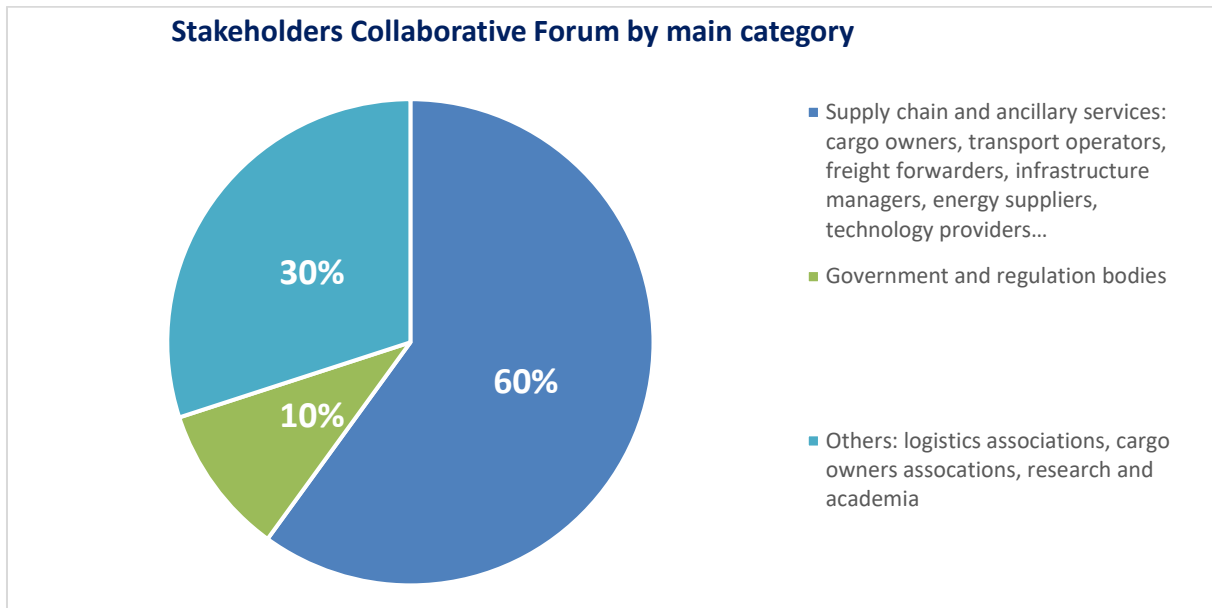


Figure 13: Stakeholders Collaborative Forum by main category

The **Supply Chain and Ancillary Services** category include 41 stakeholders (see Figure 14), primarily operational and service-oriented actors. The largest group are transport operators (15), freight forwarders and/or custom brokers (14), and warehousing and storage providers (12). Other significant roles include logistics operators (8), technology providers/IT companies (8), cargo owners (8), and consultancy firms (7). Infrastructure managers for dry ports, railroads, roads, and multimodal platforms represent smaller shares (2-4 stakeholders each), alongside vehicles manufactures and shipping agents (1 each). This distribution highlights the strong representation of logistics and transport services, which are critical for ADMIRAL’s objectives.

The **Government and Regulation bodies** category consist of 8 stakeholders (see Figure 15), ensuring regulatory compliance and policy alignment. The largest representation comes from EU national governments (4), and regional or local governments (3). Additional entities include European institutions, custom offices, standardization and certification bodies. Their involvement is essential for harmonizing standards and facilitating cross-border operations.

Finally, **the others** category includes 24 stakeholders (see Figure 16), dominated by transport or logistics associations (16) followed by research and academia (4). Smaller groups include chambers of commerce, trade unions, customers associations, think tanks, media and cargo owner associations (1-2 stakeholders each). This composition reflects the importance of advocacy, knowledge exchange, and collaborative research within the forum.

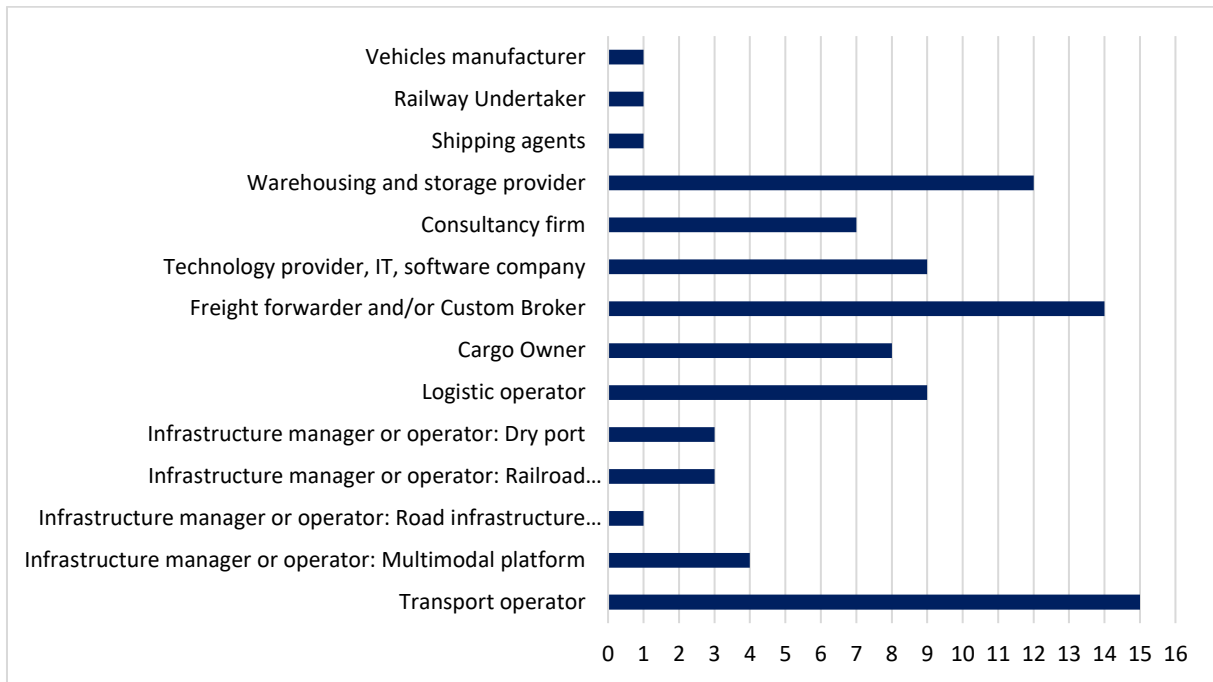


Figure 14: Stakeholders Collaborative Forum: Supply Chain players and Ancillary Services

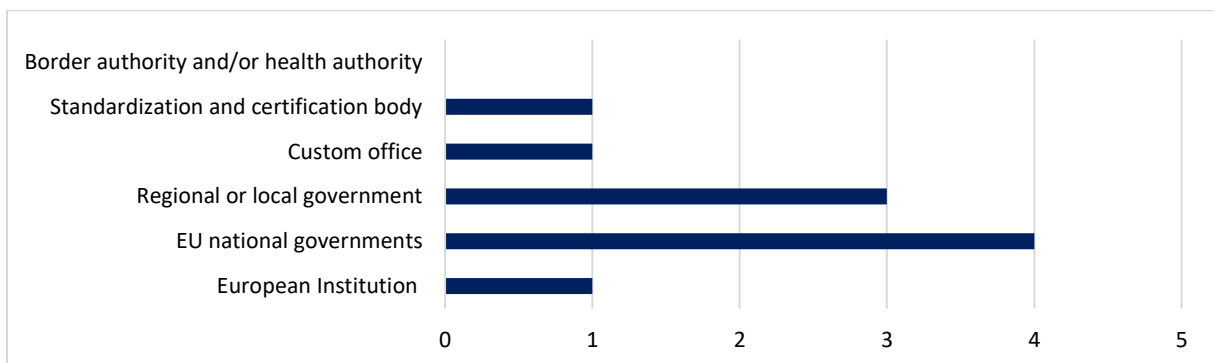


Figure 15: Stakeholders Collaborative Forum: Government and regulation bodies

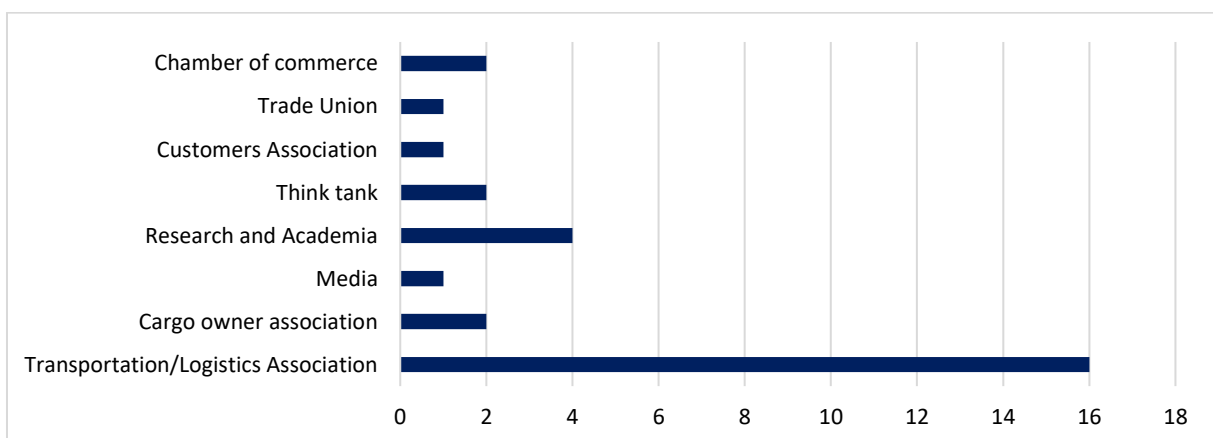


Figure 16: Stakeholders Collaborative Forum: Others category

Finally, the Figure 17 illustrates the potential use or interest in the ADMIRAL marketplace by stakeholders. The largest share, 34% reflects a general interest, indicating that many stakeholders would explore potential opportunities without a defined role yet. Both service/product providers and those with no identified use case represent 28% each, suggesting a balanced mix between proactive contributors and undecided participants. Smaller segments include potential customers (5%) and potential data users/providers (5%), highlighting niche roles focused on data-driven services. This distribution suggests that while there is overall interest, ADMIRAL project would dedicate efforts to convert general interest and undefined use cases into concrete participation models, ensuring the marketplace achieves its intended collaborative and functional objectives.

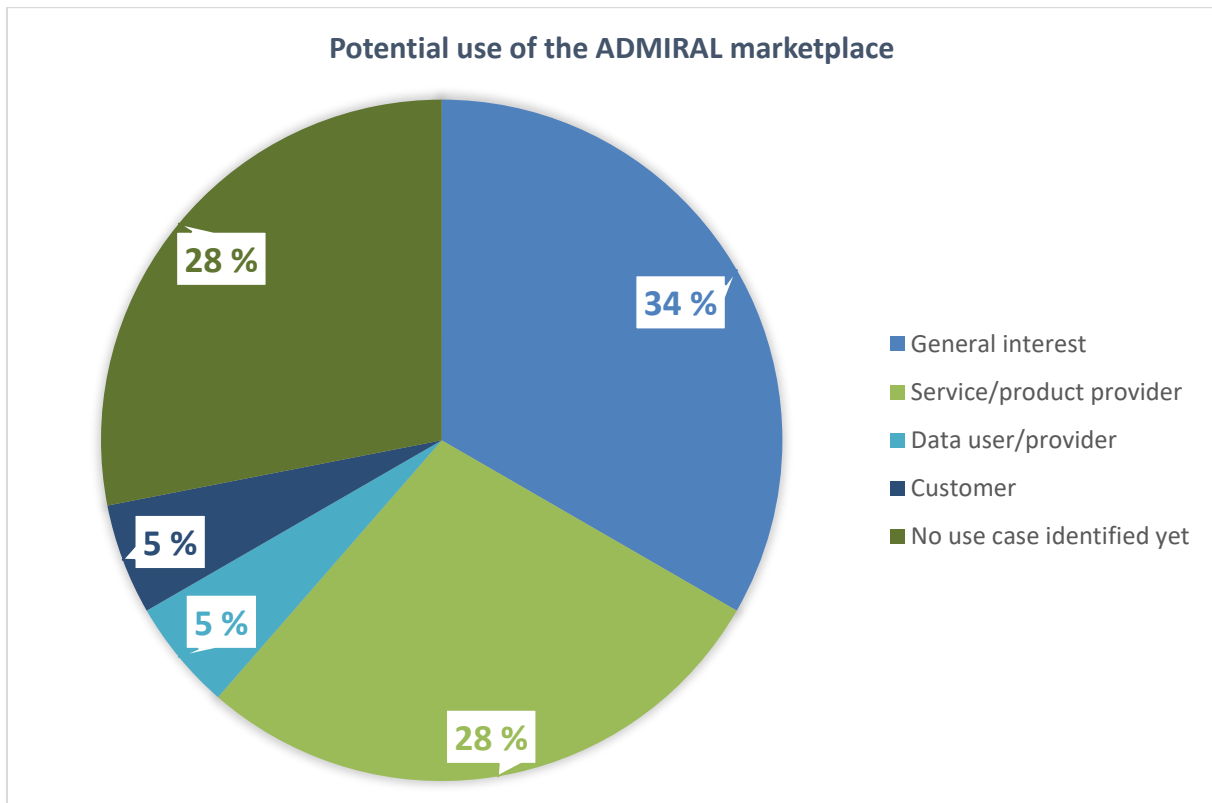


Figure 17: Stakeholders Collaborative Forum: Potential use of the ADMIRAL marketplace

2.4 Conclusions

The **ADMIRAL Sustainability Framework Architecture (SFA)** establishes a **structured, collaborative, and adaptive approach to integrating sustainability into logistics pilots**. It provides tools to identify objectives, define KPIs, and align digital innovation with environmental goals. Central to the framework is the **Stakeholders Collaborative Forum (SCF)**, which ensures continuous engagement and co-creation among diverse actors, supported by components addressing stakeholder needs, regulatory requirements, and practical constraints. This iterative process enables compliance with global and European sustainability targets while adapting to technological and operational realities.

Complementing the architecture, ADMIRAL’s stakeholder mapping and engagement strategy ensures broad participation through the SCF, involving organizations from supply chain services, regulatory bodies, and other sectors. With 57 companies and 81 representatives already engaged, the forum

reflects a diverse and influential network committed to advancing green, digital, and sustainable logistics. The **composition of the ADMIRAL Stakeholder Collaborative Forum reveals a strong operational focus, with logistics and transport actors forming the majority**. This concentration should be leveraged for implementation activities in pilots. Although government and regulatory bodies represent a smaller share, their involvement is strategically critical for policy harmonization and cross-border facilitation. Additionally, the presence of associations and research institutions offers opportunities for innovation, advocacy, and knowledge exchange. Regarding the ADMIRAL marketplace, while overall interest is high, a significant proportion of stakeholders have not yet defined specific use case. Therefore, targeted engagement strategies are essential to convert general interest into active participation, ensuring the marketplace fulfils its collaborative and functional objectives. Overall, ADMIRAL promotes a dynamic, evidence-based model that prioritizes collaboration and alignment with strategic sustainability objectives.

3 Analysis of relevant EU regulatory framework

3.1 Introduction

This section provides the analysis of the European Union's regulatory framework governing freight and logistics companies concerning sustainability practices. It aims to offer comprehensive insights into the regulatory mechanisms shaping sustainability reporting in freight transport and logistics.

The transport and logistics ecosystem encompass a wide range of stakeholders and companies, and has a key role in advancing global efforts to achieve the United Nations Sustainable Development Goals (SDGs), with particular relevance to Goals 5, 8, 9, 11, 12, 13, and 17. The attainment of these objectives necessitates a multidimensional approach that integrates environmental stewardship, technological innovation, robust governance frameworks, and the enhancement of working conditions.

To contribute effectively to environmental sustainability and climate action (SDGs 12 and 13), transport companies must undertake substantial measures to reduce their ecological footprint. This process involves transitioning to low-emission or zero-emission fleets, including electric, hybrid, and hydrogen-powered vehicles, alongside the implementation of advanced route optimization technologies to minimize fuel consumption and greenhouse gas emissions. Furthermore, encouraging a modal shift from road-based freight transport to more sustainable alternatives such as rail and waterways can significantly mitigate environmental impact. Companies should also adopt circular economy principles by prioritizing the recycling of vehicle components and minimizing packaging waste within logistics chains. The establishment of comprehensive carbon accounting systems further facilitates transparent monitoring and reporting of emissions, ensuring alignment with climate targets.

Technological innovation serves as a fundamental driver of sustainability and industry resilience, corresponding with SDG 9. Increasingly, logistics companies are leveraging Internet of Things (IoT) technologies for fleet monitoring, integrating automation within warehousing operations, and deploying artificial intelligence for predictive maintenance. Additionally, the utilization of digital twins and simulation tools enhances infrastructure planning efficiency, while blockchain technology strengthens transparency and traceability across supply chains. These advancements collectively contribute to the reduction of operational inefficiencies, optimization of resource utilization, and the positioning of companies as frontrunners in industrial modernization.

Effective governance and leadership are integral to ensuring long-term sustainability within the logistics sector, in accordance with SDG 17. Companies must establish comprehensive environmental, social, and governance (ESG) strategies that embed sustainability objectives into their core business operations. Collaboration with governmental bodies, technology developers, and civil society organizations can foster advancements in green infrastructure development and collaborative research initiatives. Transparent reporting practices, complemented by adherence to international standards such as the European Sustainability Reporting Standards (ESRS) and the Global Reporting Initiative (GRI), reinforce corporate accountability to both stakeholders and the wider public.

Equally imperative is the promotion of equitable working conditions and gender inclusivity, aligning with the objectives of SDGs 5 and 8. This entails ensuring equal remuneration, dismantling barriers to women's representation in leadership positions, and implementing inclusive recruitment and career

progression frameworks. Enhancing occupational health and safety measures, providing ergonomic work environments, and supporting mental health programs contribute to a healthier and more productive workforce. As the logistics sector undergoes digital transformation, investment in reskilling and upskilling initiatives is essential to equip employees with competencies suited to emerging technologies. Additionally, fostering flexible work arrangements and inclusive corporate cultures is instrumental in cultivating diverse and resilient teams.

In the realm of sustainable urban development (SDG 11), transport companies must actively support urban mobility strategies designed to enhance the accessibility and efficiency of public transportation while optimizing last-mile delivery solutions through electric vehicle deployment. Measures aimed at mitigating noise pollution, reducing traffic congestion, and improving air quality in urban areas—through smart logistics and synchronized delivery scheduling—play a crucial role in fostering healthier and more liveable environments. By aligning their operational frameworks with urban development objectives and the needs of local communities, transport companies can significantly contribute to the realization of inclusive and sustainable cities.

Ultimately, fostering sustainability within the transport sector necessitates a comprehensive approach that integrates environmental responsibility, technological advancement, regulatory transparency, and social equity. By embracing these principles, transport companies not only advance progress toward the UN Sustainable Development Goals but also enhance their competitive standing and resilience in an evolving global landscape.

3.2 Regulation (EU) 2020/1056 on electronic freight transport information (eFTI)

Regulation (EU) 2020/1056² on electronic freight transport information (eFTI) aims to facilitate the digital exchange of freight transport information across the European Union. This regulation is a significant step towards reducing administrative burdens, improving logistics efficiency, and harmonizing digital communication in the transport sector. It applies to all modes of freight transport, such as road, rail, inland waterways, and maritime, when operating in or between EU Member States. To comply, companies must take several practical measures within specified implementation timelines.

The regulation entered into force on August 20, 2020, and its main requirements became applicable as of August 21, 2024. From this date, companies must ensure that all regulatory transport documents, when provided electronically, comply with the eFTI framework. This means that companies are not required to go digital, but if they choose to submit regulatory information in electronic form, public authorities must be able to receive and process it electronically, under the conditions defined by the regulation.

² <https://eur-lex.europa.eu/eli/reg/2020/1056/oj/eng>

Some practical actions need to be taken by companies in order to be ready for these changes (Figure 18):

- Current transport documentation workflows must be classified according to whether the information falls under the regulation's scope. This includes data typically required to comply with EU transport laws, such as consignment notes, waybills, and certificates for waste or dangerous goods transport.
- Companies that wish to use electronic means must ensure that the information is made available through certified eFTI platforms. These platforms must be compliant with the technical and operational specifications that the European Commission will adopt. Companies should start engaging with IT providers or internal teams to prepare for integration with these platforms. This includes planning for system upgrades, data interoperability, and secure access for competent authorities.
- Ensure needs to be taken that the electronic freight transport data is provided in a structured and machine-readable format, as defined by the forthcoming common data set and data model specifications.

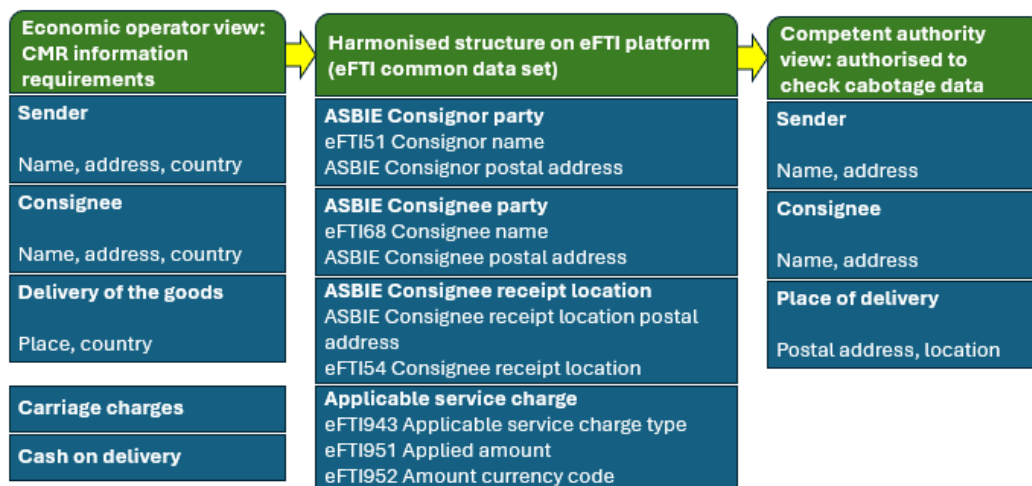


Figure 18: eFTI exchange environment in practice (adapted from Varjas, 2024)

In addition, by 2026 and every five years thereafter, the Commission will review the functioning of the regulation, and companies may need to adapt to future updates or extensions of the scope of applicable legislation. The key compliance milestones for companies under the eFTI Regulation are presented in Figure 19.

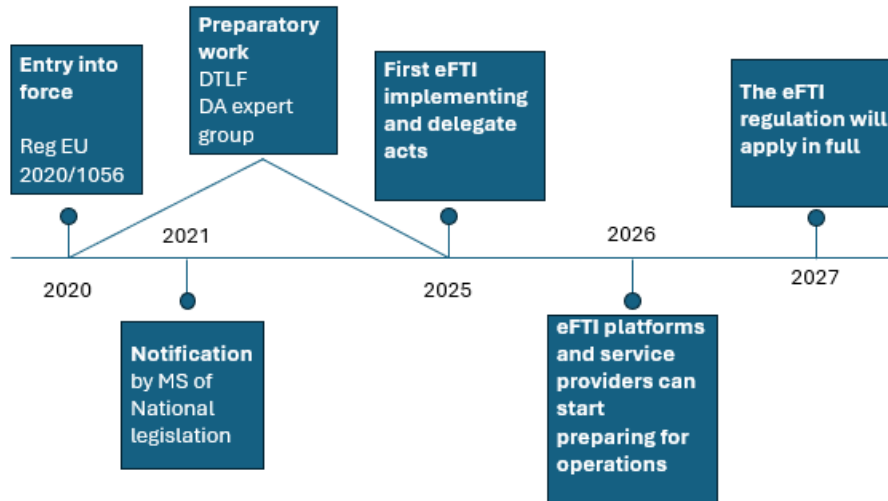


Figure 19: Timeline for eFTI Regulation implementation and application (adapted from (European Commission, 2025a; Varjas, 2024))

The regulation supports the EU’s broader goals for digitalization and transportation sustainability by simplifying administrative processes, encouraging interoperable data systems, and reducing paper use. Companies that act early to align with eFTI requirements will ensure compliance and gain a competitive edge through improved efficiency, transparency, and operational agility in cross-border freight operations. Figure 20 shows the practical information for eFTI implementation.

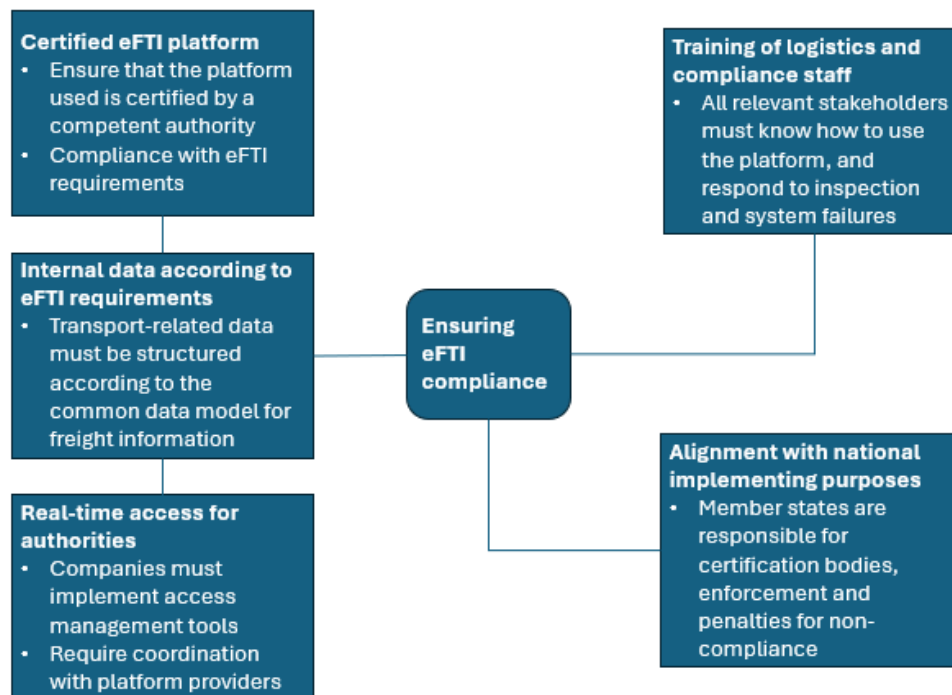


Figure 20: Practical information for eFTI implementation

3.3 Directive (EU) 2022/2464 on corporate sustainability reporting

Directive (EU) 2022/2464³ on corporate sustainability reporting (CSRD) represents a major evolution in the European Union’s regulatory framework for corporate transparency. Replacing and significantly expanding the scope of the previous Non-Financial Reporting Directive (NFRD), the CSRD introduces detailed and standardized sustainability reporting requirements applicable to a broader range of companies. Its objective is to ensure that sustainability information is consistent, comparable, and reliable across the EU, enabling investors, consumers, and other stakeholders to make informed decisions.

To comply with the Corporate Sustainability Reporting Directive (CSRD), companies must implement a range of practical measures based on their size, type, and listing status. The directive came into force on January 5, 2023, and its requirements are being introduced in stages over several years. Due to its implementation complexity, in 2025, the European Parliament and Council approved a “**Stop the Clock**” measure that postpones certain reporting obligations by up to two years. The delay is part of the EU’s effort to simplify and streamline the sustainable finance framework, while still keeping long-term climate and ESG goals intact.

The CSRD will be rolled out in four main phases. From the financial year 2024 (reporting in 2025), it applies to large public-interest entities (PIEs) already subject to the Non-Financial Reporting Directive (NFRD), including listed companies, banks, and insurance companies with more than 500 employees. From the financial year 2025 (reporting in 2026, now postponed to 2028 due to the “stop the clock” measure), the directive extends to all other large companies that meet at least two of the following three criteria: more than 250 employees, over €40 million in net turnover, or over €20 million in total assets. From the financial year 2026 (reporting in 2027, now postponed to 2029 due to the “stop the clock” measure), it will cover small and medium-sized enterprises (SMEs), excluding micro-enterprises, although these SMEs have the option to opt out until 2028. Finally, from the financial year 2028 (reporting in 2029), the directive will apply to non-EU companies with significant operations in the EU, defined as having a net turnover exceeding €150 million in the EU and at least one subsidiary or branch within the Union (Figure 21).

³ <https://eur-lex.europa.eu/eli/dir/2022/2464/oj/eng>

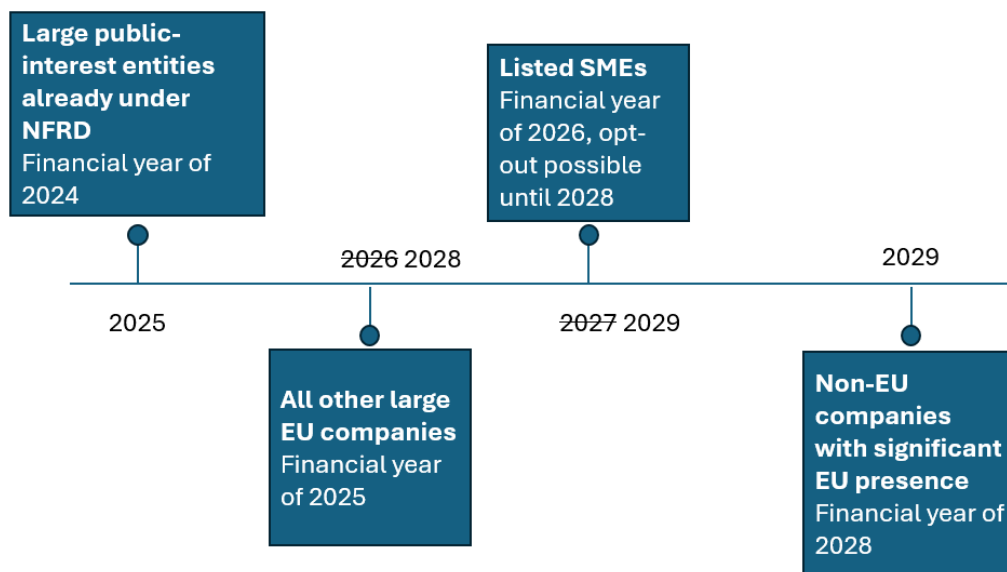


Figure 21: Timeline for CSRD application regarding the “Stop the Clock” measure

A critical aspect of compliance involves preparing for the double materiality assessment (i.e., companies must evaluate materiality considering its financial aspects – how sustainability affects the company’s financial health, and its materiality impacts – how the company’s activities affect people, the environment, and society). This means companies must report not only how sustainability issues affect their financial performance (financial materiality) but also how their operations impact society and the environment (impact materiality). To do so, companies should establish a robust process that includes stakeholder engagement, risk analysis, and internal data mapping.

In addition, companies must align their reporting with the European Sustainability Reporting Standards (ESRS), which set out detailed disclosure requirements across environmental, social, and governance (ESG) topics. These standards, adopted through Regulation (EU) 2023/2772, are applicable from January 1, 2024, for the first reporting company group. They must evaluate the relevance of the ESRS to their operations and start integrating the required metrics and disclosures into their internal reporting systems. This includes information on climate-related risks and targets, energy and resource use, workforce diversity, supply chain impacts, and governance structures.

CSRD compliance also requires an upgrade in data collection and internal controls. Companies need to gather detailed, verifiable, and auditable sustainability data with a level of rigor comparable to financial data. This requires the implementation or enhancement of data management systems, the establishment of internal controls, the definition of clear workflows, and the development of quality assurance processes aligned with ESRS requirements.

Another major component is ensuring audit and assurance readiness. The CSRD introduces mandatory limited assurance for sustainability reports, meaning companies must collaborate with statutory auditors or accredited assurance providers to verify their disclosures. Over time, the directive anticipates a transition to reasonable assurance, which will require even stronger data integrity and traceability.

Sustainability information must be incorporated into the company’s management report and presented in a digital format using the European Single Electronic Format (ESEF). This includes XHTML formatting and machine-readable tagging to enable structured data reporting. Achieving this requires close cooperation among sustainability, finance, legal, and IT teams.

To comply with all requirements in the CSRD Directive, companies need to build governance capacity and foster cross-functional coordination. This includes defining clear roles and responsibilities, designating ESG leadership at the executive level, and involving the board of directors in overseeing sustainability strategy and reporting. Ongoing training and collaboration across departments are essential to ensure that disclosures are consistent, complete, and aligned with regulatory expectations.

Companies must take proactive steps to understand their obligations, prepare systems and governance structures, and develop reporting capabilities aligned with the European Sustainability Reporting Standards. Early action will not only ensure compliance but also strengthen stakeholder trust, improve risk management, and position companies to lead in the sustainable transition of the European economy. In order to comply with the CSRD standards, companies need to follow the steps presented in Table 26.

