



Title: Climate Change Adaptation Finance: A Hybrid Reporting Model for Companies

Deliverable 7.4: Hybrid financial reporting model

WP7 Financial issues and financing instruments/ Business models

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LIST OF ABBREVIATIONS

AUEB	Athens University of Economics and Business
ESG	Environmental, Social and Governance
MI	Material Issues
KPIs	Key Performance Indicators
SDGs	Sustainable Development Goals
CSR	Corporate Sustainability Reporting
CS	Case Study
GRI	Global Reporting Initiative
CDP	Carbon Disclosure Project
PRI	Principles for Sustainable Investment
IR	Integrated Reporting
VRF	Value Reporting Foundation
SASB	Sustainability Standards Accountings Board
FSB	Financial Stability
ESRS	European Sustainability Reporting Standards
TEG	Technical Expert Group on Sustainable Finance
JRC	Joint Research Centre
NRRP	National Recovery and Resilience Plan
ETS	Emissions Trading System
NRFD	Non-Financial Reporting Directive
CRSD	Corporate Sustainability Reporting Directive
MI	Material Issues
UB	Upper Bound
LB	Lower Bound
CSRF	Corporate Sustainability Reporting Frameworks

EXECUTIVE SUMMARY

This is the fourth of the five WP7 deliverables, a work package which aims to develop the portfolios of financial instruments and financing sources, as well as the tools to support the innovation pathways designed for ARSINOE case studies. The goal of this deliverable is to:

1. Develop a Hybrid Reporting Model which combines ESG Criteria (Environmental, Social and Governance) with financial performance metrics.
2. Provide a Tool to Measure the performance of the ARSINOE Case Studies
3. Showcase the implementation of the model in the context of the ARSINOE Case Studies.

This deliverable consists of the development of a hybrid reporting model to monitor the level of implementation of short- and long-term target in relation to material Environmental, Social and Governance issues. Athens University of economics and Business (AUEB) developed the models and tools included in this deliverable, while the CS2 partners contributed to the implementation of the model for the ARSINOE case study of the Mediterranean Ports (CS2). The current deliverable reports the models, tools and its applicability to the Case Studies of ARSINOE, using CS2 as a frontrunner. The complete implementation of the tool for all case studies of the program as well as the final version of the tools will be reported in Deliverable 7.5 Development of a Manual on Sustainable Finance, due to Month 42.

1.0 INTRODUCTION

1.1 Scope of the Deliverable

The goal of this deliverable is to:

- Develop a Hybrid Reporting Model which combines ESG Criteria (Environmental, Social and Governance) with financial performance metrics.
- Provide a Tool to Measure the performance of the ARSINOE Case Studies
- Showcase the implementation of the model in the context of the ARSINOE Case Studies.

1.2 Overview

This deliverable is structured as follows:

- Section 2 introduces the concepts of Corporate Sustainability Reporting (CSR) Frameworks, the Environmental, Social and Governance (ESG) criteria and the EU frameworks in relation to Corporate Sustainability.
- Section 3 develops a transparent model, that can be used by the public and Private companies to measure the level of implementation of the Environmental, Social and Governance Criteria (ESGs) and the Sustainable Development Goals (SDGs).
- Section 4 showcases the applicability of the model to the Mediterranean Ports Case Study (ARSINOE CS2).

A list of references is provided as an Annex.

2.0 Corporate Sustainability Reporting (CSR)

2.1 Introduction

The Sustainable Development Goals (SDGs) serve as a global call to action to eradicate poverty, safeguard the environment, and ensure prosperity for all. Integrating the SDGs into corporate reporting aligns businesses with this global agenda, fostering international cooperation and consistency in addressing critical global challenges.

1. **Enhanced Transparency:** Incorporating SDGs into corporate reporting enhances transparency regarding a company's sustainability efforts. This enables stakeholders, including investors, customers, and the public, to gain a better understanding of a company's contributions to sustainable development and evaluate its impact on social and environmental issues.
2. **Risk Mitigation:** By reporting on SDGs, companies can effectively identify, and address risks associated with environmental, social, and governance (ESG) factors. This proactive approach helps mitigate risks related to regulatory changes, disruptions in the supply chain, reputational damage, and other potential challenges.
3. **Competitive Advantage:** Companies that integrate SDGs into their long-term planning and reporting strategies can gain a competitive advantage. Such reporting demonstrates a commitment to sustainability, attracting socially conscious investors, customers, and partners. It also sets the company apart in the marketplace.
4. **Long-term Value Creation:** The SDGs emphasize the importance of long-term sustainable development. When businesses align their strategies and reporting with these goals, they are more likely to prioritize creating value over the long term, rather than pursuing short-term gains that may harm the environment or society.
5. **Innovation and Efficiency:** Pursuing the SDGs often leads to innovative solutions and improved operational efficiencies. By incorporating SDGs into their reporting framework, companies can drive innovation in products, services, and processes that contribute to both sustainability and profitability.
6. **Employee Engagement:** Many employees are passionate about sustainability and making a positive social impact. Integrating SDGs into corporate reporting can engage and motivate employees by demonstrating how their work contributes to the broader goals of sustainable development.

2.2 The International ESG Reporting Framework

Several endeavours and undertakings have been made since the beginning of the 21st century to develop comprehensive and detailed structures for ESG reporting (Figure 1). The initial collaborative attempt to create a framework for ESG reporting was carried out by the Global Reporting Initiative (GRI) in 2000 (the establishment of the initiative dates to 1997).

The GRI standards are widely acknowledged and utilized by corporations, governments, and non-governmental organizations to methodically evaluate their performance on critical sustainability issues (GRI, 2023). The objective is to enhance transparency and responsibility, which in return fosters sustainable investment and bolsters the ESG framework. The current structure of the GRI framework includes three types of frameworks (DIANEOSIS, 2023):

- **Universal Standards**, which refer to generic guidelines for reporting irrespective of the sector or scope of the reporting firm.
- **Sector Standards**, which are tailored to the specific industry and sector in which the firm operates.
- **Topic Standards**, which refer to the specific thematic areas in sustainability in which company operations apply.

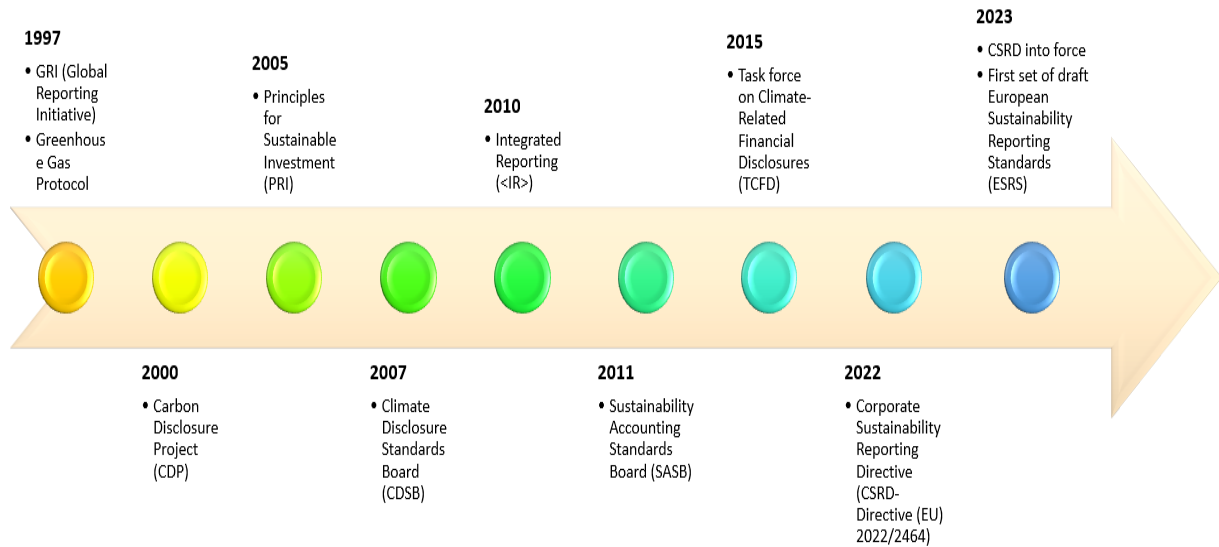


Figure 1 Evolution of the Sustainability Framework

Source: Authors' Elaborations

The Carbon Disclosure Project (CDP) is an international non-profit organization that was established in 2000. Its primary focus is on corporate reporting regarding environmental impacts. The CDP collects and analyses data from numerous companies across various sectors and countries, specifically related to climate change. This includes information on greenhouse gas emissions, deforestation, water security, and the impact on ecosystem services. The findings are then published annually in the form of reports, which serve as a means of conveying information from corporations to investors and stakeholders. The standardized reporting system developed by the CDP has become widely recognized as a benchmark for corporate environmental disclosure, playing a crucial role in encouraging private companies to integrate climate-related considerations into their business strategies. A similar approach is adopted by the Climate Disclosure Standards Board (CDSB), which focuses on incorporating meaningful information about the environmental impacts of companies into sustainability reports.

The Principles for Sustainable Investment (PRI), which were introduced in 2006 by a consortium of institutional investors and the United Nations, are guided by six fundamental principles (PRI, 2023):

- Integration of environmental, social, and governance (ESG) factors into the decision-making processes related to investments.
- Incorporation of ESG considerations into ownership policies and practices.
- Ensuring that the entities in which investments are made provide adequate disclosure regarding ESG issues.
- Encouraging the adoption and implementation of these principles within the investment industry.
- Fostering collaboration among stakeholders to enhance the effectiveness of implementing the principles.

- Regular reporting on the activities and progress made towards the implementation of these principles.

The **Integrated Reporting** (IR) framework, championed by the International Integrated Reporting Committee (IIRC), serves as a comprehensive approach to sustainability reporting. Its inception in 2010 by the IIRC aimed to encourage companies to transcend conventional financial reporting practices. The framework recognizes six distinct forms of capital: financial, manufactured, intellectual, human, social and relationship, and natural capital. As corporations amalgamate these capital sources to generate value, it becomes imperative for their reporting to reflect this integration, thereby acknowledging the fundamental principles of the Environmental, Social, and Governance (ESG) concept. In 2021, the IIRC merged with SASB to establish the **Value Reporting Foundation** (VRF).

The **Sustainability Standards Accounting Board** (SASB) is a non-profit organization established in 2011, with a primary focus on creating industry-specific sustainability accounting standards to aid companies in disclosing financially material information pertaining to ESG factors (SASB, 2023). This approach sets itself apart from others due to its emphasis on 'financial materiality', which centres on the sustainability principles that predominantly impact a firm's financial performance. Consequently, the SASB framework tracks metrics like resource efficiency, employee engagement, product safety, and business ethics, customized to suit the unique characteristics of each sector. Within this framework, the proposed standards are viewed as supplementary to the financial reporting mandates of individual companies, thereby shaping an integrated risk profile for stakeholders and investors.

The **Financial Stability Board** (FSB) established the Climate-Related Financial Disclosure Task Force (TCFD) in 2015 with the aim of incorporating climate impacts into corporate reporting. The TCFD framework consists of four core elements that provide guidance to organizations in disclosing climate-related financial information (TCFD, 2023; DIANEOSIS, 2023).

The first element, Governance, focuses on the oversight and management of climate-related risks and opportunities by the board and senior management. It involves disclosing the governance structure, the board's role in climate-related decision-making, and the allocation of responsibilities within the organization to address climate-related issues.

The second element, Strategy, pertains to the extent to which a company integrates climate impact assessment and the threats posed by climate change into its overall strategy.

The third element, Risk Management, aims to incentivize companies to measure and disclose climate-related risks in a comprehensive and cohesive manner. This involves recognizing and quantifying risks associated with the company's operations as well as the adverse impacts of climate change and extreme catastrophic events.

The fourth element, Metrics and Targets, builds upon the Risk Management element by requiring the quantification of risks and impacts to provide information for the company's sustainability reporting process. In cases where quantification is impractical, qualitative metrics and targets are imposed and reported to assess environmental performance.

Overall, the TCFD framework provides a comprehensive approach for organizations to disclose climate-related financial information, ensuring transparency and accountability in addressing climate risks and opportunities.

The European Commission introduced the Corporate Sustainability Reporting Directive (CSRD) in 2023 to reinforce its commitment to sustainable finance and corporate responsibility. This directive mandates a broader group of large companies to disclose sustainability information, along with all listed SMEs in the EU. Aligned with the principles of the European Green Deal and the EU taxonomy, the CSRD aims to equip investors and regulators with the necessary data to evaluate the environmental and social impact of companies, as well as to assess financial risks and opportunities related to sustainability issues. The initial batch of companies is expected to include all relevant information and data for the 2024 financial year in their 2025 reports. The European Sustainability Reporting Standards (ESRS), established in July 2023, represent a significant advancement as they seek to enhance the quality and comparability of sustainability reporting for all entities covered by the CSRD across the EU. Applicable to large companies, listed entities, and major financial institutions, the ESRS consist of 12 topic standards that address a wide range of ESG issues. This framework promotes greater transparency and accountability, enabling investors and stakeholders to make more informed decisions based on standardized sustainability performance indicators.

The Corporate Sustainability Reporting Directive (CSRD) imposes a requirement for companies falling within its reporting scope to conduct a "double materiality" evaluation. This concept, which serves as a distinguishing feature of CSRD in contrast to other reporting compliance frameworks, entails examining sustainability matters from two distinct perspectives:

- **Impact on People and Environment (Non-Financial Materiality):** This viewpoint focuses on the influence of a company's activities on society and the environment. It encompasses various aspects such as pollution, depletion of resources, labor practices, and impacts on local communities.
- **Financial Relevance (Financial Materiality):** The other facet of the evaluation assesses how sustainability issues can affect a company's financial performance. It encompasses both risks, such as potential regulations related to climate change or disruptions in supply chains, and opportunities, such as the development of new sustainable products or the enhancement of resource efficiency.

Moreover, CSRD outlines specific requirements for reporting greenhouse gas (GHG) emissions under three scopes:

- **Scope 1 or "Direct" emissions.** That is companies must mandatorily report all direct GHG emissions from activities that they own or control.
- **Scope 2 or "Indirect" emissions.** That is companies must mandatorily report indirect GHG emissions from the generation of electricity, heat, or steam that they purchase.
- **While not mandatory, the CSRD strongly encourages companies to report Scope 3 emissions.** These are all other indirect emissions that occur across a company's value chain, both upstream and downstream.

The Directive recognizes the intricacy involved in computing Scope 3 emissions. Corporations are afforded a degree of flexibility in their reporting approach; however, it is imperative that they maintain transparency regarding their methodology and any constraints.

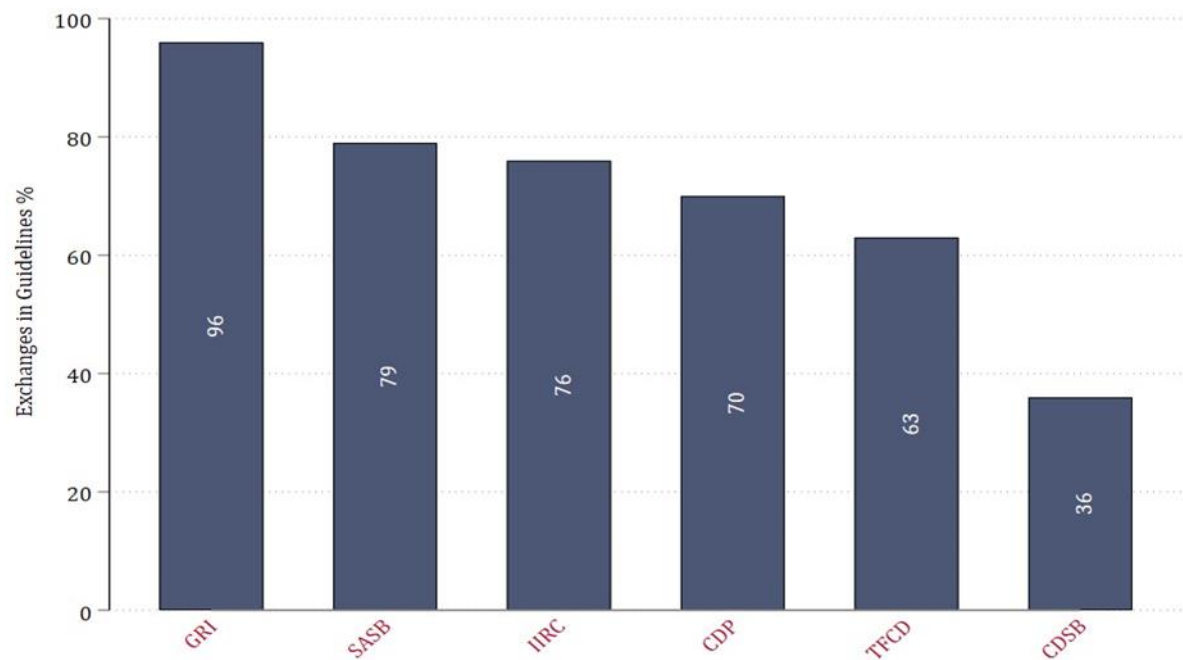


Figure 2 ESG Standards in Exchange Guidance Documents

Source: UN SSE Initiative (Sustainable Stock Exchanges, 2024)

The advancements are geared towards enhancing the future-oriented nature of sustainability reporting by linking ESG principles with the "Agenda 2030", the Sustainable Development Goals (SDGs), and the Fit-for-55 package (DIANEOSIS, 2023). According to the UN Sustainable Stock Exchanges (SSE) Initiative, 96% of the stock exchanges covered refer to the Global Reporting Initiative (GRI) in their guidance materials, followed by 79% for SASB and 70% for CDP (Figure 2). Progress in the realm of ESG frameworks is evident, as depicted in Figures 1 and 2, showcasing a global endeavour to establish a common foundation for sustainability reporting. Nevertheless, as noted by Boffo and Patalano (2020), 'While ESG methodologies are advancing and becoming more transparent, the scoring system is still in a state of transition, with certain rating agencies in the process of refining their methodology by incorporating factors like materiality'. Not all frameworks evaluate both financial and impact materiality or allocate the same analytical significance. Nonetheless, the overall sustainability evaluation process faces challenges due to significant discrepancies and disputes regarding the ratings issued by various entities post finalization of ESG reports (Boffo and Patalano, 2020; Berg et al., 2022). This underscores that standardization extends beyond reporting frameworks; however, the constructive discourse emerging can only enhance the incorporation and significance of ESG metrics and sustainability reporting.

2.3 The EU Sustainable Finance Framework

The European Union (EU) places significant emphasis on sustainable finance as it strives to establish a resilient, low-carbon, and socially inclusive economy. This commitment is evident in the EU's pursuit of ambitious environmental and climate targets outlined in the European Green Deal and the 2030 Climate Target Plan. Sustainable finance plays a crucial role in directing capital towards environmentally sound and socially responsible investments, serving as a linchpin in achieving these targets. Its significance extends beyond mitigating environmental risks, as it also aligns financial institutions and corporations with the principles of responsible business. By fostering long-term resilience and contributing to the

overall stability of the financial system, sustainable finance promotes the harmonization of regulations and practices within the EU. This holistic approach aims to establish a comprehensive sustainability framework that validates Environmental, Social, and Governance (ESG) standards and connects them with tangible outcomes that promote corporate responsibility. The EU sustainable finance framework is based on the following building blocks.

2.3.1 Corporate disclosure of climate-related information

The guidelines for disclosing climate-related information were released in March 2018, following the recommendations of the Technical Expert Group on Sustainable Finance (TEG). The European Union has provided specific instructions for organizations to comprehensively report on the environmental consequences of their operations throughout the value chain, as well as the impacts of climate change on their activities. The European Commission (2019) emphasizes that all climate-related disclosures must adhere to the Non-Financial Reporting Directive and should consider the concept of double materiality. This concept highlights the interconnected relationship between the environmental impact of financial activities and the environmental deterioration that influences them. As discussed in previous sections, these early concepts were further addressed in the CSRD (2022), which apart from climate-related aspects; it also encompasses considerations such as biodiversity, marine ecosystems, labor practices, and business conduct.

2.3.2 EU labels for benchmarks (climate, ESG) and benchmarks' ESG disclosures

The European Union has taken steps to establish labels and benchmarks for products traded within the single market to improve transparency in transactions related to environmental, social, and governance (ESG) criteria. These labels are designed to indicate low-carbon and broader ESG benchmarks within the EU, laying the groundwork for a standardized approach across the region. The European Commission's primary objective is to introduce a comprehensive label that encompasses all three pillars of ESG. While challenges exist in ensuring consistency across ESG metrics and ratings, promoting this strategy is essential for raising awareness among consumers, policymakers, and investors in the EU.

The push for a unified ESG label is driven by the need to enhance comparability among financial products, enabling investors to make informed decisions. This comparability is crucial as it allows investors to assess the ESG aspects of various financial products and make well-founded choices. The call for greater comparability is echoed by Kapellas & Siougle (2017), who highlight the influence of regulatory interventions on the international comparability and use of financial statements, which in turn impacts investment decisions. Steuer, S., & Tröger, T. H. (2022) examine disclosure regulations to assess their potential to drive the green transition of the global economy and achieve optimal climate targets, suggesting that transparency requirements in green finance regulation could involve standardized disclosure of raw data or quality labels indicating desirable green attributes of investment products.

2.3.3 Sustainability-related disclosure in the financial services sector (SFDR)

The regulation, implemented in 2019, sets out disclosure requirements on sustainability for financial product manufacturers and financial advisors with the primary goal of safeguarding investors. It seeks to influence the direction of capital towards sustainability concerns and incorporate ESG factors into risk management procedures (E&Y, 2023). The regulation strives to foster uniform transparency standards for all parties involved in financial markets, such as investors, intermediaries, and advisors, on how they incorporate ESG factors into their investment activities. Additionally, it tackles the critical problem of greenwashing in financial products by establishing a fair playing field for environmental reporting within the financial industry. According to Scherer et al. (2023), SFDR labels play a crucial role in attracting investments, with a notable and statistically significant impact on reduced flows in the month immediately following reclassification.

The SFDR takes a detailed approach as it "differentiates between disclosures related to sustainability risks and those related to sustainability factors, and distinguishes between regular financial products, financial products that promote environmental or social characteristics, and financial products with sustainable investment objectives" (Busch et al., 2021, p. 33). Specifically, all participants in the financial market are required to provide transparent information on the potential negative effects of investment decisions or financial advice on the sustainability of ESG, as well as the evaluation of risks associated with sustainability issues in their operations.

2.3.4 European Green Bond Standard

A green bond is distinguished from a regular bond by its designation, which indicates a commitment to utilizing the funds raised exclusively for the purpose of financing or refinancing 'green' projects, assets, or business activities (ICMA, 2015). Despite the increasing interest in sustainable finance, the absence of standardized environmental data poses a challenge for investors in making well-informed decisions that incorporate environmental sustainability considerations (Anyfantaki et al., 2022). The European Union (EU) takes the lead globally in terms of green bond issuance, accounting for over half of the total volume in 2021, despite representing only 3% to 3.5% of the overall bond market.

The European Green Bond Standard (EUGBS) is an EU-wide standard aimed at encouraging market participants to issue and invest in green bonds, while also enhancing the effectiveness, transparency, comparability, and credibility of the market. Political consensus was achieved in March 2023 following the TEG report in 2019 and the consultation process that commenced in 2020. This voluntary standard is closely linked to the EU Taxonomy, as the latter defines green economic activities that are eligible for financing through the green bond scheme, ensuring transparency in financial transactions and contributing to environmentally sustainable investments. All companies and public entities seeking to finance green projects through capital markets are eligible to adopt the EUGBS, provided that at least 85% of the funds raised through the bond are allocated to economic activities that align with the EU Taxonomy Regulation.

2.3.5 EU Taxonomy

The EU taxonomy serves as a comprehensive classification system that outlines a range of economically sustainable activities with a focus on environmental considerations. Its significance lies in its potential to facilitate the expansion of sustainable investment and the implementation of the European Green Deal within the EU. As the foundation of the EU sustainable finance framework, taxonomy holds a pivotal role by providing a common framework for all financial transactions and fostering consensus among stakeholders in the EU financial system. By establishing criteria for labelling financial activities as sustainable, the taxonomy enhances market transparency. The EU Taxonomy encompasses a wide array of activities, including climate change mitigation and adaptation, sustainable use and protection of water and marine resources, transition to a circular economy, pollution prevention and control, and protection and restoration of biodiversity and ecosystems. Furthermore, the ongoing process also aims to address the issue of greenwashing, aligning with other EU initiatives outlined in this section. According to the European Commission (2022), the EU taxonomy is a transparency tool that translates the EU's climate and environmental objectives into criteria for private investment purposes. However, it does not mandate investors to invest in specific activities nor impose restrictions on government bodies and regional authorities in their investment decisions.

2.3.6 The Sustainable Development Goals Framework

Since the late 2000s, the focus of ESG integration has been on evaluating the ESG policies and procedures of companies to pinpoint those effectively managing ESG-related issues impacting their financial performance. This evaluation guides investment decisions, leading to either increased (overweight) or decreased (underweight) interests in these companies accordingly.

The introduction of the SDGs in 2015 has brought about a shift in this approach. The SDGs, backed by 193 countries, tackle issues such as poverty, hunger, health, education, climate change, gender equality, water, sanitation, energy, the environment, and social justice. To meet these objectives, an estimated investment of US\$5 to US\$7 billion annually is needed by 2030. The escalating annual investment required underscores the necessity for capital mobilization. Since 2015, the SDGs have served as a tool for investors to align their investments with the SDG targets. This not only adds further layers to investment evaluation beyond ESG and traditional exclusion criteria, where certain industries are excluded from investment portfolios based on ethical or moral considerations, but also emphasizes the importance of creating appealing investment opportunities that are in line with the SDGs.