Table 26: Steps to CSRD compliance

CSRD Compliance	Description
Determination of applicability	Determination of when the company needs to start complying (Figure 21).
Internal awareness and governance structure	Set up a cross-functional CSRD task force including sustainability, finance, compliance, legal, IT, and communications.
Double materiality assessment	Identification and prioritization of ESG issues that are material from the financial perspective (impact on the company), and impact perspective (company’s impact on people and planet).
	Engage stakeholders (internal and external) in the process.
	Document methodology and outcomes to support future disclosures.
Analysis and map reporting requirements	Study of the ESRS standards adopted through Delegated Regulation (EU) 2023/2772.
	Mapping is required for disclosures against existing reporting frameworks (GRI, TCFD, SASB, etc.).
	Perform a gap analysis to identify missing data, systems, and controls.
Upgrade of the data management systems	Establishment of data collection systems for ESG metrics across business units.
	Development of data governance and quality control processes.
	Alignment of sustainability data infrastructure with financial reporting systems for integration into the management report.
Preparation for limited assurance	Coordination with auditors or assurance providers to define the scope and methodology.
	Conduct a dry-run internal audit to test the accuracy, completeness, and traceability of ESG data.
	Address any gaps or inconsistencies ahead of the official reporting year.
Integrate ESG Disclosures into the Management Report	Ensuring that the sustainability information is embedded in the management report.
	Usage of the European Single Electronic Format (ESEF) with XHTML and machine-readable tagging.
Publish the First CSRD-Compliant Report	Publish the report with the auditor's limited assurance opinion.
	Ensure timely submission and availability to investors, regulators, and stakeholders.

CSRD Compliance	Description
Plan for Continuous Improvement	Monitor future updates to ESRS, assurance requirements (e.g., transition to reasonable assurance), and scope extensions.
	Make regular reviews and refinements of double materiality, stakeholder engagement, and data systems.
	Continuous integration of sustainability into the overall business strategy and risk management.

3.4 Regulation (EU) 2023/2772 on sustainability reporting standards

Regulation (EU) 2023/2772⁴, adopted on 31 July 2023, introduces the first set of European Sustainability Reporting Standards (ESRS), which companies subject to the Corporate Sustainability Reporting Directive (CSRD) must apply in preparing their sustainability reports. These standards aim to improve transparency, consistency, and comparability in sustainability reporting across the EU. For the transport and logistics sector, where environmental impact, workforce conditions, and supply chain practices are fundamental concerns, this regulation sets out a path towards more responsible and accountable operations, including value chain transparency regarding GHG emissions.

To comply with the regulation, transport and logistics companies must implement a set of clear and practical measures aligned with their reporting obligations under the CSRD. The first step is determining the timeline for applicability. Large public-interest entities already subject to the Non-Financial Reporting Directive (NFRD) were expected to begin reporting using the ESRS for the 2024 financial year, with the first reports due in 2025. Other large EU companies, such as freight carriers, logistics service providers, and warehouse operators, must begin reporting in 2028. Listed SMEs in the sector are expected to start reporting in 2029. Non-EU logistics or transport groups with significant operations in the EU (over €150 million in turnover and a branch or subsidiary in the EU) must begin reporting for the 2028 financial year, with their first disclosures due in 2029.

Once companies establish their reporting timeline, they must familiarize themselves with the twelve ESRS introduced by the regulation. These include two cross-cutting standards, being ESRS 1 (General Requirements) and ESRS 2 (General Disclosures), as well as ten topical standards covering environmental, social, and governance issues (Table 27). For the transport and logistics sector, key topical standards include ESRS E1 (Climate change), ESRS E2 (Pollution), and ESRS E5 (Resource use and circular economy), as well as social standards related to workforce management (ESRS S1) and business conduct (ESRS G1).

Table 27: Content requirements of sustainability reports

ESRS Requirement		Information to be reported
Environmental standards	Climate change (ESRS E1)	Greenhouse gas (GHG) emissions: scope 1, 2, and 3 emissions.
		Transition plans: strategies to achieve climate-related targets.
		Climate-related risks and opportunities: identification and management approaches.
	Pollution (ESRS E2)	Energy consumption and mix: details on energy sources and usage.
Pollutants emitted: types and quantities released into air, water, and soil.		

⁴ https://eur-lex.europa.eu/eli/reg_del/2023/2772/oj/eng

ESRS Requirement		Information to be reported
		Pollution prevention measures: strategies and technologies employed.
		Compliance: adherence to environmental regulations and standards.
	Water and marine resources (ESRS E3)	Water consumption: volumes used and sources.
		Water discharge: quality and quantity of wastewater released.
		Impact on marine ecosystems: activities affecting aquatic environments.
	Biodiversity and ecosystems (ESRS E4)	Ecosystem impacts: effects of operations on biodiversity.
		Conservation efforts: initiatives to protect and restore habitats.
		Land use: changes and measurement practices.
	Resource use and circular economy (ESRS E5)	Resource consumption: materials used and efficiency measures.
		Waste management: generation, treatment, and disposal practices.
Circularity initiatives: efforts to recycle, reuse, and reduce resource use.		
Social standards	Own workforce (ESRS S1)	Employee demographics: age, gender, and other relevant data.
		Working conditions: hours, remuneration, and benefits.
		Health and safety: incidents, policies, and programs.
		Training and development: opportunities provided to employees.
	Workers in the value chain (ESRS S2)	Labour and practices: conditions of workers not directly employed.
		Human rights: due diligence processes and findings.
		Engagement: mechanisms for worker feedback and grievances.
	Affected communities (ESRS S3)	Community engagement: consultation processes and outcomes.
		Impact assessment: social and environmental effects on local populations.
		Mitigation measures: actions taken to address negative impacts.
	Consumers and end-users (ESRS S4)	Product safety: standards and incidents.
		Data protection: policies and breaches.
Marketing practices: transparency and fairness.		
Governance standard	Business conduct (ESRS G1)	Ethical policies: codes of conduct and compliance programs.
		Anti-corruption measures: controls and incidents.
		Lobbying activities: expenditures and objectives.
		Whistle-blower mechanism: channels and protections.

A central obligation of companies is to conduct a double materiality assessment. For transport and logistics firms, this may include assessing the materiality of GHG emissions from fleet operations, working conditions for drivers and warehouse staff, or the resilience of global supply chains. Engaging with stakeholders, such as clients, regulators, employees, and local communities, is critical to establishing a robust and defensible assessment.

Following this, companies must distinguish between mandatory and materiality-dependent disclosures. General disclosures under ESRS 2 are required from all in-scope companies, and certain climate-related disclosures under ESRS E1, such as greenhouse gas emission data, energy consumption, and transition planning, must be reported regardless of whether climate change is considered material. This is particularly important for transport companies, given the sector's high carbon footprint and growing regulatory pressure to decarbonize.

To report accurately, companies must upgrade their data collection and reporting systems. This includes capturing data on fuel usage, energy efficiency, emissions per kilometre travelled, workforce turnover, and health and safety incidents. Many logistics firms will have to establish new digital infrastructure to monitor these indicators across operational divisions and subcontractors. Data must be collected systematically and supported by internal controls that ensure accuracy and traceability. The integration with financial data systems is also essential, as the sustainability information will be embedded within the management report.

In parallel, companies must prepare for independent auditors to verify that the disclosures meet required standards of reliability. To meet this obligation, companies should begin working with assurance providers early, establishing documentation trails, clear methodologies, and quality checks for each ESG metric. In a sector as operationally complex as transport and logistics, where third-party providers, subcontractors, and dynamic routing introduce multiple variables, the assurance of data quality will require internal collaboration and possibly third-party data validation.

Finally, governance frameworks must be adapted to reflect the new reporting responsibilities. Company boards and executive teams must oversee the ESG disclosure process, ensure alignment with long-term strategy, and regularly review sustainability risks and opportunities. For logistics providers, this includes considering how environmental policies affect route planning, fleet renewal, or intermodal transportation strategies, and how social policies affect retention, training, and subcontractor management.

The compliance with Regulation (EU) 2023/2772 involves not only meeting regulatory requirements but also strengthening long-term resilience, improving operational efficiency, and reinforcing stakeholder trust. Companies that start to insert sustainability into their data systems, governance structures, and strategic planning will be best positioned to lead the transition toward a low-carbon, socially responsible transport and logistics ecosystem.

In 2025, the European Commission launched the “Omnibus Simplification Package”, which included the European Financial Reporting Advisory Group (EFRAG) mandate to streamline and simplify ESRS, especially for SMEs. The Commission is expected to adopt a revised delegated act in time for application from FY27 (reporting in 2028), with possible early adoption for FY26.

3.5 The Global Reporting Initiative Standards

The Global Reporting Initiative (GRI) Standards are the most widely used voluntary framework worldwide. Recent research from KPMG found that across all global regions, including Europe, the GRI Standards are the most widely used sustainability reporting standards, adopted by 71% of the top 100 companies in 58 countries (KPMG, 2024). The GRI analysis indicates that 65% of EU companies with more than 1,000 employees reported on sustainability using the GRI Standards in 2024.

The GRI Standards are a modular system of interconnected standards that allow organizations to publicly report the impacts of their activities in a structured way that is transparent to stakeholders and other interested parties, organized into three series: GRI Universal Standards, GRI Sector Standards, and GRI Topic Standards:

- Universal Standards: GRI 1, GRI 2 and GRI 3; GRI 1: Foundation 2021 specifies the requirements that the organization must comply with to report in accordance with the GRI Standards; GRI 2: General Disclosures 2021 contains disclosures that the organization uses to provide information about its reporting practices and other organizational details, such as its activities, governance, and policies; GRI 3: Material Topics 2021 provides guidance on how to determine material topics. It also contains disclosures that the organization uses to report information about its process of determining material topics, its list of material topics, and how it manages each topic.
- Sector Standards: these provide information for organizations about their likely material topics. The organization uses the Sector Standards that apply to its sectors when determining its material topics and when determining what to report for each material topic.
- Topic Standards: these contain disclosures that the organization uses to report information about its impacts in relation to particular topics. The organization uses the Topic Standards according to the list of material topics it has determined using GRI 3.

The GRI Standards (see Annex 2) enable an organization to report information about its most significant impacts on the economy, environment, and people, including impacts on their human rights, and how it manages these impacts. For example, GRI 102: Climate Change 2025 (Global Sustainability Standards Board, July 2025) contains disclosures for organizations to report information about their climate change-related impacts, and how they manage these impacts. GRI 102 is effective for reports or other materials published on or after 1 January 2027.

3.6 Council Directive 92/106/EEC on the establishment of common rules for certain types of combined transport of goods between Member States

Council Directive 92/106/EEC⁵ sets out important rules and incentives for companies operating in freight transport, particularly those involved in combined transport, which blends road transport with rail, inland waterways, or short-sea shipping.

Transport companies engaged in combined transport must ensure that the road part of the journey is as short as possible, with a typical maximum of 150 kilometres between the road segment and the nearest combined transport terminal. This requirement encourages companies to optimize routing so that most of the long-distance freight moves in a more sustainable mode, reducing road congestion and emissions.

Companies also benefit from exemptions in road transport regulations for these short road parts of the journey. This includes easing restrictions on cross-border operations (cabotage) and simplified authorization procedures for vehicles used in combined transport. Such measures reduce administrative burdens and costs, making intermodal transport more competitive with pure road transport.

Besides, transport operators should collaborate with terminal operators, rail companies, and shipping lines to develop effective logistics chains that enable the smooth transfer of goods between modes.

⁵ <https://eur-lex.europa.eu/eli/dir/1992/106/oj/eng>

This requires investment in planning, coordination, and possibly in IT systems that facilitate tracking and scheduling.

Additionally, transport companies are encouraged to support or engage with infrastructure development initiatives, such as expanding or modernizing terminals and improving connections between transport modes. This infrastructure is essential to enable efficient transshipment and reduce delays.

Finally, by adopting combined transport solutions in line with the directive, companies contribute directly to European sustainability goals by lowering carbon emissions and enhancing overall transport efficiency.

3.7 ISO 14093:2023 on Greenhouse Gas Quantification and Reporting Arising from Transport Chain Operations

ISO 14083⁶ was developed to support consistent and transparent greenhouse gas (GHG) emissions accounting in the transport and logistics sector. Created to serve both freight and passenger transport across all modes, including road, rail, inland waterways, maritime, and air, it provides a harmonized methodology to quantify and report GHG emissions generated during transport activities. For transport and logistics companies, the standard plays a crucial role in enabling robust climate reporting and contributing to broader sustainability goals.

The first practical step that companies need to take under ISO 14083 is to clearly define the scope and boundaries of their emissions accounting. This includes identifying the transport activities to be included (e.g., conducted with owned assets, subcontracted fleets, or through intermodal arrangements) and deciding whether emissions will be measured at the operational, shipment, or organizational level. Through this, companies determine whether to include just the direct fuel use or also upstream emissions from fuel production and energy consumption (known as well-to-wheel emissions).

Next, companies are required to identify and categorize the relevant emission sources. These include direct emissions from vehicles, such as CO₂ emissions from trucks and ships, as well as indirect emissions, such as those from purchased electricity used to power electric trains or the production of fuel. It is important to mention that ISO 14083 applies across the entire transport chain, meaning that logistics providers must assess emissions from door to door, including first-mile pick-up and last-mile delivery.

An important asset to ISO 14083 is the emphasis on data quality. Transport companies must try to use primary data (e.g., actual fuel consumption, mileage, and load factors) collected through fleet management systems, telematics, or transport documents. Where primary data is not available, secondary data or standard emission factors may be used, but these must be appropriately justified and documented. This requirement accentuates the need for companies to strengthen their digital infrastructure and data collection capabilities.

⁶ <https://www.iso.org/standard/78864.html>

Through the application of emission factors, ISO 14083 provides flexibility while maintaining scientific rigor. These emission factors are then used to calculate emissions based on fuel use, energy consumption, or activity data (like tonne-kilometres for freight or passenger-kilometres for transit operations). Moreover, another important requirement is the fair and transparent allocation of emissions. For instance, in logistics operations involving multiple clients or shipments, emissions must be allocated using consistent methods, such as proportional allocation based on weight, volume, distance, or time. This is particularly important for companies providing carbon footprint information to customers, as it enables comparability and supports supply chain transparency.

Reporting is an important element of ISO 14083. Transport companies must prepare clear and comprehensive reports that document the methodology, data sources, assumptions, and results. Reports should include total GHG emissions, emission intensities (e.g., grams of CO₂ equivalent per tonne-kilometre), and comparisons over time to show progress. The standard encourages publications in a format compatible with broader corporate sustainability frameworks, such as the EU’s Corporate Sustainability Reporting Directive (CSRD) and the European Sustainability Reporting Standards (ESRS).

ISO 14083 also supports external verification in order to ensure credibility and reliability. Companies are expected to maintain identifiable records and documentation that allow third parties to review and validate the results. This can be considered an asset to build confidence among stakeholders, from regulators to clients and investors, and aligns emissions data with climate-related financial disclosures.

Although ISO 14083 is a voluntary standard, it is strategically aligned with major EU and global climate initiatives. For European transport and logistics companies, it complements regulatory requirements such as the CSRD, the EU Taxonomy for Sustainable Activities, and the European Green Deal’s climate targets. It also enables more accurate emissions declarations under the EU Emissions Trading System (EU ETS) and prepares companies for participation in green acquisition schemes or logistics partnerships requiring certified emissions data. Table 28 presents a collection of steps for the implementation of ISO 14083⁷.

Table 28: Steps for the implementation of ISO14083

Step	Description
Definition of system boundaries	Organizational boundary (company-wide or specific units).
	Operational boundary (what transport activities will be measured).
	Focus is on direct emissions, indirect emissions, or both.
	Scope (e.g., from vehicle use only or also upstream fuel production and electricity).
	Documentation of boundaries to guide consistent data collection.
Identification of emission sources and transport modes	Listing of all relevant transport modes and operational activities that generate emissions.
	Listing of all parts of the journey (first-mile, main transport, last-mile).
	Development of a transport map that includes all modes and logistics flows.
Collection of activity data	Primary data: fuel consumption, distance travelled, load factors, vehicle type, and efficiency, telematics or onboard systems data.
	Secondary data: industry averages, public emission databases, default energy use assumptions.

⁷ <https://www.iso.org/es/contents/data/standard/08/19/81923.html>

Step	Description
	It is important to identify gaps in data and put in place systems to improve data accuracy (e.g., telematics, fleet management software).
Application of emission factors	Usage of appropriate emission factors to convert activity data into GHG emissions.
	It is important to ensure emission factors align with the scope and are up to date.
Allocation of emissions	Distribution of emissions across shipments, clients, routes, or services as needed.
	the allocation method chosen needs to be suited to the business model and reporting needs.
Calculation and compilation of results	Performance of the calculations to determine total emissions and intensity metrics.
	It is important to use calculation tools or software that supports ISO 14083 methodology.
Report transparently	Preparation of internal or external reports in line with ISO 14083 guidelines.
	Include in the report the methodology and boundaries, data sources and quality indicators, emission totals and intensities, assumptions, and limitations.
	Align the reporting format with requirements under the CSRD, ESRS, or client expectations.
Enable Verification	Insurance of traceability and transparency of calculations to allow external review or certification: third-party verification, internal audit, or client review, assurance in sustainability reporting.
	It is important to maintain organized records and calculation documentation.

3.8 Regulation EU 2024/1679 on the development of the trans-European network and the EU green freight corridors

According to the EU 2024/1679⁸ regulation, the planning, development and operation of the trans-European transport network should enable sustainable forms of transport, provide for improved multimodal and interoperable transport solutions and for an enhanced intermodal integration of the entire logistic chain, thereby contributing to a smooth functioning of the internal market by creating the arteries that are necessary for smooth passenger and freight transport flows across the Union, and by establishing seamless transport connections with neighbouring countries. The law merges the former Core Network Corridors and Rail Freight Corridors into nine European Transport Corridors (ETCs), which are the backbone for sustainable and multimodal freight. These corridors are explicitly designed to support transport decarbonisation, with emphasis on rail interoperability, electrification, and multimodal logistics. This regulation creates a legal and operational framework that obliges Member States and operators to align investments and policies with sustainability goals and strict timelines.

According to the International Forwarding Association (2025), the new corridors merge the previous Core Network Corridors and Rail Freight Corridors, and are subject to phased completion deadlines: the core network by 2030, the extended cross-border layer by 2040, and the comprehensive network by 2050. Complementing this legislative framework is the Alternative Fuels Infrastructure Regulation (AFIR), which sets ambitious infrastructure targets. By 2025, fast electric chargers of at least 350 kW must be available every 60 kilometres along TEN-T core roads, and all EU airports must electrify aircraft

⁸ <https://eur-lex.europa.eu/eli/reg/2024/1679/oj/eng>

stands. By 2030, hydrogen refuelling stations must be installed every 200 kilometres and in all urban nodes, while core ports must provide shoreside electricity for container and large passenger vessels.

To support these goals, the EU awarded €422 million in February 2025 to 39 projects under the Alternative Fuels Infrastructure Facility (AFIF), funding initiatives such as megawatt-level truck chargers, hydrogen stations, and shore power systems. An additional €578 million remains available for the next funding round in June 2025. In parallel, the EU is advancing digitalization through the Electronic Freight Transport Information (eFTI) Regulation. As of January 2025, Member States can deploy certified platforms for electronic freight data exchange, with mandatory acceptance of e-documents by public authorities beginning in July 2027. This digital shift is expected to save the logistics sector approximately €1 billion annually in administrative costs.

Early corridor projects illustrate the tangible impact of these policies. The Rotterdam–Duisburg Hydrogen Corridor will deliver green hydrogen to the Ruhr region via pipeline infrastructure, with the first segment operational by 2027. Additionally, the Duqm–Amsterdam–Duisburg Liquid Hydrogen Route, formalized in April 2025, will connect Oman to Europe through multimodal logistics infrastructure. Together, these measures signal a decisive shift from policy vision to operational reality, enabling logistics operators to plan and implement zero-emission freight routes with greater confidence and clarity.

3.9 Conclusions

Regulation is a cornerstone in advancing sustainability within the European transport and logistics sector. By establishing binding requirements, harmonized standards, and clear implementation timelines, the EU regulatory framework transforms sustainability from a voluntary aspiration into a mandatory, measurable, and enforceable objective. Instruments such as the Corporate Sustainability Reporting Directive (CSRD) and the European Sustainability Reporting Standards (ESRS) embed transparency and accountability into corporate governance, compelling companies to disclose environmental, social, and governance (ESG) impacts with rigor comparable to financial reporting. This ensures that sustainability performance becomes a critical dimension of business evaluation and stakeholder trust.

Complementary regulations, including Regulation (EU) 2020/1056 on electronic freight transport information (eFTI), accelerate digitalization and interoperability, reducing administrative burdens and enabling data-driven decision-making. Similarly, infrastructure-focused measures such as Regulation (EU) 2024/1679 on the Trans-European Transport Network (TEN-T) and the Alternative Fuels Infrastructure Regulation (AFIR) create the physical and technological backbone for decarbonized freight corridors, promoting modal shifts and zero-emission transport solutions. Voluntary standards like ISO 14083 further reinforce this regulatory ecosystem by providing robust methodologies for greenhouse gas quantification and reporting, aligning operational practices with global climate targets.

Collectively, these regulations foster a systemic transformation that integrates environmental responsibility, technological innovation, and social equity into the core of logistics operations. By aligning corporate practices with regulatory requirements, businesses not only reduce emissions and optimize resource use but also enhance resilience, competitiveness, and stakeholder trust. Ultimately,

regulation transforms sustainability from a voluntary initiative into a strategic imperative, accelerating the transition toward a low-carbon, socially responsible logistics ecosystem.

4 ADMIRAL pilots' sustainability reporting and solutions

4.1 Sustainability reporting insights from supply chain players

As sustainability becomes a key part of corporate strategy, transport companies are increasingly expected to report on their environmental, social, and governance (ESG) performance due to the requirements in Regulation (EU) 2023/2772 on sustainability reporting standards. This analysis reviews the sustainability reports of a sample of twenty-three companies involved in the four pilots within the ADMIRAL project (i.e., Portugal-Spain, Slovenia-Croatia, Lithuania, and Finland). Using only the data from the sustainability reports, the analysis examined the companies' sustainability targets, key performance indicators (KPIs), and alignment with global frameworks, including the United Nations Sustainable Development Goals (UN SDGs) and the principles of a circular economy.

4.1.1 Portugal-Spain pilot

APS

APS is a public port authority operating globally, with a staff of 180 employees, including 136 men and 44 women. In its 2023 sustainability report, the company details its operational scope, which involves managing 42.9 million tons of goods each year. Although the report does not specify clear environmental, economic, or social targets, it provides various key performance indicators (KPIs) that demonstrate APS's commitment to sustainability across different areas.

From an economic and governance perspective, **APS monitors several indicators that suggest an awareness of equity and ethical business practices.** These include the ratio of men's to women's salaries, the proportion of board directors originating from the local community, and the implementation of anti-corruption operations. Although these metrics are not tied to specific targets, their inclusion indicates a foundational approach to corporate responsibility and governance transparency.

Social sustainability is addressed through KPIs that focus on workforce development and occupational safety. APS reports the creation of new jobs, the identification of workplace hazards, the evaluation of risks to employees, and the provision of training programs. These indicators indicate a proactive approach toward employee well-being and capacity building, although the lack of formal social targets limits the ability to measure progress over time.

Environmental performance is captured through a set of KPIs that include energy consumption, biodiversity impact, and greenhouse gas (GHG) emissions across scopes 1, 2, and 3. Notably, scope 3 emissions are acknowledged in relation to employee commuting, demonstrating an effort to account for indirect environmental impacts. However, the company does not calculate its total GHG emissions comprising the entire supply chain, which constrains the comprehensiveness of its environmental reporting.

Technological innovation is referenced in the report, with APS stating that it has implemented technology-related solutions to support its sustainability efforts. However, the nature and scope of these solutions are not specified. Nonetheless, the company affirms that its actions are aligned with the United Nations Sustainable Development Goals (UN SDGs), and it explicitly considers circular

economy principles in its operations. This alignment suggests a broader commitment to global sustainability frameworks and resource efficiency.

A key feature of APS's sustainability report is its recognition of global trends and their impact on the company's targets and business strategy. While specific targets are not articulated, the report reflects an understanding of the dynamic external environment and its implications for long-term planning and resilience.

COSCO

COSCO is a private maritime transport company that has a global presence and a workforce of 17,200 employees. With a transportation capacity of 2,130,219 twenty-foot equivalent units (TEUs), the company plays a significant role in international logistics and shipping. In its 2023 sustainability report, COSCO outlines a long-term environmental ambition while providing selected performance indicators that reflect its approach to sustainability.

The company's primary environmental target is the achievement of **net-zero emissions from vessels by or around 2050**. This long-term goal aligns with global decarbonization efforts in the maritime sector and signals COSCO's strategic commitment to reducing its environmental footprint. Despite this ambition, the report does not specify intermediate milestones, implementation strategies, or supporting metrics that would enable stakeholders to assess progress toward this objective.

COSCO's environmental performance is partially captured through the reporting of **tons of CO₂ equivalent emitted under scopes 1 and 2**. However, the company does not include scope 3 emissions in its disclosures, nor does it calculate its total greenhouse gas (GHG) emissions using standardized methodologies. This omission limits the comparability of its environmental data, particularly given the growing importance of scope 3 emissions in supply chain-intensive industries.

On the social dimension, COSCO provides a set of KPIs that offer insight into workforce composition and occupational safety. These include the **proportion of regular employees by gender, age, and region**, the **number of accidents resulting in work-related injuries**, the **total number of injuries**, and the **number of employees who received training**. While these indicators suggest a degree of operational monitoring, there is an absence of defined social targets or qualitative context. There is no information on diversity initiatives, employee well-being, or labour rights, which are increasingly central to social sustainability assessments.

The report does not present any economic or governance targets or KPIs, leaving a critical gap in understanding COSCO's approach to ethical business practices, financial sustainability, and stakeholder engagement. Nevertheless, the company has implemented **technology-related solutions**, specifically through the **digitalization of supply chain management**.

COSCO affirms that its actions align **with the United Nations Sustainable Development Goals (UN SDGs)**, indicating a general alignment with global sustainability frameworks. However, the company does **not consider circular economy principles**. The report also includes a section on **risk identification and potential mitigation responses**, suggesting that COSCO is aware of the vulnerabilities and uncertainties associated with its operations and is taking steps to address them.

CP

CP (Comboios de Portugal) is a public rail transport company operating within the national boundaries of Portugal. With a workforce of 3,736 employees and an annual passenger volume of 86.9 million, CP plays a pivotal role in the country's mobility infrastructure. The company's 2020 sustainability report provides limited information on its environmental, social, and economic performance. While the report does not articulate specific sustainability targets, it includes selected key performance indicators (KPIs) and demonstrates alignment with global sustainability frameworks.

From an environmental standpoint, CP reports its **GHG emissions under scopes 1 and 2**, expressed in tons of CO₂ equivalent. These emissions are calculated using the **GHG Protocol**, a globally recognized standard for corporate carbon accounting. The inclusion of **scope 3 emissions**, specifically those associated with **trips for working meetings**, reflects an awareness of indirect environmental impacts. However, the report does not provide broader scope 3 data or detailed mitigation strategies. Moreover, **no formal environmental targets** are described, leaving stakeholders without a benchmark for evaluating progress or ambition.

In terms of social sustainability, the report presents a single KPI: the **number of lost days of work**. This metric offers insight into occupational health and safety, but is insufficient to assess broader social dimensions such as employee well-being, diversity, inclusion, or labor conditions. The absence of **defined social targets** suggests that CP's social sustainability strategy remains underdeveloped or underreported.

Economically, CP discloses the **economic value generated**, an indicator of financial performance and contribution to the national economy. However, the report does not elaborate on governance practices, ethical standards, or stakeholder engagement mechanisms.

Technological innovation is notably absent from CP's sustainability strategy. The company **does not report the implementation of technology-related solutions**, which may delay its ability to enhance operational efficiency, reduce environmental impacts, or improve service delivery.

Despite these limitations, CP affirms that its actions are **in consonance with the United Nations Sustainable Development Goals (UN SDGs)**. This alignment indicates a general commitment to global sustainability principles. However, CP does **not consider circular economy principles**, which restricts its engagement with resource efficiency, waste reduction, and regenerative practices.

Logifrio

Logifrio is a private road transport company operating at a regional scale, with a workforce of 656 employees and an annual freight volume of 585,000 tons. The company's 2024 sustainability report provides a qualitative overview of its environmental, social, and governance (ESG) commitments, though it lacks formalized targets and quantitative key performance indicators (KPIs). Despite these limitations, the report reflects a growing organizational awareness of sustainability principles and outlines several initiatives that contribute to its broader strategic orientation.

From a governance standpoint, Logifrio demonstrates a commitment to ethical business conduct through the establishment of a **whistle-blower channel** and adherence to **anti-corruption and anti-bribery policies**. These mechanisms suggest a foundational approach to corporate integrity and

compliance, although the absence of economic KPIs or detailed governance targets limits the ability to assess performance or progress in this domain.

Social sustainability is addressed through descriptive data on workforce composition and internal support programs. The report notes that **32% of employees are female**, that most employees are aged **41 to 50**, and that many have been employed for **two to five years**. The workforce is characterized by **diverse nationalities**, indicating a degree of inclusivity. Additionally, Logifrio provides **employee training courses** and has implemented **mental health and well-being programs**, which reflect a commitment to employee development and holistic care. However, the company does not present formal **social targets or KPIs**, making it difficult to evaluate the effectiveness or scope of these initiatives.

Environmental sustainability is referenced through the company's participation in several external programs, although **no specific environmental targets or KPIs** are disclosed. Logifrio does not report **scope 3 emissions** or calculate its **greenhouse gas (GHG) emissions**, and it has not implemented **technology-related solutions** internally. Nevertheless, the company engages with multiple sustainability-focused initiatives that suggest a strategic orientation toward environmental responsibility. These include:

- **Lean and Green Program:** A collaborative effort to reduce carbon dioxide emissions in logistics operations.
- **UPAC:** A solar energy capture system used to generate electricity for company operations.
- **ADDVOLT:** A plug-in system designed to electrify refrigerated freight, reducing fuel consumption and emissions.
- **CHEP:** A platform for sharing and reusing containers and pallets, promoting resource efficiency.

Logifrio's involvement in these programs indicates a willingness to adopt external innovations and collaborate on sustainability goals, even in the absence of internal technological deployment. The company's actions are **in consonance with the United Nations Sustainable Development Goals (UN SDGs)**, and it explicitly **considers circular economy principles**, particularly through its engagement with CHEP and other resource-sharing initiatives.

Institutional affiliations further reinforce Logifrio's commitment to sustainability. The company is a member of the **Business Council for Sustainable Development (BCSD)**, which provides strategic support for corporate sustainability efforts. It also participates in **Grace**, an association dedicated to enhancing **social responsibility and corporate sustainability**. These memberships suggest that Logifrio is actively seeking guidance, benchmarking opportunities, and collaborative platforms to advance its ESG agenda.

Medway/MSC Group

Medway/MSC Group is a private global transport conglomerate with a workforce of 91,967 employees and operations spanning maritime, rail, road, and air transport. The company moves 6.3 million twenty-foot equivalent units (TEUs) on land and 24.5 million TEUs by sea, positioning itself as a key

player in international freight mobility. In its 2023 sustainability report, Medway/MSC Group outlines a comprehensive environmental strategy, although it does not specify future targets or provide detailed strategic plans in the economic and social domains.

The company aims to reduce CO₂ emissions per transport work in international shipping by at least 40% by 2030 compared to 2008 levels, achieve a 20% reduction in total GHG emissions by 2030, and **reach a 70% reduction by 2040**. Its long-term objective is to attain net-zero GHG emissions by or around 2050. Additionally, Medway/MSC Group targets the uptake of zero or near-zero GHG emission technologies, fuels, or sources to represent at least 5%, with a goal of 10%, of the energy used in international shipping by 2030. These environmental goals are supported by key performance indicators such as Scope 1 and 2 GHG emissions (measured in tons of CO₂ equivalent), Scope 3 GHG emissions, GHG emissions intensity (tCO₂eq/TEU), and the percentage reduction of Scope 1 and 2 emissions. Emissions are calculated using the GHG Protocol, ensuring methodological consistency and transparency. Although Scope 3 emissions are reported, the company does not provide future targets for these indirect emissions. The report also confirms the implementation of technology-related solutions, though it does not specify their nature or scope.

In terms of social and economic dimensions, the report includes selected performance indicators but lacks explicit strategic targets. Social KPIs include average hours of training per employee, segmented by blue-collar, male, and female categories, as well as the percentage of females in top positions, reflecting a degree of attention to workforce development and gender representation. Economically, the company discloses legal actions related to anti-competitive behaviour, antitrust, and monopoly practices, indicating a commitment to transparency in governance.

Medway/MSC Group demonstrates a **strong commitment to ethical conduct and governance through several internal mechanisms**. These include the MSC Code of Business Conduct, which promotes fair and responsible business practices; the MSC Supplier Code of Conduct, which extends ethical standards to partners; and the MSC Speak-Up Line, a whistle-blower platform that allows employees to report misconduct or raise concerns confidentially. These tools reflect a structured approach to corporate accountability and stakeholder engagement.

The company's sustainability efforts are aligned with the United Nations Sustainable Development Goals (UN SDGs) and incorporate circular economy principles. Medway/MSC Group also actively participates in collaborative initiatives addressing climate change, including partnerships with the Global Industry Alliance to Support Low Carbon Shipping, the Global Logistics Emissions Council, and the Global Centre for Maritime Decarbonization. These affiliations underscore the company's proactive role in sector-wide decarbonization and its commitment to global sustainability standards.

PSA-BDP International

PSA-BDP International is a private global logistics and port operations company employing approximately 55,000 individuals worldwide, with an annual cargo volume of 94.8 million twenty-foot equivalent units (TEUs). Its 2023 sustainability report outlines a multifaceted approach to environmental stewardship, social responsibility, and governance, although it does not present economic key performance indicators or align its actions explicitly with the United Nations Sustainable Development Goals (UN SDGs) or circular economy principles.

The company's environmental strategy is anchored in **ambitious decarbonization targets**. PSA-BDP International aims to reduce absolute **Scope 1 and 2 carbon emissions by 50% by 2030 and by 75% by 2040**, using 2019 as the baseline year. Its long-term goal is to achieve net-zero carbon emissions by 2050. In addition to emissions reduction, the company targets 90% electrification or hybridisation of all cranes by 2030 and plans to implement PSA recommendations for sustainable concrete in 80% of new civil infrastructure construction projects by the same year. These commitments are supported by a range of environmental key performance indicators, including gross direct Scope 1 GHG emissions (measured in kilotons of CO₂ equivalent), Scope 2 emissions (energy), and other indirect Scope 3 emissions, specifically considering category 9 (downstream transportation and distribution). Additional metrics include fuel consumption from non-renewable sources (in terajoules), water withdrawn (in megaliters), and waste generated (in metric tons). Emissions are calculated using the GHG Protocol, ensuring methodological rigor and comparability across industry standards. The company also invests in research and development and innovation projects, indicating a proactive stance on technology-driven sustainability solutions.

In the social domain, PSA-BDP International articulates a clear **commitment to diversity, equity, and workforce development**. The company seeks to recruit top-tier talent from diverse backgrounds and promotes regular performance and career development reviews. Training programs and occupational health and safety initiatives are central to its human capital strategy. The company emphasizes the promotion of a balanced and diverse workforce, encompassing a wide range of backgrounds, races, cultures, genders, ages, and religions across all organizational levels. Social KPIs include the percentage of individuals within the board, executive, and non-executive employee categories by gender, as well as the distribution of individuals by age across governance bodies and the broader employee base.

Governance practices at PSA-BDP International are established by a **zero-tolerance policy against corruption, bribery, and fraud**. The company maintains a whistle-blowing policy that enables employees, business partners, and other stakeholders to report concerns related to compliance with the Code of Conduct. This mechanism supports ethical accountability and reinforces the company's commitment to integrity in its operations. However, the report does not present specific economic KPIs, limiting the evaluative scope of its financial governance and performance.

Although PSA-BDP International does not explicitly align its sustainability actions with the UN SDGs or circular economy principles, it demonstrates **active engagement in global collaborative initiatives**. The company is a member of numerous associations and coalitions that advocate for decarbonization and digital transformation in the shipping and logistics sectors. These include the Call for Action for Shipping Decarbonization, the Carbon Pricing Leadership Coalition, the Global Logistics Emissions Council, the Global Maritime Forum, the Global Shipping Business Network, Green and Digital Shipping Corridors, New Energies, SG Trade Data Exchange, The Silk Alliance, and the World Economic Forum. These affiliations highlight the company's commitment to sector-wide innovation and policy dialogue, positioning it as a forward-looking actor in the global maritime ecosystem.

Renfe

Renfe, a public Spanish rail transport company employing 16,082 individuals, serves approximately 437 million passengers annually, positioning itself as a cornerstone of Spain's mobility infrastructure. The company's 2022 sustainability report outlines a multidimensional strategy focused on environmental

responsibility, social transformation, and technological innovation, while also acknowledging the influence of global trends on its operational and strategic priorities. Although economic and governance targets are not explicitly presented, Renfe demonstrates a clear commitment to sustainable development, aligning its actions with the United Nations Sustainable Development Goals (UN SDGs) and incorporating circular economy principles.

Renfe's environmental strategy is structured around a series of **actionable goals aimed at reducing its ecological footprint and enhancing operational sustainability**. By 2025, the company plans to implement solar panels for self-consumption, acquire electric locomotives, and install noise reduction systems. It also seeks full environmental adequacy of its railway operations through compliance with current environmental regulations. A key component of its strategy is the **reduction of emissions via decreased energy consumption and the substitution of fossil fuels**. Additionally, Renfe offers carbon emissions certificates to freight customers and adopts a Scope 3 emissions approach, although it does not specify the categories considered, nor does it calculate emissions using the GHG Protocol.

In the social domain, Renfe articulates a transformative agenda aimed at fostering inclusivity and professional development. By 2025, the company intends to address challenges related to gender diversity, multiculturalism, intergenerational diversity, and equal opportunities through targeted cultural transformation initiatives. It also emphasizes the training of professionals and the implementation of anti-corruption and anti-bribery measures. Social key performance indicators include the number of training hours and average hours of training disaggregated by gender, providing insight into the company's commitment to workforce development. Additionally, Renfe reports the salary ratio between men and women, contributing to transparency in compensation practices and gender equity.

Technological innovation plays a central role in Renfe's sustainability strategy. The company has implemented a range of technology-related solutions to improve operational efficiency, environmental performance, and occupational risk prevention. Notably, Renfe integrated the Doco platform, becoming the first public company in Spain to manage door-to-door mobility services. It also adopted technology watch and competitive intelligence services to enhance strategic decision-making and competitiveness. Furthermore, the use of artificial intelligence technologies enables the digitalization and optimization of train and rolling stock maintenance activities, reflecting a forward-looking approach to asset management and operational resilience.

Renfe's sustainability report also contextualizes its strategic objectives within broader global trends, acknowledging how shifts in environmental policy, technological advancement, and societal expectations influence its business model and long-term planning. Although the report does not present specific economic key performance indicators or governance targets, the company's alignment with the UN SDGs and its consideration of circular economy principles underscores its commitment to responsible and adaptive corporate conduct.

Repsol

Repsol is a private global energy company employing approximately 25,000 individuals. While its 2024 sustainability report does not specify the volume of goods handled or the mode of transport involved in its operations, the document outlines a broad strategic vision centred on long-term environmental

responsibility, technological innovation, and corporate integrity. Despite the absence of detailed targets, key performance indicators (KPIs), or quantified metrics across environmental, social, and economic dimensions, the report conveys Repsol's overarching commitment to sustainable development and its alignment with the United Nations Sustainable Development Goals (UN SDGs).

The company's environmental ambitions are framed by its **stated goal of becoming a net-zero emissions entity by 2050**. Although no specific interim targets or emissions reduction pathways are provided, Repsol emphasizes its intention to use only essential natural resources in the generation of energy and the development of more efficient products. This principle reflects a resource-conscious approach to energy production, though it does not extend to circular economy practices, which are notably absent from the report. Furthermore, the company does not report Scope 3 emissions, nor does it calculate its greenhouse gas (GHG) emissions using standardized protocols such as the GHG Protocol, limiting the transparency and comparability of its environmental performance.

In the social domain, Repsol outlines general commitments to employee safety, professional training, and ethical conduct. These priorities suggest a foundational concern for human capital development and organizational integrity, although the report does not present specific social targets or KPIs to assess progress in these areas. The company's emphasis on acting responsibly and with integrity indicates a values-driven approach to governance, yet no formal economic or governance targets are disclosed, and no economic KPIs are provided to evaluate financial performance or compliance.

Technological innovation is identified as a strategic pillar in Repsol's sustainability framework. The company expresses its intent to develop and implement technology-related solutions to support its transition toward more sustainable operations. However, the report does not elaborate on the nature, scope, or impact of these innovations, nor does it link them to measurable outcomes. This lack of specificity limits the ability to assess the effectiveness of Repsol's innovation strategy in contributing to its environmental or social goals.

Tramesa/Armando Alvarez Group

Tramesa, a rail transport division of the Armando Alvarez Group, is a private company employing approximately 2,600 individuals. The 2023 sustainability report of the Armando Alvarez Groups outlines a detailed and ambitious **roadmap for environmental, social, and governance (ESG) performance**, with clear targets set for 2030 across multiple dimensions. Although the volume of goods transported is not specified, the company's strategic orientation reflects a strong commitment to sustainable development, circular economy principles, and alignment with the United Nations Sustainable Development Goals (UN SDGs).

The environmental strategy of Tramesa/Armando Alvarez Group is comprehensive and quantitatively defined. By 2030, the company aims to recover 95% of its internal waste compared to a 2020 baseline and eliminate hazardous waste sent to landfills entirely. It also targets a reduction of 20,000 tons of plastic waste compared to 2018 levels and a decrease in energy consumption by 30 GWh relative to 2020. Additional environmental goals include obtaining OCS certification for 100% of its extrusion plants and securing ISO 14001 certification by 2030. The company also commits to achieving carbon neutrality for Scope 1 and 2 emissions and developing a full decarbonization plan encompassing Scopes 1, 2, and 3. Although Scope 3 emissions are not currently reported, the company calculates its

greenhouse gas emissions using MITECO's 2023 calculator, ensuring methodological consistency with national standards. The report confirms the implementation of technology-related solutions, though it does not specify the nature of these innovations.

Governance and economic targets are equally robust. Tramesa/Armando Alvarez Group plans to increase the use of sustainable materials by 70% by 2030 compared to 2020 and to develop and implement a sustainable procurement policy by 2030, using 2023 as the baseline. The company also aims to achieve a "Gold" rating in the Ecovadis sustainability assessment for its plants and to obtain ISO 37301 certification for compliance management and ISO 27001 certification for information security by 2030. A key governance initiative includes the development and implementation of an Antitrust Policy, reflecting a proactive stance on ethical business conduct. The company integrates ESG clauses into its supply chain controls, requires supplier adherence to its ethics code, and conducts ESG assessment questionnaires. Over 60% of its purchases are made from suppliers who have undergone ESG evaluation, indicating a structured approach to responsible sourcing.

Social targets are articulated and reflect a commitment to workforce safety, diversity, and community engagement. By 2030, the company aims to reduce accident frequency by 5% compared to 2023 and obtain ISO 45001 certification to cover 20% of its workforce. It also plans to implement a corporate selection policy and increase the proportion of female team members by 7% relative to 2023. Beyond internal metrics, Tramesa/Armando Alvarez Group contributes to projects that promote health and well-being in local communities, support quality training and youth employability, and provide financial backing for social action initiatives, with a commitment of €300,000 annually by 2030. While specific social and economic KPIs are not presented, the breadth of initiatives suggests a holistic approach to corporate responsibility.

4.1.2 Slovenian-Croatian pilot

Posta Slovenije

Posta Slovenije is a national public company employing 5,733 individuals and managing the daily dispatch of approximately 3,500 delivery notes and 3,500 postal items. The company's 2023 sustainability report presents a structured and **multidimensional approach to environmental, social, and governance (ESG) performance, with a particular emphasis on operational efficiency, employee well-being, and technological innovation**. Although economic and governance targets are not explicitly defined, the report includes a range of key performance indicators (KPIs) and certifications that reflect a mature sustainability framework and a commitment to continuous improvement.

The company's environmental strategy is centred on **reducing its ecological footprint through lower fuel consumption, decreased emissions, and minimized noise pollution**. These goals are supported by a detailed set of environmental KPIs, including the quantity of greenhouse gas (GHG) emissions measured in tonnes of CO₂, total water consumption, drinking water usage in cubic meters, and the number of solar plants in operation. Additional metrics include the energy generated by solar power plants, the share of electricity derived from solar energy relative to total consumption, and the proportion of clean vehicles in the company's fleet. Posta Slovenije calculates its GHG emissions using the GHG Protocol, ensuring methodological consistency and transparency. Although Scope 3 emissions

are not reported, the company demonstrates a proactive stance on environmental responsibility through its investment in renewable energy and fleet modernization.

Social sustainability is addressed through both **strategic commitments and performance indicators**. The company promotes employee development through education and training, ensures a healthy and safe working environment, and organizes activities to mitigate psychosocial risks in the workplace. Employees also benefit from performance-related incentives, reinforcing a culture of recognition and motivation. Social KPIs include the sick leave rate expressed as a percentage, the number of workplace injuries per 1,000 employees, the number of days lost due to workplace injuries, and employee turnover. These indicators provide insight into workforce stability, occupational health, and organizational climate.

Governance practices are reflected in a series of economic KPIs that monitor ethical conduct and compliance. These include the number of reports of irregularities handled, disclosures of conflicts of interest and related breaches, cases involving human rights violations in business, and incidents of corruption, bribery, and fraud. The company also tracks the organization of education and training activities in alignment with its strategic objectives. While formal governance targets are not specified, these metrics suggest a structured approach to internal accountability and ethical oversight.

Technological innovation is a cornerstone of Posta Slovenije's sustainability strategy. The company has embraced **digital transformation, artificial intelligence, and data analytics to enhance operational efficiency and environmental performance**. It is actively pursuing decarbonization through the adoption of alternative fuels and energy sources, and is exploring autonomous logistics operations and robotization. Furthermore, the development of new sustainable business models in logistics and delivery reflects a forward-looking approach to market adaptation and environmental stewardship.

Posta Slovenije's sustainability credentials are reinforced by certifications across environmental, social, and governance domains. These include ISO 50001 for energy management, ISO 14001 for environmental management, ISO 45001 for occupational health and safety, and ISO 27001 for information security. The company also holds ISO 9001 for quality management and is recognized as a family-friendly and disability-friendly employer. It has committed to respecting human rights in its business operations and is a signatory to the Diversity Charter. Additionally, the company's computer center infrastructure is certified for compliance, and it holds the status of an Authorized Economic Operator (AEO), further validating its operational integrity and regulatory alignment.

Although Posta Slovenije does not explicitly align its sustainability actions with the United Nations Sustainable Development Goals (UN SDGs), it incorporates circular economy principles into its operations, particularly through its emphasis on clean energy, resource efficiency, and sustainable logistics. The integration of advanced technologies and comprehensive certifications positions the company as a progressive and responsible actor in the national transport and logistics sector.

4.1.3 Lithuanian pilot

Espersen Lietuva

Espersen Lietuva is a private regional maritime company employing 2,860 individuals. Although the volume of goods transported is not specified in the document, the company's 2023 sustainability

report presents a robust and multidimensional strategy that aligns closely with the United Nations Sustainable Development Goals (UN SDGs) and incorporates circular economy principles. The report outlines clear environmental, social, and governance targets, supported by key performance indicators (KPIs) and a commitment to technological innovation.

The company's environmental strategy is established in emissions reduction goals. Espersen Lietuva aims to **reduce Scope 1 and 2 emissions by 42% by 2030, using 2021 as the base year, and to reduce Scope 3 emissions intensity by 52% within the same timeframe**. The environmental KPIs include total Scope 1 direct operational emissions, Scope 2 indirect emissions, and total Scope 3 emissions, all measured in tons of CO₂ equivalent. Scope 3 emissions are further disaggregated into categories such as purchased goods and services, fuel and energy-related activities, upstream transportation, and waste generated in operations. However, the methodology for GHG emissions calculation is not specified.

Espersen Lietuva's governance strategy emphasizes **ethical conduct and sustainable growth**. The company has implemented whistleblower systems accessible to employees and stakeholders, reinforcing its commitment to integrity and compliance. It also aims to dissociate economic growth from environmental degradation, a principle that reflects a forward-looking approach to sustainable business development. While specific economic KPIs are not presented, these strategic goals indicate a foundational alignment with responsible governance practices.

Social sustainability is a central pillar of the company's ESG framework. Espersen Lietuva has adopted several targets that reflect the UN SDGs, including **cutting half of the per capita global food waste at the retail and consumer levels and reducing food losses along production and supply chains by 2030**. The company also seeks to substantially reduce waste generation through prevention, reduction, recycling, and reuse. Gender equity is a prominent focus, with targets to ensure that both genders are represented by at least 25% of appointed board members and 40% of senior managers reporting directly to directors by 2025. A broader strategy is being developed to promote a more balanced gender distribution across all levels of management. Additionally, the company is committed to analyzing significant health and safety risks in the workplace and implementing action plans to mitigate them.

Social KPIs include the ratio of males to females in board and management positions, the number of workplace accidents, the accident frequency rate, and the accident severity rate. These indicators provide a quantitative basis for evaluating progress in occupational safety and gender representation. The integration of these metrics into the company's reporting framework reflects a data-driven approach to social responsibility.

Espersen Lietuva also demonstrates a commitment to technological advancement as a driver of sustainability. Although the report does not specify the nature of the technology-related solutions implemented, their inclusion signals an intent to leverage innovation to support environmental and operational goals. This emphasis on technology complements the company's broader strategic alignment with circular economy principles, particularly in its efforts to reduce waste and optimize resource use.

IKI Logistics

IKI Logistics is a private regional company operating in the road transport sector, employing 5,465 individuals. The company's 2023 sustainability report outlines a strategic commitment to environmental responsibility, social development, and alignment with global sustainability frameworks. Prepared following the Global Reporting Initiative (GRI) standards, the report reflects a structured approach to transparency and accountability in corporate sustainability.

The company's environmental ambitions are clearly articulated through several long-term targets. IKI Logistics aims to **reduce its greenhouse gas emissions, transition to 100% recycled plastic in the packaging of private label products by 2030, cut food waste by 50% by 2030 compared to 2022 levels, and ensure that 70% of its energy consumption comes from renewable sources by the same year.** These goals demonstrate a strong commitment to circular economy principles and a proactive response to climate-related risks. Although the report does not specify environmental key performance indicators or the methodology used to calculate emissions, it does acknowledge Scope 3 emissions, indicating a comprehensive understanding of its environmental impact across the supply chain.

Social sustainability is also a key focus of the company's strategy. By 2025, IKI Logistics aims to enhance its employer image, improve compensation and benefits, invest in talent development, and increase organizational efficiency. While specific social key performance indicators are not provided, these targets suggest a deliberate effort to strengthen human capital and foster a supportive and productive workplace culture. The emphasis on employee well-being and organizational effectiveness aligns with broader trends in corporate social responsibility and workforce sustainability.

Although the report does not present explicit economic or governance targets, the company's integration of climate risk considerations and its adherence to GRI standards reflect a foundational commitment to ethical business practices and strategic foresight. Technological innovation is also part of IKI Logistics' sustainability agenda, with the company implementing technology-related solutions to support its environmental and operational goals, though the report does not detail the nature of these innovations.

IKI Logistics affirms that its actions are in consonance with the United Nations Sustainable Development Goals (UN SDGs), reinforcing its role as a responsible actor in the regional logistics sector. The company's sustainability strategy, while lacking in detailed performance metrics, is marked by clear long-term objectives and a values-driven approach to environmental and social impact. Its focus on circular economy principles, climate resilience, and workforce development positions it as a forward-looking organization committed to sustainable growth and operational excellence.

Lietuvos Pastas

Lietuvos Paštas is a national public company, employing 2,681 individuals and delivering approximately 80,686 parcels daily. Its 2023 sustainability report outlines a foundational commitment to environmental, social, and governance performance, framed by select quantitative goals and supported by a range of social indicators. While the report presents current measures and achievements, it does not articulate specific short- or long-term sustainability targets beyond the year in review, which limits the strategic depth of its disclosures. Nonetheless, the company affirms its

alignment with the United Nations Sustainable Development Goals (UN SDGs) and integrates circular economy principles into its operations, reflecting a broader orientation toward responsible and future-focused logistics.

In terms of environmental responsibility, Lietuvos Paštas set a goal **to reduce CO₂ emissions by 14% in 2023 compared to 2020 levels**. Although the report does not specify environmental key performance indicators or the methodology used to calculate greenhouse gas emissions, it does acknowledge Scope 3 emissions, indicating an awareness of indirect environmental impacts across its value chain. The company also reports the implementation of technology-related solutions to support its sustainability efforts, though the nature and scope of these innovations are not detailed.

From an economic and governance perspective, the company established a target to maintain a debt-to-equity ratio below 0.8 by 2023, suggesting a focus on financial prudence and capital structure management. However, no additional economic key performance indicators are presented, and the report does not elaborate on broader governance mechanisms, compliance systems, or stakeholder engagement practices.

Social sustainability is addressed with greater specificity. The company aimed to increase employee engagement by 47% in 2023, reflecting a strategic emphasis on workforce morale and organizational culture. A series of social key performance indicators is included to support this goal, such as the percentage of employees by gender and age group, the number of new hires disaggregated by gender and age, and the ratio of women to men across different employee categories. The report also tracks the number of classroom and e-learning programs offered, the percentage of employees receiving regular performance and career development reviews, and the incidence of work-related injuries. These metrics suggest a structured approach to human capital development, training, and occupational health, even though no long-term social targets are outlined.

While the report provides a snapshot of current sustainability measures, its lack of forward-looking targets and detailed performance metrics in the environmental and economic domains limits its evaluative precision. Nevertheless, Lietuvos Paštas demonstrates a foundational commitment to sustainability through its stated goals, technological integration, and alignment with global frameworks. The company's emphasis on emissions reduction, employee engagement, and financial stability positions it as a responsible actor in the national logistics sector, with clear potential for advancing its sustainability agenda through more comprehensive and strategic planning in future reporting cycles.

UAB Orion Global pet

UAB Orion Global PET is a private global company with a workforce of 25,000 employees and a core business centered on recycling polyethylene terephthalate (PET) materials. By 2022, the company had recycled 15.4 billion PET bottles annually. Its 2020 sustainability report presents strategies structured around short-, medium-, and long-term goals, with clear alignment to the United Nations Sustainable Development Goals (UN SDGs) and a stated commitment to achieving a circular economy by 2050.

The company's environmental targets are ambitious and quantitatively defined. By 2025, Orion Global PET aims to reduce combined Scope 1 and 2 greenhouse gas (GHG) intensity by 10%, achieve a 5% reduction in energy intensity, and source 10% of its electricity from renewable sources, increasing to

25% by 2030. It also **plans to recycle 50 billion PET bottles annually and incorporate 750,000 tons of post-consumer PET as feedstock into polyester production by 2025**. Long-term environmental goals include reaching carbon neutrality and full circularity by 2050. These targets are supported by environmental key performance indicators (KPIs), including renewable energy consumption and generation (in gigajoules), total volume of recycled or reused water (in cubic meters), and direct and indirect GHG emissions (Scope 1 and 2) measured in tons of CO₂ equivalent. Scope 3 emissions are also reported, and the company confirms the use of standardized GHG emissions calculation methodologies.

Social sustainability is addressed through both operational safety and public engagement. Orion Global PET targets fewer than 0.5 cases of lost time injury frequency rate (LTIFR) per 200,000 man-hours by 2025, with a further reduction to below 0.1 cases by 2050. It also aims to **educate one million consumers on recycling practices by 2030 and to deliver measurable social, economic, and environmental value to society by 2050**. Social KPIs include the number of employees by gender, the percentage of the workforce represented in formal joint management-worker health and safety committees, total recordable injury rate, occupational illness frequency rate, total number of occupational disease cases, and the number of workers exposed to high-risk occupational conditions. These indicators reflect a structured and data-driven approach to workplace safety and employee well-being.

Although the report does not specify economic or governance targets or KPIs, the company's broader sustainability framework incorporates technology-related solutions and strategic partnerships to advance its goals. The implementation of innovative technologies supports both environmental efficiency and operational resilience. Furthermore, Orion Global PET's long-term vision for circularity includes collaboration with external associations and organizations, reinforcing its commitment to systemic transformation and cross-sectoral engagement.

Rehau Production

Rehau Production is a private global company with a workforce of 12,877 employees and a reported turnover of 2.6 billion euros in 2022. Its 2022 sustainability report outlines a strategic commitment to environmental, social, and governance performance, with particular emphasis on climate neutrality, circular economy principles, and gender equity. While the report presents a table of sustainability goals and key performance indicators (KPIs), it does not extend its targets beyond the reporting year, nor does it provide a framework for how these KPIs will be measured. Nonetheless, the company affirms its alignment with the United Nations Sustainable Development Goals (UN SDGs) and demonstrates a structured approach to sustainability through its stated ambitions and design principles.

Rehau Production's environmental strategy is centred on **achieving climate neutrality across all emission scopes**. The company aims to reach climate neutrality for Scope 2 emissions at all locations by 2025, for Scope 1 emissions by 2035, and for Scope 3 emissions by 2040. These targets reflect a phased and location-wide approach to decarbonization. Environmental KPIs include the average portion of recycled content used globally, indicating a commitment to resource efficiency and materials recovery. The company calculates its greenhouse gas (GHG) emissions using the GHG Protocol, ensuring methodological rigor and comparability. Scope 3 emissions are acknowledged, further underscoring the company's comprehensive view of its environmental impact.

Social sustainability is addressed through **gender representation and workplace safety**. Rehau Production has set a target to achieve a 17% proportion of women in management positions by 2025 and 20% by 2030, reflecting a strategic focus on gender equity in leadership. Social KPIs include the number of accidents resulting in fewer than three lost days per one million working hours, suggesting a commitment to occupational health and safety. However, the report does not specify how these indicators are tracked or evaluated, limiting its monitoring.

Although the report does not present explicit economic or governance targets, it identifies a gradual transition from a linear to a circular economy as a core economic KPI. This transition is supported by the company's adoption of ten circular design principles: conscious materials, contextual longevity, material identification, dismantling capacity, modular construction principle, open standards, simple design, closed loops, positive footprint, and service design. These principles reflect a systems-oriented approach to product development and lifecycle management.

Technology-related solutions are also part of the company's sustainability strategy, though the report does not elaborate on their specific applications or impacts. The integration of innovation into environmental and operational practices complements the company's broader commitment to circularity and climate action.

Retal Baltic Films

Retal Baltic Films is a private regional company with a workforce of 220 employees and a reported turnover of 621 million euros in 2023. Its sustainability report for the same year outlines a structured commitment to environmental responsibility, social equity, and economic transparency, though it does not present specific short- or long-term targets beyond the stated goals. The company's actions are aligned with the United Nations Sustainable Development Goals (UN SDGs) and incorporate circular economy principles, reflecting a broader orientation toward sustainable industrial practices and value chain accountability.

The company's environmental strategy is defined by some decarbonization targets. Retal Baltic Films aims to reduce Scope 1 and Scope 2 greenhouse gas (GHG) emissions by 42% by 2030, demonstrating a commitment to operational and energy-related emissions mitigation. Additionally, the company targets a 94% share of **suppliers with category 3 emissions to have science-based targets validated by 2030**, indicating a strategic effort to extend climate accountability across its supply chain. Environmental key performance indicators include the reduction of GHG emissions and the monitoring of ozone-depleting substances, and the company calculates its emissions using the GHG Protocol, ensuring methodological rigor and comparability. Scope 3 emissions are acknowledged, further reinforcing the company's comprehensive approach to environmental impact assessment.

Social sustainability is addressed through a range of performance indicators, although no formal targets are articulated. The report includes data on the ratio of standard entry-level wages by gender compared to the local minimum wage, the proportion of senior and team management hired from the local community, and the diversity of the workforce. It also tracks worker training on occupational health and safety and reports the average hours of training per employee per year. These indicators suggest a structured approach to workforce development, equity, and safety, even in the absence of time-bound goals.

Economic transparency is reflected in the reporting of direct economic value generated and distributed, which serves as the company's primary economic key performance indicator. While no governance targets or additional economic metrics are presented, this disclosure indicates a foundational commitment to financial accountability and stakeholder engagement.

Retal Baltic Films also reports the implementation of technology-related solutions to support its sustainability objectives, though the specific nature of these innovations is not detailed. The integration of technological advancement complements the company's broader strategic alignment with circular economy principles, particularly in its efforts to reduce emissions and promote responsible sourcing.

4.1.4 Finnish pilot

Finnlines/Grimaldi Group

Finnlines is part of the Grimaldi Group, which is a private global maritime transport company employing approximately 17,000 individuals and generating 736.1 million euros in revenue. Its 2023 sustainability report outlines a strategic commitment to environmental stewardship and occupational safety, supported by technological innovation and operational enhancements. While the report presents a range of initiatives and performance indicators, it does not include specific yearly targets, nor does it align its actions with the United Nations Sustainable Development Goals (UN SDGs) or circular economy principles, which limits the broader contextual framing of its sustainability agenda.

The company's environmental strategy is anchored in a **long-term goal of achieving climate neutrality by 2050, primarily through the incorporation of newly built ships equipped with advanced energy-saving technologies**. These include the installation of solar panels, variable frequency drive (VFD) devices, waste heat recovery systems, air quality systems, and intelligent LED lighting. These measures reflect a proactive approach to reducing emissions and improving energy efficiency across the fleet. Environmental key performance indicators include energy drawn from ship batteries during port stays and grams of CO₂ emitted per cargo capacity per nautical mile, which are reported multiple times to emphasize operational efficiency. However, the company does not calculate its greenhouse gas emissions using standardized methodologies, and Scope 3 emissions are not reported, limiting the comprehensiveness of its environmental impact assessment.

Social sustainability is addressed through a detailed focus on **occupational health and safety**. Finnlines promotes and consolidates a culture of safety by developing risk awareness and encouraging responsible behavior among employees and collaborators. The company prioritizes the preservation of health and safety through preventive actions and aims for continuous improvement in safety performance by defining appropriate measurement methods. It seeks to meet the highest applicable safety standards in the maritime sector, guided by the most advanced scientific and technological knowledge recognized by industry standards. Despite these commitments, the report does not present specific social key performance indicators or time-bound goals, which constrains the ability to evaluate progress or effectiveness.

Economic and governance dimensions are not explicitly addressed in the report, and no economic key performance indicators or governance targets are provided. This absence suggests that the company's current sustainability reporting prioritizes environmental and social aspects, particularly those related

to operational efficiency and workforce safety, while leaving financial and governance metrics underdeveloped.

Technological innovation is a central component of Finnlines' sustainability strategy. The integration of advanced systems on new ships demonstrates a commitment to using technology for environmental and operational gains. These innovations support the company's long-term decarbonization goals and contribute to improved energy management and emissions reduction.

Kone

Kone is a private global company operating in the vertical transport sector, with a workforce of 63,536 employees and a service footprint that moves over one billion people annually through its elevators and escalators. Its 2023 sustainability report integrates environmental, social, and governance dimensions, supported by measurable targets and key performance indicators. The company's actions are aligned with the United Nations Sustainable Development Goals (UN SDGs) and incorporate circular economy principles, reflecting a mature and forward-looking approach to corporate sustainability. The report also contextualizes its targets within broader global trends, demonstrating strategic responsiveness to evolving environmental and societal challenges.

Kone's environmental strategy is based on ambitious decarbonization and resource efficiency goals. **By 2030, the company aims to reduce absolute greenhouse gas emissions by 50% from a 2018 baseline and cut product-related Scope 3 emissions by 40% relative to ordered products. It also targets 100% renewable energy use across its operations by 2030 and requires all key suppliers to be ISO 14001 certified.** By the end of 2023, Kone committed to covering 20 products with environmental product declarations, enhancing transparency in product lifecycle impacts. Environmental key performance indicators include emissions from own operations, product-related emissions, the share of renewable electricity used in facilities, the proportion of key suppliers certified under ISO 14001, the share of landfill waste at manufacturing units, and the number of products with environmental product declarations. Emissions are calculated using the GHG Protocol, ensuring methodological rigor and comparability. The inclusion of Scope 3 emissions related to products further underscores the company's comprehensive approach to environmental accountability.

Social sustainability is addressed through a range of well-defined targets and performance metrics. Kone aims to reduce its industrial injury frequency rate to 0.6 by 2030, maintain high levels of employee engagement, and achieve a 35% share of women in director-level positions by the same year. In 2023, the company sought to increase average learning hours per employee to more than 40 and ensure that 92% of employees completed at least one ethics and compliance training. It also required 100% of distributors to sign the distributor code of conduct, reinforcing ethical standards across its value chain. **Social key performance indicators include the injury frequency rate, employee engagement scores, voluntary turnover rate, gender representation in leadership, average annual learning hours, ethics training completion rates, and distributor compliance with the code of conduct.** These metrics reflect a structured and inclusive approach to workforce development, safety, and ethical governance.

While the report does not specify economic targets, it includes governance-related performance indicators such as the percentage of overall external spend covered by the supplier's code of conduct

or equivalent. This metric highlights Kone's commitment to responsible sourcing and supplier accountability.

Technology plays a central role in Kone's sustainability strategy. The company reports the implementation of technology-related solutions to support its environmental and operational goals, though specific innovations are not detailed. The integration of digital tools and smart systems complements its efforts to reduce emissions, enhance product efficiency, and improve safety outcomes.