Agenda 2030 is a comprehensive agenda that is applicable to and must be implemented by all nations and stakeholders at the local level and in any instance of economic activities. The utilization of accurate metrics and data is crucial in transforming the Sustainable Development Goals (SDGs) into practical tools for addressing problems. The United Nations Sustainable Development Solutions Network (SDSN) collaborates with various organizations to assess the progress made towards achieving the SDGs at both the national and local levels. To determine the distance to the targets for each SDG, both official and unofficial metrics are employed. This enables the identification of action priorities, comprehension of key implementation challenges, tracking of progress, ensuring accountability, and identifying gaps that need to be closed to attain the SDGs by 2030. The SDSN methodology, as outlined by Sachs et al. (2020), underwent an audit conducted by the European Union Joint Research Centre (EU JRC) in July 2019.

In their work, Sachs et al. (2019) proposed an approach to operationalize the SDGs for governments and policymakers, which is based on Six Transformational themes. Additionally, Koundouri et al. (2021, 2022) presented a methodology for mapping European Green Deal policy documents to the SDGs. Furthermore, Koundouri et al. (2022) introduced a methodology for assessing the extent to which the National Recovery and Resilience Plans (NRRPs) of the NextGenerationEU program support the SDGs. This methodology was applied to the NRRPs of seven European countries.

2.3.7 The Impact of Corporate Sustainability Framework on Firm Behaviour

Corporate sustainability reporting frameworks (CSRF) have a significant impact on the behaviour and environmental performance of firms, although the degree of influence can vary across sectors and individual companies. Czerny and Letmathe (2017) conducted research that highlights the EU Emissions Trading System's (ETS) ability to incentivize companies to make cost-effective environmental investments and improve their eco-efficiency. However, Joltreau and Sommerfeld (2018) found that the EU ETS has limited effects on a firm's competitiveness and profitability, suggesting that the system's impact is nuanced.

CSRF prompts companies to allocate more resources towards CSR efforts by offering a systematic method for evaluating and disclosing a firm's sustainability achievements. This level of openness sheds light on the ecological and societal effects of a company, enhancing their responsibility to stakeholders. Investors, customers, and authorities are progressively seeking out businesses that emphasize sustainability, and robust corporate social responsibility initiatives can confer a competitive edge. Moreover, CSRF plays an important role in facilitating the evaluation of sustainability performance by providing a shared language and a set of metrics. This enables companies to monitor their progress over time, compare themselves to their competitors, and make informed decisions based on data analysis when allocating resources. By gaining a comprehensive understanding of the impact of their corporate social responsibility (CSR) efforts, companies can justify investing more in areas that will yield the most positive outcomes.

Additionally, frameworks provide standardized reporting guidelines, streamlining the CSR reporting process and enhancing its efficiency. This streamlined approach has the potential to reduce costs associated with reporting. As a result, companies can allocate their resources more effectively towards actual CSR initiatives, rather than expending significant resources solely on reporting activities. Finally, CSRF challenges companies in identifying crucial sustainability concerns that are pertinent to their specific industry and operational activities. These concerns encompass both environmental and social risks, such as regulations pertaining to climate change or labor disputes, as well as potential avenues for cost reduction or innovation through the implementation of sustainable practices. By comprehending these risks and opportunities, companies are better equipped to advocate for the allocation of resources towards effectively addressing them.

Indeed, within the realm of corporate social responsibility (CSR), Christensen et al. (2021) argue that CSR practices may restrict a firm's flexibility in responding to productivity declines. In contrast, Mittelbach-Hörmanseder et al. (2020) emphasize the significance of CSR disclosures, noting their role in enhancing a firm's value and reducing the cost of equity capital. The EU Non-Financial Reporting Directive (NFRD) has particularly influenced firms that previously lacked transparency, leading to more consistent disclosure practices across different industries, as demonstrated by research conducted by Cuomo et al. (2022) and Arif et al. (2021).

The role of green bonds in supporting sustainable development has also been extensively studied. Studies, including those by Sisodia et al. (2022), indicate that green bonds can enhance a firm's reputation, align with environmental, social, and governance (ESG) factors, and finance environmentally sustainable projects. This suggests that green bonds serve as an effective tool for companies to secure funding for green initiatives, potentially guiding their strategic decisions and promoting more sustainable practices.

2.4 ESGs, SDGs, and Corporate Sustainability Reporting

Corporate sustainability reporting has become a significant concern in today's business landscape, particularly due to the global shift towards sustainable practices. This shift is not solely driven by social pressures but also by global requirements aimed at promoting sustainable business operations. However, Tam et al. (2022) highlights a research gap in the context of SMEs and financial institutions in Europe, indicating the critical need for a comprehensive sustainability report that integrates the criteria of Environmental, Social, and Governance (ESG) with the Sustainable Development Goals (SDGs). The prominence of ESG criteria has grown in the discourse of corporate strategy and, more recently, in firm valuation.

The number of entities that have joined the United Nations Principles for Responsible Investment (PRI) has increased from 734 in 2010 to 3038 in 2020. Additionally, the assets corresponding to these signatories have surged from \$21 trillion to \$103 trillion over the same period (Avramov et al., 2022). This demonstrates the increasing recognition of ESG considerations by investors for their potential to mitigate

risks and enhance long-term financial performance. The incorporation of ESG criteria has influenced capital allocation and investment decisions, leading to a shift towards sustainable and responsible investing practices. Institutional investors, such as pension funds and asset managers, are now integrating ESG considerations into their investment strategies to align with stakeholders' values and fulfil their fiduciary duties (Cohen, 2023). Furthermore, studies by Nagy et al. (2015) using data from the MSCI ESG database and Koundouri and Landis (2023) using Thomson Reuters Refinitiv, both highlight the presence of a strong ESG momentum in international stock returns and markets. The European Commission's revision of the directive on corporate sustainability reporting represents a significant development in this field. By 2024, companies will be required to report on their business activities by 2023. However, research conducted by Patrick and Metzger (2022) suggests that many companies may not be adequately prepared for these evolving requirements, indicating potential challenges soon. Halkos & Nomikos (2021) conducted a trend analysis on the diffusion of the Global Reporting Initiative worldwide, examining notable trends from 1999 to 2017 across different continents. Their findings, particularly regarding Europe's transition from a mature stage to a downturn stage in recent years, provide valuable insights into the current landscape and trajectory of corporate sustainability reporting. Additionally, Oleh et al. (2022) offer a comprehensive overview of historical shifts in the relationship between sustainability reporting and corporate governance. Through the analysis of a large dataset comprising 935 articles, they identify dominant trends, leading journals, and major thematic occurrences, shedding light on the evolution and focal areas within this domain.

Sustainability reporting encompasses various dimensions of corporate performance, including financial, environmental, and social aspects. This holistic approach is crucial in addressing the needs of diverse stakeholders (GRI, 2021). The convergence between sustainability reporting and corporate governance is evident and is expected to attract increasing research interest, particularly with a focus on ESG disclosures and governance performance (Pasko, A., & Stolowy, H., 2022). However, despite the growing number of sustainability reports, Darshi et al. (2023) raises concerns about their quality. To enhance their credibility and transparency, there is an urgent need for external assurance.

The financial performance of companies in relation to Environmental, Social, and Governance (ESG) criteria has garnered significant attention from academics, financial investors, and asset owners in the past decade. This increased interest is evident in the examination of cost of capital (Bauer and Hann, 2010; Schneider, 2011), stock valuation (Jiao, 2010), and stock returns (Gerhart et al., 2015; Kahn et al., 2016; Henriksson et al., 2018) as indicators of the impact of good or bad performance in relation to ESG criteria.

One area that has gained growing interest is the relationship between ESG disclosure and financial performance at the firm level. Scholars have conducted numerous empirical studies to investigate the influence of ESG disclosure on various financial metrics, such as profitability, stock returns, and capital cost. The extensive empirical literature presents mixed evidence, which can be attributed to the nonlinear nature of the relationship due to variations in sample characteristics, such as firm size and sectoral coverage, as well as the specific aspects of the ESG agenda being examined (Khan, 2020; Veeravel et al., 2024).

While there are numerous studies that establish a positive link between strong corporate ESG performance and improved financial performance, Whelan et al. (2021), p. 9 found that a meta-analysis of the literature only partially supports this claim:

26% of studies that focused only on disclosure found a positive correlation with financial performance compared to 53% for performance based ESG measures (e.g., assessing a firm's performance on issues such as greenhouse gas emission reductions). This result holds in a regression analysis that controls for several factors simultaneously. '

In a recent study by Cohen (2023), it was found that the failure to address environmental, social, and governance issues can have a detrimental impact on financial stability, while improved ESG compliance can enhance corporate survival rates. Veeravel et al. (2024) utilized a method of moments panel quantile regression to analyse a dataset of Indian listed firms from 2010 to 2019 and discovered that high ESG scores positively influence accounting (ROA) and market performance (Tobin's Q). Furthermore, Cohen et al. (2020) conducted a comprehensive analysis on green patents and revealed that firms with low ESG scores in sectors such as energy significantly contribute to green innovation and emissions abatement. These findings emphasize the importance of further research on the relationship between ESG performance and firm attributes, as it is a complex issue.

The study of Sustainable Development Goals (SDGs) in the context of corporate sustainability reporting has also been explored. Bekaert et al. (2023) established a strong connection between ESGs, SDGs, and portfolio Alphas using company-specific SDG related scores. Moreover, Van Zanten and Huij (2022) demonstrated that an SDG score aligns with EU taxonomy regulation, reflects sustainability preferences, and aids in climate change mitigation, unlike ESG ratings. Ngan et al. (2022) focused on ASEAN countries and found a positive correlation between ESG performance, SDG performance, and economic growth. Additionally, Pastun et al. (2020) highlighted the influence of ESG disclosure regulation on a country's position in SDGI and the rankings of the 50 largest economies. The inclusion of ESG criteria is considered a crucial step in the economic development of a country.

2.5 Integrating SDGs into the ESG framework

Studies have shown a connection between the integration of Sustainable Development Goals (SDGs) in Environmental, Social, and Governance (ESG) analyses. However, there is limited research on frameworks that directly incorporate the SDGs into ESG metrics and frameworks. The Global Reporting Initiative (GRI) and the United Nations, in collaboration with partners and stakeholders, have developed guidelines to assist companies in effectively integrating SDGs into their reporting processes. By utilizing the appropriate business reporting database, companies can access relevant disclosures to report on their progress towards achieving the SDGs.

Consolandi et al. (2018) have introduced a framework that aligns material ESG issues for each of the 79 industries with the SDGs and their respective targets. This framework identifies specific SDGs that have a significant impact on each sector, as well as sectors that significantly contribute to individual SDGs. It also highlights sectors that play a crucial role in advancing the overall progress of the SDGs.

Koundouri et al. (2023) have developed an innovative framework that involves a three-step process for adapting the UN SDSN SDG framework to the company level. The framework includes:

- mapping the company's value chain.
- conducting a double materiality assessment to define quantitative ESG key performance indicators (KPIs) at different levels (such as generic, sector-specific, and unit-specific).
- establishing KPI-specific targets for 2030 and 2050. The extensive list of KPIs is aligned with the Corporate Sustainability Reporting Directive (CSRD) and other commonly used frameworks like GRI, SASB, IIRC, and CDP.

This novel framework offers a more comprehensive approach than traditional ESGs, highlighting the intricate relationships between ESG KPIs in achieving the SDGs.

3.0 A Hybrid Reporting Model for EU Private and Public Companies and authorities

3.1 Methodology

In this section we briefly describe the three-step approach of Koundouri and Landis (2023), modified to be applicable in the context of ARSINOE case studies. The framework describes the integrated reporting model for the implementation of long-term ESG Targets and commitments, as well as the integration of the SDGs into the Corporate Sustainability Reporting Scheme. The model is based on the methodology of UN SDSN

The Hybrid Reporting model consists of an integrated model to measure the performance of an entity in relation material Environmental, Social and Governance Issues. The performance against the material issues (MI) under each of the three Pillars E (Environment), S (Social) and G (Governance) measured by one or more Key Performance Indicators (KPIs), intended to cover holistically all aspects in relation to the specific Material issue under consideration.

Based on Koundouri et al (2023), the identification of the material issues is performed through a materiality assessment. This assessment refers to the identification of the Most material issues under the 3 pillars and the ranking of those based on the priorities of the entity as well as its stakeholders (Figure 3).