Metsä Group

Metsä Group is a private global company with a workforce of 9,200 employees and a reported sales volume of 6,980 million euros in 2022. Its 2022 sustainability report presents a comprehensive and target-driven strategy that integrates environmental, social, and governance dimensions, supported by a wide array of key performance indicators and a clear alignment with the United Nations Sustainable Development Goals (UN SDGs). The company also incorporates circular economy principles and leverages technology-related solutions to advance its sustainability objectives, demonstrating a mature and forward-looking approach to responsible business practices.

The environmental strategy of Metsä Group is defined by goals to be achieved by 2030. These include **ensuring 100% retention of trees at regeneration sites, achieving 90% coverage of four high-biodiversity stumps in harvesting sites, and eliminating fossil-based carbon dioxide emissions (Scope 1)**. The company also aims for a complete transition to fossil fuel-free raw materials and packaging materials and a 25% reduction in process water usage per tonne produced compared to 2018. These targets are supported by detailed environmental key performance indicators, including fossil-based CO₂ emissions (Scope 1 and Scope 2) measured in tonnes, the area of regeneration and management of young stands, the percentage of carbon stored in products, the share of fossil-free raw materials, acidification measured in tonnes of SO₂ equivalent, eutrophication in tonnes of phosphorus equivalent, and the share of biofuels used in production. Emissions are calculated using the GHG Protocol, ensuring methodological consistency and transparency, although Scope 3 emissions are not reported.

Governance and economic responsibility are addressed through a series of supplier-related targets, all set for completion by 2030. These include 100% supplier commitment to the supplier code of conduct, 100% compliance evaluation passed, 100% sustainability evaluation passed, and full traceability of raw materials. Economic key performance indicators include the percentage of suppliers committed to the code of conduct and the percentage of compliance evaluation passes, reflecting a structured approach to ethical sourcing and supply chain accountability.

Social sustainability is equally emphasized, with targets such as **achieving a 100% ethical index in the ethics barometer and reaching zero frequency of workplace accidents per million hours worked by 2030**. Social key performance indicators include the share of employees by age and gender, the proportion of women in management and executive positions, the number of training hours, registered occupational diseases, and work-related fatalities. These metrics indicate a strong commitment to workforce diversity, safety, and professional development.

Technology-related solutions are implemented to support the company's sustainability goals, although the report does not specify the nature of these innovations. Nevertheless, their inclusion signals an

intent to enhance operational efficiency and environmental performance through digital and process-based advancements.

Stora Enso

Stora Enso is a private global company employing approximately 19,000 individuals and generating 9,396 million euros in sales. Its 2024 sustainability report presents a strategically integrated approach to environmental, social, and governance performance, supported by measurable targets and key performance indicators. While the company does not explicitly align its actions with the United Nations Sustainable Development Goals (UN SDGs), it incorporates circular economy principles and acknowledges the influence of global megatrends, such as climate change, resource scarcity, and eco-awareness, on its business strategy. This contextual awareness reinforces its commitment to long-term sustainability and operational resilience.

The company's environmental strategy is anchored in ambitious decarbonization goals. Stora Enso aims to reduce absolute **CO₂ emissions from Scope 1 and 2 sources by 50% by 2030, using 2019 as the baseline year, and to achieve an equivalent reduction in Scope 3 emissions within the same timeframe**. It also reports a forest certification coverage of 96%, reflecting its commitment to sustainable forestry practices, and has set a target of achieving 100% circularity by 2030. These goals are supported by environmental key performance indicators, including total CO₂ equivalent emissions across Scopes 1, 2, and 3, measured in million tonnes. Emissions are calculated using the GHG Protocol, ensuring methodological consistency and transparency. The integration of circularity and forest certification into its environmental agenda highlights the company's holistic approach to resource management and ecosystem stewardship.

Economic and governance targets are clearly defined, with a focus on financial stability and ethical conduct. Stora Enso aims for annual sales growth of 5%, maintains a net debt target of less than 2%, and seeks to keep its net debt-to-equity ratio below 60%. Economic key performance indicators include the number of confirmed incidents of corruption or bribery and the number of cases in which employees were dismissed or disciplined for related misconduct. These metrics reflect a structured approach to corporate governance and ethical accountability, reinforcing the company's commitment to integrity in business operations.

Social sustainability is addressed through initiatives **that support professional development, promote work-related rights, advance gender diversity, and provide training opportunities**. Social key performance indicators include the number of employees by gender and country of origin, the distribution of employees by contract type and gender, the gender composition of top management, and the age distribution of the workforce. Additional metrics include the percentage of the workforce covered by a health and safety management system, the rate of recordable work-related accidents, and the number of fatalities resulting from occupational injuries. These indicators demonstrate a comprehensive approach to workforce inclusion, safety, and well-being.

Technology-related solutions are implemented to support the company's sustainability objectives, although the report does not specify the nature of these innovations. Their inclusion signals a commitment to leveraging digital and process-based advancements to enhance environmental performance and operational efficiency.

Transfennica/Spliethoff Group

Transfennica is a subsidiary of the Spliethoff Group, which is a private maritime transport company operating on a global scale with a workforce of 2,208 employees and an annual goods volume of approximately 292.9 million euros. The company's 2022 sustainability report is characterized by its simplicity and limited scope. Unlike more comprehensive ESG frameworks, Transfennica's report concentrates exclusively on environmental sustainability, with particular emphasis on the decarbonization of maritime operations through fleet modernization and fuel replacement.

The company's principal environmental targets centre on reducing the carbon intensity of its shipping activities. Specifically, the Spliethoff Group aims to **achieve a 70% reduction in carbon emissions by 2050, using 2008 as the baseline year**. This long-term goal is supported by an intermediate objective to reduce the average emissions of its fleet by approximately 2% annually. These targets reflect a gradual and incremental approach to emissions mitigation, aligned with broader industry trends toward low-carbon maritime transport. However, the absence of Scope 3 emissions accounting and the lack of adherence to standardized greenhouse gas (GHG) calculation protocols limit the accountability of the company's environmental performance.

Although the report confirms the implementation of technology-related solutions, it does not provide detailed information regarding the nature or impact of these innovations. The emphasis on replacing ships and transitioning to alternative fuels suggests a capital-intensive strategy aimed at improving operational efficiency and reducing direct emissions. Nonetheless, the lack of specific environmental key performance indicators (KPIs) and the omission of metrics related to fuel types, energy consumption, or emission reductions hinder a rigorous assessment of progress.

The Spliethoff Group sustainability report does not address economic or governance targets, nor does it include social objectives or KPIs. This omission reflects a limited engagement with broader sustainability dimensions, such as labor practices, stakeholder governance, or financial resilience. Furthermore, the company does not align its actions with the United Nations Sustainable Development Goals (UN SDGs), nor does it incorporate circular economy principles into its strategic framework. These gaps underscore the report's narrow focus and its departure from integrated sustainability reporting standards.

UPM Logistics

UPM Logistics, a private global company with a workforce of 15,800 employees and annual sales amounting to 10,183 million euros, operates across maritime, rail, and road transport modes. Its 2024 sustainability report presents a comprehensive and strategically integrated framework encompassing environmental, social, and economic dimensions, supported by measurable targets and key performance indicators. The company's actions are aligned with the United Nations Sustainable Development Goals (UN SDGs) and reflect a strong commitment to circular economy principles and technological innovation, positioning UPM Logistics as a forward-thinking actor in sustainable logistics and supply chain management.

By 2030, UPM Logistics aims to achieve a 100% share of certified fibre, restore 500 kilometres of obstacle-free streams, **reduce fossil CO₂ emissions from on-site combustion and purchased energy by 65% compared to 2015 levels, and reach a 70% share of renewable fuels in its energy mix**. These

goals are supported by detailed environmental key performance indicators, including the share of certified fiber, the extent of stream restoration, fossil CO₂ emissions, coal and peat usage in on-site energy generation, annual energy efficiency improvements, and the proportion of renewable fuels. Emissions are calculated using the GHG Protocol, and Scope 3 emissions, particularly those related to materials and logistics, are included, demonstrating a comprehensive approach to carbon accounting and environmental stewardship.

On the economic and governance front, UPM Logistics sets financial targets for 2030, including comparable EBIT growth through focused top-line expansion and margin improvement, a 10% return on equity (ROE), and maintaining a net debt-to-EBITDA ratio of two or less. Economic key performance indicators include profitable EBIT, comparable ROE, net debt/EBITDA, participation in code of conduct training, and Scope 3 CO₂ emissions compared to 2018. These metrics reflect a balanced approach to financial performance, ethical governance, and environmental accountability.

Social sustainability is addressed through a set of goals and indicators. By 2030, the company **aims for 100% completion of individual learning and development plans for all employees, 40% female representation in its organizational culture, and the continuous implementation of diversity and inclusion initiatives**. It also commits to fair rewarding practices and gender pay equity for all employees, alongside a zero-tolerance policy for fatalities and serious accidents. Social key performance indicators include employee engagement levels, progress on diversity and inclusion, the proportion of employees earning at least the local living wage, gender pay equity, and the number of fatal or serious accidents in operations.

Technology-related solutions are actively implemented to support the company's sustainability objectives, although the report does not specify the exact nature of these innovations. Their integration into operational and strategic processes signals a commitment to continuous improvement and efficiency through digitalization and advanced systems.

VR Group

VR Group is a publicly owned regional transport company employing 7,539 individuals and operating primarily through rail and city bus services. In 2023, the company transported 23.4 million tonnes of freight via rail, underscoring its central role in regional logistics and mobility. The company's sustainability report for that year outlines a focused environmental strategy, supported by measurable performance indicators and aligned with global frameworks such as the United Nations Sustainable Development Goals (UN SDGs) and circular economy principles.

The environmental targets set by VR Group **aim for a 15% reduction in emissions and energy consumption by 2025 compared to 2019 levels, an 80% recycling rate, and zero chemical leakages**. These goals are monitored through a set of environmental key performance indicators, including CO₂-equivalent emission intensity for both passenger train services (measured in grams per passenger-kilometre) and rail logistics (grams per tonne-kilometre), energy efficiency metrics for both service types (measured in watt-hours per passenger-kilometre and tonne-kilometre, respectively), recycling rate percentages, and the quantity of chemical leakages. Emissions are calculated using the GHG Protocol, and Scope 3 emissions are included in the company's reporting, reflecting a comprehensive approach to environmental accountability.

Although VR Group does not state the implementation of technology-related solutions to support its sustainability goals, its operational model benefits from long-term megatrends favouring low-emission rail traffic. These trends enhance the feasibility and strategic relevance of the company’s sustainability initiatives, positioning rail transport as a key component of climate-resilient infrastructure. The company’s actions are in consonance with the UN SDGs and demonstrate a commitment to circular economy principles, particularly through its emphasis on recycling and energy efficiency.

Social and economic targets are not explicitly defined in the 2023 report. However, VR Group monitors critical safety-related social indicators, including railway safety incident frequency, measured as the number of accidents per million hours worked, and lost-time injury frequency by business operation, calculated as lost hours per million hours worked. These metrics reflect the company’s attention to occupational health and safety, which is essential in the transport sector.

While economic and governance performance indicators are not specified, VR Group’s status as a public company operating in a regulated regional market implies adherence to national governance standards and financial oversight. Its sustainability strategy is implicitly supported by public accountability mechanisms and policy frameworks that guide infrastructure investment and service delivery.

4.2 Sustainability Reports baseline according to the GRI Sustainability Reporting Standards (GRI Standards)

Besides the identification of the baseline of Sustainability Reports according to sustainability and technology aspects, it is of utmost importance to assess if these documents display specific information that is required according to Regulation (EU) 2023/2772 on Sustainability Reporting Standards and the latest GRI Sustainability Reporting Standards (GRI Standards) released in 2025 (Global Sustainability Standards Board (GSSB, 2025).

According to Regulation (EU) 2023/2772, companies are required to disclose information regarding Environmental standards (e.g., climate change, pollution, resource use, and circular economy), Social standards (e.g., own workforce, workers in the value chain, affected communities), and Governance standards (e.g., business conduct). Therefore, five disclosures regarding these matters were selected from the GRI standards to be evaluated in the Sustainability Reports from companies in the four pilots of the ADMIRAL project:

- Disclosure 102-1 Transition plan for climate change mitigation (ten requirements)
- Disclosure 102-2 Climate change adaptation plan (Description of the adaptation plan: six requirements)
- Disclosure 102-3 Just transition (ten requirements)
- Disclosure 102-4 GHG emissions reduction targets and progress (ten requirements)
- Disclosure 205-2 Communication and training about anti-corruption policies and procedures (five requirements)

The alignment of the companies’ Sustainability Reports with the requirements of the GRI Standards was qualitatively evaluated using the traffic light or RAG (Red-Amber-Green) approach. According to Nowak (1998), the RAG approach can be used to encourage companies to self-regulate by the introduction of a flexible system for different performance/alignment indicators. The Green permit is

associated with excellent performance, the Amber permit with average/standard performance, and the Red permit with transitional conduct.

There is no universally standardized threshold for assigning Red, Amber, or Green (RAG) ratings, as these depend on the specific context and objectives of each assessment. Nevertheless, a commonly adopted reference framework for interpreting the percentage of alignment with predefined requirements is as follows:

- **Red:** ≤ 50% alignment with requirements
- **Amber:** > 50% and ≤ 80% alignment
- **Green:** > 80% alignment

In the context of this assessment, each Sustainability Report submitted by members of the ADMIRAL Stakeholder Forum is evaluated based on the percentage of alignment with the requirements associated with each disclosure. In addition to these individual disclosure-level assessments, a global alignment score is calculated for each report. This global score reflects the overall degree of compliance across all selected disclosures included in the evaluation framework. Table 29 shows the anonymized qualitative results of the Sustainability Reports assessment.

Table 29: RAG assessment of Sustainability Reports

Stakeholder category and ID	Pilot	GRI Disclosures					
		102-1	102-2	102-3	102-4	205-2	Global
Transport operator ID1	FI	Red	Red	Red	Red	Red	Red
Transport operator ID2	FI	Green	Yellow	Yellow	Green	Yellow	Yellow
Cargo owner ID3	FI	Green	Green	Red	Yellow	Yellow	Yellow
Cargo owner ID4	FI	Green	Green	Red	Green	Yellow	Yellow
Transport operator ID5	FI	Red	Red	Red	Red	Red	Red
Cargo owner, transport operator ID6	FI	Green	Green	Yellow	Green	Yellow	Yellow
Transport operator ID7	FI	Yellow	Yellow	Red	Yellow	Red	Yellow
Cargo owner, transport operator ID8	LT	Yellow	Red	Red	Yellow	Red	Red
Cargo owner, transport operator ID9	LT	Yellow	Red	Red	Yellow	Red	Yellow
Transport operator ID10	LT	Red	Red	Red	Red	Yellow	Red
Cargo owner, freight forwarder ID11	LT	Green	Green	Yellow	Yellow	Red	Yellow
Cargo owner ID12	LT	Red	Red	Red	Yellow	Yellow	Red
Cargo owner ID13	LT	Yellow	Red	Red	Yellow	Red	Yellow
Infrastructure manager or operator ID14	PT-ES	Red	Red	Yellow	Red	Yellow	Red
Transport operator ID15	PT-ES	Yellow	Yellow	Yellow	Red	Yellow	Yellow
Transport operator ID16	PT-ES	Red	Red	Red	Red	Red	Red
Transport operator ID17	PT-ES	Red	Red	Red	Red	Red	Red
Transport operator ID18	PT-ES	Yellow	Green	Yellow	Yellow	Red	Yellow
Transport operator ID19	PT-ES	Red	Red	Red	Red	Red	Red

Stakeholder category and ID	Pilot	GRI Disclosures					
		102-1	102-2	102-3	102-4	205-2	Global
Transport operator ID20	PT-ES	Yellow	Red	Red	Red	Red	Red
Transport operator ID21	PT-ES	Yellow	Green	Yellow	Yellow	Red	Yellow
Cargo owner ID22	PT-ES	Red	Red	Red	Red	Red	Red
Transport operator ID23	SI-HR	Red	Red	Red	Red	Red	Red
Transport operator ID24	SI-HR	Yellow	Yellow	Red	Yellow	Yellow	Yellow
Cargo owner ID25	SI-HR	Yellow	Red	Red	Red	Yellow	Red
Transport operator ID26	SI-HR	Yellow	Red	Red	Yellow	Red	Red
Transport Operator ID27	SI-HR	Red	Red	Red	Red	Red	Red
Transport Operator ID28	SI-HR	Yellow	Red	Red	Yellow	Red	Red

The RGA assessment reveals persistent gaps in the information disclosed by companies in their Sustainability Reports (SRs). Notably, **Disclosure 205-2, which concerns the communication and training on anti-corruption policies and procedures, received the lowest qualitative classification.** This indicates that many companies fail to provide clear and comprehensive information about their anti-corruption training and procedures for both employees and governance bodies.

In contrast, the areas with the highest levels of compliance, reflected in Green evaluations, are:

- Disclosure 102-1: Transition Plan for Climate Change Mitigation
- Disclosure 102-2: Climate Change Adaptation Plan

These two disclosures show the most consistent alignment with the assessment requirements.

Conversely, Disclosure 102-3, which addresses the Just Transition, also exhibits significant information gaps. Many SRs lack detail on organizational efforts to support workers, local communities, and indigenous peoples during the transition to a low-carbon economy.

Overall, sustainability reporting is needed in most pilots. The RAG (Red-Amber-Green) analysis confirms these tendencies: most organizations achieve “Green” ratings for environmental disclosures but “Amber” or “Red” for social and governance aspects. The assessment suggests that companies tend to prioritize environmental strategies and goals in their reporting, while social and governance dimensions, particularly those related to equity, inclusion, and ethical practices, receive comparatively less attention. This imbalance implies that sustainability strategies within the logistics and supply chain sectors remain environmentally centered rather than holistic.

4.3 Conclusions

The analysis of sustainability reports from companies participating in the ADMIRAL pilots reveals a clear trend: while environmental commitments—such as decarbonization targets and energy efficiency measures—are increasingly integrated into corporate strategies, social and governance dimensions remain underdeveloped. Most organizations demonstrate alignment with global frameworks like the UN Sustainable Development Goals and, in some cases, circular economy principles. However, the absence of comprehensive targets, standardized methodologies, and measurable KPIs across ESG domains limits the transparency, comparability, and strategic depth of current reporting practices.

Environmental disclosures generally achieve higher compliance levels, particularly in areas related to climate change mitigation and adaptation plans. Conversely, social and governance aspects—such as just transition measures, diversity and inclusion, and anti-corruption training—receive insufficient attention, as evidenced by the prevalence of “Amber” and “Red” ratings in the RAG assessment. This imbalance suggests that sustainability strategies within the logistics and supply chain sectors remain predominantly environmentally focused, rather than holistic and integrated.

To address these gaps and strengthen sustainability performance, companies should adopt the following recommendations:

- *Define clear, time-bound targets across all ESG dimensions.* Establish measurable objectives for environmental, social, and governance areas, supported by robust KPIs and aligned with international standards such as the GRI and ESRS.
- *Enhance governance and ethical practices.* Implement comprehensive anti-corruption policies, training programs, and whistleblower mechanisms, ensuring transparency and accountability throughout the organization and its supply chain.
- *Advance social sustainability.* Develop strategies for workforce diversity, equity, and inclusion, alongside occupational health and safety initiatives. Incorporate just transition principles to support employees and communities during decarbonization efforts.
- *Improve data quality and reporting systems.* Invest in digital tools and standardized methodologies for GHG emissions accounting, including Scope 3, and integrate sustainability data with financial reporting systems to ensure consistency and audit readiness.
- *Leverage technological innovation and circular economy principles.* Accelerate the adoption of technology-driven solutions for operational efficiency and resource optimization, while embedding circularity into product design, procurement, and logistics processes.

By implementing these measures, companies will not only comply with evolving regulatory requirements but also enhance resilience, competitiveness, and stakeholder trust. A holistic approach to sustainability—encompassing environmental, social, and governance dimensions—will position ADMIRAL pilot participants as leaders in the transition toward a low-carbon, inclusive, and digitally integrated logistics ecosystem.

5 Mapping key sustainability challenges and priorities in the logistics sector: A stakeholders-driven approach

The transition toward sustainable practices in logistics has become a central concern for businesses, policymakers, and society at large. The green logistics paradigm represents a strategic approach aimed at reducing the environmental footprint of logistics operations while maintaining efficiency and competitiveness. This paradigm is shaped by multiple interrelated factors that reflect economic, technological, regulatory, and social dimensions.

First, organizations face the challenge of minimizing environmental impact without compromising operational efficiency, which requires innovative solutions across transportation, warehousing, and supply chain management. The integration of Sustainable Development Goals (SDGs) and Corporate Social Responsibility (CSR) principles further reinforces the need for ethical and environmentally responsible practices. At the same time, technological innovation and digitalization play a pivotal role in enabling greener logistics through advanced analytics, automation, and smart systems.

External pressures also influence this transformation. European Union environmental regulations impose stringent requirements on emissions and resource use, compelling firms to adapt their strategies. Additionally, the rise in consumer demand for sustainability creates market-driven incentives for companies to adopt green practices. Finally, the complexity of a diverse stakeholder ecosystem, including manufacturers, logistics providers, regulators, and consumers, necessitates collaborative approaches to achieve shared sustainability objectives.

Against this backdrop, the present study seeks to identify the key goals and drivers that underpin the implementation of green logistics and to examine how these are perceived by different stakeholders within the European context. Understanding these dynamics is essential for designing effective policies and strategies that align environmental objectives with economic performance.

A recent report surveying European shippers, logistics providers, and service companies found that around 30% consider themselves sustainability leaders, citing the implementation of effective decarbonization strategies (McKinnon & Petersen, 2021). Logistic service providers (LSPs) are increasingly seen as central enablers of the transition to low-carbon supply chains. Their control over critical transportation and warehousing functions allows them to adopt energy-efficient technologies, switch to alternative fuels, and optimize logistics operations (McKinnon & Petersen, 2021). As more companies outsource their logistics operations, they transfer a significant portion of their carbon mitigation responsibility to third-party providers. This trend has intensified following the introduction of the EU's Corporate Sustainability Reporting Directive (CSRD) (EU, 2022), which obliges companies to account for indirect emissions across their supply chains. As a result, collaborative governance models between governments, shippers, and logistics operators have become essential to achieving stricter environmental standards. Only through collective commitment towards the same sustainability priorities can a truly green logistics transition be achieved.

This chapter is focused on designing a methodological approach for mapping key sustainability challenges and priorities within the logistics domain in Europe, built upon the insights and perspectives of diverse stakeholders. By using the ADMIRAL Stakeholders Collaborative Forum where supply chain

players, policymakers, researchers, and related association were engaged, the analysis identifies not only the most pressing sustainability issues but also the areas where collaboration and innovation can generate the greatest impact. Additionally, social sustainability aspects analysis is also included in order to investigate their main contribution to achieving sustainability. The present stakeholder-driven approach ensures that the resulting priorities reflect real-world needs and aspirations, offering a foundation for developing targeted strategies and policy recommendations that can accelerate the sector's transition toward sustainability. The methodology should seek to answer the following questions:

- How do logistic stakeholders prioritize sustainability goals (environmental, economic, social and governance), and are there differences across regions or stakeholders' categories?
- What are the main drivers of change -regulation, technology, investment, or collaboration?
- How do stakeholders evaluate the effectiveness of current policies and innovations?
- How effective are current policies and innovation, such as emissions, standards, green technologies or data sharing?
- To what extent do digital marketplaces like ADMIRAL promote inclusive, resilient, and sustainable logistics through socially driven digital transformation?

The methodological framework is presented below (section 5.1), followed by a description of the survey (section 5.2) and focus group (section 5.3) conducted.

5.1 Methodological approach

This chapter presents a comprehensive methodology for mapping key sustainability challenges and priorities within the logistics domain in Europe, built upon the insights and perspectives of diverse stakeholders. The present stakeholder-driven approach ensures that the resulting priorities reflect real-world needs and aspirations, offering a foundation for developing targeted strategies and policy recommendations that can accelerate the sector's transition toward sustainability.

The methodological approach adopted in this task combines quantitative and qualitative methods to capture a comprehensive understanding of sustainability challenges and priorities in the logistics sector. The analysis is primarily based on two complementary activities: a general survey conducted through the Stakeholders Collaborative Forum (SCF) and a focus group dedicated to exploring social dimensions related to project pilots.

The stakeholder survey was designed to gather perceptions, experiences, and expectations from a diverse range of participants, including industry representatives, public authorities, research institutions, and community organizations. This allowed for the identification of common challenges and emerging priorities across different segments of the logistics ecosystem.

In parallel, the focus group provided a deeper qualitative insight into the practical and social implications of sustainability initiatives, with particular attention to the pilot activities implemented within the ADMIRAL project. Discussions emphasized the human, organizational, and societal aspects

of innovation, ensuring that both technical feasibility and social acceptability were considered in defining future sustainability pathways.

5.2 ADMIRAL survey

A survey was conducted to collect information on key sustainability goals, drivers, barriers, innovative solutions, and European regulations relevant to green and sustainable logistics. The aim was to understand stakeholder perspectives across different sectors and geographies, focusing on both the current state and potential advancements in sustainable logistics practices.

The survey was structured into four main sections, designed to capture both qualitative and quantitative information from participants. Questions employed 7-point and 5-point Likert scales, binary responses, and multiple-choice selections to ensure comprehensive data collection (see Annex 3 with the survey form).

- *Section 1. Sustainability key goals.* It included a pairwise comparison of the four sustainability dimensions—environmental, economic, social, and governance—where participants evaluated each dimension against the others to determine relative preferences ranging from strong to weak or indifference. In addition, this section asked respondents to rate the importance of 27 sustainability goals, divided across the four dimensions, using a 7-point Likert scale from “not important at all” to “extremely important.”
- *Section 2. Drivers and potential of innovative solutions.* It examined the drivers and barriers influencing green logistics. Participants assessed the potential of various drivers on a 7-point Likert scale and provided information on how their organizations are addressing innovative solutions and emerging technologies to promote sustainability, rated on a 5-point scale. Respondents also identified the main barriers or challenges faced by the sector in achieving green logistics through multiple-choice selections.
- *Section 3. Potential of EU regulation and the role of stakeholder collaboration.* Participants rated the impact of EU regulations on advancing green logistics using a 5-point scale. The survey also asked respondents to identify the most effective types of collaboration between supply chain stakeholders that support progress towards sustainable logistics practices.
- *Section 4. Respondent profile.* The survey collected demographic and professional information to contextualize the results. Respondents provided details about their professional role, the country in which they operate, and their experience in the logistics sector. This information enables the analysis of trends and opinions across different stakeholder groups and regions.

The survey questions were designed to capture personal opinions through ranking scales, Likert scales, and binary responses, providing a robust dataset to understand priorities, challenges, and opportunities for green and sustainable logistics. The data collected serves as a foundation for identifying key sustainability goals, innovative solutions, and policy recommendations to advance sustainable practices across the European logistics sector.

The related ADMIRAL survey questions and their responses are available as a dataset in *Zenodo* platform at: Sobrino et al. (2025).

The survey was distributed via email and social media and targeted project partners and members of the Stakeholder Collaborative Forum (SCF). Surveying within this SCF ensured representation of individual with diverse roles across the logistics sector and from multiple European countries. The responses were collected using the **SurveyMonkey platform between July and November 2024**, with a total of 136 submissions. Following data cleaning to remove incomplete and duplicate entries, 115 validated responses were retained for analysis.

5.2.1 Stakeholders and the geographical context of respondents

The respondents are categorised by both European territory and by stakeholder role. For the geographical classification, four European regions are defined⁹: northern (22%), southern (41%), western (11%), and eastern (26%). Table 30 includes the respondent’s division.

Table 30: Survey respondents by EU regions

Region	Country	Responses	%
North	Finland	24	22%
	Norway	1	
South	Greece	1	41%
	Italy	3	
	Portugal	15	
	Spain	28	
East	Croatia	9	26%
	Estonia	1	
	Lithuania	9	
	Poland	2	
	Romania	1	
	Slovenia	8	
West	Austria	1	11%
	Belgium	2	
	France	2	
	Germany	6	
	Ireland	1	
	Netherlands	1	

Regarding the stakeholders’ role is classified into seven groups (see Figure 22): cargo owners (7.8%), logistics operators (17.4%), infrastructure managers (10.4%), ancillary services (19.1%), government and regulation bodies (18.3%), research academia and think tanks (20.0%), and logistic associations and other entities (7.0%). These classifications ensure adequate participation within each group.

⁹ Northern: Finland and Norway; Southern: Spain, Portugal, Italy and Greece; Eastern: Lithuania, Estonia, Poland, Croatia, Slovenia and Romania; Western: Austria, Germany, Belgium, France, Netherlands and Ireland

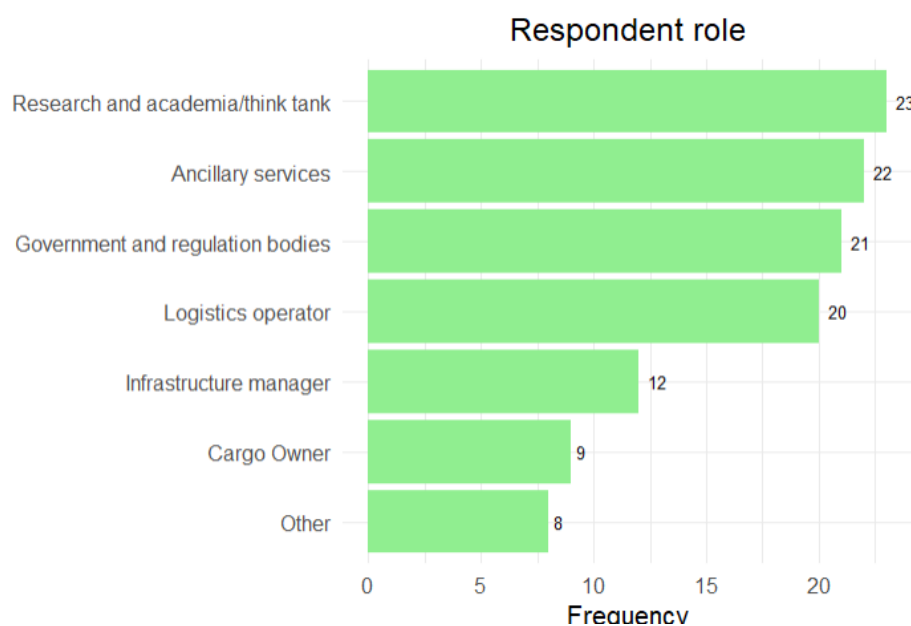


Figure 22: Survey respondents by stakeholder categorization

5.2.2 Main goals and sustainability dimensions

Table 31 presents the perceived importance of the goals across the four sustainability dimensions. Overall, the median ratings indicate that most of the goals are considered very important (median = 6). Among them, reducing greenhouse gas emissions, reducing air pollution, and increasing energy efficiency were rated the highest, with IQR scores of 6 and 7, reflecting that they are viewed as very to extremely important. Similarly, within the economic dimension, improving operational efficiency received the same high valuation. In the social dimension, improving safety and ensuring appropriate labour conditions were also rated very important. For the governance dimension, political stability and absence of violence and long-term government planning achieved the highest median scores. In contrast, the goals with the lowest perceived importance were reducing noise exposure, reducing land occupation, and promoting global economic growth, each with a median rating of moderately important (median = 5).

Table 31: Descriptive statistics of the perceived level of importance of sustainable goals

Dimension	Goals	Median (50%)	IQR (Q1–Q3) ¹⁰	Mean (SD)	Min–Max
Environmental	Reducing GHG emissions	7	6 – 7	6.37 (0.78)	3 – 7
	Reducing air pollution	6	6 – 7	6.23 (0.92)	2 – 7
	Increasing energy efficiency	6	6 – 7	6.18 (0.82)	4 – 7
	Reducing waste	6	5 – 6.5	5.78 (1.00)	2 – 7
	Avoiding chemical leaks	6	5 – 7	5.71 (1.28)	2 – 7
	Increasing circular economy	6	5 – 6	5.55 (1.16)	2 – 7
	Reducing noise exposure	5	4 – 6	5.00 (1.28)	2 – 7
	Reducing land occupation	5	4 – 6	4.67 (1.51)	1 – 7

¹⁰ The interquartile range (IQR) is the difference between the 75th and 25th percentiles, and shows the dispersion of the central 50% of the data.