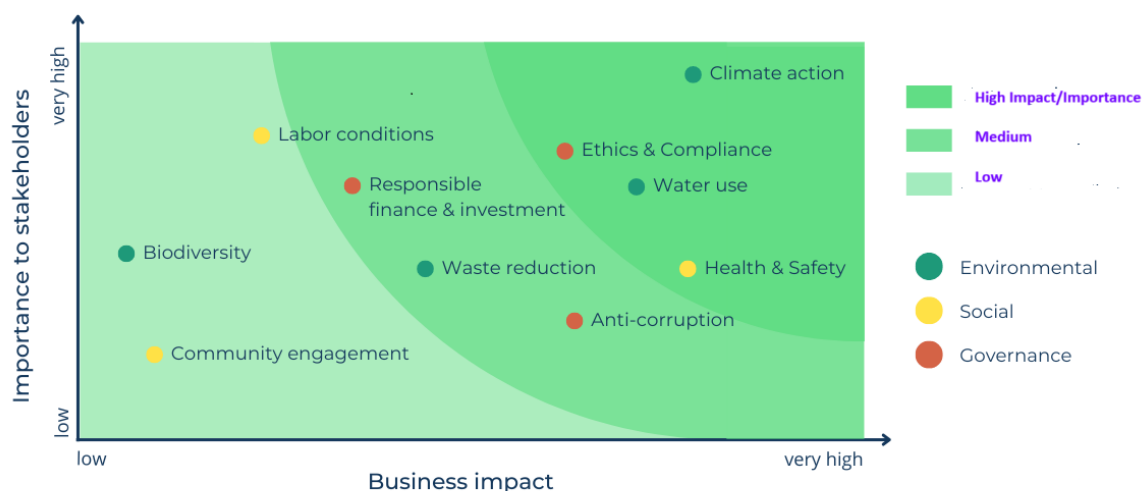


Figure 3 Materiality Assessment

The identification of the most important topics to be monitored under the reporting model, is followed by the definition of quantitative KPIs at various scales (generic – applies to all companies -, sector specific – applies to companies incorporating in a specific sector – and entity specific – applies to different types of entities, e.g. Companies vs Public Authorities) as well as the setting of the entities targets to 2030 and 2050 for each KPI included in the analysis. The choice of the KPIs is based on a long list of available KPIs which are compatible and in line with the Corporate Sustainability Reporting Framework (CRSD) and all currently applied frameworks we discussed in previous sections (GRI, SASB, IIRC, CDP etc.). The

Materiality assessment and the metrics used in the analysis are compatible with the First set of European Sustainability Reporting Standards (ESRS), the Climate Delegate Act¹ and the Disclosures Delegate Act².

3.2 Hybrid Reporting Model

3.2.1 Pillars, Material Issues and Key Performance Indicators

Consider K key performance indicators kpi_k , where $k=1, \dots, K$, M material issues/ categories, denoted by $m=1, \dots, M$ and three pillars, denoted by $p=1, 2, 3$ ³.

Also, let $d_{k,m}$, as a dummy variable, which takes the value of 1 if the k^{th} key performance indicator is classified under the m^{th} material issue and zero otherwise. Moreover let $d_{m,p}$ a dummy variable which takes the value of 1 if m^{th} material issue is classified under the p^{th} pillar and zero otherwise.

Table presents an example for a hypothetical company, with sixteen KPIs classified under twelve Material Issues/Categories grouped under the three Pillars.

¹ https://finance.ec.europa.eu/publications/sustainable-finance-package_en, https://finance.ec.europa.eu/publications/eu-taxonomy-complementary-climate-delegated-act-accelerate-decarbonisation_en, <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32023R2485>

² <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32021R2178>

³ $p=1, 2$ and 3 refers to Environmental, Social and Governance Pillars respectively.

Table 1 Material Issues and Key Performance Indicators - Example

Pillar	Material Issue	KPI
Environment	GHG Emissions	Scope 1 emissions Scope 2 emission Scope 3 emissions to Turnover
	Energy Management	Energy consumption to Turnover
	Water Consumption	Water consumption to Turnover
	Food Waste	Volume of food waste
	Waste Management & Circular Economy	% waste to landfill % recyclable waste
	Biodiversity	Protection of biological diversity
	Sustainable Packaging	% of recyclable packaging % of packaging from recycled raw material
Social	Employee Training and Development	Average employee training and development hours
	Diversity; Equality & Inclusion	% of women in total workforce
	Human Rights	Number of human rights violations
	Community Support & Social Contribution	Number of ethics-related incidents
Governance	Regulatory Compliance	Number of non-compliance incidents

Model requires the definition of at least one Material Issue under each pillar, as well as the definition of at least one KPI under each one of the Material Issues. KPIs can be either quantitative (indicators taking discrete or continuous numerical values) or qualitative (binary or discrete indicators based on logical conditions). As mentioned in the previous sections, the KPIs need to be compatible and so to be defined based on the ESRS and/or all currently applied frameworks/ definitions (e.g. GRI, SASB, etc.). The example of Table 1 was randomly chosen and applies to an entity (company in this case) incorporating in the Food Sector. As also discussed, the KPIs can either be generic in the sense that they are sector agnostic and they do apply to any entity (e.g. Scope 1 Emissions), or sector specific, in the sense that they are applicable only for entities incorporating in a specific sector (e.g. Food Waste for example is only applicable to entities incorporating in the Food Sector⁴).

3.2.2 Hybrid Financial Metrics

For a set of Quantitative Key Performance Indicators, our analysis defines Hybrid financial metrics, where the indicator is divided by the Turnover⁵. “Hybrid” metrics are used in the cases where the target of the company to ameliorate its sustainability performance needs to be adjusted for the impact on its financial performance.

The concept of Water Consumption, which is measured in cubic meters, presents an interesting case to examine. Setting an absolute target for the company to optimize its water use efficiency, needs to also consider that water is also used in production and its nominal value is directly related to the overall level of production and revenues. Indeed, for such cases, a “hybrid” metric serves as a measure that effectively

⁴ Sector is defined based on EU NACE classifications (https://ec.europa.eu/competition/mergers/cases/index/nace_all.html).

⁵ Turnover is defined as company’s total Revenues (e.g. Sales) in Millions of Euros.

gauges the efficiency of a company's water use in relation to its operating revenue. So, company targets to ameliorate its efficiency in resources use while staying profitable. It is important to note that as the company's revenues increase and/or Water Consumption decreases, this ratio decreases. The target for the company is to minimize this ratio, as it signifies a higher level of efficiency. These ratios can be classified as hybrid financial/resource use efficiency metrics, which are asymptotically bounded within the range of $[0, \infty)$.

3.2.3 Targets and Low Bounds

The series of the K individual KPIs (kpi_k) are adjusted to account for the directionality of the indicators, whether "More is better" or "Lower is Better." In cases where a lower value of the indicator signifies better performance, the indicator is adjusted as $-kpi_k$. Within this context, the term "upper bound" (UB_k) is used to denote the optimal or target value, even if the raw indicator data shows a descending trend and progress is best represented by a smaller numerical value. UB_k is established based on science-based or policy targets, where applicable. Conversely, the "lower bound" (LB_k) for the KPIs is defined as the 2.5th percentile, serving to filter out extreme values on the lower end of the cross-sectional distribution after comparing against other entities/companies with similar characteristics. In instances where a science-based target is not feasible for quantitative variables, such as when a hybrid metric is utilized, UB and LB are determined through benchmarking against other companies within the same sector. This process is elaborated further in subsequent sections. The same methodology is employed for setting the lower bounds, which are established as the 2.5 percentile of the distribution of ratios within the relevant sector. To address the impact of outliers, all KPI series are censored to the range $[LB_k, UB_k]$.

3.2.4 ESG Scores

After determining the upper and lower limits for normalization, the indicators were transformed using a min-max transformation to convert them into a linear scale ranging from 0 to 100.:

$$score_k^{kpi} = 100 \frac{(kpi_k - LB_k)}{(UB_k - LB_k)} \quad (eq1)$$

A score of 100 signifies the highest level of performance for the specific KPI. Consequently, the normalized data can be understood as the measure of deviation from the ideal performance. For instance, a score of 50 indicates the midpoint between the poorest performance and the optimal outcome.

The KPI scores (eq3) are aggregated over the M_p material issues/categories for each pillar:

$$score_m^{mi} = \frac{\sum_{k=1}^K score_k^{kpi} d_{k,m}}{\sum_{k=1}^K d_{k,m}} \quad (eq2)$$

and consequently, the material issue scores are aggregated at the pillar level using:

$$score_p^{pillar} = \frac{\sum_{m=1}^M score_m^{mi} d_{m,p}}{\sum_{m=1}^M d_{m,p}} \quad (eq 3)$$

Finally, an aggregated score for the ESGs is calculated as follows:

$$score^{esg} = \sum_{p=1}^3 score_p^{pillar} w_p, \text{ where } w_p = \frac{\sum_{m=1}^M d_{m,p}}{M} \quad (eq\ 4)$$

3.2.5 Benchmarking

When an entity consists of a public company, Benchmarking utilizes the ESG scores (by pillar and by material issue) sourced from Thomson Reuters REFINITIVE (TRF). TRF is a prominent platform that provides ESG data and time series of ESG KPIs for over 15,000 companies listed on International Exchanges. TRF boasts one of the most extensive ESG databases in the field, encompassing more than 90% of the global market capitalization, spanning across 600 diverse ESG KPIs, with historical data dating back to 2002. These scores are percentile rank scores that are easy to interpret, benchmarked against Thomson Reuters Business Classifications (TRBC - Industry Group) from TRF. The ESG scores are grounded in data, taking into consideration the most significant industry metrics, while minimizing biases related to company size and transparency.

The first step of the Benchmarking analysis is to filter companies using the SIC Codes 1&2 (Sector Identification Codes) to identify companies incorporating in the same sector. SIC code 1 identifies the main sector of incorporation of the company, that is its primary economic activity based on its turnover. Similarly, SIC 2 refers to its secondary activity.

Based on the filtered list, we identify the top 10% Performers as the companies with the highest “Resource Use Score”. Resource Use is a material issue classified under the Environmental Pillar in the ESG classification scheme and weights the performance of several resource related KPIs such as Energy, Water etc.

For the cases where an entity is not a public company, then other sources such as EUROSTAT, World Bank and National Statistical Agencies are used to derive data required for benchmarking.

3.2.5 Model Ratings

The methodology for building the ratings consists of establishing quantitative thresholds to classify performance on indicators into a traffic light table. The indicator-level ratings are then aggregated into an overall rating by **ESG material issue, ESG pillar and an aggregate ESG score for the company/entity**. To evaluate progress on each indicator, a system of four bands (red, orange, yellow, and green) is utilized. These bands are determined as:

- the green thresholds, which indicate the achievement of ESG targets.
- the red thresholds, which signify significant challenges in reaching ESG targets.
- The orange and yellow bands indicate varying degrees of challenges, ranging from significant to minor, in implementing the desired targets.

For each ESG Key Performance Indicator (KPI), the Yellow/Orange Limit (YOL) is defined as the average between the lower and upper bounds (e.g., 50 for the normalized series defined in the set [0,100]). In the case of benchmarking approaches, such as hybrid metrics/ratios included in the analysis, the green and red thresholds are determined as the YOL plus or minus one standard deviation of the cross-sectional distribution of the metric for all companies included in the benchmarking.

Finally, for all the non-tangible KPIs, the green and red limits are defined as follows:

$$Green\ Limit_k = Yellow/Orange\ Limit\ (YOL)_k + \frac{|UB_k - Yellow/Orange\ Limit\ (YOL)_k|}{2} \quad (eq5a)$$



$$\text{Red Limit}_k = \text{Yellow/Orange Limit (YOL)}_k - \frac{|UB_k - \text{Yellow/Orange Limit (YOL)}_k|}{2} \quad (\text{eq5b})$$

For the targets for which Benchmarking approach is applied (e.g., all Hybrid metrics included in the analysis), the green and red thresholds were determined as $\text{YOL} \pm$ one standard deviation of the cross-sectional distribution of the metric for all companies included in the Benchmarking. Let kpi_k^j , where $j=1, \dots, J$, to denote the value of the k^{th} key performance indicator for the j^{th} company included in benchmarking:

$$\text{Green Limit}_k = \text{Yellow/Orange Limit (YOL)}_k + \frac{\sum_{j=1}^J \left(kpi_k^j - \frac{\sum_{j=1}^J kpi_k^j}{J} \right)}{J-1} \quad (\text{eq6a})$$

$$\text{Red Limit}_k = \text{Yellow/Orange Limit (YOL)}_k - \frac{\sum_{j=1}^J \left(kpi_k^j - \frac{\sum_{j=1}^J kpi_k^j}{J} \right)}{J-1} \quad (\text{eq6b})$$

3.2.6 Integrating Sustainable Development Goals (SDGs)

The methodology to translate the ESG scores to SDGs refers to mapping individual ESG KPIs to specific SDG indicators using the most updated list of the 170 indicators for the 17 SDGs⁶.

Consider $i = 1, \dots, 17$ refers to the index of the seventeen SDGs. Also consider k index refers to the K individual KPIs included in the analysis. Then, the raw SDG weight of all KPIs against all the SDGs is defined as follows:

$$W_{i,k}^{SDG} = \frac{\sum \text{Indicators mapped to } kpi_k \text{ under } SDG_i}{\sum \text{Indicators under } SDG_i} \quad (\text{eq7})$$

The raw weights, as described in equation *eq7* are normalized as follows:

$$\widehat{W}_{i,k}^{SDG} = \frac{W_{i,k}^{SDG}}{\sum_{k=1}^K W_{i,k}^{SDG}} \quad (\text{eq8})$$

Please note that:

$$\sum_{k=1}^K \widehat{W}_{i,k}^{SDG} = 1 \quad (\text{eq9})$$

⁶ <https://unstats.un.org/sdgs/indicators/indicators-list/>

Using the above weights, we can transpose the ESG KPI scores into the relevant scores in relation to the SDGs:

$$Score_i^{SDG} = \sum_{k=1}^K \widetilde{W}_{i,k}^{SDG} score_k^{kpi} \quad (eq10)$$

For each SDG the limits for the ratings are calculated as follows:

$$\text{Yellow/Orange Limit (YOL)}_i = \sum_{k=1}^K \widetilde{W}_{i,k}^{SDG} \frac{(UB_k - LB_k)}{2} \quad (eq11)$$

$$\text{Green Limit}_i = \sum_{k=1}^K \widetilde{W}_{i,k}^{SDG} \text{Green Limit}_k \quad (eq12a)$$

$$\text{Red Limit}_i = \sum_{k=1}^K \widetilde{W}_{i,k}^{SDG} \text{Red Limit}_k \quad (eq12b)$$

To perform the mapping between the ESG KPIs and the SDG Indicators, we use Machine Learning Algorithms and the methodology developed in Kountouri et al. (2021). The Mapping for the set of KPIs used in this example is presented in the Appendix, Table A.1.