Dimension	Goals	Median (50%)	IQR (Q1–Q3) ₁₀	Mean (SD)	Min–Max
Economic	Improving operational efficiency	6	6 – 7	6.09 (0.88)	3 – 7
	Improving customer satisfaction	6	5 – 7	5.83 (1.16)	2 – 7
	Reducing congestion	6	5 – 7	5.68 (1.22)	2 – 7
	Increasing regional development	6	5 – 6	5.60 (1.18)	2 – 7
	Maximizing business profits	6	5 – 6	5.33 (1.50)	1 – 7
	Promoting global economy growth	5	4 – 6	5.02 (1.42)	1 – 7
Social	Improving safety	7	6 – 7	6.26 (1.00)	2 – 7
	Ensuring appropriate labour conditions	6	6 – 7	6.15 (0.97)	1 – 7
	Safeguarding security	6	5 – 7	5.97 (1.07)	2 – 7
	Ensuring people's quality of life	6	5 – 7	5.73 (1.17)	1 – 7
	Increasing access to goods and services	6	5 – 6	5.72 (1.02)	2 – 7
	Promoting social equity	6	5 – 6	5.64 (1.19)	2 – 7
	Increasing employment rate	6	5 – 6	5.46 (1.18)	1 – 7
Governance	Political stability and absence of violence	6	6 – 7	6.09 (0.94)	4 – 7
	Long-term planning by governments	6	6 – 7	6.08 (0.83)	4 – 7
	Regulatory quality	6	5 – 6.5	5.87 (0.90)	3 – 7
	Promoting collaboration and data sharing	6	5 – 6	5.82 (0.94)	3 – 7
	Rule of law	6	5 – 7	5.81 (1.00)	2 – 7
	Safeguarding intellectual property	6	5 – 6	5.37 (1.13)	2 – 7

The following Figures compare sustainability dimensions in pairs, showing the median perception of their relative importance across four European regions (Figure 23): Eastern (pink circles), Northern (blue triangles), Southern (green diamonds), and Western (orange circles); and across stakeholder role (Figure 24). Both figures compare six pairs of dimensions: Social vs Governance, Social vs Environmental, Environmental vs Governance, Economic vs Social, Economic vs Governance, and Economic vs Environmental, with the horizontal axis indicating the strength of preference and the vertical axis listing the dimension pairs.

Across **Social vs Governance**, Eastern Europe shows the strongest preference for Social, while other regions remain near indifference. A similar pattern emerges by role, where Academia and Government lean toward Social, confirming that institutional actors and certain regions prioritize community and social impact over governance structures. For **Social vs Environmental**, Northern and Southern Europe moderately favour Social, whereas Eastern Europe is neutral. By role, Academia and Government again prefer Social, while operational actors such as Logistics Operators and Ancillary Services exhibit a more balanced stance, sometimes leaning toward Environmental goals. This suggests that social priorities dominate in policy and research contexts, while environmental considerations gain traction among operational stakeholders.

In **Environmental vs Governance**, Northern Europe clearly favours Environmental, while other regions are neutral. Roles mirror this trend: Logistics Operators and Ancillary Services prioritize Environmental aspects, whereas Academia and Government remain closer to indifference. This alignment indicates that environmental sustainability is a key concern for operational actors and regions with strong

ecological agendas. For **Economic vs Social**, Northern Europe leans toward Economic, while Western Europe slightly favours Social. By role, Cargo Owners and Infrastructure Managers strongly prioritize Economic goals, contrasting with Academia and Government, which favour Social objectives. This divergence underscores a tension between efficiency-driven roles and socially oriented institutions.

When comparing **Economic vs Governance**, Eastern and Northern Europe favour Economic, while Southern and Western Europe are neutral. Similarly, Cargo Owners and Infrastructure Managers show a clear preference for Economic over Governance, reinforcing the perception that governance is considered a baseline requirement rather than a strategic differentiator. Finally, in **Economic vs Environmental**, Northern and Southern Europe lean toward Environmental, while Eastern Europe is indifferent. Roles reveal a sharper divide: Logistics Operators and Ancillary Services favour Environmental goals, whereas Cargo Owners and Infrastructure Managers prioritize Economic efficiency. This contrast highlights the operational challenge of balancing cost competitiveness with environmental responsibility.

Overall, governance consistently ranks as the least influential dimension across both regions and roles, suggesting it is viewed as a compliance necessity rather than a driver of strategic differentiation. Environmental priorities dominate in Northern Europe and among operational actors, while social goals resonate strongly with institutional roles and certain regions. Economic considerations remain central for asset-heavy roles and regions focused on competitiveness. These findings imply that sustainability strategies in logistics must be highly contextual: emphasizing green innovation for operational actors and Northern regions, social engagement for institutional stakeholders and Eastern Europe, and flexible approaches for regions and roles with more balanced or less defined preferences.

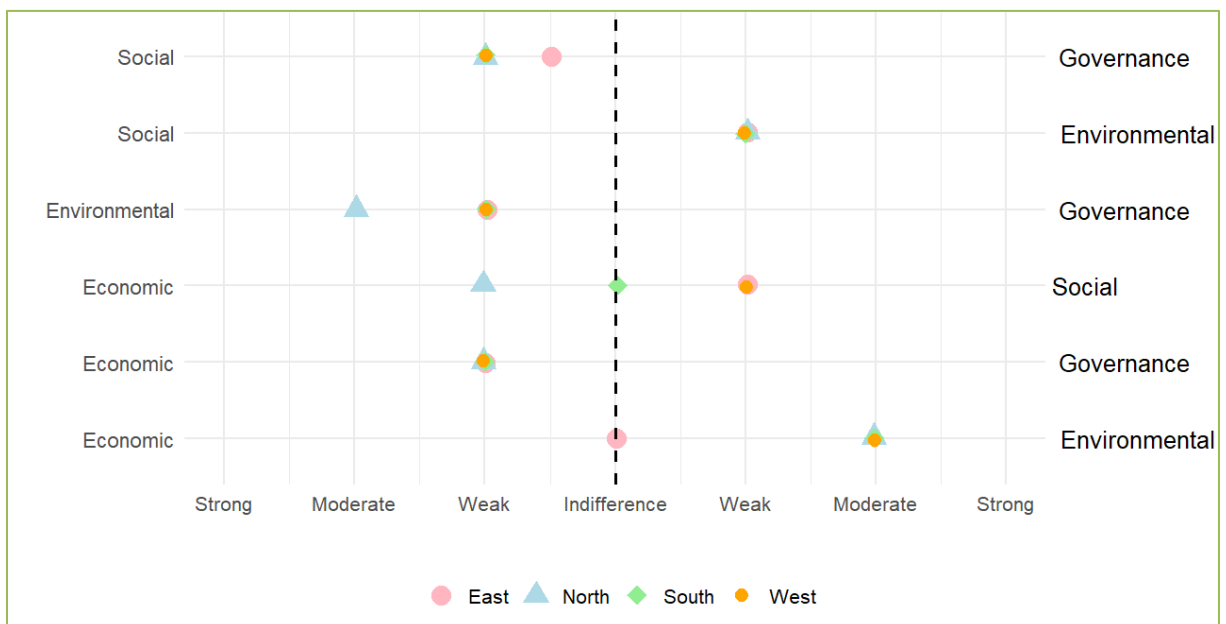


Figure 23: Key sustainability dimension comparison (median) by European region



Figure 24: Key sustainability dimension comparison (median) by stakeholder role

5.2.3 Drivers and barriers identified in logistics

The second section of the survey consisted of identifying the perceived potential of various drivers to promote green and sustainable logistics. Figure 25 shows that overall, **respondents expressed a strong belief in the importance of all listed drivers**, with most categories showing high or very high potential. Respondents **identified emerging technologies and innovative solutions and investment in physical and digital infrastructure as the most influential**, with the highest share of “high” and “very high” ratings. Stakeholder collaboration also ranked strongly, though slightly lower. Regulatory compliance and awareness, education, and training were considered important but showed more moderate potential compared to the other drivers. Overall, the findings highlight technology and infrastructure as primary enablers, supported by collaboration and regulatory measures.

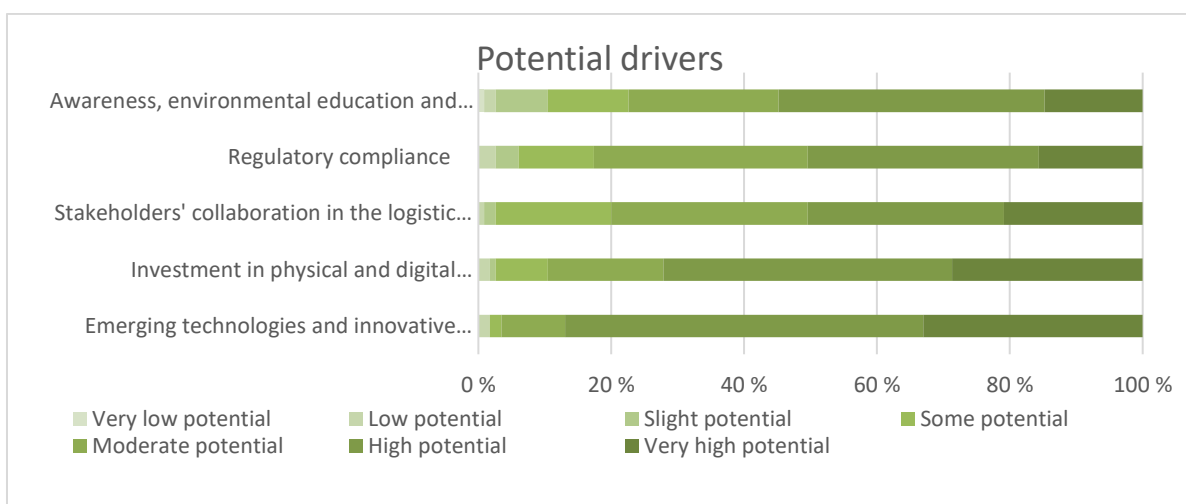


Figure 25: ADMIRAL survey results: perceived potential of various drivers to promote green and sustainable logistics

As, the emerging technologies and innovative solutions were identified as the most influential driver, the survey also evaluated **six emerging technology categories for their potential to advance sustainable logistics**. The following Figure 26 shows that alternative fuels and technologies to improve energy efficiency were rated highest, **with the majority of respondents assigning “high” or “very high potential.”** Digitalization and connectivity and automation also scored strongly, reflecting their perceived role in optimizing operations and reducing emissions. Selective emissions reducers and non-technical solutions showed more moderate ratings, and a notable share of respondents indicated unfamiliarity with these options. Overall, the findings suggest that **energy-related innovations and digital transformation are considered the most impactful technologies** for driving sustainability in logistics.

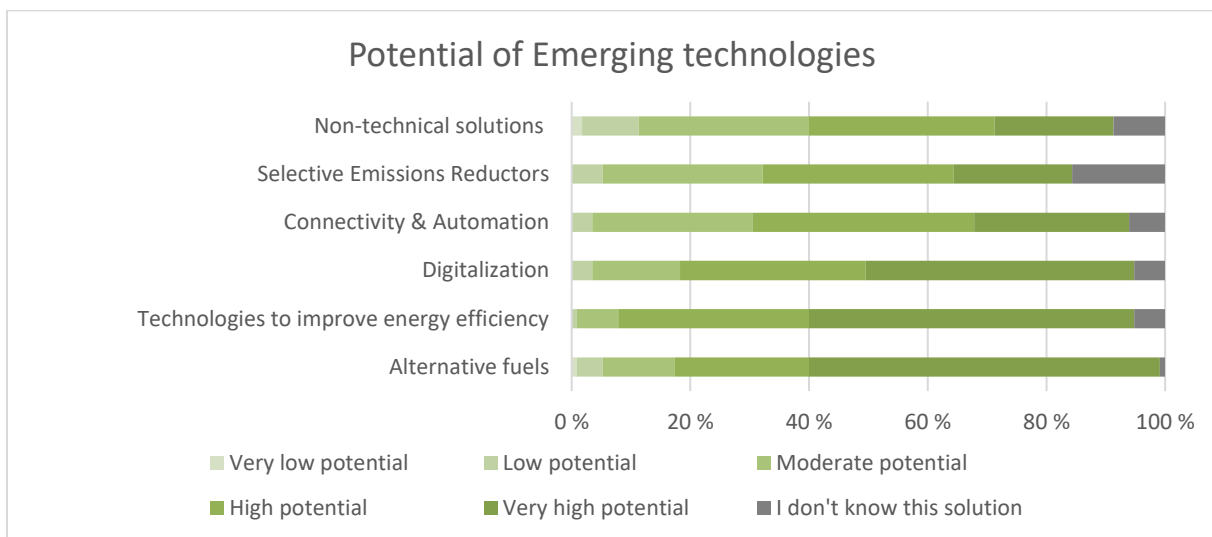


Figure 26: ADMIRAL survey results: perceived potential emerging technologies and innovative solutions

The survey also **examined the progress made by logistics and freight transport companies in implementing eight key innovations**. Figure 27 shows the results. **Data sharing and CO₂ emissions calculation tools show the highest levels of advancement**, with a significant share of respondents reporting “high” or “very high progress.” Optimization of supply chain processes and smart and digital infrastructure also rank strongly, indicating growing efforts to enhance efficiency and sustainability. Conversely, IoT in warehouses and smart trucking, intermodal transport, and use of electric/fuel cell vehicles display more moderate progress, suggesting these areas face greater implementation challenges. Connectivity and automated systems fall in the mid-range, reflecting ongoing but uneven adoption. Overall, the results highlight that digital solutions and emissions monitoring are leading innovation efforts, while physical and operational changes are progressing at a slower pace.

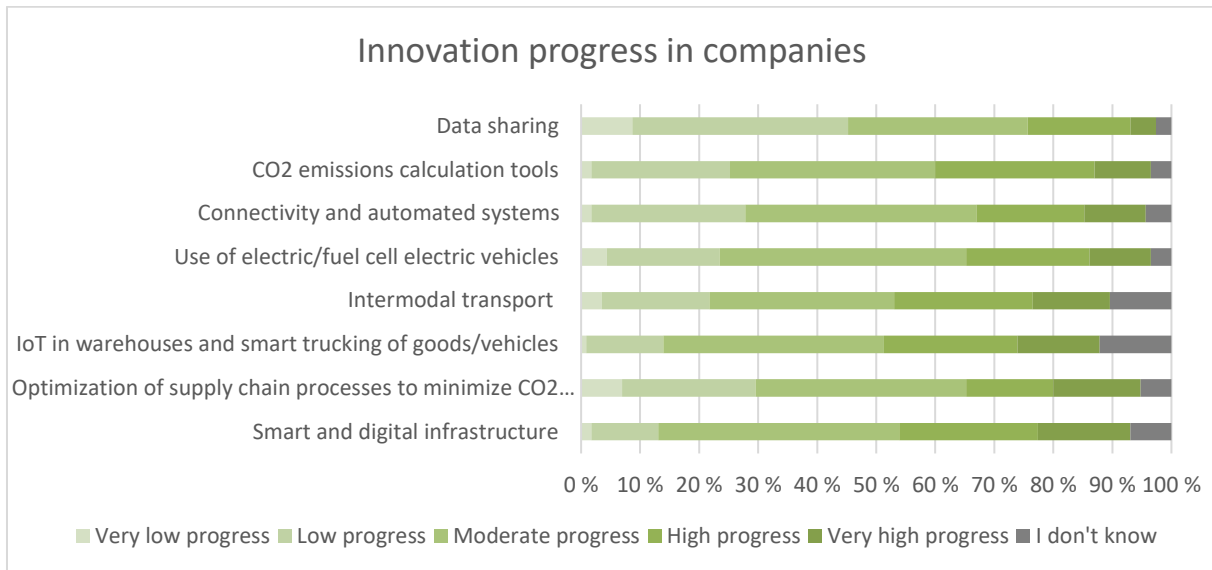


Figure 27: ADMIRAL survey results: innovation progress by logistics and freight transport companies

Finally, the survey identified the main challenges or barriers hindering progress toward sustainable logistics (see Figure 28). **The most significant barrier is uncertainty about return on investment, cited by 50% of respondents. This is followed by lack of standardization (46%) and lack of political support or funding (43%), along with insufficient CO₂ emissions data across the supply chain (43%) and lack of holistic supply chain transparency (43%).** Other notable obstacles include limited infrastructure availability (39%) and technological maturity (38%), while issues such as regulatory hurdles, lack of technical knowledge, and lack of social responsibility were mentioned less frequently (around 30–33%). Overall, financial uncertainty and systemic gaps—such as standardization, data availability, and policy support—emerge as the most critical barriers to advancing green logistics.

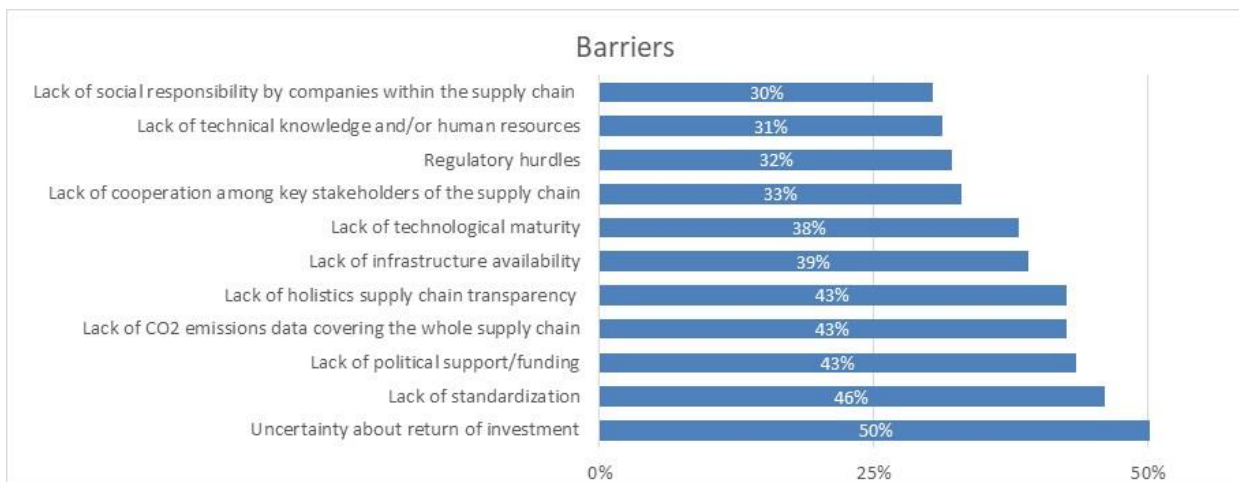


Figure 28: ADMIRAL survey results: greatest barriers the sector faces in achieving green logistics and sustainability

5.2.4 Regulation and collaboration

In the last part of the survey, there were asked about the perceived effectiveness of six EU regulatory measures in advancing sustainable logistics and freight transport. **Figure 29 shows that respondents rated CO₂ emissions performance standards and regulations and reducing GHG emissions by at least**

55% by 2030 as having the highest potential, with a strong concentration of “high” and “very high potential” responses. Implementing the EU Emissions Trading System and internalizing external transport costs also scored positively, though slightly lower. Replacing paper-based documentation with electronic systems and reporting Scope-3 emissions were considered relevant but showed more moderate potential, with a notable share of respondents unfamiliar with these measures. Overall, the findings suggest that emission reduction targets and performance standards are viewed as the most impactful regulatory drivers, while digitalization and reporting requirements are seen as supportive but less transformative.

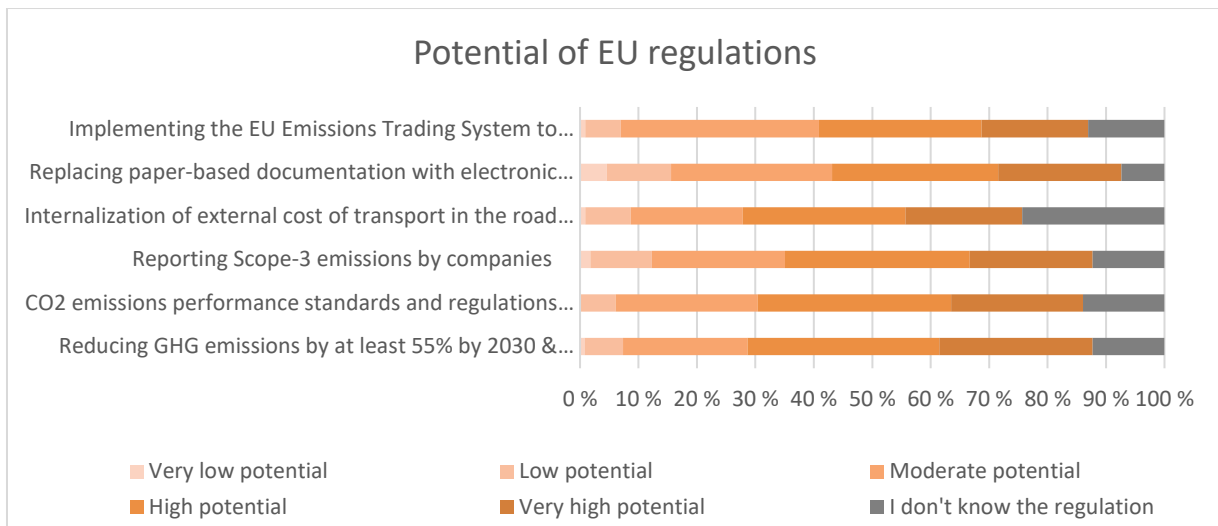


Figure 29: ADMIRAL survey results: Effectiveness of EU regulation towards low-carbon and sustainable logistics

The questionnaire included a question on which types of stakeholder collaboration experts considered most effective for advancing green logistics. **Figure 30 shows that collaboration among logistics service providers and public-private partnerships were identified as the most effective forms of collaboration by around 50% of experts**, followed by industry associations, selected by 46% of respondents.

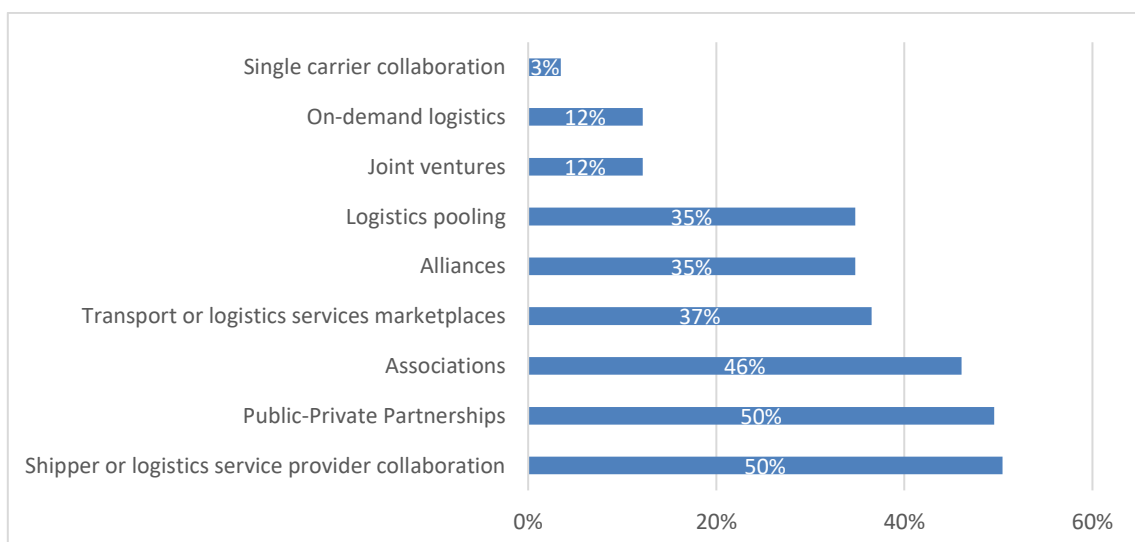


Figure 30: ADMIRAL survey results: most effective stakeholders' collaboration towards green logistics

5.3 Focus group

On October 7th, 2025, a focus group was held in the Consortium Meeting in Stuttgart. This session brought together stakeholders from various pilot regions to collaboratively reflect on the challenges and opportunities facing the logistics ecosystem in its transition toward low-carbon, digital, and socially equitable freight transport. The primary objective of the focus group was to explore how the ADMIRAL digital marketplace could contribute to sustainable logistics, with a particular emphasis on **social sustainability goals and equity impact assessment**. 31 participants engaged in structured discussions and surveys designed to gather insights that will inform future policy development, equity frameworks, and cross-sector collaboration. The focus group aimed to ensure that the ADMIRAL platform is inclusive, accessible, and impactful for all actors in the logistics value chain.



Figure 31: ADMIRAL focus group in Stuttgart

The focus group was divided into pilot-related groups and structured in different sections as follows (see Annex 4 with the template and answers from the pilots-groups).

- Introduction. Brief overview of the session's objectives and structure.
- Pilot-Level Warm-up Questions. Group discussion on recent logistics trends, digitalization challenges, and low-carbon adoption barriers.
- Social Sustainability Goals. Prioritization of social objectives (e.g., labor conditions, equity) and discussion on how ADMIRAL marketplace can support them.
- Equity Impact Assessment. Evaluation of the pilot's impact across five dimensions: Access & Participation; Economic Fairness; Environmental Justice; Labor Equity; Governance & Stakeholder Inclusion
- Wrap-up. Summary of key insights and next steps.

5.3.1 General insights from ADMIRAL pilots

As a preparatory step in the ADMIRAL focus group sessions, a structured Warm-up Questions activity was conducted to stimulate participant reflection and gather initial insights on the evolving logistics landscape. This activity served to contextualize the discussion, align participants on key themes, and collect baseline perceptions regarding sustainability, digitalization, and low-carbon logistics.

The warm-up activity aimed to:

- Encourage participants to reflect on recent developments in their respective pilot areas since the start of the ADMIRAL project.
- Identify perceived challenges and opportunities related to digital transformation and sustainable logistics.

- Establish a shared understanding of the pilot's context before engaging in deeper discussions.

Participants engaged in a collaborative discussion within their pilot-specific focus groups. This segment included three open-ended questions:

- Key Changes:
“What key changes have you noticed in logistics or freight transport trends affecting your pilot since the ADMIRAL project began?”
Participants were encouraged to identify at least two significant developments, such as shifts in demand, regulatory changes, or technological adoption.
- Challenges in Digitalization:
“What challenges have you faced in your pilot area concerning the adoption of digitalization?”
This question aimed to uncover barriers such as infrastructure limitations, resistance to change, or interoperability issues.
- Challenges in Low-Carbon Transition:
“What challenges are you facing in your pilot area concerning the possibility to offer low-carbon options?”
Responses were expected to highlight obstacles like cost constraints, lack of incentives, or insufficient infrastructure for sustainable transport modes.

Each group documented their responses on a shared worksheet, ensuring that the perspectives of all stakeholder types (e.g., public authorities, SMEs, logistics providers, technology developers) were captured.

The findings reveal that across all pilots, logistics and freight transport **systems are strongly influenced by new EU-level environmental and reporting regulations**. The introduction of CO₂ calculation standards (GLEC, eFTI, CSRD) has increased awareness of emissions among cargo owners and policymakers. However, **implementation remains uneven**—while awareness is high; concrete actions and harmonized tools are still lacking. External disruptions, such as the energy crisis and geopolitical instability, have further reshaped supply chains, highlighting the need for resilient and adaptive logistics systems.

Regarding challenges in digitalization, all pilots report progress toward digital transformation, yet most face barriers related to data governance, interoperability, and organizational resistance.

- Many logistics companies operate in siloed digital ecosystems, using custom-built platforms that hinder data sharing.
- Integration with existing legacy systems and high infrastructure costs limit the adoption of new digital tools like those developed under ADMIRAL.
- There is a clear lack of EU-level digital building blocks specific to logistics, such as standardized data exchange protocols or shared platforms.

Overall, the transition toward a fully interoperable digital logistics ecosystem requires both policy coordination and financial incentives.

Pilots converge on the **view that low-carbon logistics remain aspirational rather than operational**.

- Infrastructure gaps—especially in rail and inland waterways—limit alternatives to road transport.

- The cost of low-emission technologies and limited readiness of infrastructure (charging networks, green fleets, etc.) are significant barriers.
- There is a lack of government incentives and market willingness to pay for greener transport services.

In some regions, sustainability objectives are even perceived as tension with resilience and competitiveness, especially where alternative modes are underdeveloped.

In a nutshell, The ADMIRAL pilots reveal that while regulatory alignment and emission awareness are advancing, digital and low-carbon transitions face significant infrastructural and governance barriers. Strengthening coordination, improving data accessibility, and fostering financial incentives are key to accelerating sustainable logistics transformation in the EU.

5.3.2 Social priorities and the role of digital Marketplaces

Focus group participants were asked to rank key social priorities relevant to the logistics and mobility sectors. In general, the findings reveal shared concerns across ADMIRAL pilots and regions, particularly regarding access to goods and services, people’s quality of life, and ensuring fair working conditions (see Table 31).

Table 32: Focus group results: Ranking of social priorities by pilots and the general weights

The social priorities. Rank them from 1 (most important) to 7 (important)	Portugal-Spain pilot	Finland pilot	Slovenia-Croatia pilot	Lithuania pilot	Weights Total
Ensuring appropriate labour conditions	3	6	2	2	13.75%
Increase employment rate	7	7	1	7	6.35%
Improving safety	4	1	3	6	10.31%
Safeguarding security	6	3	4	4	8.25%
Increasing access to goods and services	1	4	6	1	27.50%
Ensuring people's quality of life	2	2	5	3	27.50%
Promoting social equity	5	5	7	5	6.35%

Across the pilots, participants were also asked about how digital marketplaces such as ADMIRAL could help to meet those social priorities. They underlined that digital marketplaces could contribute meaningfully to these priorities. By improving **efficiency, visibility, and coordination in logistics flows**, such platforms enhance access to goods and ensure greater resilience in supply chains. In parallel, the **promotion of greener logistics and digital skills development supports sustainability and workforce empowerment**, directly improving people’s quality of life. Moreover, digitalization enables better monitoring of working conditions, including rest times and workload distribution, thereby fostering fairer and safer labor practices.

Overall, the focus group results confirm that digital marketplaces like ADMIRAL can play a key role in efficiency and visibility; greener logistics and upskilling, contributing to a more inclusive and resilient European transport ecosystem.

5.3.3 Equity Impact Assessment

As part of the ADMIRAL project’s commitment to inclusive and sustainable innovation, an Equity Impact Assessment (EIA) was conducted during the focus group sessions held across pilot regions. The

EIA aimed to systematically evaluate the potential impacts of the ADMIRAL digital marketplace and associated pilot activities on different stakeholder groups, with a particular emphasis on fairness, accessibility, and social inclusion.

Purpose and Scope

The EIA was designed to: i) identify potential equity-related risks and opportunities associated with the implementation of the ADMIRAL marketplace and pilots; ii) ensure that the transition to low-carbon logistics does not disproportionately disadvantage vulnerable or underrepresented groups; iii) inform the design and governance of the pilots to enhance their social and economic inclusiveness.

Methodological Approach

The assessment was carried out through a structured, participatory process embedded within the focus group methodology. Each pilot region (e.g., Portugal–Spain, Finland, Slovenia–Croatia, Lithuania) conducted the EIA using a standardized template that included both quantitative and qualitative components (see Annex 4 Focus group questions and answers).

1. Participant Preparation. Participants were briefed on the purpose of the EIA and encouraged to:

- Provide honest and reflective responses.
- Consider the broader impacts of the pilot on various stakeholder groups (e.g., SMEs, local communities, workers, vulnerable populations).
- Use a Likert scale (1 to 5) to rate each statement, where:
 - 1 = Strongly disagree / Very poor
 - 2 = Disagree / Poor
 - 3 = Neutral / Acceptable
 - 4 = Agree / Good
 - 5 = Strongly agree / Excellent

2. Thematic Assessment Areas. The EIA was structured into five key dimensions, each comprising multiple evaluative statements:

- **Access and Participation:** Assessed the inclusivity of the platform in terms of access for all logistics actors, including SMEs and smaller carriers, and the absence of barriers related to language, IT systems, or procedures.
- **Cost and Economic Fairness:** Evaluated the affordability of the platform for smaller operators and its potential to level the playing field in terms of competition and cost efficiency.
- **Environmental Justice and Sustainability:** Focused on the environmental benefits of the pilot, particularly for communities along logistics corridors, and the transparency of environmental performance reporting.
- **Labor and Workforce Equity:** Examined the pilot’s contribution to fair wages, safe working conditions, skills development, and equitable employment opportunities across diverse workforce profiles.
- **Governance and Stakeholder Balance:** Investigated the inclusiveness of decision-making processes and the extent to which governance structures prevent dominance by large actors.

3. Data Collection and Group Discussion. Each focus group was divided by pilot and facilitated by a designated leader. Participants completed the assessment collaboratively, ensuring that all voices

were heard. For each statement, participants provided a score and were encouraged to include qualitative comments to contextualize their responses, share examples, or suggest improvements.

4. Output and Integration. The collected data served as a foundation for:

- Identifying equity gaps and areas for improvement in pilot design and implementation.
- Informing the Socio-economic and Equity Impact Assessment.
- Supporting the development of inclusive policy recommendations in the ADMIRAL Policy in Brief.