The corporate sustainability assessment framework dynamically maps the ESG to the SDGs (Figure 4), which are more holistic and reveal the complex interdependencies between the ESG KPIs in the implementation of the SDGs.

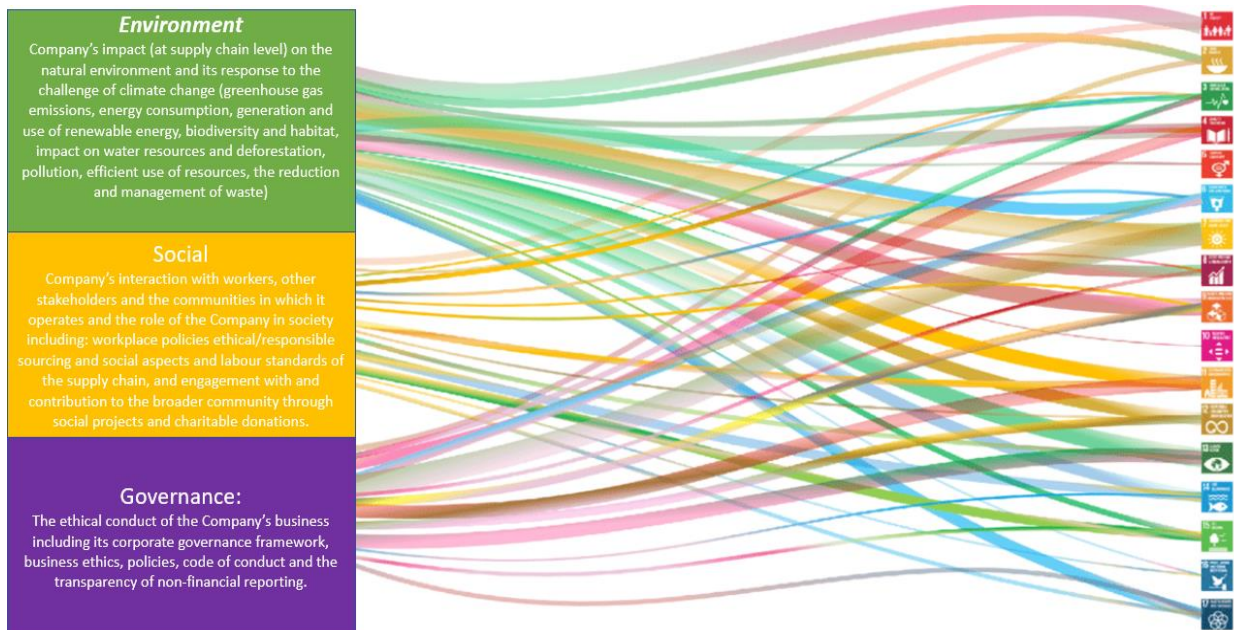


Figure 4 Corporate Sustainability Reporting Framework

The Sustainable Development Goals (SDGs) serve as a global call to action to eradicate poverty, safeguard the environment, and ensure prosperity for all. Integrating the SDGs into corporate reporting aligns businesses with this global agenda, fostering international cooperation and consistency in addressing critical global challenges.

- **Enhanced Transparency:**

Incorporating SDGs into corporate reporting enhances transparency regarding a company's sustainability efforts. This enables stakeholders, including investors, customers, and the general public, to gain a better understanding of a company's contributions to sustainable development and evaluate its impact on social and environmental issues.

- **Risk Mitigation:**

By reporting on SDGs, companies can effectively identify, and address risks associated with environmental, social, and governance (ESG) factors. This proactive approach helps mitigate risks related to regulatory changes, disruptions in the supply chain, reputational damage, and other potential challenges.

- **Competitive Advantage:**

Companies that integrate SDGs into their long-term planning and reporting strategies can gain a competitive advantage. Such reporting demonstrates a commitment to sustainability, attracting socially conscious investors, customers, and partners. It also sets the company apart in the marketplace.

- **Long-term Value Creation:**

The SDGs emphasize the importance of long-term sustainable development. When businesses align their strategies and reporting with these goals, they are more likely to prioritize creating value over the long term, rather than pursuing short-term gains that may harm the environment or society.

- **Innovation and Efficiency:**

Pursuing the SDGs often leads to innovative solutions and improved operational efficiencies. By incorporating SDGs into their reporting framework, companies can drive innovation in products, services, and processes that contribute to both sustainability and profitability.

- Employee Engagement:

Many employees are passionate about sustainability and making a positive social impact. Integrating SDGs into corporate reporting can engage and motivate employees by demonstrating how their work contributes to the broader goals of sustainable development.

1.3 Technical Details – Implementation

The Hybrid Financial Reporting Model is currently implemented in Microsoft Office EXCEL and is currently at a TRL Level 7. Figures 5 to 12 present screenshots for all methodological details presented in the previous section. During the last year of the project the Model will also be implemented in Java and the final version will be included in Deliverable 7.5 “Development of a Manual on Sustainable Finance”, due to Month 42. A Manual for all the tools will also be included as an annex.

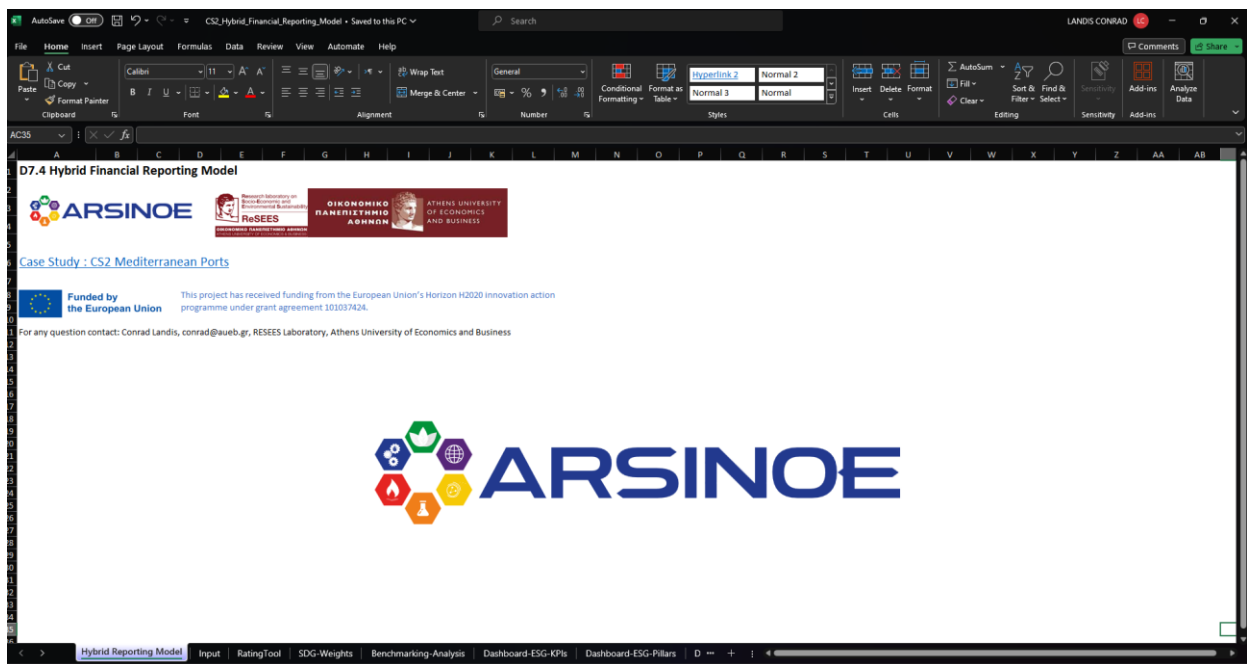
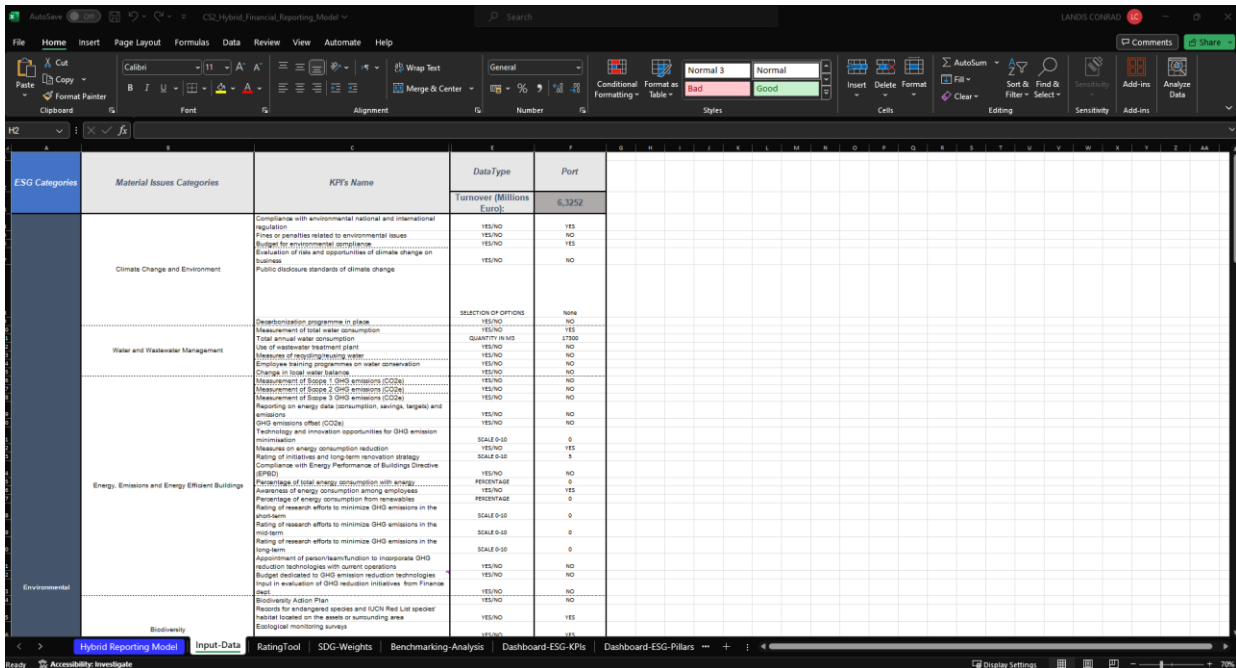
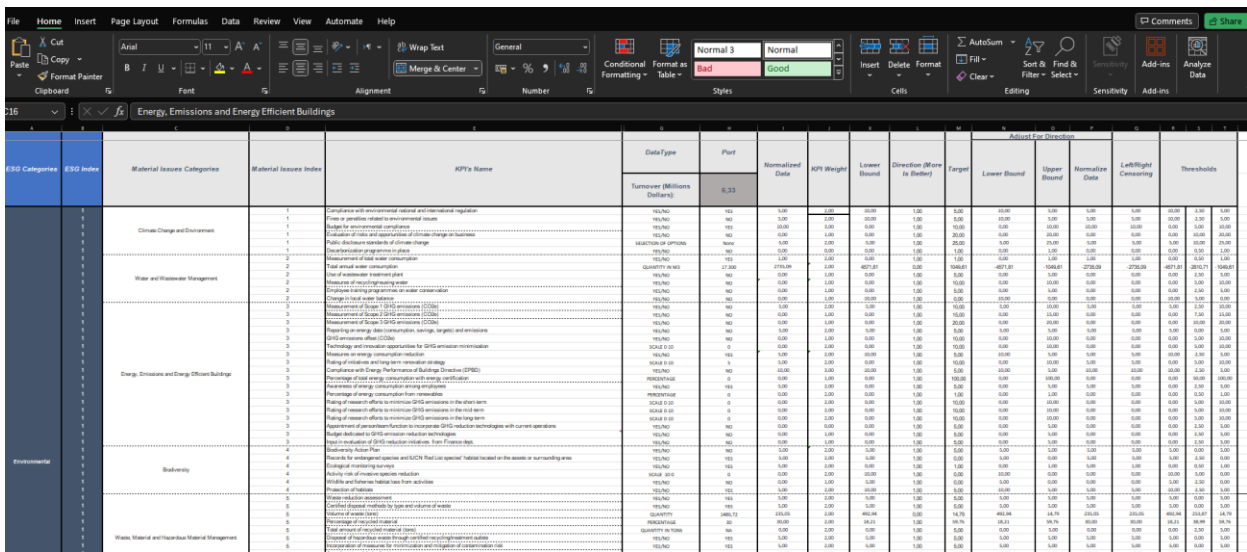


Figure 5 Hybrid Financial Reporting Model- Technical Implementation Screenshot 1



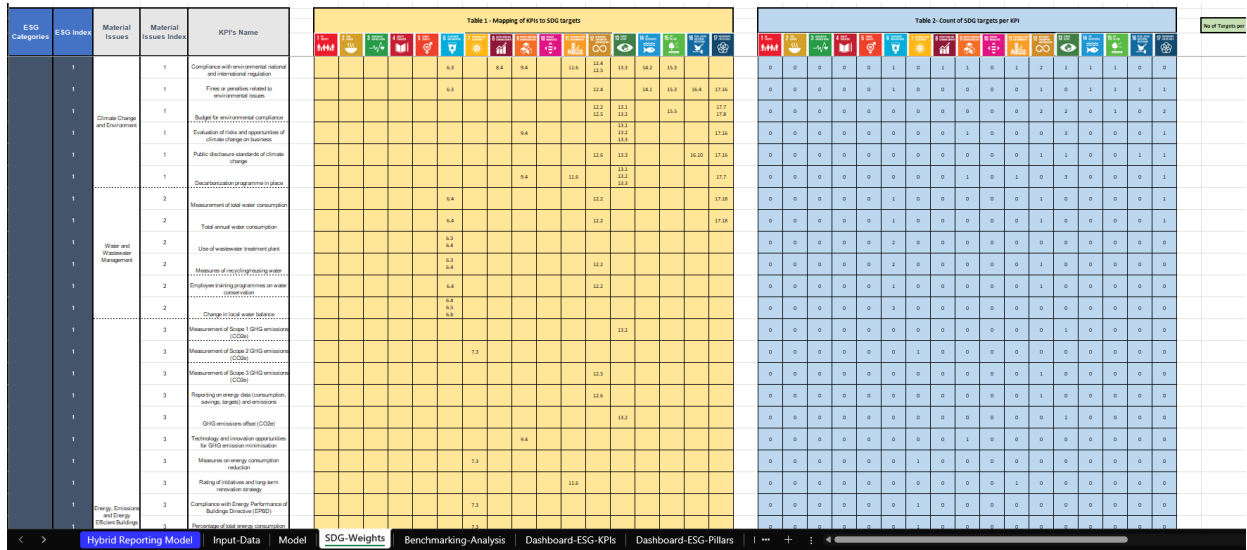
ESG Categories	Material Issues Categories	KPIs Name	Data Type	Port
			Turnover (Millions Dollars)	6,3252
Climate Change and Environment		Compliance with environmental national and international regulation	YES/NO	YES
		Direct or penalties related to environmental issues	YES/NO	NO
		Budget for environmental compliance	YES/NO	YES
		Evaluation of risks and opportunities of climate change on business	YES/NO	NO
Water and Wastewater Management		Public disclosure standards of climate change	YES/NO	NO
		Decarbonation programme in place	SELECTION OF OPTIONS	NO/4
		Measurement of total water consumption	YES/NO	YES
		Total annual water consumption	QUANTITY IN LITERS	27580
		Use of wastewater treatment plant	YES/NO	NO
		Measures of reusing/treating water	YES/NO	NO
		Employees training programmes on water conservation	YES/NO	NO
		Change in total water balance	YES/NO	NO
		Measurement of Scope 1 GHG emissions (CO2e)	YES/NO	NO
		Measurement of Scope 2 GHG emissions (CO2e)	YES/NO	NO
Energy, Emissions and Energy Efficient Buildings		Measurement of Scope 3 GHG emissions (CO2e)	YES/NO	NO
		Reporting on energy data (consumption, savings, targets) and emissions	YES/NO	NO
		GHG emissions offset (CO2e)	YES/NO	NO
		Technology and innovation opportunities for GHG emission minimization	SCALE 0-10	0
		Measures on energy consumption reduction	SCALE 0-10	5
		Compliance with Energy Performance of Buildings Directive (EPBD)	YES/NO	NO
		Percentage of total energy consumption with energy efficiency	PERCENTAGE	5
		Percentage of energy consumption among employees	PERCENTAGE	0
		Percentage of energy consumption from renewables	PERCENTAGE	0
		Rating of research efforts to minimize GHG emissions in the short-term	SCALE 0-10	0
Environmental	Biodiversity	Rating of research efforts to minimize GHG emissions in the mid-term	SCALE 0-10	0
		Rating of research efforts to minimize GHG emissions in the long-term	SCALE 0-10	0
		Appointment of person/team/function to incorporate GHG reduction technologies with current operations	YES/NO	NO
		Budget dedicated to GHG emission reduction technologies	YES/NO	NO
Biodiversity		Invest in evaluation of GHG reduction initiatives from Finance Dept.	YES/NO	NO
		Biodiversity Action Plan	YES/NO	NO
		Reports for endangered species and IUCN Red List species/habitat located on the assets or surrounding area	YES/NO	YES
		Biological monitoring surveys	YES/NO	NO

Figure 6 Hybrid Financial Reporting Model-Technical Implementation Screenshot 2



ESG Categories	ESG Index	Material Issues Categories	Material Issues Index	KPIs Name	Data Type	Port	Assess One Direction													
							Normalized Data	KPIs Weight	Lower Bound	Direction (More is Better)	Target	Lower Bound	Upper Bound	Normalized Data	Left/Right Censoring	Thresholds				
Climate Change and Environment			1	Compliance with environmental national and international regulation	YES/NO	YES	5.00	100	0.00	1.00	5.00	10.00	5.00	1.00	1.00	0.00	1.00	1.00		
				Direct or penalties related to environmental issues	YES/NO	NO	5.00	100	0.00	1.00	5.00	10.00	5.00	1.00	1.00	0.00	1.00	1.00	1.00	
				Budget for environmental compliance	YES/NO	NO	5.00	100	0.00	1.00	5.00	10.00	5.00	1.00	1.00	0.00	1.00	1.00	1.00	
				Evaluation of risks and opportunities of climate change on business	YES/NO	NO	5.00	100	0.00	1.00	5.00	10.00	5.00	1.00	1.00	0.00	1.00	1.00	1.00	
				Public disclosure standards of climate change	SELECTION OF OPTIONS	None	5.00	100	0.00	1.00	5.00	10.00	5.00	1.00	1.00	0.00	1.00	1.00	1.00	
				Decarbonation programme in place	SELECTION OF OPTIONS	None	5.00	100	0.00	1.00	5.00	10.00	5.00	1.00	1.00	0.00	1.00	1.00	1.00	
				Measurement of total water consumption	YES/NO	YES	1.00	2.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
				Total annual water consumption	QUANTITY IN LITERS	27580	27580	27580	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
				Use of wastewater treatment plant	YES/NO	NO	5.00	1.00	0.00	1.00	5.00	10.00	5.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
				Measures of reusing/treating water	YES/NO	NO	5.00	1.00	0.00	1.00	5.00	10.00	5.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Water and Wastewater Management			2	Employees training programmes on water conservation	YES/NO	NO	5.00	1.00	0.00	1.00	5.00	10.00	5.00	1.00	1.00	1.00	1.00	1.00		
				Change in total water balance	YES/NO	NO	5.00	2.00	1.00	1.00	10.00	20.00	10.00	1.00	1.00	1.00	1.00	1.00	1.00	
				Measurement of Scope 1 GHG emissions (CO2e)	YES/NO	NO	5.00	2.00	1.00	1.00	10.00	20.00	10.00	1.00	1.00	1.00	1.00	1.00	1.00	
				Measurement of Scope 2 GHG emissions (CO2e)	YES/NO	NO	5.00	2.00	1.00	1.00	10.00	20.00	10.00	1.00	1.00	1.00	1.00	1.00	1.00	
				Measurement of Scope 3 GHG emissions (CO2e)	YES/NO	NO	5.00	2.00	1.00	1.00	10.00	20.00	10.00	1.00	1.00	1.00	1.00	1.00	1.00	
				Reporting on energy data (consumption, savings, targets) and emissions	YES/NO	NO	5.00	1.00	0.00	1.00	10.00	20.00	10.00	1.00	1.00	1.00	1.00	1.00	1.00	
				GHG emissions offset (CO2e)	YES/NO	NO	5.00	1.00	0.00	1.00	10.00	20.00	10.00	1.00	1.00	1.00	1.00	1.00	1.00	
				Technology and innovation opportunities for GHG emission minimization	SCALE 0-10	0	5.00	2.00	1.00	1.00	10.00	20.00	10.00	1.00	1.00	1.00	1.00	1.00	1.00	
				Measures on energy consumption reduction	SCALE 0-10	5	5.00	2.00	1.00	1.00	10.00	20.00	10.00	1.00	1.00	1.00	1.00	1.00	1.00	
				Compliance with Energy Performance of Buildings Directive (EPBD)	YES/NO	NO	10.00	2.00	1.00	1.00	10.00	20.00	10.00	1.00	1.00	1.00	1.00	1.00	1.00	
Energy, Emissions and Energy Efficient Buildings			3	Percentage of total energy consumption with energy efficiency	PERCENTAGE	5	5.00	1.00	0.00	1.00	10.00	20.00	10.00	1.00	1.00	1.00	1.00	1.00		
				Percentage of energy consumption among employees	PERCENTAGE	0	5.00	2.00	1.00	1.00	10.00	20.00	10.00	1.00	1.00	1.00	1.00	1.00		
				Percentage of energy consumption from renewables	PERCENTAGE	0	5.00	2.00	1.00	1.00	10.00	20.00	10.00	1.00	1.00	1.00	1.00	1.00		
				Rating of research efforts to minimize GHG emissions in the short-term	SCALE 0-10	0	5.00	2.00	1.00	1.00	10.00	20.00	10.00	1.00	1.00	1.00	1.00	1.00		
				Rating of research efforts to minimize GHG emissions in the mid-term	SCALE 0-10	0	5.00	2.00	1.00	1.00	10.00	20.00	10.00	1.00	1.00	1.00	1.00	1.00		
				Rating of research efforts to minimize GHG emissions in the long-term	SCALE 0-10	0	5.00	2.00	1.00	1.00	10.00	20.00	10.00	1.00	1.00	1.00	1.00	1.00		
				Appointment of person/team/function to incorporate GHG reduction technologies with current operations	YES/NO	NO	5.00	2.00	1.00	1.00	10.00	20.00	10.00	1.00	1.00	1.00	1.00	1.00		
				Budget dedicated to GHG emission reduction technologies	YES/NO	NO	5.00	1.00	0.00	1.00	10.00	20.00	10.00	1.00	1.00	1.00	1.00	1.00		
				Investment in evaluation of GHG reduction initiatives from Finance Dept.	YES/NO	NO	5.00	1.00	0.00	1.00	10.00	20.00	10.00	1.00	1.00	1.00	1.00	1.00		
				Biodiversity Action Plan	YES/NO	NO	5.00	2.00	1.00	1.00	10.00	20.00	10.00	1.00	1.00	1.00	1.00	1.00		
Environmental	Biodiversity		4	Reports for endangered species and IUCN Red List species/habitat located on the assets or surrounding area	YES/NO	YES	5.00	2.00	1.00	1.00	10.00	20.00	10.00	1.00	1.00	1.00	1.00	1.00		
				Biological monitoring surveys	YES/NO	NO	5.00	2.00	1.00	1.00	10.00	20.00	10.00	1.00	1.00	1.00	1.00			
				Invest in evaluation of GHG reduction technologies with current operations	YES/NO	NO	5.00	2.00	1.00	1.00	10.00	20.00	10.00	1.00	1.00	1.00	1.00			
				Biological monitoring surveys	YES/NO	NO	5.00	2.00	1.00	1.00	10.00	20.00	10.00	1.00	1.00	1.00	1.00			
Water and Wastewater Management			5	Water reduction programmes	YES/NO	NO	5.00	2.00	1.00	1.00	10.00	20.00	10.00	1.00	1.00	1.00	1.00	1.00		
				Control of water consumption by the use of water saving devices	YES/NO	NO	5.00	2.00	1.00	1.00	10.00	20.00	10.00	1.00	1.00	1.00	1.00			
				Water saving devices	QUANTITY	485.73	283.00	2.00	482.00	14.70	482.00	14.70	20.00	20.00	20.00	20.00	20.00	20.00		
				Percentage of water saving devices	PERCENTAGE	26	20.00	0.00	20.00	14.70	14.70	14.70	14.70	14.70	14.70	14.70	14.70			
				Total amount of recycled water (m³)	QUANTITY IN TONS	NA	0.00	2.00	0.00	1.00	5.00	10.00	5.00	1.00	1.00	1.00	1.00			
				Percentage of production water recycled (total consumption water)	PERCENTAGE	NA	0.00	2.00	0.00	1.00	5.00	10.00	5.00	1.00	1.00	1.00	1.00			
				Investment in water saving devices	YES/NO	YES	5.00	2.00	1.00	1.00	10.00	20.00	10.00	1.00	1.00	1.00	1.00			
				Investment in water saving devices	YES/NO	YES	5.00	2.00	1.00	1.00	10.00	20.00	10.00	1.00	1.00	1.00	1.00			
				Investment in water saving devices	YES/NO	YES	5.00	2.00	1.00	1.00	10.00	20.00	10.00	1.00	1.00	1.00	1.00			
				Investment in water saving devices	YES/NO	YES	5.00	2.00	1.00	1.00	10.00	20.00	10.00	1.00	1.00	1.00	1.00			