6 Key findings on sustainability challenges and priorities from the stakeholders' perspective

To explore how different groups, perceive sustainability challenges and priorities, several statistical analyses were conducted to identify significant differences between stakeholder categories and across European territories. This approach provides valuable insights into how perceptions vary among sectors and regions, revealing diverse perspectives on sustainability and green logistics. Understanding these variations helps capture the range of opinions that shape sustainable practices and decision-making, thereby contributing to a more comprehensive understanding of sustainability across Europe.

6.1 Prioritization of Sustainability Goals Across European Stakeholders and Territories

To determine which sustainability dimensions—environmental, economic, social, and governance—were considered most important, the Analytic Hierarchy Process (AHP) was applied. AHP is a well-established method used to compare alternatives and assign weights based on expert opinions and is widely used in the fields of green logistics and the green economy (Karam et al., 2021; Saaty, 1977; Tian et al., 2023; Tang & Solangi, 2023). These weights reflect the relative priority of each dimension and were derived from the average responses of experts. The results of this analysis help strengthen the sustainability framework for collaborative, digital, and green logistics.

The AHP analysis was carried out three times:

- Using the overall average of all expert responses,
- Using the averages for each geographic region, and
- Using the averages for each stakeholder group.

Results of the AHP analysis

Table 33 presents the results of the AHP methodology. The findings show that the environmental dimension is clearly prioritized over the others (1.93), as it is 2.3 times higher than the weighting of the economic and social dimension (0.84), which are equally weighted, while governance has the lowest weighting (0.39), with less than half of the above scores. These results, consistent with previous studies (Lazar et al., 2021; Kayikci et al., 2022; Tang & Solangi, 2023), suggest a notable shift in mindset in recent years toward emphasizing environmental concerns within sustainability strategies.

Across European regions, the environmental dimension remains dominant overall, but with regional variations: Northern countries place the highest importance on environmental sustainability, Eastern countries emphasize economic aspects, and Western countries prioritize social dimensions. These general results reflect a growing consensus on the urgency of environmental issues while revealing how different contexts and roles shape sustainability priorities.

The results by stakeholder highlight categories reveal distinct perspectives. Infrastructure managers and academics assign the highest weight to the environmental dimension, while cargo owners and logistics operators place greater emphasis on the economic dimension. Overall, governance

consistently receives the lowest weighting across all groups, except for those in the government or other stakeholder categories. Interestingly, cargo owners rate the economic, environmental, and social dimensions almost equally, while logistics operators give slightly more importance to the environmental dimension. These results suggest a possible shift from the traditional economic perspective among all of the stakeholders considered, although with varying weights.

Table 33: Weighting factors for the sustainability dimensions – AHP results

Categorisation		Economic	Environmental	Social	Governance	
1	General	0.84	1.93	0.84	0.39	
2	By European territory	East	1.22	1.55	0.72	0.52
		North	0.83	2.10	0.63	0.44
		South	0.84	1.93	0.84	0.39
		West	0.49	1.89	1.13	0.49
3	By stakeholder role	Academia	0.65	1.94	0.90	0.52
		Ancillary services	0.84	1.93	0.84	0.39
		Cargo owner	1.20	1.20	1.20	0.40
		Government	0.97	1.30	0.77	0.97
		Infrastructure manager	0.64	2.16	0.57	0.64
		Logistics operator	1.16	1.33	1.16	0.35
		Other	0.77	1.30	0.97	0.97

Weighting of sustainability goals

Following the AHP analysis, the original 7-point questionnaire scores for each sustainability goal were adjusted according to the AHP dimension weight (Table 33). This step allows for a more accurate comparison between goals, reflecting their importance within the context of each sustainability dimension.

Each goal's weighted importance value (G_l) was calculated using the following formula:

$$G_l = W_i * P_l$$

Where:

- P_l is the level of importance assigned to each goal by respondents, and
- W_i is the weight of the corresponding sustainability dimension obtained from the AHP.

This means that each goal's importance score was adjusted based on how important its overall dimension was considered. The resulting weighted values were expressed on a numerical scale, making it possible to compare them statistically.

Table 34 presents the results of this weighting process. The column labelled "AHP-W" (on the left side) shows the overall average of the weighted importance for each of the 27 sustainability goals.

Differences between stakeholders and regions

To evaluate how perceptions, vary among groups, Welch’s ANOVA test was applied to each goal. This test identifies whether there are statistically significant differences in the average ratings between stakeholder categories and geographic regions.

The results shown in Table 34 (right-hand columns) indicate that significant differences were found among stakeholder groups for all 27 goals (highlighted in bold), showing that priorities vary considerably depending on each stakeholder’s role. In contrast, for geographic regions, significant differences appeared in only two economic goals, suggesting a more consistent perception of sustainability priorities across territories. Overall, these findings suggest that while European regions share a similar understanding of sustainability challenges, stakeholders differ widely in how they prioritize goals, reflecting their unique interests, responsibilities, and operational contexts.

Table 34: AHP-weighted factors for the sustainability goals

Dimension	Sustainability Goals	AHP-W	sd	stakeholder's role (p-value)	European region (p-value)
Environmental	Reducing GHG emissions	12,27	1,50	0,000	0,214
	Reducing air pollution	12,00	1,77	0,000	0,505
	Increasing energy efficiency	11,90	1,58	0,000	0,756
	Reducing waste	11,13	1,92	0,000	0,303
	Avoiding chemical leaks	11,00	2,46	0,000	0,536
	Increasing the circular economy	10,68	2,24	0,000	0,341
	Reducing noise exposure	9,63	2,46	0,000	0,935
	Reducing land occupation	8,99	2,90	0,000	0,650
Economic	Improving operational efficiency	5,12	0,74	0,000	0,278
	Improving customer satisfaction	4,90	0,97	0,000	0,062
	Reducing congestion	4,78	1,03	0,000	0,355
	Increasing regional development	4,71	1,00	0,000	0,030
	Maximizing business profits	4,49	1,26	0,000	0,066
	Promoting global economic growth	4,22	1,20	0,000	0,018
Social	Improving safety	5,27	0,84	0,000	0,709
	Ensuring appropriate labor conditions	5,17	0,81	0,000	0,553
	Safeguarding security	5,02	0,90	0,000	0,702
	Increasing access to goods and services	4,82	0,86	0,000	0,509
	Ensuring people's quality of life	4,82	0,99	0,000	0,359
	Promoting social equity	4,75	1,00	0,000	0,776
	Increasing employment rate	4,60	0,99	0,000	0,325
Governance	Long-term planning by governments	2,38	0,32	0,000	0,285
	Political stability and absence of violence	2,38	0,37	0,000	0,549
	Regulatory quality	2,30	0,35	0,000	0,346
	Promoting collaboration and data sharing	2,28	0,37	0,000	0,215
	Rule of law	2,28	0,39	0,000	0,401
	Safeguarding intellectual property	2,10	0,44	0,000	0,771

Further analysis involved pairwise comparisons using Welch's ANOVA to identify, for each sustainability goal, which stakeholder categories held significantly different or similar views. To simplify the interpretation of these results, stakeholder groups that showed no significant differences in their opinions for a given goal were grouped into clusters. Each cluster, therefore, represents stakeholders who assign a similar level of importance to that goal.

Figure 32 illustrates the average weighted importance (AHP-W) assigned to each goal by stakeholder category, along with the clusters of groups sharing similar perspectives (shown in grey). The results indicate that, in most cases, logistics operators and cargo owners belong to the same cluster, showing a common tendency to prioritize economic and social goals over other dimensions. Within the economic dimension, these two stakeholder groups consider improving customer satisfaction and enhancing operational efficiency to be the most important goals. In the social dimension, they assign higher importance to improving safety and ensuring appropriate labour conditions.

These findings are consistent with previous studies, which show that logistics service providers tend to prioritize economic sustainability, reflecting their focus on cost efficiency and delivery performance (Abbasi & Nilsson, 2016; Hüge-Brodin et al., 2020; Prativiera et al., 2024). However, the literature also indicates a growing concern within the logistics sector for social sustainability, particularly regarding the health impacts of emissions on employees and nearby communities (Jayarathna et al., 2022).

Infrastructure managers, academia, and ancillary services place greater emphasis on the environmental dimension, especially reducing greenhouse gas emissions, improving energy efficiency, and promoting circular economy practices. In contrast, governments and other stakeholders prioritize the governance dimension, focusing on long-term planning, policy development, and collaboration initiatives. These perspectives align with Gündoğdu et al. (2023), who emphasize the role of governments and associations in promoting standards and policies for pollution control, waste management, and environmental reporting.

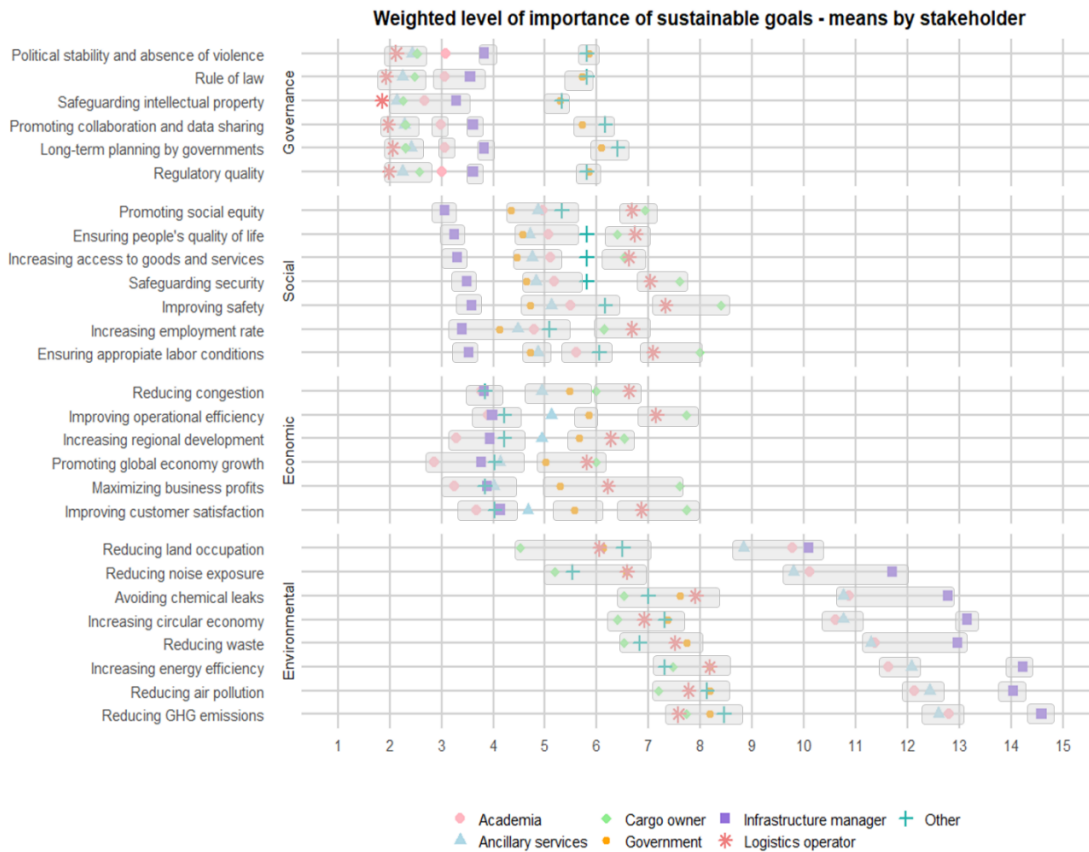


Figure 32: Level of importance of sustainability goals by stakeholder group - AHP-weighted

6.2 ADMIRAL Pilots Performance on Equity, Accessibility, and Environmental Justice

The ADMIRAL project pilots were evaluated through an Equity Impact Assessment (EIA) framework to understand how well they address accessibility, fairness, and sustainability objectives (see focus group on subchapter 5.3.3). Equity in logistics and freight transport refers to the fair and inclusive distribution of resources, opportunities, and service across the supply chain, ensuring that all stakeholder) -such as shippers, carriers, workers, and other communities-benefit (i.e. economic opportunities...) without discrimination or disproportionate disadvantages.

So the objectives of this EIA per pilot area is to identify inequalities to ensure that benefits of the logistics marketplace and AI-based tools from the pilots are equitably distributed and that potential adverse impacts on vulnerable groups are mitigated. The assessment covered five dimensions: Access and Participation, Cost and Economic Fairness, Environmental Justice and Sustainability, Labor and Workforce Equity, and Governance and Stakeholder Balance. Each dimension was rated on a Likert scale (1–5), complemented by qualitative comments providing context. In Annex 4 is included all answers by pilots.

6.2.1 Overall Performance

Across all pilots, the ADMIRAL marketplace and related AI-based tools demonstrates strong alignment with environmental goals and moderate success in economic fairness, while accessibility and

governance mechanisms require improvement. The aggregated equity performance scores by pilots are:

- Portugal–Spain: 77.1%
- Finland: 70.0%
- Slovenia–Croatia: 61.4%
- Lithuania: 72.9%

The Table 35 below summarizes the aggregated results across all pilots.

Table 35: Equity Impact Assessment: Overall assessment

Dimension	Average Score (out of possible total)	Summary
Access & Participation	9 / 15	Moderate equity, needs language & SME support
Cost & Economic Fairness	11.5 / 15	Strong SME orientation, minor hidden costs
Environmental Justice	14 / 15	Excellent, strong sustainability commitment
Labour & Workforce Equity	9.25 / 15	Developing area, requires more active planning
Governance & Stakeholder Balance	5.5 / 10	Weakest area, limited participation of smaller actors
Total (Equity Index)	49 / 70 (70%)	Moderately equitable pilot implementation

Access and Participation. Access equity is moderate across pilots. While the ADMIRAL marketplace is designed to include all logistics actors, language barriers (Portugal–Spain, Slovenia–Croatia) and IT system compatibility issues (Finland) remain significant obstacles for SMEs. Lithuania shows promise by leveraging digitalization to reduce traditional barriers, but accessibility for visually impaired users was flagged in Portugal–Spain. These gaps risk reinforcing inequalities unless addressed through multilingual support and inclusive design.

Cost and Economic Fairness. Economic fairness scored high, reflecting strong SME orientation through affordable pricing models (e.g., €30/month subscriptions, freemium options). Lithuania emphasizes flexibility for smaller operators. However, hidden costs—such as additional devices or system upgrades—could disadvantage SMEs, particularly in Slovenia–Croatia. Overall, pilots are well-aligned with affordability goals but require cost transparency and support mechanisms.

Environmental Justice and Sustainability. This is the best-performing dimension, with nearly all pilots scoring at the top. Emission reduction and energy efficiency are core objectives, and alignment with EU sustainability goals is evident. Transparent reporting of environmental results was highlighted in Lithuania and Finland. Equity risks are minimal, positioning ADMIRAL as a strong contributor to regional and corridor-level sustainability.

Labor and Workforce Equity. Workforce equity remains in a developing area. Portugal–Spain promotes modal shift (road to rail), which may improve job safety, and Lithuania highlights eco-driving

and digital skills as marketable. However, structured programs for upskilling and diversity are limited, and gender/age equity largely depends on existing legislation rather than pilot design. Future efforts should focus on training for green and digital competencies.

Governance and Stakeholder Balance. Governance equity is the weakest dimension. While some pilots (Portugal–Spain) include forums for stakeholder input, engagement is low, and mechanisms to prevent dominance by large companies are absent. Without stronger governance structures, there is a risk of power imbalances undermining inclusivity.

The ADMIRAL pilots demonstrate moderate-to-strong equity performance, particularly in environmental sustainability and affordability. However, systemic equity gaps persist in accessibility, governance inclusion, and workforce development.

6.2.2 Recommendations for improving equity and accessibility in ADMIRAL Pilots

From the focus group analysis conducted before, ADMIRAL pilots are recommended to strengthen equity and inclusivity across, several targeted actions are recommended:

Enhance accessibility and language support. Multilingual interfaces should be integrated into the marketplace to remove language barriers, particularly for SMEs operating in cross-border corridors. Additionally, accessibility features—such as screen reader compatibility and simplified navigation—must be prioritized to ensure participation by visually impaired users and other vulnerable groups.

Improve IT interoperability for SMEs. Many smaller operators face challenges integrating their existing systems with the ADMIRAL platform. Developing standardized protocols and offering technical assistance will help reduce these barriers and promote equal participation.

Increase cost transparency and mitigate hidden expenses. While subscription models are affordable, additional hardware or software requirements can create financial strain for SMEs. Clear communication of all potential costs and the provision of subsidies or shared infrastructure options will ensure that smaller actors are not disadvantaged.

Invest in workforce development and diversity. Equity in labor requires proactive measures. Structured training programs on digital tools, AI-based logistics, and eco-driving should be introduced to enhance employability and support the transition to low-carbon transport. Diversity and inclusion strategies should also be embedded to ensure fair opportunities across gender, age, and other profiles.

Strengthen governance and stakeholder engagement. Governance mechanisms must go beyond consultation forums. Establishing formal stakeholder committees and transparent decision-making processes will prevent dominance by large companies and ensure that SMEs and local actors have a meaningful voice in shaping the marketplace.

6.3 Conclusions

The previous study set out to identify the key goals and drivers of green logistics and to understand how stakeholders perceive them. The findings reveal that environmental sustainability is the dominant priority across Europe, significantly outweighing economic, social, and governance dimensions. However, regional and stakeholder-specific variations persist: Northern countries emphasize

environmental goals most strongly, Eastern regions lean toward economic considerations, and Western regions show a higher focus on social aspects. Similarly, infrastructure managers and academia prioritize environmental objectives, while logistics operators and cargo owners place greater importance on economic and social goals, reflecting their operational realities.

Across all stakeholder groups, governance consistently ranks lowest, indicating a need for stronger policy frameworks and collaborative mechanisms to support sustainability transitions. The analysis of 27 specific goals confirms that reducing greenhouse gas emissions, improving energy efficiency, and promoting circular economy practices are perceived as the most critical environmental actions, while operational efficiency and customer satisfaction dominate economic priorities. Social goals such as safety and labour conditions also emerge as significant, particularly for logistics operators and cargo owners.

These insights have clear implications for policy and practice. First, strategies for green logistics must be tailored to accommodate diverse stakeholder priorities while reinforcing environmental objectives as the overarching driver. Second, governance structures should be strengthened to ensure inclusive decision-making and equitable participation, particularly for SMEs and vulnerable groups. Finally, targeted initiatives—such as multilingual platforms, IT interoperability, cost transparency, and workforce training—are essential to bridge equity gaps and accelerate the adoption of sustainable logistics solutions. By aligning these measures with stakeholder expectations, policymakers and industry leaders can foster a collaborative, resilient, and environmentally responsible logistics ecosystem across Europe.

7 Conclusions and recommendations

This deliverable presents the outcomes of Task 2.1 “Sustainability framework for collaborative, digital and green logistics” of the ADMIRAL project, which aims to support the development of a collaborative, digital, and low-emission logistics marketplace. The findings offer actionable insights for EU policymakers, industry stakeholders, and sustainability practitioners. The main themes and their policy-relevant implications are summarised below in line with main Task 2.1 goals.

Stakeholder identification and collaborative engagement

The **ADMIRAL Sustainability Framework Architecture (SFA) (Figure 10)** has proven effective in structuring collaboration and aligning digital innovation with environmental goals through an iterative, evidence-based approach. Its core instrument—the Stakeholders Collaborative Forum (SCF)—has already convened 57 companies and 81 representatives across supply chain services, regulators, associations, and research bodies. The composition is based on logistics and transport operators, which is advantageous for pilot implementation, while the comparatively smaller participation of government/regulatory authorities underscores the need for stronger policy interface and cross-border harmonization. Interest in the ADMIRAL marketplace is high, but many stakeholders have yet to define concrete use cases, indicating a conversion gap from interest to active participation. Overall, ADMIRAL SFA promotes a dynamic, evidence-based model that prioritizes collaboration and alignment with strategic sustainability objectives.

Sustainability challenges and alignment with long-term strategies and regulation

EU regulation is a key driver that turns sustainability from voluntary aspiration into enforceable practice. The CSRD/ESRS embeds ESG disclosure rigor; eFTI accelerates digitalization and interoperability; TEN-T and AFIR build the infrastructure backbone for decarbonized, multimodal freight; voluntary standards like ISO 14083 strengthen comparability of GHG accounting. Collectively, these regulations foster a systemic transformation that integrates environmental responsibility, technological innovation, and social equity into the core of logistics operations. By aligning corporate practices with regulatory requirements, businesses not only reduce emissions and optimize resource use but also enhance resilience, competitiveness, and stakeholder trust. Ultimately, regulation transforms sustainability from a voluntary initiative into a strategic imperative, accelerating the transition toward a low-carbon, socially responsible logistics ecosystem.

Treatment of sustainability dimensions by stakeholders

On the one hand, the findings from the document reveal that environmental sustainability is the dominant priority across European stakeholders, significantly outweighing economic, social, and governance dimensions. However, regional and stakeholder-specific variations persist: Northern countries emphasize environmental goals most strongly, Eastern regions lean toward economic considerations, and Western regions show a higher focus on social aspects. Similarly, infrastructure managers and academia prioritize environmental objectives, while logistics operators and cargo owners place greater importance on economic and social goals, reflecting their operational realities. These insights have clear implications for policy and practice. First, **strategies for green logistics must be tailored to accommodate diverse stakeholder priorities** while reinforcing environmental

objectives as the overarching driver. Second, **governance structures should be strengthened** to ensure inclusive decision-making and equitable participation, **particularly for SMEs and vulnerable groups**. On the other hand, **sustainability reports from pilot participants show stronger maturity on environmental metrics** (decarbonization, energy efficiency) than on social and governance aspects. Many organizations align with global frameworks, yet still lack comprehensive time-bound targets, standardized methodologies, and measurable KPIs across the full ESG scope. Social topics—such as just transition, diversity and inclusion, occupational health and safety, and community impact—receive comparatively less attention, reflected in “Amber/Red” RAG ratings. Governance consistently ranks lowest across stakeholder groups, highlighting a structural gap in accountability and collaborative mechanisms.

A multidimensional, collaborative strategy for the multimodal marketplace

To accelerate decarbonization and resilience of the supply chain, multimodal marketplaces such as ADMIRAL marketplace should be designed around clear sustainability principles and enabled by advanced digital and AI solutions. **Environmental integrity** must be embedded from the outset by incorporating emissions accounting aligned with ISO 14083, ensuring default Scope 3 coverage, and applying corridor-level carbon budgets to guide operational and strategic decisions. **Economic viability** should be supported through smart tools, including total cost of logistics calculators, dynamic pricing, and service-level guarantees that leverage real-time performing monitoring. **Social inclusion** is equally critical and should be reflected in platform features such as supplier diversity, living-wage commitments, health and safety compliance, and accessibility standards across digital interfaces and operational workflows. **Governance and trust are critical** must be reinforced through secure audit trails, role-based permissions, standardized data-sharing agreements, ensuring full compliance with frameworks such as eFTI and ESRS. Blockchain or similar technologies can further enhance transparency and accountability.

Synchromodal services should enable mode-shift recommendations based on emissions, costs, and time trade-offs. Flexible delivery windows and priority access **to green slots at TEN-T nodes** can be incentivized through intelligent scheduling algorithms, unlocking low-emission and resilient routing options. A **federated data collaboration** layer is essential to integrate terminal operators, carriers, shippers, and authorities. This requires secure APIs, consent management, and fine-grained access controls to enable public–private data reuse without compromising competitiveness. **Interoperable platforms such as eFTI** can streamline compliance, reduce costs, and improve transparency across the supply chain.

Building capabilities for SMEs and regional actors is a priority to ensure alignment with CSRD and ESRS requirements. This involves **providing training on ESG reporting, digital onboarding, and marketplace analytics**, alongside co-funded pilots that demonstrate measurable emissions reductions and social outcomes. Structured multi-stakeholder collaboration through public–private partnerships, EU-level forums, and pilot-based learning frameworks will foster innovation and shared accountability.

Finally, green innovation must be de-risked through targeted investment in low-emission technologies, multimodal infrastructure, and circular economy solutions. Blended finance, performance-based procurement, and guarantee mechanisms can accelerate adoption while ensuring a just and inclusive

transition. These findings reinforce the importance of a coordinated, multidimensional approach to sustainability in logistics-one that is grounded in stakeholder engagement, enabled by digital innovation, and supported by coherent policy frameworks.

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Annex 1 – Stakeholder Collaborative Forum Contact Form

Dear stakeholder,

The ADMIRAL project will develop a multimodal low carbon emissions marketplace “ADMIRAL Marketplace” applicable to the supply chain with the aim of providing services, share information, and connect logistics service providers and cargo owners to promote a more sustainable freight transport. The ADMIRAL marketplace will improve the visibility of the carbon emissions of the whole supply chain so that companies may purchase their logistics and transportation services based on emissions to comply with incoming regulation requirements. The marketplace will be demonstrated in 4 pilots: (i) Portugal-Spain, (ii) Slovenia-Croatia, (iii) Lithuania and (iv) Finland.

This contact form will be used to register your institution as a member of the ADMIRAL Stakeholders Collaborative Forum, which will serve as a platform to communicate the project progress and results, and to promote collaboration on ADMIRAL activities (pilots’ validation, surveys, workshops, marketplace acceptance, etc.). Membership of the Forum does not imply any formal commitment, beyond giving opinions on certain issues and providing feedback on the results of the project.

We would be grateful if you could spend around 5 minutes filling the contact form.

The form can be filled on a mobile phone, but it is preferable to complete it on a computer or tablet.

Please indicate your consent to the use of your contact information in accordance with the following privacy policy (Tick the boxes to complete the form).

INSERT HERE –POP-UP – PRIVACY NOTICE FOR RESEARCH ADMIRAL PROJECT (from VTT)

YES NO

Thank you very much for your cooperation!

1. Company / Organization / Government

Name: _____

Country: _____

Enterprise size:

Micro enterprise: less than 10 persons employed

Small enterprise: 10-49 persons employed

Medium-sized enterprise: 50-249 persons employed

Small and medium sized enterprise (SMEs): 1-249 persons employed

Large enterprise: 250 or more persons employed

Area of business:

Local

Regional

National

International

2. Briefly describe **the purpose or mission** of your Company/Organization

(Maximum 2-3 lines):

3. Contact **person** *(add all the persons that you consider)*

Name: _____

Surname: _____

Email: _____

Position: _____

Years of experience: _____

4. Company/organization **role** under ADMIRAL project *(multiple choice)*

Project Partner

Advisory Board

Pilot Related

Other

5. **Potential user** of ADMIRAL marketplace

Yes

No

6. To which of the following **category/s and subcategory/s** does the activity of the organization you represent best fit? *(Tick all the categories that identify your institution)*

SUPPLY CHAIN PLAYERS & ANCILLARY SERVICES

- Cargo Owner
 - Agriculture, forestry and fishing*
 - Mining and quarrying*
 - Manufacturing*
 - Construction*
 - Wholesale and retail trade; repair of motor vehicles and motorcycles*
 - Accommodation and food service activities*
 - Chemicals & other dangerous materials?*
 - Other: _____*
- Transport operator:
- Freight forwarder and/or Custom Broker
- Infrastructure manager or operator:
 - Port authority*
 - Dry port*
 - Multimodal platform*
 - Berth service provider*
 - Railroad infrastructure manager*
 - Road infrastructure manager*
 - Other: _____*
- Logistic service provider:
 - Warehousing and storage provider*
 - Logistic operator*
 - Courier service*
- Energy supplier
- Technology provider, IT, software company
- Financial institution
- Consultancy firm
- Other: _____

If 6.1, 6.2, 6.3, 6.4, or 6.5 is selected. Please, Indicate the means of transport involved in your activity:

Road

- Rail*
- Maritime*
- Inland waterways*
- Air*
- Multimodal / Intermodal*

GOVERNMENT AND REGULATION BODIES

- European Institution (Commission, Parliament, EU Agency, etc.)
- EU national governments
- Regional or local government
- Market and/or competition regulator
- Standardization and certification body
- Custom office
- Border authority and/or health authority
- Cities authorities

OTHERS

- Transportation/Logistics Association
- Cargo owner association
- Research and Academia
- Think tank
- Consultancy firm
- Trade Union
- Media
- Consumer Association
- Chamber of commerce
- EU fora
- Customers Association
- NGOs
- Other: _____

Annex 2 – List of GRI Consolidated Standards

GRI	Disclosure	Requirement
GRI 1: Foundation 2021	Purpose and system of GRI Standards	-
	Key concepts	-
	Reporting in accordance with the GRI standards	-
	Reporting principles	-
	Additional recommendations for reporting	-
GRI 2: General Disclosure 2021	Disclosure 2-1 Organizational details	Report its legal name
		Report its nature of ownership and legal form
		Report the location of its headquarters
		Report its countries of operation
	Disclosure 2-2 Entities included in the organization's sustainability reporting	List all its entities included in its sustainability reporting
		If the organization has audited consolidated financial statements or financial information filed on public record, specify the differences between the list of entities included in its financial reporting and the list included in its sustainability reporting
		If the organization consists of multiple entities, explain the approach used for consolidating the information
	Disclosure 2-3 Reporting period, frequency and contact point	Specify the reporting period for, and the frequency of, its sustainability reporting
		Specify the reporting period for its financial reporting and, if it does not align with the period for its sustainability reporting, explain the reason for this
		Report the publication date of the report or reported information
		Specify the contact point for questions about the report or reported information
	Disclosure 2-4 Restatements of information	Report restatements of information made from previous reporting periods
	Disclosure 2-5 External assurance	Describe its policy and practice for seeking external assurance, including whether and how the highest governance body and senior executives are involved
		If the organization's sustainability reporting has been externally assured
	Disclosure 2-6 Activities, value chain and other business relationships	Report the sector(s) in which it is active
		Describe its value chain
		Report other relevant business relationships
Disclosure 2-6 Activities, value chain and other business relationships	Describe significant changes in 2-6-a, 2-6-b, and 2-6-c compared to the previous reporting period	
	Report the total number of employees, and a breakdown of this total by gender and by region	
Disclosure 2-7 Employees	Report the total number of i. permanent employees, and a breakdown by gender and by region; ii. temporary employees, and a breakdown	

GRI	Disclosure	Requirement
GRI 203		by gender and by region; iii. non-guaranteed hours employees, and a breakdown by gender and by region; iv. full-time employees, and a breakdown by gender and by region; v. part-time employees
		Describe the methodologies and assumptions used to compile the data, including whether the numbers are reported: i. in head count, full-time equivalent (FTE), or using another methodology; at the end of the reporting period, as an average across the reporting period, or using another methodology;
		Report contextual information necessary to understand the data reported under 2-7-a and 2-7-b;
		Describe significant fluctuations in the number of employees during the reporting period and between reporting periods
	Disclosure 2-8 Workers who are not employees	Report the total number of workers who are not employees and whose work is controlled by the organization
		Describe the methodologies and assumptions used to compile the data
		Describe significant fluctuations in the number of workers who are not employees during the reporting period and between reporting periods
	Disclosure 2-9 Governance structure and composition	Describe its governance structure, including committees of the highest governance body
		List the committees of the highest governance body that are responsible for decision making on and overseeing the management of the organization's impacts on the economy, environment, and people
		describe the composition of the highest governance body and its committees
	Disclosure 2-10 Nomination and selection of the highest governance body	Describe the nomination and selection processes for the highest governance body and its committees
		Describe the criteria used for nominating and selecting highest governance body members
Disclosure 2-11 Chair of the highest governance body	Report whether the chair of the highest governance body is also a senior executive in the organization	
	If the chair is also a senior executive, explain their function within the organization's management, the reasons for this arrangement, and how conflicts of interest are prevented and mitigated	
Disclosure 2-12 Role of the highest governance body in overseeing the management of impacts	Describe the role of the highest governance body and of senior executives in developing, approving, and updating the organization's purpose, value or mission statements, strategies, policies, and goals related to sustainable development	
	Describe the role of the highest governance body in overseeing the organization's due diligence and other processes to identify and manage the organization's impacts on the economy, environment, and people	

GRI	Disclosure	Requirement
GRI 2		Describe the role of the highest governance body in reviewing the effectiveness of the organization’s processes as described in 2-12-b, and report the frequency of this review.
	Disclosure 2-13 Delegation of responsibility for managing impacts	Describe how the highest governance body delegates responsibility for managing the organization’s impacts on the economy, environment, and people,
		Describe the process and frequency for senior executives or other employees to report back to the highest governance body on the management of the organization’s impacts on the economy, environment, and people
	Disclosure 2-14 Role of the highest governance body in sustainability reporting	Report whether the highest governance body is responsible for reviewing and approving the reported information, including the organization’s material topics, and if so, describe the process for reviewing and approving the information
		If the highest governance body is not responsible for reviewing and approving the reported information, including the organization’s material topics, explain the reason for this.
	Disclosure 2-15 Conflicts of interest	Describe the processes for the highest governance body to ensure that conflicts of interest are prevented and mitigated
		Report whether conflicts of interest are disclosed to stakeholders
	Disclosure 2-16 Communication of critical concerns	Describe whether and how critical concerns are communicated to the highest governance body
		Report the total number and the nature of critical concerns that were communicated to the highest governance body during the reporting period
	Disclosure 2-17 Collective knowledge of the highest governance body	Report measures taken to advance the collective knowledge, skills, and experience of the highest governance body on sustainable development
	Disclosure 2-18 Evaluation of the performance of the highest governance body	Describe the processes for evaluating the performance of the highest governance body in overseeing the management of the organization’s impacts on the economy, environment, and people
		Report whether the evaluations are independent or not, and the frequency of the evaluations
		Describe actions taken in response to the evaluations, including changes to the composition of the highest governance body and organizational practices
	Disclosure 2-19 Remuneration policies	Describe the remuneration policies for members of the highest governance body and senior executives
Describe how the remuneration policies for members of the highest governance body and senior executives relate to their objectives and performance in relation to the management of the organization’s impacts on the economy, environment, and people		