Figure 7 Hybrid Financial Reporting Model-Technical Implementation Screenshot 3

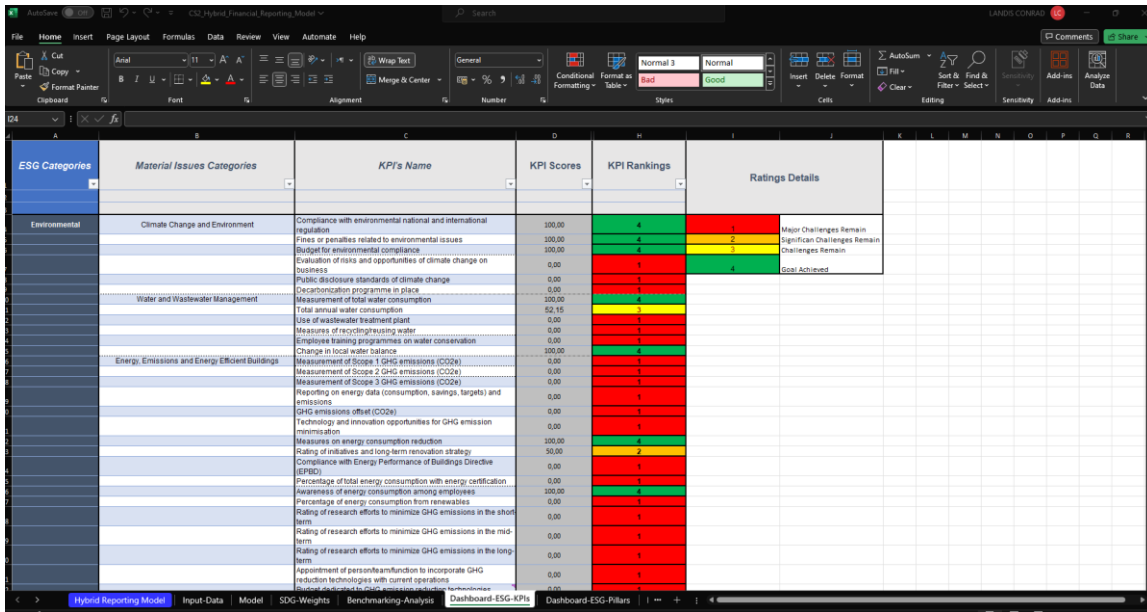


The screenshot displays the 'Hybrid Reporting Model' interface. It features a table with columns for 'ESG Categories', 'ESG Index', 'Material Issues', 'Material Issues Index', and 'KPI's Name'. The table is divided into two main sections: 'Table 1 - Mapping of KPIs to SDG targets' and 'Table 2 - Count of SDG targets per KPI'. The interface includes navigation buttons at the bottom: 'Hybrid Reporting Model', 'Input-Data', 'Model', 'SDG-Weights', 'Benchmarking-Analysis', 'Dashboard-ESG-KPIs', and 'Dashboard-ESG-Pillars'.

Figure 8 Hybrid Financial Reporting Model- Technical Implementation Screenshot 4

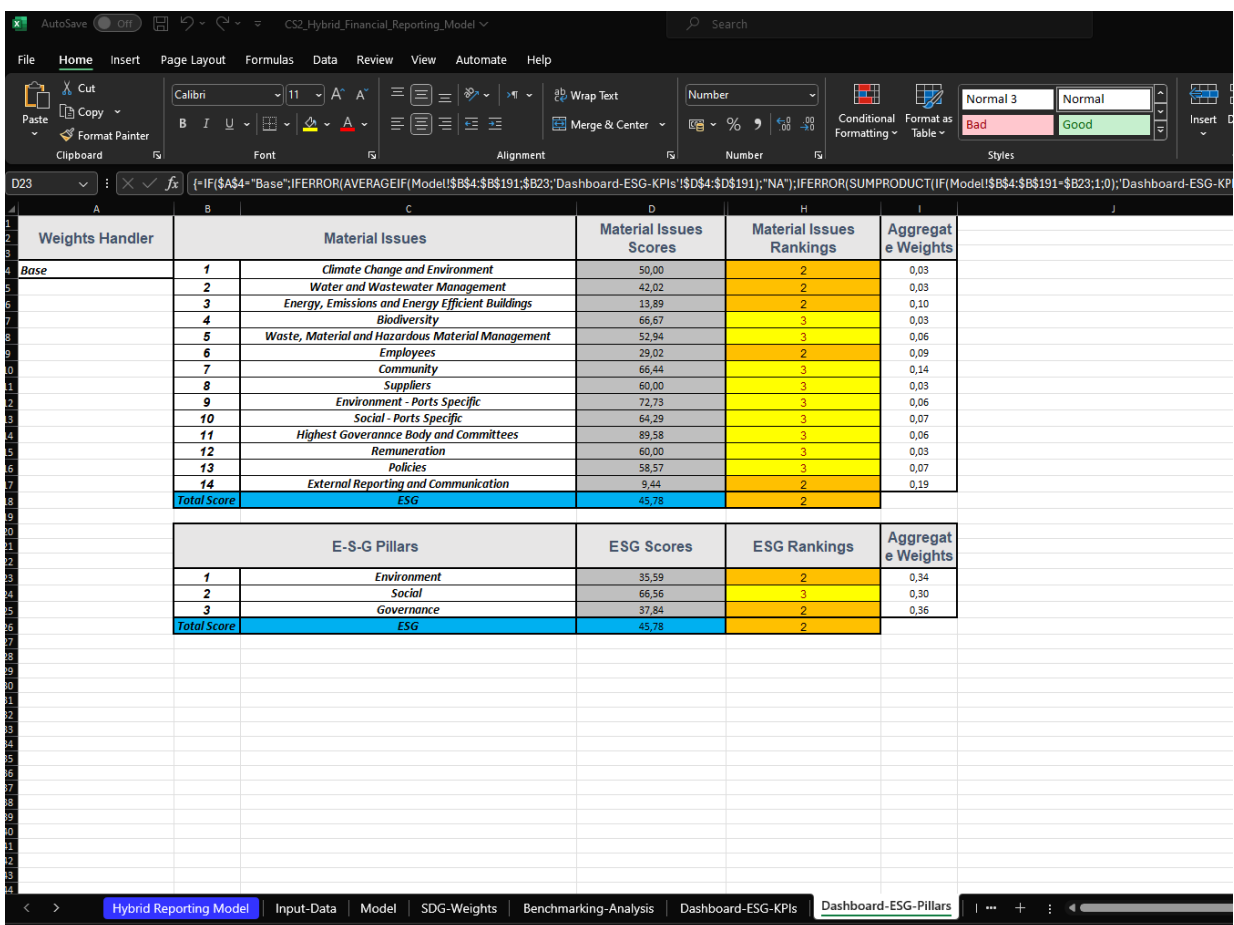
COMPANY NAME	SIC CODE 1	SIC CODE 2	SIC CODE 3	GEO	Environment Pillar Score	Governance Pillar Score	Social Pillar Score	Water Use To Revenues USD in millions	Total Waste To Revenues USD in millions	Total Recycled Waste To Revenues USD in millions	Waste Recycling Ratio	Envic
A P MOLLER MAERSK B	4412	4491	1389	Europe	74,28	77,55	60,67	30,71	5,64			
CARNIVAL	4481	4491	4725	Europe	81,79	62,77	85,37	3003,30	64,15	22,97	35,80	
COMPAGNIE DE L ODET	7812	4412	4491	Europe	52,43	32,19	57,48	73,02	1,59	1,37	86,00	
EMSKIPAFELAG ISLAND	4412	4481	4499	Europe	37,13	66,78	62,57	347,17	1,11	0,81	73,00	
EUROKAI GMBH & KGAA PREFERENCE	6719	4491		Europe	3,50	41,33	7,24					
GLOBAL PORTS HOLDING	4491			Europe	21,50	46,86	56,21					
GLOBAL PORTS INVESTMENTS GDR	4491	5171		Europe	17,85	55,03	38,76					
GLOBAL YATIRIM HOLDING	4491	6519	4911	Europe	68,53	90,33	68,00	6011,30	11,22			
HAMBURGER HAFEN UND LOGISTIK	4491	4499	6531	Europe	62,04	68,61	74,96	57,50	4,41			
KONINKLIJKE VOPAK	4226	4491	4729	Europe	74,75	63,91	77,30					
OCEAN WILSONS HOLDINGS	4491	4731	4499	Europe	11,88	47,27	28,19					
PIRAEUS PORT AUTHORITY CR	4491	4225	4499	Europe	49,49	38,47	61,68	3247,03	12,69	5,29	41,71	
WILHELMSENS WILHELMSEN HOLDINGS 'A'	4731	4449	4491	Europe	58,57	55,50	52,05		0,71	0,47	65,57	
CARNIVAL	4481	4491	4725	North America	69,50	70,67	59,53	3003,30	64,15	22,97	35,80	
MATSON	4412	4491	4011	North America	51,39	73,35	58,60					
NAVIOS MARITIME HOLDINGS	4412	4491	6719	North America	9,48	36,67	26,17					
ORION GROUP HOLDINGS	1629	4499	1611	North America	22,44	75,57	27,30					
TIDEWATER	1389	4412	4499	North America	43,30	85,65	65,76					
WESTSHORE TERMINALS INVESTMENT	4491	1241		North America	21,56	21,85	10,87					
ADANI PORTS AND SPECIAL ECONOMIC ZONE	4491	1629	1541	Asia Pacific	85,01	44,23	77,74	2285,18	3,51	3,02	86,00	
AEGIS LOGISTICS	1389	5541	4491	Asia Pacific	10,81	37,47	13,95					
AUSTAL	3731	3732	4499	Asia Pacific	63,06	70,56	25,09					
CHINA MERCHANTS PORT GROUP 'A'	4491	4499	4731	Asia Pacific	76,58	77,84	67,77	2622,97	6,24	1,61	25,74	
CHINA MERCHANTS PORT HOLDINGS	4491	4581	4731	Asia Pacific	70,61	60,29	43,39	1782,20	8,45			
CJ CENTURY LOGISTICS HOLDINGS	4731	4225	4499	Asia Pacific	27,57	17,36	49,89					
CJ LOGISTICS	4491	4213	4013	Asia Pacific	48,75	57,12	79,26	82,57	5,53	4,67	84,52	
COSCO SHIPPING INTERNATIONAL	4412	4731	4499	Asia Pacific	0,00	20,22	27,08					

Figure 9 Hybrid Financial Reporting Model- Technical Implementation Screenshot 5



ESG Categories	Material Issues Categories	KPI's Name	KPI Scores	KPI Rankings	Ratings Details
Environmental	Climate Change and Environment	Compliance with environmental national and international legislation	100.00	3	Major Challenges Remain. Significant Challenges Remain Challenges Remain Goal Achieved
		Practices or penalties related to environmental issues	100.00	2	
		Budget for environmental compliance	100.00	2	
		Evaluation of risks and opportunities of climate change on business	0.00	4	
	Water and Wastewater Management	Public disclosure standards of climate change	0.00	2	
		Decarbonization programme in place	0.00	2	
		Measurement of total water consumption	100.00	2	
		Total annual water consumption	52.15	2	
	Energy, Emissions and Energy Efficient Buildings	Use of wastewater treatment plant	0.00	2	
		Measures of recycling/reusing water	0.00	2	
		Employee training programmes on water conservation	0.00	2	
		Change in local water balance	100.00	2	
		Measurement of Scope 1 GHG emissions (CO2e)	0.00	2	
		Measurement of Scope 2 GHG emissions (CO2e)	0.00	2	

Figure 10 Hybrid Financial Reporting Model- Technical Implementation Screenshot 6



Weights Handler	Material Issues	Material Issues Scores	Material Issues Rankings	Aggregate Weights
Base	1 Climate Change and Environment	50,00	2	0,03
	2 Water and Wastewater Management	42,02	2	0,03
	3 Energy, Emissions and Energy Efficient Buildings	13,89	2	0,10
	4 Biodiversity	66,67	3	0,03
	5 Waste, Material and Hazardous Material Management	52,94	3	0,06
	6 Employees	29,02	2	0,09
	7 Community	66,44	3	0,14
	8 Suppliers	60,00	3	0,03
	9 Environment - Ports Specific	72,73	3	0,06
	10 Social - Ports Specific	64,29	3	0,07
	11 Highest Governance Body and Committees	89,58	3	0,06
	12 Remuneration	60,00	3	0,03
	13 Policies	58,57	3	0,07
	14 External Reporting and Communication	9,44	2	0,19
	Total Score ESG	45,78	2	

E-S-G Pillars	ESG Scores	ESG Rankings	Aggregate Weights
1 Environment	35,59	2	0,34
2 Social	66,56	3	0,30
3 Governance	37,84	2	0,36
Total Score ESG	45,78	2	

Figure 11 Hybrid Financial Reporting Model- Technical Implementation Screenshot 7