GRI	Disclosure	Requirement
	Disclosure 2-20 Process to determine remuneration	Describe the process for designing its remuneration policies and for determining remuneration
		Report the results of votes of stakeholders (including shareholders) on remuneration policies and proposals, if applicable
	Disclosure 2-21 Annual total compensation ratio	Report the ratio of the annual total compensation for the organization's highest-paid individual to the median annual total compensation for all employees(excluding the highest-paid individual)
		Report the ratio of the percentage increase in annual total compensation for the organization's highest-paid individual to the median percentage increase in annual total compensation for all employees (excluding the highest-paid individual)
		Report contextual information necessary to understand the data and how the data has been compiled
	Disclosure 2-22 Statement on sustainable development strategy	Report a statement from the highest governance body or most senior executive of the organization about the relevance of sustainable development to the organization and its strategy for contributing to sustainable development
	Disclosure 2-23 Policy commitments	Describe its policy commitments for responsible business conduct
		Describe its specific policy commitment to respect human rights
		Provide links to the policy commitments if publicly available, or, if the policy commitments are not publicly available, explain the reason for this
		Report the level at which each of the policy commitments was approved within the organization, including whether this is the most senior level
		Report the extent to which the policy commitments apply to the organization's activities and to its business relationships
		Describe how the policy commitments are communicated to workers, business partners, and other relevant parties
	Disclosure 2-24 Embedding policy commitments	Describe how it embeds each of its policy commitments for responsible business conduct throughout its activities and business relationships
	Disclosure 2-25 Processes to remediate negative impacts	Describe its commitments to provide for or cooperate in the remediation of negative impacts that the organization identifies it has caused or contributed to
		Describe its approach to identify and address grievances, including the grievance mechanisms that the organization has established or participates in
Describe other processes by which the organization provides for or cooperates in the remediation of		

GRI	Disclosure	Requirement
		negative impacts that it identifies it has caused or contributed to
		Describe how the stakeholders who are the intended users of the grievance mechanisms are involved in the design, review, operation, and improvement of these mechanisms
		Describe how the organization tracks the effectiveness of the grievance mechanisms and other remediation processes, and report examples of their effectiveness, including stakeholder feedback
	Disclosure 2-26 Mechanisms for seeking advice and raising concerns	Describe the mechanisms for individuals to seek advice on implementing the organization’s policies and practices for responsible business conduct and raise concerns about the organization’s business conduct
	Disclosure 2-27 Compliance with laws and regulations	Report the total number of significant instances of non-compliance with laws and regulations during the reporting period, and a breakdown of this total
		Report the total number and the monetary value of fines for instances of noncompliance with laws and regulations that were paid during the reporting period, and a breakdown of this total
		Describe the significant instances of non-compliance
		Describe how it has determined significant instances of non-compliance
	Disclosure 2-28 Membership associations	Report industry associations, other membership associations, and national or international advocacy organizations in which it participates in a significant role
	Disclosure 2-29 Approach to stakeholder engagement	Describe its approach to engaging with stakeholders
Disclosure 2-30 Collective bargaining agreements	Report the percentage of total employees covered by collective bargaining agreements	
	For employees not covered by collective bargaining agreements, report whether the organization determines their working conditions and terms of employment based on collective bargaining agreements that cover its other employees or based on collective bargaining agreements from other organizations	
GRI 3: Material Topic 2021	Disclosure 3-1 Process to determine material topics	Describe the process it has followed to determine its material topics
		Specify the stakeholders and experts whose views have informed the process of determining its material topics
	Disclosure 3-2 List of material topics	List its material topics
		Report changes to the list of material topics compared to the previous reporting period
Disclosure 3-3 Management of material topics	Describe the actual and potential, negative and positive impacts on the economy, environment, and people, including impacts on their human rights	

GRI	Disclosure	Requirement
		Report whether the organization is involved with the negative impacts through its activities or as a result of its business relationships, and describe the activities or business relationships
		Describe its policies or commitments regarding the material topic
		Describe actions taken to manage the topic and related impacts
		Track the effectiveness of the actions taken
		Describe how engagement with stakeholders has informed the actions taken (3-3-d) and how it has informed whether the actions have been effective (3-3-e)
GRI 101: Biodiversity 2024	Disclosure 101-1 Policies to halt and reverse biodiversity loss	Describe its policies or commitments to halt and reverse biodiversity loss, and how these are informed by the 2050 Goals and 2030 Targets in the Kunming-Montreal Global Biodiversity Framework
		Report the extent to which these policies or commitments apply to the organization’s activities and to its business relationships
		Report the goals and targets to halt and reverse biodiversity loss, whether they are informed by scientific consensus, the base year, and the indicators used to evaluate progress
	Disclosure 101-2 Management of biodiversity impacts	101-2 Report how it applies the mitigation hierarchy
		Report for each site with the most significant impacts on biodiversity
		List which of its sites with the most significant impacts on biodiversity have a biodiversity management plan and explain why the other sites do not have a management plan
		Describe how it enhances synergies and reduces trade-offs between actions taken to manage its biodiversity and climate change impacts
		Describe how it ensures that the actions taken to manage its impacts on biodiversity avoid and minimize negative impacts and maximize positive impacts for stakeholders
	Disclosure 101-3 Access and benefit-sharing	Describe the process to ensure compliance with access and benefit-sharing regulations and measures
		Describe voluntary actions taken to advance access and benefit-sharing that are additional to legal obligations or when there are no regulations and measures
	Disclosure 101-4 Identification of biodiversity impacts	Explain how it has determined which of its sites and which products and services in its supply chain have the most significant actual and potential impacts on biodiversity
	Disclosure 101-5 Locations with biodiversity impacts	Report the location and size in hectares of its sites with the most significant impacts on biodiversity

GRI	Disclosure	Requirement	
		For each site reported under 101-5-a, report whether it is in or near an ecologically sensitive area, the distance to these areas	
		Report the activities that take place in each site reported under 101-5-a	
		Report the products and services in its supply chain with the most significant impacts on biodiversity and the countries or jurisdictions where the activities associated with these products and services take place	
	Disclosure 101-6 Direct drivers of biodiversity loss		For each site reported under 101-5-a where its activities lead or could lead to land and sea use change
			For each site reported under 101-5-a where its activities lead or could lead to the exploitation of natural resources
			For each site reported under 101-5-a where its activities lead or could lead to pollution, report the quantity and the type of each pollutant generated
			For each site reported under 101-5-a where its activities lead or could lead to the introduction of invasive alien species, describe how invasive alien species are or may be introduced
			For each product and service in its supply chain reported under 101-5-d, report the information required under 101-6-a, 101-6-b, 101-6-c, and 101-6-d, with a breakdown by country or jurisdiction
			Report contextual information necessary to understand how the data has been compiled, including standards, methodologies, and assumptions used
	Disclosure 101-7 Changes to the state of biodiversity		For each site reported under 101-5-a, report the following information on affected or potentially affected ecosystems: the ecosystem type for the base year, the ecosystem size in hectares for the base year, the ecosystem condition for the base year and the current reporting period
			Report contextual information necessary to understand how the data has been compiled, including standards, methodologies, and assumptions used
		Disclosure 101-8 Ecosystem services	For each site reported under 101-5-a, list the ecosystem services and beneficiaries affected or potentially affected by the organization's activities
			Explain how the ecosystem services and beneficiaries are or could be affected by the organization's activities
	GRI 102: Climate Change 2025	Disclosure 102-1 Transition plan for climate change mitigation	Describe its transition plan, including policies and actions to mitigate climate change
Describe how the transition plan aligns with the latest scientific evidence on the global effort needed to limit global warming to 1.5 °C, including the source of the climate change-related scenarios			

GRI	Disclosure	Requirement	
GRI 102		used, and the methodologies and assumptions used to develop the transition plan	
		Report the total expenditure incurred by the implementation of the transition plan as monetary value and percentage of the total expenditure incurred in the reporting period	
		Report the governance bodies or individual roles responsible for overseeing and implementing the transition plan and their responsibilities	
		Describe how the transition plan is embedded in its business strategy	
		Report the targets to achieve the transition plan and progress toward them	
		Describe how the transition plan aligns with just transition principles and how engagement with stakeholders informs its development and implementation	
		Describe the impacts on people and the environment from implementing the transition plan and the actions taken to manage them, including: workers, local communities, and Indigenous Peoples; biodiversity	
		Describe how its public policy activities, including lobbying activities, are consistent with the transition plan	
		Explain, in the absence of a transition plan, why it does not exist, and describe the steps being taken to develop it and the expected time frame	
		Disclosure 102-2 Climate change adaptation plan	Describe the impacts on people and the environment associated with its climate change-related risks and opportunities and how they were considered in the development of the adaptation plan
	Describe its adaptation plan		
	Describe the impacts on people and the environment from implementing the adaptation plan and the actions taken to manage them		
	Explain, in the absence of an adaptation plan, why it does not exist, and describe the steps being taken to develop it and the expected time frame		
	Disclosure 102-3 Just transition		Report the total number of new employees recruited and a breakdown of this total
			Report the total number of employees whose work was terminated and a breakdown of this total
			Report the total number of redeployed employees and a breakdown of this total
			Report the total number of employees who received training for up- and re-skilling, and a breakdown of this total
			Report the total number of new workers who are not employees recruited and a breakdown of this total by gender

GRI	Disclosure	Requirement
		<p>Report the total number of workers who are not employees whose work was terminated and a breakdown of this total by gender</p> <p>Report the total number and percentage of new employees recruited whose basic pay is at or above the cost-of-living estimate, and describe actions taken or commitments made to address any gaps between basic pay and the cost-of-living estimate for workers reported under 102-3-a and 102-3-e</p> <p>List the locations of operation where the organization has impacts on local communities and Indigenous Peoples</p> <p>Report the percentage of locations of operation listed under 102-3-h in which an agreement has been reached with affected or potentially affected local communities or Indigenous Peoples to safeguard their interests</p> <p>Report contextual information necessary to understand the data reported under 102-3 and describe the methodologies and assumptions used to compile the data</p>
	<p>Disclosure 102-4 GHG emissions reduction targets and progress</p>	<p>Report short-, medium-, and long-term gross Scope 1, Scope 2, and Scope 3 GHG emissions reduction targets in metric tons of CO₂ equivalent and as a percentage of base year emissions</p> <p>For each gross GHG emissions reduction target, report whether biogenic CO₂ emissions are included in the target</p> <p>For each gross Scope 2 GHG emissions reduction target, report whether the targets use the location-based or market-based method</p> <p>For each gross Scope 3 GHG emissions reduction target, list the Scope 3 categories covered by the targets</p> <p>For each gross GHG emissions reduction target, report the gases covered by the target</p> <p>Explain how the gross GHG emissions reduction targets align with the latest scientific evidence on the effort needed to limit global warming to 1.5°C</p> <p>Describe its gross GHG emissions reduction target revision policy</p> <p>For each gross GHG emissions reduction target, report the base year</p> <p>Report the progress toward each gross GHG emissions reduction target using the inventory method, in metric tons of CO₂ equivalent, and as a percentage of a base year emissions</p> <p>For each gross GHG emissions reduction target, explain how the progress toward the target was achieved</p> <p>Report standards, methodologies, assumptions, and calculation tools used</p>

GRI	Disclosure	Requirement
	Disclosure 102-5 Scope 1 GHG emissions	Report gross Scope 1 GHG emissions in metric tons of CO ₂ equivalent, and in the calculation
		Provide a breakdown of gross Scope 1 GHG emissions by CO ₂ , CH ₄ , N ₂ O, HFCs, PFCs, SF ₆ , and NF ₃ , in metric tons and metric tons of CO ₂ equivalent
		Report biogenic CO ₂ emissions from the combustion or biodegradation of biomass from owned or controlled sources in metric tons, separately from gross Scope 1 GHG emissions
		Report the base year for the calculation
		Report the consolidation approach for Scope 1 GHG emissions that is consistently applied across Scope 1, Scope 2, and Scope 3 GHG emissions, whether equity share, financial control, or operational control
		Report standards, methodologies, assumptions, and calculation tools used, including the source of the emission factors used
	Disclosure 102-6 Scope 2 GHG emissions	Report gross location-based and, if applicable, market-based Scope 2 GHG emissions in metric tons of CO ₂ equivalent
		Provide a breakdown of gross location-based Scope 2 GHG emissions by CO ₂ , CH ₄ , and N ₂ O in metric tons and metric tons of CO ₂ equivalent
		Report location-based and, if applicable, market-based biogenic CO ₂ emissions from electricity use in metric tons, separately from gross Scope 2 GHG emissions
		Report the base year for the calculation
		Report the consolidation approach for Scope 2 GHG emissions that is consistently applied across Scope 1, Scope 2, and Scope 3 GHG emissions, whether equity share, financial control, or operational control
		Report standards, methodologies, assumptions, and calculation tools used, including the source of the emission factors used
	Disclosure 102-7 Scope 3 GHG emissions	Report gross Scope 3 GHG emissions in metric tons of CO ₂ equivalent
		Provide a breakdown of gross Scope 3 GHG emissions by each of the 15 Scope 3 categories in metric tons of CO ₂ equivalent
		Report biogenic CO ₂ emissions from the combustion or biodegradation of biomass in the upstream and downstream value chain in metric tons, separately from gross Scope 3 GHG emissions, and a breakdown of this total by each of the 15 Scope 3 categories
Report the base year for the calculation		
Report the consolidation approach for Scope 3 GHG emissions that is consistently applied across Scope 1, Scope 2, and Scope 3 GHG emissions, whether		

GRI	Disclosure	Requirement
		equity share, financial control, or operational control
		Report standards, methodologies, assumptions, and calculation tools used, including the sources of the emission factors used
	Disclosure 102-8 GHG emissions intensity	Report GHG emissions intensity ratio(s), including the gross GHG emissions in metric tons of CO ₂ equivalent (the numerator) and the organization-specific metric (the denominator) chosen to calculate the ratio(s)
		Report the scope(s) of GHG emissions included in the intensity ratio(s), whether Scope 1, Scope 2, or Scope 3
	Disclosure 102-9 GHG removals in the value chain	Report the total Scope 1 GHG removals in metric tons of CO ₂ equivalent, excluding any GHG trades, and a breakdown of this total by each storage pool
		For each type of storage pool, describe how quality criteria are monitored to manage the risk of non-permanence
		Report the intended use of GHG removals
		Describe the impacts on people and the environment from its Scope 1 GHG removals and the actions taken to manage them
		report standards, methodologies, assumptions, and calculation tools used
	Disclosure 102-10 Carbon credits	Report the total amount of carbon credits canceled in metric tons of CO ₂ equivalent and a breakdown of this total by removal or reduction projects
	For each project where carbon credits have been canceled, report: project name and ID, project type, cancelation serial number, cancellation date, and vintage, host country and issuing registry	
	For each carbon credit project reported under 102-10-b, describe how the project adheres to each of the following quality criteria: additionality, credible baselines, permanence, leakage avoidance, unique issuance and claiming, regular monitoring, independent validation and verification, GHG program governance	
	Report the purpose of carbon credit cancelation	
	Describe the impacts on people and the environment from projects where carbon credits are purchased and how the organization continuously monitors and evaluates them	
GRI 103: Energy	Disclosure 103-1 Energy policies and commitments	Describe how its energy-related policies and commitments contribute to energy consumption reduction, energy efficiency, and the transition to renewable energy sources
		Describe the impacts on the economy, environment, and people that may result from its energy consumption and the transition to renewable energy sources

GRI	Disclosure	Requirement
	Disclosure 103-2 Energy consumption and self-generation within the organization	Report total fuel consumption within the organization in joules, watt-hours, or multiples, and a breakdown of this total
		Report total purchased electricity, heating, cooling, and steam consumption within the organization in joules, watt-hours, or multiples, and a breakdown of this total
		Report total self-generated renewable electricity, heating, cooling, and steam consumption within the organization in joules, watt-hours, or multiples, and a breakdown of this total by electricity, heating, cooling, and steam consumption for each activity in which it is consumed for each renewable energy source
		Report total self-generated electricity, heating, cooling, and steam sold in joules, watthours, or multiples, and a breakdown of this total
		Report whether contractual instruments are used to disclose information on purchased electricity, heating, cooling, and steam consumption, and if so, describe how the contractual instruments adhere to quality criteria to ensure accuracy and consistency
		Report standards, methodologies, assumptions, and calculation tools used, including the source of the conversion factors used
	Disclosure 103-3 Upstream and downstream energy consumption	Report total significant energy consumption in its upstream and downstream value chain in joules, watt-hours, or multiples, and list the upstream and downstream categories in which significant energy consumption occurs
		Report standards, methodologies, assumptions, and calculation tools used, including the source of the conversion factors used
	Disclosure 103-4 Energy intensity	Report energy intensity ratio(s), including the energy consumption in joules, watt-hours, or multiples (the numerator) and the organization-specific metric (the denominator) chosen to calculate the ratio(s)
		report whether the energy intensity ratio(s) include energy consumption within the organization, in its upstream and downstream value chain, or both
		Report the types of energy consumption included in the energy intensity ratio(s), whether fuel, electricity, heating, cooling, or steam
	Disclosure 103-5 Reduction in energy consumption	Report the reduction in energy consumption achieved in joules, watt-hours, or multiples
		Report the types of energy consumption included in the reduction, whether fuel, electricity, heating, cooling, or steam
		Report whether the reduction in energy consumption was achieved within the organization, in its upstream and downstream value chain, or

GRI	Disclosure	Requirement
		both, and list the upstream and downstream categories in which reduction was achieved
		Report whether the reduction in energy consumption is estimated, modeled, or sourced from direct measurements and, if applicable, the estimations or modeling methods used
		Report the base year or baseline for calculating the reduction in energy consumption
		Report standards, methodologies, assumptions, and calculation tools used
GRI 201: Economic Performance 2016	Disclosure 201-1 Direct economic value generated and distributed	Direct economic value generated and distributed (EVG&D) on an accruals basis, including the basic components for the organization's global operations
		Where significant, report EVG&D separately at country, regional, or market levels, and the criteria used for defining significance
	Disclosure 201-2 Financial implications and other risks and opportunities due to climate change	Risks and opportunities posed by climate change that have the potential to generate substantive changes in operations, revenue, or expenditure
	Disclosure 201-3 Defined benefit plan obligations and other retirement plans	If the plan's liabilities are met by the organization's general resources, the estimated value of those liabilities
		If a separate fund exists to pay the plan's pension liabilities
		If a fund set up to pay the plan's pension liabilities is not fully covered, explain the strategy, if any, adopted by the employer to work towards full coverage, and the timescale, if any, by which the employer hopes to achieve full coverage
		Percentage of salary contributed by employee or employer
		Level of participation in retirement plans, such as participation in mandatory or voluntary schemes, regional, or country-based schemes, or those with financial impact
	Disclosure 201-4 Financial assistance received from government	Total monetary value of financial assistance received by the organization from any government during the reporting period
The information in 201-4-a by country		
Whether, and the extent to which, any government is present in the shareholding structure		
GRI 202: Market Presence 2016	Disclosure 202-1 Ratios of standard entry level wage by gender compared to local minimum wage	When a significant proportion of employees are compensated based on wages subject to minimum wage rules, report the relevant ratio of the entry level wage by gender at significant locations of operation to the minimum wage
		When a significant proportion of other workers (excluding employees) performing the organization's activities are compensated based on wages subject to minimum wage rules, describe the

GRI	Disclosure	Requirement
		actions taken to determine whether these workers are paid above the minimum wage
		Whether a local minimum wage is absent or variable at significant locations of operation, by gender. In circumstances in which different minimums can be used as a reference, report which minimum wage is being used
		The definition used for 'significant locations of operation'
	Disclosure 202-2 Proportion of senior management hired from the local community	Percentage of senior management at significant locations of operation that are hired from the local community
		The definition used for 'senior management'
		The organization's geographical definition of 'local'
GRI 203: Indirect Economic Impacts 2016	Disclosure 203-1 Infrastructure investments and services supported	Extent of development of significant infrastructure investments and services supported
		Current or expected impacts on communities and local economies, including positive and negative impacts where relevant
		Whether these investments and services are commercial, in-kind, or pro bono engagements
	Disclosure 203-2 Significant indirect economic impacts	Examples of significant identified indirect economic impacts of the organization, including positive and negative impacts
		Significance of the indirect economic impacts in the context of external benchmarks and stakeholder priorities, such as national and international standards, protocols, and policy agendas
GRI 204: Procurement Practices 2016	Disclosure 204-1 Proportion of spending on local suppliers	Percentage of the procurement budget used for significant locations of operation that is spent on suppliers local to that operation (such as percentage of products and services purchased locally)
		The organization's geographical definition of 'local'
		The definition used for 'significant locations of operation'
GRI 205: Anti-corruption 2016	Disclosure 205-1 Operations assessed for risks related to corruption	Total number and percentage of operations assessed for risks related to corruption
		Significant risks related to corruption identified through the risk assessment
	Disclosure 205-2 Communication and training about anti-corruption policies and procedures	Total number and percentage of governance body members that the organization's anticorruption policies and procedures have been communicated to, broken down by region
		Total number and percentage of employees that the organization's anti-corruption policies and procedures have been communicated to, broken down by employee category and region
		Total number and percentage of business partners that the organization's anticorruption policies and procedures have been communicated to, broken

GRI	Disclosure	Requirement	
		down by type of business partner and region. Describe if the organization's anti-corruption policies and procedures have been communicated to any other persons or organizations	
		Total number and percentage of governance body members that have received training on anti-corruption, broken down by region	
		Total number and percentage of employees that have received training on anticorruption, broken down by employee category and region	
		Disclosure 205-3 Confirmed incidents of corruption and actions taken	
		Total number and nature of confirmed incidents of corruption	
		Total number of confirmed incidents in which employees were dismissed or disciplined for corruption	
		Total number of confirmed incidents when contracts with business partners were terminated or not renewed due to violations related to corruption	
		Public legal cases regarding corruption brought against the organization or its employees during the reporting period and the outcomes of such cases	
GRI 206: Anti-competitive Behavior 2016	Disclosure 206-1 Legal actions for anti-competitive behavior, antitrust, and monopoly practices	Number of legal actions pending or completed during the reporting period regarding anti-competitive behavior and violations of anti-trust and monopoly legislation in which the organization has been identified as a participant	
		Main outcomes of completed legal actions, including any decisions or judgements	
GRI 207: Tax 2019	Disclosure 207-1 Approach to tax	A description of the approach to tax, including: whether the organization has a tax strategy and, if so, a link to this strategy if publicly available, the governance body or executive-level position within the organization that formally reviews and approves the tax strategy, and the frequency of this review, the approach to regulatory compliance, how the approach to tax is linked to the business and sustainable development strategies of the organization	
		Disclosure 207-2 Tax governance, control, and risk management	A description of the tax governance and control framework
			A description of the mechanisms to raise concerns about the organization's business conduct and the organization's integrity in relation to tax
			Disclosure 207-3 Stakeholder engagement and management of concerns related to tax
A description of the approach to stakeholder engagement and management of stakeholder concerns related to tax			

GRI	Disclosure	Requirement
	Disclosure 207-4 Country-by-country reporting	All tax jurisdictions where the entities included in the organization's audited consolidated financial statements, or in the financial information filed on public record, are resident for tax purposes
		The time period covered by the information reported in Disclosure 207-4
GRI 301: Materials 2016	Disclosure 301-1 Materials used by weight or volume	Total weight or volume of materials that are used to produce and package the organization's primary products and services during the reporting period
	Disclosure 301-2 Recycled input materials used	Percentage of recycled input materials used to manufacture the organization's primary products and services
	Disclosure 301-3 Reclaimed products and their packaging materials	Percentage of reclaimed products and their packaging materials for each product category How the data for this disclosure have been collected
GRI 302: Energy 2016	Disclosure 302-1 Energy consumption within the organization	Total fuel consumption within the organization from non-renewable sources, in joules or multiples, and including fuel types used
		Total fuel consumption within the organization from renewable sources, in joules or multiples, and including fuel types used
		In joules, watt-hours or multiples, the total: electricity consumption, heating consumption, cooling consumption, steam consumption
		In joules, watt-hours or multiples, the total: electricity sold, heating sold, cooling sold, steam sold
		Total energy consumption within the organization, in joules or multiples
		Standards, methodologies, assumptions, and/or calculation tools used
		Source of the conversion factors used
	Disclosure 302-2 Energy consumption outside of the organization	Energy consumption outside of the organization, in joules or multiples
		Standards, methodologies, assumptions, and/or calculation tools used
		Source of the conversion factors used
	Disclosure 302-3 Energy intensity	Energy intensity ratio for the organization
		Organization-specific metric (the denominator) chosen to calculate the ratio
		Types of energy included in the intensity ratio; whether fuel, electricity, heating, cooling, steam, or all
Whether the ratio uses energy consumption within the organization, outside of it, or both		
Disclosure 302-4 Reduction of energy consumption	Amount of reductions in energy consumption achieved as a direct result of conservation and efficiency initiatives, in joules or multiples	
	Types of energy included in the reductions; whether fuel, electricity, heating, cooling, steam, or all	
	Basis for calculating reductions in energy consumption, such as base year or baseline, including the rationale for choosing it	

GRI	Disclosure	Requirement	
		Standards, methodologies, assumptions, and/or calculation tools used	
	Disclosure 302-5 Reductions in energy requirements of products and services	Reductions in energy requirements of sold products and services achieved during the reporting period, in joules or multiples	
		Basis for calculating reductions in energy consumption, such as base year or baseline, including the rationale for choosing it	
		Standards, methodologies, assumptions, and/or calculation tools used	
GRI 303: Water and Effluents 2018	Disclosure 303-1 Interactions with water as a shared resource	A description of how the organization interacts with water, including how and where water is withdrawn, consumed, and discharged, and the water-related impacts the organization has caused or contributed to, or that are directly linked to its operations, products, or services by its business relationships (e.g., impacts caused by runoff)	
		A description of the approach used to identify water-related impacts, including the scope of assessments, their timeframe, and any tools or methodologies used	
		A description of how water-related impacts are addressed, including how the organization works with stakeholders to steward water as a shared resource, and how it engages with suppliers or customers with significant water-related impacts	
		An explanation of the process for setting any water-related goals and targets that are part of the organization's approach to managing water and effluents, and how they relate to public policy and the local context of each area with water stress	
		Disclosure 303-2 Management of water discharge-related impacts	A description of any minimum standards set for the quality of effluent discharge, and how these minimum standards were determined
		Disclosure 303-3 Water withdrawal	Total water withdrawal from all areas in megaliters, and a breakdown of this total by the following sources
	Total water withdrawal from all areas with water stress in megaliters, and a breakdown of this total by the following sources		
	A breakdown of total water withdrawal from each of the sources listed in Disclosures 303-3-a and 303-3-b in megaliters		
	Any contextual information necessary to understand how the data has been compiled, such as any standards, methodologies, and assumptions used		
	Disclosure 303-4 Water discharge	Total water discharge to all areas in megaliters, and a breakdown of this total by the following types of destination	
A breakdown of total water discharge to all areas in megaliters			

GRI	Disclosure	Requirement
		Total water discharge to all areas with water stress in megaliters, and a breakdown of this total
		Priority substances of concern for which discharges are treated
	Disclosure 303-5 Water consumption	Total water consumption from all areas in megaliters
		Total water consumption from all areas with water stress in megaliters
		Change in water storage in megaliters, if water storage has been identified as having a significant water-related impact
	Any contextual information necessary to understand how the data have been compiled, such as any standards, methodologies, and assumptions used, including whether the information is calculated, estimated, modeled, or sourced from direct measurements, and the approach taken for this, such as the use of any sector-specific factors	
GRI 304: Biodiversity 2016	Disclosure 304-1 Operational sites owned, leased, managed in, or adjacent to, protected areas and areas of high biodiversity value outside protected areas	For each operational site owned, leased, managed in, or adjacent to, protected areas and areas of high biodiversity value outside protected areas, the following information: Geographic location, Subsurface and underground land that may be owned, leased, or managed by the organization, Position in relation to the protected area (in the area, adjacent to, or containing portions of the protected area) or the high biodiversity value area outside protected areas, Type of operation (office, manufacturing or production, or extractive), Size of operational site in km ² (or another unit, if appropriate), Biodiversity value characterized by the attribute of the protected area or area of high biodiversity value outside the protected area (terrestrial, freshwater, or maritime ecosystem), Biodiversity value characterized by listing of protected status (such as IUCN Protected Area Management Categories, Ramsar Convention, national legislation)
	Disclosure 304-2 Significant impacts of activities, products and services on biodiversity	Nature of significant direct and indirect impacts on biodiversity
		Significant direct and indirect positive and negative impacts with reference to the following: Species affected, Extent of areas impacted, Duration of impacts, Reversibility or irreversibility of the impacts
Disclosure 304-3 Habitats protected or restored	Size and location of all habitat areas protected or restored, and whether the success of the restoration measure was or is approved by independent external professionals	
	Whether partnerships exist with third parties to protect or restore habitat areas distinct from where the organization has overseen and implemented restoration or protection measures	

GRI	Disclosure	Requirement
GRI 305: Emissions 2016		Status of each area based on its condition at the close of the reporting period
		Standards, methodologies, and assumptions used
	Disclosure 304-4 IUCN Red List species and national conservation list species with habitats in areas affected by operations	Total number of IUCN Red List species and national conservation list species with habitats in areas affected by the operations of the organization, by level of extinction risk
	Disclosure 305-1 Direct (Scope 1) GHG emissions	Gross direct (Scope 1) GHG emissions in metric tons of CO2 equivalent
		Gases included in the calculation; whether CO2 , CH4 , N2O, HFCs, PFCs, SF6 , NF3 , or all
		Biogenic CO2 emissions in metric tons of CO c. 2 equivalent
		Base year for the calculation, if applicable
		Source of the emission factors and the global warming potential (GWP) rates used, or a reference to the GWP source
		Consolidation approach for emissions; whether equity share, financial control, or operational control
Standards, methodologies, assumptions, and/or calculation tools used		
Disclosure 305-2 Energy indirect (Scope 2) GHG emissions		Gross location-based energy indirect (Scope 2) GHG emissions in metric tons of CO2 equivalent
		If applicable, gross market-based energy indirect (Scope 2) GHG emissions in metric tons of CO2 equivalent
		If available, the gases included in the calculation; whether CO , CH , N O, HFCs, PFCs, SF , NF , or all
		Base year for the calculation, if applicable
		Source of the emission factors and the global warming potential (GWP) rates used, or a reference to the GWP source
		Consolidation approach for emissions; whether equity share, financial control, or operational control
		Standards, methodologies, assumptions, and/or calculation tools used
Disclosure 305-3 Other indirect (Scope 3) GHG emissions		Gross other indirect (Scope 3) GHG emissions in metric tons of CO2 equivalent
	If available, the gases included in the calculation; whether CO , CH , N O, HFCs, PFCs, SF , NF , or all	
	Biogenic CO2 emissions in metric tons of CO2equivalent	
	Other indirect (Scope 3) GHG emissions categories and activities included in the calculation	
	Base year for the calculation, if applicable	
	Source of the emission factors and the global warming potential (GWP) rates used, or a reference to the GWP source	
	Standards, methodologies, assumptions, and/or calculation tools used	