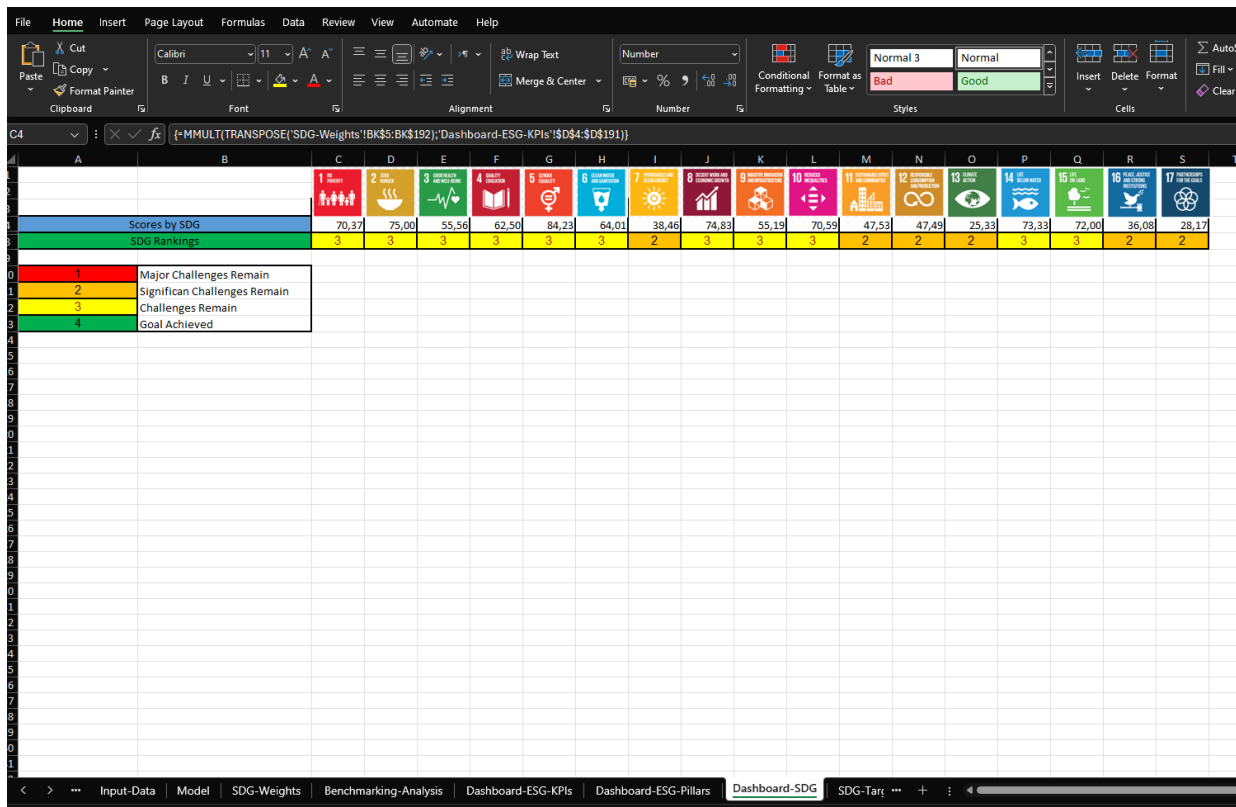


Figure 12 Hybrid Financial Reporting Model- Technical Implementation Screenshot 8

2. Applicability of the Model to ARSINOE Case Studies

4.1 Implementation of the Hybrid Reporting Model for Mediterranean Ports

This section demonstrates the applicability of the model to the ARSINOE Mediterranean Ports Case Study (CS2). CS2 was a frontrunner in the development and the implementation of the model, while the complete implementation of the model for CS2 and CS1 ARSINOE case studies will be included in the Deliverable 7.5 “Development of a Manual on Sustainable Finance”, due to Month 42.

The Case Study worked on identifying a total of 188 KPIs classified under 13 Material issues (Figure 13). Just to mention few examples: total annual water consumption, use of wastewater treatment plant, Measures of recycling/reusing water, employee training programs on water conservation are some of the KPIs to be considered under the “Water and Wastewater Management” material issue, while electricity use reduction measures, flood risk management plan and development of clean energy vessels initiatives are some of the KPIs under the “Environmental Port Specific” material issue.

Following our framework and using equation 6, the mapping between the ESG and the SDG KPIs are presented in Figure 14.

Finally Figure 15 presents the identification of companies to be used in the Benchmarking. The set contains all public companies with a SIC Code 1 or SIC Code 2 defined in [4191,4199], which correspond to Ports and Port authorities. Among the 73 peers identified in Thomson Reuters, the table reports the top 10% industry performers internationally, as well as its Environmental Pillar score and its performance to the set of hybrid metrics which are currently included in our analysis.

ESG Categories	Material Issues / Categories	# KPIs
Environmental	Climate Change and Environment	6
	Water and Wastewater Management	6
	Energy, Emissions and Energy Efficient Buildings	18
	Biodiversity	6
	Waste, Material and Hazardous Material Management	11
	Environment - Ports Specific	17
Social	Employees	27
	Suppliers	5
	Community	11
	Social - Ports Specific	14
Governance	Highest Governance Body and Committees	12
	Remuneration	5
	Policies	14

Figure 13 Material Issues and KPIs – Mediterranean Ports

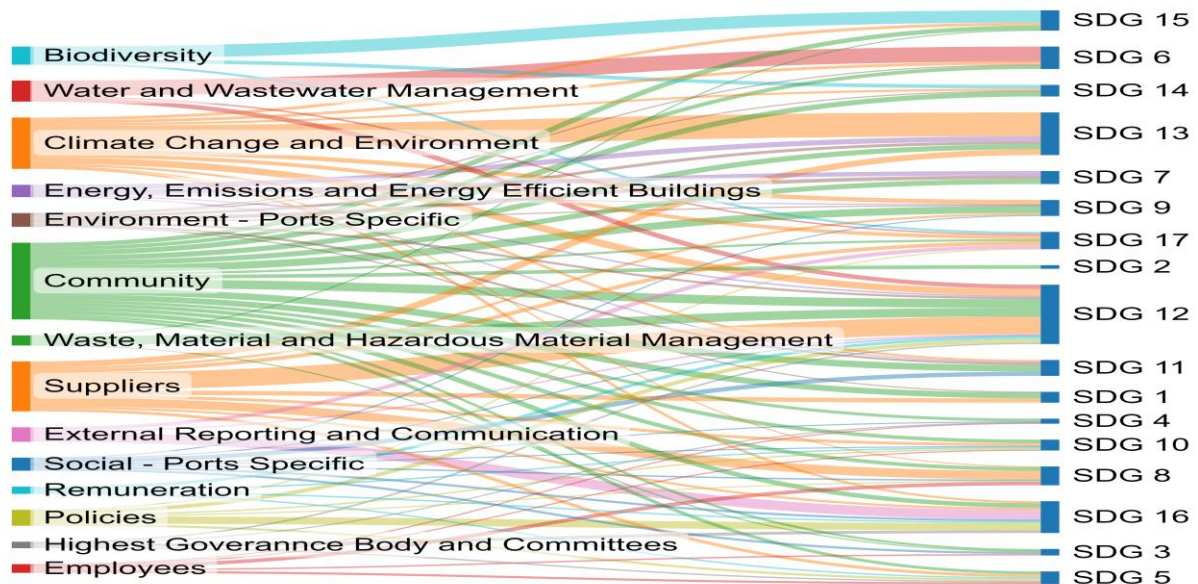


Figure 14 ESG vs SDG Mapping

<i>FULL NAME</i>	<i>Environment Pillar Score</i>	<i>Water Use To Revenues USD in millions</i>	<i>Total Waste To Revenues USD in millions</i>	<i>GEO</i>
ADANI PORTS AND SPECIAL ECONOMIC ZONE	85.01	2285.18	3.51	Asia Pacific
CARNIVAL	81.79	3003.30	64.15	Europe
SINOPEC KANTONS HOLDINGS	80.65	906.74	1.97	Asia Pacific
CHINA MERCHANTS PORT GROUP	76.58	2622.97	6.24	Asia Pacific
SANTOS BRASIL PARTICIPACOES ON	76.45	236.79	15.79	Latin America
HMM	75.18	3.75	1.58	Asia Pacific
NIPPON YUSEN KK	74.84	15.60	0.30	Asia Pacific
COSCO SHIPPING PORTS	74.60	821.32	6.63	Asia Pacific
A P MOLLER MAERSK	74.28	30.71	5.64	Europe

Figure 15 Benchmarking

4.2 Work in Progress

Following March 2024, the CS will work on:

- Reducing the number of KPIs to be included in the model.
- Setting the 2050 targets for all the KPIs.
- Finalize the input data collection for all the three ports using updated 2022 data

Moreover, in relation to CSR, Valencia is the most mature port, which very recently (October 2023) developed a port performance management system, in collaboration the United Nations Conference on Trade and Statistics (UNCTAD)⁷. Figure 13 presents the material issues, under the seven pillars contained in the proposed management system.

In this direction, the CS will also work in aligning as much as possible to the metrics also proposed by UNCTAD, by further properly classifying the material issues under the ESG pillars.

The final version of the CS2 model together with extended details on the KPIs, Targets and Data used will be included in Deliverable 7.4, due to Month 42.

⁷ https://unctad.org/system/files/official-document/dtltlb2023d2_en.pdf

GROUP	CATEGORIES
Governance	<ul style="list-style-type: none"> • Indicators characterising the Level of Management Autonomy • Performance indicators in terms of governance
Human resources	<ul style="list-style-type: none"> • Equal opportunities • Quality of employment • Social welfare • Productivity
Financial	<ul style="list-style-type: none"> • Accounting • Activity-related • Financial standing and investment • Financial performance
Vessel operations	<ul style="list-style-type: none"> • Time • Vessel characteristics
Resilience	<ul style="list-style-type: none"> • Physical safety • Cybersecurity
Cargo operations	<ul style="list-style-type: none"> • Operational performance • Service level • Utilisation
Sustainability	<ul style="list-style-type: none"> • Climate change • Emissions from port activities • Consumption of resources • Waste production • Port development • Impact on biodiversity • Environmental management

Figure 16 UNCTAD Port Management System

Source: UNCTAD, Volume 11, 2023

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Appendix

Table A.1 ESGs and SDG Indicators Mapping

ESG	KPI	SDG Mapping									
Environment	Scope 1 emissions	13.1	13.2	13.3	9.2	9.4	12.4	12.5	12.6		
	Scope 2 emissions	13.1	13.2	13.3	9.2	9.4	12.4	12.5	12.6		
	Scope 3 emissions	13.1	13.2	13.3	9.2	9.4	12.4	12.5	12.6		
	Energy consumption to sales	7.2	7.3	12.2	12.4	12.5	12.6	13.2			
	Water consumption to sales	12.2	12.6	6.3	6.4	6.5	6.6	15.4	15.5	15.9	
	% of food waste	12.2	12.3	12.4	12.5	12.6	1.3	2.2	2.4		
	% waste to landfill	15.2	15.4	15.5	12.2	12.3	12.4	12.5	12.6	9.1	9.4
	% recyclable waste	15.2	15.4	15.5	12.2	12.3	12.4	12.5	12.6	9.1	9.4
	Protection of biological diversity	14.2	14.4	15.b	15.5	15.8	15.9	17.19			
% of recyclable packaging	9.2	9.4	9.5	12.3	12.4	12.5	12.6	15.5	15.9		
% of Packaging from recycled raw materials	9.2	9.4	9.5	12.3	12.4	12.5	12.6	15.5	15.9		
Social	Employee training and development	8,2	8,3	8,5	8,6	8,7	8,8	4,3			
	% of women in total workforce	5.1	5.2	5.5	5.6	5.a	10.2	10.3	10.4	16.6	16.7
	Number of human rights violations	16.1	16.2	16.3	16.9	16.1	10.2	10.3	8.7	8.8	
	Number of ethics-related incidents	1.1	1.2	1.3	1.4	1.5	2.4	2.a	3.7	3.8	17.3
Governance	Number of non-compliance incidents	16.5	16.6	16.7	8.7	8.8					

Systems Innovation Approach (SIA) addresses the growing complexity, interdependencies and interconnectedness of modern societies and economies, focusing on the functions of the cross-sectoral system as a whole and on the variety of actors. The Climate Innovation Window (CIW) is the EU reference innovations marketplace for climate adaptation technologies. ARSINOE shapes the pathways to resilience by bringing together SIA and CIW, to build an ecosystem for climate change adaptation solutions. Within the ARSINOE ecosystem, pathways to solutions are co-created and co-designed by stakeholders, who can then select either existing CIW technologies, or technologies by new providers (or a combination) to form an innovation package. This package may be designed for implementation to a specific region, but its building blocks are transferable and re-usable; they can be re-adapted and updated. In this way, the user (region) gets an innovation package consisting of validated technologies (expanding the market for CIW); new technologies implemented in the specific local innovation package get the opportunity to be validated and become CIW members, while the society (citizens, stakeholders) benefits as a whole. ARSINOE applies a three-tier, approach: (a) using SIA it integrates multi-faceted technological, digital, business, governance and environmental aspects with social innovation for the development of adaptation pathways to climate change for specific regions; (b) it links with CIW to form innovation packages by matching innovators with end-users/regions; (c) it fosters the ecosystem sustainability and growth with cross-fertilization and replication across regions and scales, at European level and beyond, using specific business models, exploitation and outreach actions. The ARSINOE approach is show-cased in nine widely varied demonstrators, as a proof-of-concept with regards to its applicability, replicability, potential and efficacy.



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