GRI	Disclosure	Requirement
	Disclosure 305-4 GHG emissions intensity	GHG emissions intensity ratio for the organization
		Organization-specific metric (the denominator) chosen to calculate the ratio
		Types of GHG emissions included in the intensity ratio; whether direct (Scope 1), energy indirect (Scope 2), and/or other indirect (Scope 3)
		Gases included in the calculation; whether CO ₂ , CH ₄ , N ₂ O, HFCs, PFCs, SF ₆ , NF ₃ , or all
	Disclosure 305-5 Reduction of GHG emissions	GHG emissions reduced as a direct result of reduction initiatives, in metric tons of CO ₂ equivalent
		Gases included in the calculation; whether CO ₂ , CH ₄ , N ₂ O, HFCs, PFCs, SF ₆ , NF ₃ , or all
		Base year or baseline, including the rationale for choosing it
		Scopes in which reductions took place; whether direct (Scope 1), energy indirect (Scope 2), and/or other indirect (Scope 3)
		Standards, methodologies, assumptions, and/or calculation tools used
	Disclosure 305-6 Emissions of ozone-depleting substances (ODS)	Production, imports, and exports of ODS in metric tons of CFC-11 (trichlorofluoromethane) equivalent
		Substances included in the calculation
		Source of the emission factors used
		Standards, methodologies, assumptions, and/or calculation tools used
Disclosure 305-7 Nitrogen oxides (NO _x), sulphur oxides (SO _x), and other significant air emissions	Significant air emissions, in kilograms or multiples, for each of the following: No _x , So _x , Persistent organic pollutants (POP), Volatile organic compounds (VOC), Hazardous air pollutants (HAP), Particulate matter (PM), Other standard categories of air emissions identified in relevant regulations	
	Source of the emission factors used	
	Standards, methodologies, assumptions, and/or calculation tools used	
GRI 306: Effluents and Waste 2016	Disclosure 306-3 Significant spills	Total number and total volume of recorded significant spills
		The following additional information for each spill that was reported in the organization's financial statements: Location of spill, Volume of spill, Material of spill, categorized by: oil spills (soil or water surfaces), fuel spills (soil or water surfaces), spills of wastes (soil or water surfaces), spills of chemicals (mostly soil or water surfaces), and other (to be specified by the organization)
		Impacts of significant spills
GRI 306: Waste 2020	Disclosure 306-1 Waste generation and significant waste-related impacts	For the organization's significant actual and potential waste-related impacts
	Disclosure 306-2 Management of significant waste-related impacts	Actions, including circularity measures, taken to prevent waste generation in the organization's own activities and upstream and downstream in its value

GRI	Disclosure	Requirement
GRI 308: Supplier Environmental Assessment 2016		chain, and to manage significant impacts from waste generated
		If the waste generated by the organization in its own activities is managed by a third party, a description of the processes used to determine whether the third party manages the waste in line with contractual or legislative obligations
		The processes used to collect and monitor waste-related data
	Disclosure 306-3 Waste generated	Total weight of waste generated in metric tons, and a breakdown of this total by composition of the waste
		Contextual information necessary to understand the data and how the data has been compiled
	Disclosure 306-4 Waste diverted from disposal	Total weight of waste diverted from disposal in metric tons, and a breakdown of this total by composition of the waste
		Total weight of hazardous waste diverted from disposal in metric tons, and a breakdown of this total
		Total weight of non-hazardous waste diverted from disposal in metric tons, and a breakdown of this total
		For each recovery operation listed in Disclosures 306-4-b and 306-4-c, a breakdown of the total weight in metric tons of hazardous waste and of non-hazardous waste diverted from disposal
		Contextual information necessary to understand the data and how the data has been compiled
	Disclosure 306-5 Waste directed to disposal	Total weight of waste directed to disposal in metric tons, and a breakdown of this total by composition of the waste
		Total weight of hazardous waste directed to disposal in metric tons, and a breakdown of this total
		Total weight of non-hazardous waste directed to disposal in metric tons, and a breakdown of this total
		For each disposal operation listed in Disclosures 306-5-b and 306-5-c, a breakdown of the total weight in metric tons of hazardous waste and of non-hazardous waste directed to disposal
Contextual information necessary to understand the data and how the data has been compiled		
Disclosure 308-1 New suppliers that were screened using environmental criteria	Percentage of new suppliers that were screened using environmental criteria	
Disclosure 308-2 Negative environmental impacts in the supply chain and actions taken	Number of suppliers assessed for environmental impacts	
	Number of suppliers identified as having significant actual and potential negative environmental impacts	

GRI	Disclosure	Requirement
		Significant actual and potential negative environmental impacts identified in the supply chain
		Percentage of suppliers identified as having significant actual and potential negative environmental impacts with which improvements were agreed upon as a result of assessment
		Percentage of suppliers identified as having significant actual and potential negative environmental impacts with which relationships were terminated as a result of assessment, and why
GRI 401: Employment 2016	Disclosure 401-1 New employee hires and employee turnover	Total number and rate of new employee hires during the reporting period, by age group, gender and region
		Total number and rate of employee turnover during the reporting period, by age group, gender and region
	Disclosure 401-2 Benefits provided to full-time employees that are not provided to temporary or part-time employees	Benefits which are standard for full-time employees of the organization but are not provided to temporary or part-time employees, by significant locations of operation
		The definition used for 'significant locations of operation'
	Disclosure 401-3 Parental leave	Total number of employees that were entitled to parental leave, by gender
		Total number of employees that took parental leave, by gender
		Total number of employees that returned to work in the reporting period after parental leave ended, by gender
		Total number of employees that returned to work after parental leave ended that were still employed 12 months after their return to work, by gender
		Return to work and retention rates of employees that took parental leave, by gender
	GRI 402: Labor/Management Relations 2016	Disclosure 402-1 Minimum notice periods regarding operational changes
For organizations with collective bargaining agreements, report whether the notice period and provisions for consultation and negotiation are specified in collective agreements		
GRI 403: Occupational Health and Safety 2018	Disclosure 403-1 Occupational health and safety management system	A statement of whether an occupational health and safety management system has been implemented
		A description of the scope of workers, activities, and workplaces covered by the occupational health and safety management system, and an explanation of whether and, if so, why any workers, activities, or workplaces are not covered
	Disclosure 403-2 Hazard identification, risk	A description of the processes used to identify work-related hazards and assess risks on a routine

GRI	Disclosure	Requirement
	assessment, and incident investigation	<p>and non-routine basis, and to apply the hierarchy of controls in order to eliminate hazards and minimize risks</p> <p>A description of the processes for workers to report work-related hazards and hazardous situations, and an explanation of how workers are protected against reprisals</p> <p>A description of the policies and processes for workers to remove themselves from work situations that they believe could cause injury or ill health, and an explanation of how workers are protected against reprisals</p> <p>A description of the processes used to investigate work-related incidents, including the processes to identify hazards and assess risks relating to the incidents, to determine corrective actions using the hierarchy of controls, and to determine improvements needed in the occupational health and safety management system</p>
	Disclosure 403-3 Occupational health services	A description of the occupational health services' functions that contribute to the identification and elimination of hazards and minimization of risks, and an explanation of how the organization ensures the quality of these services and facilitates workers' access to them
	Disclosure 403-4 Worker participation, consultation, and communication on occupational health and safety	<p>A description of the processes for worker participation and consultation in the development, implementation, and evaluation of the occupational health and safety management system, and for providing access to and communicating relevant information on occupational health and safety to workers</p> <p>Where formal joint management-worker health and safety committees exist, a description of their responsibilities, meeting frequency, decision-making authority, and whether and, if so, why any workers are not represented by these committees</p>
	Disclosure 403-5 Worker training on occupational health and safety	A description of any occupational health and safety training provided to workers, including generic training as well as training on specific work-related hazards, hazardous activities, or hazardous situations
	Disclosure 403-6 Promotion of worker health	<p>An explanation of how the organization facilitates workers' access to non-occupational medical and healthcare services, and the scope of access provided</p> <p>A description of any voluntary health promotion services and programs offered to workers to address major non-work-related health risks, including the specific health risks addressed, and how the organization facilitates workers' access to these services and programs</p>
	Disclosure 403-7 Prevention and mitigation of	A description of the organization's approach to preventing or mitigating significant negative

GRI	Disclosure	Requirement
	occupational health and safety impacts directly linked by business relationships	occupational health and safety impacts that are directly linked to its operations, products, or services by its business relationships, and the related hazards and risks
	Disclosure 403-8 Workers covered by an occupational health and safety management system	If the organization has implemented an occupational health and safety management system based on legal requirements and/or recognized standards/guidelines
		Whether and, if so, why any workers have been excluded from this disclosure, including the types of workers excluded
		Any contextual information necessary to understand how the data have been compiled, such as any standards, methodologies, and assumptions used
	Disclosure 403-9 Work-related injuries	For all employees: The number and rate of fatalities as a result of work-related injury, the number and rate of high-consequence work-related injuries (excluding fatalities), the number and rate of recordable work-related injuries, the main types of work-related injury, the number of hours worked
		For all workers who are not employees but whose work and/or workplace is controlled by the organization: The number and rate of fatalities as a result of work-related injury, The number and rate of high-consequence work-related injuries (excluding fatalities), The number and rate of recordable work-related injuries, The main types of work-related injury, The number of hours worked
		The work-related hazards that pose a risk of high-consequence injury
		Any actions taken or underway to eliminate other work-related hazards and minimize risks using the hierarchy of controls
		Whether the rates have been calculated based on 200,000 or 1,000,000 hours worked
		Whether and, if so, why any workers have been excluded from this disclosure, including the types of workers excluded
		Any contextual information necessary to understand how the data have been compiled, such as any standards, methodologies, and assumptions used
Disclosure 403-10 Work-related ill health	For all employees: The number of fatalities as a result of work-related ill health, The number of cases of recordable work-related ill health, The main types of work-related ill health	
	For all workers who are not employees but whose work and/or workplace is controlled by the organization: The number of fatalities as a result of work-related ill health, The number of cases of recordable work-related ill health, The main types of work-related ill health	

GRI	Disclosure	Requirement
		The work-related hazards that pose a risk of ill health
		Whether and, if so, why any workers have been excluded from this disclosure, including the types of workers excluded
		Any contextual information necessary to understand how the data have been compiled, such as any standards, methodologies, and assumptions used
GRI 404: Training and Education 2016	Disclosure 404-1 Average hours of training per year per employee	Average hours of training that the organization's employees have undertaken during the reporting period
	Disclosure 404-2 Programs for upgrading employee skills and transition assistance programs	Type and scope of programs implemented, and assistance provided to upgrade employee skills
		Transition assistance programs provided to facilitate continued employability and the management of career endings resulting from retirement or termination of employment
	Disclosure 404-3 Percentage of employees receiving regular performance and career development reviews	Percentage of total employees by gender and by employee category who received a regular performance and career development review during the reporting period
GRI 405: Diversity and Equal Opportunity 2016	Disclosure 405-1 Diversity of governance bodies and employees	Percentage of individuals within the organization's governance bodies in each of the following diversity categories: Gender, Age group: under 30 years old, 30-50 years old, over 50 years old, other indicators of diversity where relevant (such as minority or vulnerable groups)
		Percentage of employees per employee category in each of the following diversity categories: Gender, Age group: under 30 years old, 30-50 years old, over 50 years old, other indicators of diversity where relevant (such as minority or vulnerable groups).
	Disclosure 405-2 Ratio of basic salary and remuneration of women to men	Ratio of the basic salary and remuneration of women to men for each employee category, by significant locations of operation
		The definition used for 'significant locations of operation'
GRI 406: Non-discrimination 2016	Disclosure 406-1 Incidents of discrimination and corrective actions taken	Total number of incidents of discrimination during the reporting period
		Status of the incidents and actions taken
GRI 407: Freedom of Association and Collective Bargaining 2016	Disclosure 407-1 Operations and suppliers in which the right to freedom of association and collective bargaining may be at risk	Operations and suppliers in which workers' rights to exercise freedom of association or collective bargaining may be violated or at significant risk
		Measures taken by the organization in the reporting period intended to support rights to exercise freedom of association and collective bargaining
GRI 408: Child Labor 2016	Disclosure 408-1 Operations and suppliers at significant risk for incidents of child labor	Operations and suppliers considered to have significant risk for incidents of: child labor, young workers exposed to hazardous work

GRI	Disclosure	Requirement
		<p>Operations and suppliers considered to have significant risk for incidents of child labor either in terms of: type of operation (such as manufacturing plant) and supplier, countries or geographic areas with operations and suppliers considered at risk</p> <p>Measures taken by the organization in the reporting period intended to contribute to the effective abolition of child labor</p>
GRI 409: Forced or Compulsory Labor 2016	Disclosure 409-1 Operations and suppliers at significant risk for incidents of forced or compulsory labor	Operations and suppliers considered to have significant risk for incidents of forced or compulsory labor
		Measures taken by the organization in the reporting period intended to contribute to the elimination of all forms of forced or compulsory labor
GRI 410: Security Practices 2016	Disclosure 410-1 Security personnel trained in human rights policies or procedures	Percentage of security personnel who have received formal training in the organization's human rights policies or specific procedures and their application to security
		Whether training requirements also apply to third-party organizations providing security personnel
GRI 411: Rights of Indigenous Peoples 2016	Disclosure 411-1 Incidents of violations involving rights of indigenous peoples	Total number of identified incidents of violations involving the rights of indigenous peoples during the reporting period
		Status of the incidents and actions taken
GRI 413: Local Communities 2016	<p>Disclosure 413-1 Operations with local community engagement, impact assessments, and development programs</p> <p>Disclosure 413-2 Operations with significant actual and potential negative impacts on local communities</p>	Percentage of operations with implemented local community engagement, impact assessments, and/or development programs
		Operations with significant actual and potential negative impacts on local communities
GRI 414: Supplier Social Assessment 2016	<p>Disclosure 414-1 New suppliers that were screened using social criteria</p> <p>Disclosure 414-2 Negative social impacts in the supply chain and actions taken</p>	Percentage of new suppliers that were screened using social criteria
		Number of suppliers assessed for social impacts
		Number of suppliers identified as having significant actual and potential negative social impacts
		Significant actual and potential negative social impacts identified in the supply chain
		Percentage of suppliers identified as having significant actual and potential negative social impacts, with which improvements were agreed upon as a result of assessment
		Percentage of suppliers identified as having significant actual and potential negative social impacts, with which relationships were terminated as a result of assessment, and why
GRI 415: Public Policy 2016	Disclosure 415-1 Political contributions	Total monetary value of financial and in-kind political contributions made directly and indirectly by the organization by country and recipient/beneficiary

GRI	Disclosure	Requirement
		If applicable, how the monetary value of in-kind contributions was estimated
GRI 416: Customer Health and Safety 2016	Disclosure 416-1 Assessment of the health and safety impacts of product and service categories	Percentage of significant product and service categories for which health and safety impacts are assessed for improvement
	Disclosure 416-2 Incidents of non-compliance concerning the health and safety impacts of products and services	Total number of incidents of non-compliance with regulations and/or voluntary codes concerning the health and safety impacts of products and services within the reporting period
		If the organization has not identified any non-compliance with regulations and/or voluntary codes, a brief statement of this fact is sufficient
GRI 417: Marketing and Labeling 2016	Disclosure 417-1 Requirements for product and service information and labeling	Whether each of the following types of information is required by the organization's procedures for product and service information and labeling: The sourcing of components of the product or service, Content, particularly with regard to substances that might produce an environmental or social impact, Safe use of the product or service, Disposal of the product and environmental or social impacts, Other (explain)
		Percentage of significant product or service categories covered by and assessed for compliance with such procedures
	Disclosure 417-2 Incidents of non-compliance concerning product and service information and labeling	Total number of incidents of non-compliance with regulations and/or voluntary codes concerning product and service information and labeling
		If the organization has not identified any non-compliance with regulations and/or voluntary codes, a brief statement of this fact is sufficient
	Disclosure 417-3 Incidents of non-compliance concerning marketing communications	Total number of incidents of non-compliance with regulations and/or voluntary codes concerning marketing communications, including advertising, promotion, and sponsorship
		If the organization has not identified any non-compliance with regulations and/or voluntary codes, a brief statement of this fact is sufficient
	GRI 418: Customer Privacy 2016	Disclosure 418-1 Substantiated complaints concerning breaches of customer privacy and losses of customer data
Total number of identified leaks, thefts, or losses of customer data		
If the organization has not identified any substantiated complaints, a brief statement of this fact is sufficient		

Annex 3 – ADMIRAL Survey Form

ADMIRAL Survey: Understanding key sustainability challenges and goals in the logistics sector

Thank you very much for your help to the research activities of the **ADMIRAL project** funded by the **Horizon Europe program of the EU**. By filling this questionnaire you will contribute to promote a more sustainable mobility and logistic supply chains in the future.

The objective of this survey is twofold. First, it intends **to understand key sustainability challenges and goals in the logistics sector** covering all the sustainability dimensions (economic, environmental, social and governance). Second, it aims to understand the potential of different drivers and solutions that **could be applied to advance to green, digital and sustainable logistics**.

The questionnaire **is anonymous**. The information will be treated according to the General Data Protection Regulation (GDPR) of the EU. We are interested in **hearing your independent opinion**, as experts in logistics, irrespective of the opinion of the company/institution you are working for.

The survey will take you around **10 minutes**. It can be filled on a mobile phone, but it is preferable to complete it on a computer or tablet. If you have any questions, please contact us by email at:

Natalia Sobrino - natalia.sobrino@upm.es
Daniela Castaño - daniela.castano@upm.es

Thank you very much for your cooperation!

Key Goals for Sustainable Logistics

Indicate, **in your opinion**, the **level of importance** of the following **Goals** for achieving **green and sustainable logistics**.

* Environmental-related goals

	Not at all important	Low importance	Slightly important	Somewhat important	Moderately important	Very important	Extremely important
Reducing GHG emissions (i.e. CO ₂ , CH ₄ , ...)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Reducing air pollution (i.e. NO _x , SO ₂ , PM _s ,...)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Increasing energy efficiency	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Reducing waste	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Increasing circular economy	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Avoiding major chemical leakages of dangerous goods	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Reducing noise exposure	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Reducing land occupation	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

* Economic-related goals

	Not at all important	Low importance	Slightly important	Somewhat important	Moderately important	Very important	Extremely important
Improving customer satisfaction	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Maximizing business profits	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Promoting global economy growth	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Increasing regional development	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Improving operational efficiency	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Reducing congestion	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

*** Social-related goals**

	Not at all important	Low importance	Slightly important	Somewhat important	Moderately important	Very important	Extremely important
Ensuring appropriate labor working conditions (i.e. human and labor rights...)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Increasing employment rate	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Improving safety (i.e. accidents reductions...)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Safeguarding security (i.e. reducing thefts, cybersecurity, ensuring protection...)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Increasing people's accessibility to goods and services	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ensuring people's quality of life (i.e. logistics operations should disturb the population as less as possible)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Promoting social equity	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

*** Governance-related goals**

	Not at all important	Low importance	Slightly important	Somewhat important	Moderately important	Very important	Extremely important
Regulatory quality (ensuring legal and institutional quality, safeguarding justice...)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Long-term strategic planning by governments	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Promoting stakeholders' collaboration and data sharing	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Safeguarding intellectual property protection	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Rule of law (enforcing the laws and regulations, control of corruption...)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Political stability and absence of violence/terrorism	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Key Logistics Goals Comparison

For each pairwise comparison of two sustainability related-goals, point out the one which, **in your personal opinion**, is preferable for **logistics sector**. If, for example, you select a **Strong preference for the “economic” criteria over the “environmental” criteria**; you are implicitly claiming that economic criteria are much more important for logistics sector than environmental criteria.

* Please state your preference:

Strong Preference Economic Criteria	Moderate Preference Economic Criteria	Weak Preference Economic Criteria	Indifference	Weak Preference Environmental Criteria	Moderate Preference Environmental Criteria	Strong Preference Environmental Criteria
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

* Please state your preference:

Strong Preference Economic Criteria	Moderate Preference Economic Criteria	Weak Preference Economic Criteria	Indifference	Weak Preference Governance Criteria	Moderate Preference Governance Criteria	Strong Preference Governance Criteria
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

* Please state your preference:

Strong Preference Economic Criteria	Moderate Preference Economic Criteria	Weak Preference Economic Criteria	Indifference	Weak Preference Social Criteria	Moderate Preference Social Criteria	Strong Preference Social Criteria
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

* Please state your preference:

Strong Preference Social Criteria	Moderate Preference Social Criteria	Weak Preference Social Criteria	Indifference	Weak Preference Environmental Criteria	Moderate Preference Environmental Criteria	Strong Preference Environmental Criteria
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

* Please state your preference:

Strong Preference Social Criteria	Moderate Preference Social Criteria	Weak Preference Social Criteria	Indifference	Weak Preference Governance Criteria	Moderate Preference Governance Criteria	Strong Preference Governance Criteria
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

* Please state your preference:

Strong Preference Environmental Criteria	Moderate Preference Environmental Criteria	Weak Preference Environmental Criteria	Indifference	Weak Preference Governance Criteria	Moderate Preference Governance Criteria	Strong Preference Governance Criteria
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Drivers & Barriers to Boost Green and Sustainable Logistics

* In your opinion, **evaluate the potential of the following drivers** to promote green and sustainable logistics:

	Very low potential	Low potential	Slight potential	Some potential	Moderate potential	High potential	Very high potential
Emerging technologies and innovative solutions	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Regulatory compliance (i.e. CSRD Scope 3 emissions, Emission Trading System, ...)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Stakeholders' collaboration in the logistic market	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Awareness, environmental education and training	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Investment in physical and digital infrastructure	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

* Indicate, in your opinion, which are **the greatest barriers/challenges the sector faces** in achieving green logistics and sustainability (tick up to 5 barriers).

- Regulatory hurdles
- Lack of standardization
- Lack of holistic supply chain transparency (i.e. data sharing)
- Lack of technological maturity
- Lack of infrastructure availability
- Lack of technical knowledge and/or human resources
- Lack of political support/funding
- Uncertainty about return of investment
- Lack of social responsibility by companies within the supply chain (i.e. freight buyer "ownership" to indirect Scope 3 emissions)
- Lack of cooperation among key stakeholders of the supply chain
- Lack of CO2 emissions data covering the whole supply chain
- Any other (please specify)

Emerging Technologies and Innovative Solutions

* In your opinion, **evaluate the potential of the following emerging technologies and innovative solutions** to boost green and sustainable logistics supply chains.

	Very low potential	Low potential	Moderate potential	High potential	Very high potential	I don't know this solutions/technology
Alternative fuels	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Technologies to improve energy efficiency	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Digitalization	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Connectivity & Automation	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Selective Emissions Reductors	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Non-technical solutions (i.e. collaboration between carriers/shippers/etc.)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

* In your opinion, **evaluate how logistics and freight transport companies** are dealing with the following **logistics innovations**.

	Very low progress	Low progress	Moderate progress	High progress	Very high progress	I don't know
Use of electric/fuel cell electric vehicles	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Data sharing	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
CO2 emissions calculation tools	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Optimization of supply chain processes to minimize CO2 emissions	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Connectivity and automated systems	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Intermodal transport (i.e. maritime-rail)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
IoT in warehouses and smart trucking of goods/vehicles	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Smart and digital infrastructure	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Regulatory Compliance

* In your personal opinion, rank the potential of the following EU regulations to make significant progress towards green logistics and freight transport.

	Very low potential	Low potential	Moderate potential	High potential	Very high potential	I don't know the regulation
Reducing GHG emissions by at least 55% by 2030 & carbon neutral by 2050 (<i>The European Climate Law Regulation EU 2021/119</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Implementing the EU Emissions Trading System to maritime and road transport (<i>EU Directive 2023/959</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
CO2 emissions performance standards and regulations for vans and heavy-duty vehicles (<i>EU Regulation 2019/631 and 2019/1242</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Reporting Scope-3 emissions by companies (<i>The Corporate Sustainability Reporting Directive CSRD EU 2022/2464</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Replacing paper-based documentation with electronic data in all freight transport modes (<i>e-FTI Regulation EU 2020/1056</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Internalization of external cost of transport in the road sector (<i>Eurovignette Directive EU 2022/362</i>)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

If you consider that there are an important EU regulation that are not reflected in the table above, please include them below.

* In your opinion, please select which is **the best type of methodology for measuring GHG emissions of freight logistics**.

- Sustainability Reporting methodologies by international non-profit organizations (i.e. GLEC Framework for calculating and reporting logistics emissions)
- Worldwide harmonized methodologies/initiatives (i.e. ECOTRANSIT calculator tool)
- The forthcoming CountEmissionsEU (a harmonized EU methodology for quantifying the GHG emissions of transport services across different modes)
- Don't know, No answer
- Other type (please specify)

Supply Chain Stakeholders' Collaboration

* In your opinion, please **select up to 3 types of stakeholders' collaboration** you think are the most effective for progressing towards green logistics and sustainability (tick up to 3 aspects).

- Alliances (i.e. Shipping alliances)
- Associations (i.e. cargo owner associations, shippers' associations, etc.)
- Single carrier collaboration
- Shipper or logistics service provider collaboration
- Logistics pooling (i.e. shared warehousing, etc.)
- Transport or logistics services marketplaces
- Joint ventures (i.e. tramp shipping pools)
- On-demand logistics
- Public-Private Partnerships (to reach common sustainability goals along most critical supply chains)
- Other type (please specify)

Professional Profile

Please indicate the following information about your background:

* How many years of experience do you have in logistics, mobility, sustainability or IT?

- Less than 2 years
- 2-5 years
- 5-10 years
- 10-15 years
- More than 15 years

* Please provide the following information regarding your job position:

Country where your job is mostly based:

Position:

* Size of the company / organization / government unit you work for:

- Self-employed.
- Micro enterprise: less than 10 persons employed
- Small enterprise: 10-49 persons employed
- Medium-sized enterprise: 50-249 persons employed
- Large enterprise: 250 or more persons employed
- I am retired

* Scope of business / activity:

- Local
- Regional
- National
- International
- Not applicable

* Select the role of your company/organization under ADMIRAL project:

- I do not know
- Project Partner
- Advisory Board
- Stakeholders Collaborative Forum
- None
- Other (please specify)

Annex 4 – Focus group questions and answers

Warm-up questions

Questions	Portugal-Spain pilot	Finland pilot	Slovenia-Croatia pilot	Lithuania pilot
What key changes have you noticed in logistics or freight transport trends affecting your pilot since the ADMIRAL project began?	<i>EU regulatory landscape changes -Calculation of CO2 emissions (harmonization needs, GLEC) -Increase in the awareness of CO2 emissions by cargo owners</i>	<i>CSRD reporting standard (Scope 3); - Talks about emissions increased in the sector, but not much action yet</i>	<i>Introduction of GLEC framework Development of emission reporting tool for business customers</i>	<i>Change of regulatory environment (release of eFTI specifications, CO2 calculation standards) Volatile logistics environment (energy crisis caused by Russian invasion, sanctions and changes to supply chains)</i>
What challenges have you faced in your pilot area concerning the adoption of digitalization ?	<i>Data governance and company organization Willingness and difficult to change</i>	<i>Adopting ADMIRAL platform to existing legacy systems. Cost of infrastructures</i>	<i>Data consolidation, lack of key data sources; Lack of granular data as a consequence of the non-existence of knowing services</i>	<i>Resistance from logistics sector to adopt digital solutions. Fragmentation of digital environment (major companies have own, custom made platform). Lack of EU level building blocks and tools for logistics digitalization.</i>
What challenges are you facing in your pilot area concerning the possibility to offer low-carbon options ?	<i>Rail construction in not finished Low readiness of Infrastructure to low emissions cargo vehicles</i>	<i>No one ready to pay extra on emissions efficient technologies (cost) Technical restrictions</i>	<i>Lack of data Lack of green delivery fleet Lack of customize management</i>	<i>Lack of equivalent options (railway and inland waterway network not sufficient). Lack of government incentives to transition to low-carbon. Sustainability as it is, is not compatible with resilience in our region.</i>

Social priorities

The social priorities. Rank them from 1 (most important) to 7 (less important)	Portugal-Spain pilot	Finland pilot	Slovenia-Croatia pilot	Lithuania pilot
Ensuring appropriate labour conditions	3	6	2	2
Increase employment rate	7	7	1	7
Improving safety	4	1	3	6
Safeguarding security	6	3	4	4
Increasing access to goods and services	1	4	6	1
Ensuring people's quality of life	2	2	5	3
Promoting social equity	5	5	7	5

How could digital marketplaces such as ADMIRAL help to meet the 3 most important social priorities previously defined? Only for the 3 main priorities	1. Efficiency of cargo flows; visibility of services; increase collaboration / 2. Promoting greener logistics supply chain; more efficient logistics/ 3. Upskilling jobs; Digital skills	1.; 3. No direct effect can find info on companies easier (e.g. emergency supply need - find new suppliers)	1. Increasing employment rate: we can not identify how the marketplace meets this social priority; 2. Ensuring appropriate labour conditions: better discrimination of work between workers organizations; 3. Improving safety: steady stream of work guarantees financial/social safety of workers	1. Ensuring flow of goods and resilience of supply chains; / 2. Digitalization allows to observe driving times resting multimodal marketplace could have rating for working conditions; / 3. Reduction negative impact from logistics
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Equity Impact Assessment

Before answering the questions, please keep in mind the following:

- **Be honest:** There are no right or wrong answers. This is not about presenting the pilot as the most equitable, but about identifying possible areas for improvement.
- **Focus on impact:** Think about how the pilot affects different groups in the logistics ecosystem, whether positively, negatively, or neutrally.
- **Consider all perspectives:** Try to reflect not only on your own experience, but also on how different stakeholders (e.g., SMEs, local communities, workers, vulnerable groups) might be affected.
- **Use the scale consistently:** Each question will be rated on a **Likert scale from 1 to 5**, where:
 - **1 = Strongly disagree / Very poor**
 - **2 = Disagree / Poor**
 - **3 = Neutral / Acceptable**
 - **4 = Agree / Good**
 - **5 = Strongly agree / Excellent**
- **Optional comments:** After each category, you will find space to add any explanations, examples, or suggestions you feel are important. These comments will help us better understand your score.

Your sincere answers will help us **improve the design of the pilots**, ensuring they contribute fairly to the transition towards low-carbon freight transportation.

Section / Questions	Portugal-Spain pilot					Finland pilot					Slovenia-Croatia pilot					Lithuania pilot								
	1	2	3	4	5	Comments	1	2	3	4	5	Comments	1	2	3	4	5	Comments	1	2	3	4	5	Comments
<i>Likert Scale 1 to 5 (1 disagree/poor to 5 agree/excellent)</i>																								
Section 1: Access and participation						9						8						8						11
All logistics service providers, SMEs and smaller carriers can access the digital AI based tool.				4		Marketplace focus			3			Steveco personnel have access				4						4		Access for SME is more difficult
Language, IT systems, or operational procedures do not create barriers for any stakeholder group		2				Language may be a problem for small companies. Accessibility blind people.	1					IT system compatibility issues		2				Language barrier				4		Digital reduce access barriers (like auto transaction)
Large and small operators are expected to have equitable opportunities to use the marketplace			3						4					2				larger companies have lowerage a priori			3			
Section 2: Cost and Economic fairness						12						14						10						10
The price of using the marketplace is expected to be affordable for SMEs.				4		Low monthly price - 30€/month start - based model				4		Free premium model available			3						2			Additional devices/systems will be needed to rise all feature
The pilot does not create financial or competitive barriers for SMEs and smaller operators compared to larger actors				4						5				2				Larger companies have lower					5	Our tools are for SME, we are flexible and build for SME

Section / Questions	Portugal-Spain pilot					Finland pilot					Slovenia-Croatia pilot					Lithuania pilot								
	1	2	3	4	5	Comments	1	2	3	4	5	Comments	1	2	3	4	5	Comments	1	2	3	4	5	Comments
<i>Likert Scale 1 to 5 (1 disagree/poor to 5 agree/excellent)</i>																								
Using the ADMIRAL marketplace and related AI-based tools help improve overall cost efficiency in freight transport				4							5	For sure					5				3			If AI help to reduce empty miles, huge impact
Section 3: Environmental justice and sustainability						14						14						13						15
The implementation of the pilot is expected to reduce emissions affecting communities along the corridor					5					4						4							5	Main objective of the pilot
Environmental results (e.g. emissions reduction, energy saving...) are reported in a transparent and understandable way to all stakeholders				4							5					4							5	Core principles data quality and standard application
The pilot supports broader local and regional sustainability goals					5						5						5						5	EU aligned
Section 4: Labor and workforce equity						11						9						8						9
The implementation of the pilot promotes fairer wages and safer working conditions.				4		Considering modal shift Promoting jobs in rail (shift from road)					3						4						1	Not intentional objective

Section / Questions	Portugal-Spain pilot					Finland pilot					Slovenia-Croatia pilot					Lithuania pilot								
	1	2	3	4	5	Comments	1	2	3	4	5	Comments	1	2	3	4	5	Comments	1	2	3	4	5	Comments
<i>Likert Scale 1 to 5 (1 disagree/poor to 5 agree/excellent)</i>																								
The implementation of the pilot provides (or is expected to provide) programs to upgrade employee skills (i.e. data analytics, low carbon technologies...) to facilitate continues employability				4					3						3								5	Ecodriving very marketable skill also CMR is friendly for newbies
The implementation of the pilot ensures that employment opportunities are distributed fairly across different workforce profiles (gender, age, etc.)			3						3				1					Beyond the pilot this was already a legislation requirement				3		Our tools are very accessible to anyone regardless of their demo
Section 5: Governance and stakeholder balance						8						4						4						6
All stakeholders are actively included in decision-making once the pilot is implemented,				4		Marketplace includes suggestion and discussion forum				3					2							3		We tried to engage, but they did not want to participate
The governance of the pilot, once implemented, prevents dominance by large companies over small operators				4			1								2							3		Not actively pursued, but tools kind of support it