Bridging Sustainability Frameworks: A Comparative Study of GRI, CSRD(and ESRS), EMAS and ISO – CERN's Case Study

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BRIDGING SUSTAINABILITY FRAMEWORKS: A COMPARATIVE STUDY OF GRI, CSRD (AND ESRS), EMAS AND ISO – CERN'S CASE STUDY

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ACRONYMS

AI: Artificial Intelligence
CDP: Carbon Disclosure Project
CEPS: CERN Environmental Protection Steering
CERN: European Organization for Nuclear Research
CIPEA: CERN Innovation Programme on Environmental Applications
CSR: Corporate Social Responsibility
DG: Director General
EFRAG: European Financial Reporting Advisory Group
EMAS: Eco-Management and Audit Scheme
EMS: Environmental Management System
ESA: European Space Agency
ESG: Environmental, Social and Governance
ESRS: European Sustainability Reporting Standards
EU: European Union
FCC: Future Circular Collider
GHG: Green House Gas
GRI: Global Reporting Initiative
HSE: Occupational Health & Safety and Environmental Protection
IIRC: International Integrated Reporting Council
ISO: International Organization for Standardization
ISSB: International Sustainability Standards Board
ITER: International Thermonuclear Experimental Reactor
LHC: Large Hadron Collider
LS2: Long Shutdown
MPS: Max Planck Society
NFRD: Non-Financial Reporting Directive
NGOs: Non-Governmental Organizations
OECD: Organisation for Economic Cooperation and Development
SASB: Sustainability Accounting Standards Board
SDGs: Sustainable Development Goals
SMEs: Small or Medium-sized Entities
STIs: Science and Technology Institutes
TCFD: Task Force on Climate-related Financial Disclosures
UN: United Nations
UNEP: United Nations Environment Program
UNESCO: United Nations Educational, Scientific and Cultural Organization
WCED: World Commission on Environment and Developmen

ABSTRACT

Sustainability reporting is increasingly expected to support governance, not only external communication. This thesis examines how leading sustainability frameworks organise accountability and what this implies for large scientific and research institutions, using CERN as a case study. It compares GRI, CSRD/ESRS, EMAS, ISO 14001 and ISO 26000 in a structured matrix and applies the results to CERN's Environment Reports (2017–2024), complemented by a brief peer institutions benchmark and semi-structured interviews. Findings show that the instruments encode distinct accountability logics (disclosure-oriented, regulatory and management-system based) which shape topic selection, responsibility allocation and credibility. CERN's reporting is comparatively mature on environmental disclosure, but less integrated across ESG. The thesis argues for functional complementarity: retain a strong GRI baseline while selectively adopting mostly CSRD/ESRS connectivity and management-system routines to strengthen materiality, governance and performance tracking.

INTRODUCTION

In 1987, the General Assembly of the United Nations (UN) requested the World Commission on Environment and Development (WCED) to formulate "A global agenda for change". This agenda included the purpose of proposing long-term environmental strategies for achieving sustainable development by the year 2000 and beyond, recommending ways to translate concern for the environment into greater cooperation between countries at different stages of economic and social development, and helping to define shared perceptions of long-term environmental issues and the appropriate efforts needed to deal successfully with environmental protection and enhancement (WCED, 1987).

Under these indications, the Commission published the Brundtland Report, "Our Common Future", where they introduced the concept of sustainable development, defining it as development that "meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987, p. 16). The focus of Brundtland resides in the concept of maintaining natural capital, meaning not diminishing the resources passed on to future generations, operating as a "do no harm" philosophy (Barker, 2025).

As a consequence, concern for sustainable development and sustainability has grown considerably since the mid-20th century. This increasing awareness led national governments and multilateral institutions to realize that it is impossible to separate economic development from environmental problems (WCED, 1987). Business activity, while providing essential goods and services, can generate negative externalities that impose costs on society and the environment (Barker, 2025).

In this context, there has been a growing demand for non-financial information from investors and a wide range of other stakeholders. This information is crucial for understanding how sustainability-related risks and opportunities affect corporations' financial prospects (Bose, 2020). Thus, the need for systems that could quantify and communicate the impact of corporate activities on global sustainability became evident. This need gave rise to the concept of sustainability reporting, aiming to improve standardized disclosure of environmental, social, and governance (ESG) information (Bose, 2020).

Sustainability reporting is of vital importance for several reasons. It allows the monitoring and evaluation of corporate impact on global sustainability (De Lima et al., 2016), also, by making externalities and market failures visible, it encourages companies to align their economic interests with social and environmental goals. Moreover, standardized disclosures have the potential to accelerate the transition towards a more sustainable future by providing comparable data and fostering collective learning (Barker, 2025).

As a result, numerous sustainability reporting frameworks and standards have emerged and evolved over the last quarter-century to organize and harmonize the diversity of non-financial information. All these frameworks are fundamentally based on the concept of the Triple Bottom Line, which evaluates organizational performance across three interdependent dimensions: "People, Profit, and Planet" (Delgado-Ceballos et al., 2022).

Some of the most prominent frameworks and standards are: Global Reporting Initiative (GRI), International Integrated Reporting Council (IIRC), Sustainability Accounting Standards Board (SASB), Carbon Disclosure Project (CDP), Task Force on Climate-related Financial Disclosures

(TCFD), European Sustainability Reporting Standards (ESRS), Eco-Management and Audit Scheme (EMAS), ISO 14001 and 26000 and International Sustainability Standards Board (ISSB).

However, the proliferation of frameworks has also created an "alphabet soup" of standards. The lack of uniform comparability remains a challenge for organizations, which can be costly for them due to "sustainability reporting fatigue" (Bose, 2020). Some organizations question which frameworks they should follow and what their differences are. A key distinction lies in the target audience: for example, while GRI focuses on a broad range of stakeholders "aiming to be used by a variety of different entities" (De Lima et al., 2016, p. 147), SASB and IIRC are primarily investor oriented (Bose, 2020). This leads to different interpretations of materiality: financial materiality (how ESG factors affect the company's financial results) and stakeholder materiality (the external impact of the company's activities on society and the environment). The integration of both perspectives is known as "double materiality" (Delgado-Ceballos et al., 2022), a concept increasingly present in new European standards.

Although some frameworks seek standardization, the reality is that there is not a 'single recipe' that dominates the provision of ESG information (Bose, 2020). This reality underscores the value of comparative analysis and cross-institutional assessment tools that allow organizations to evaluate their sustainability performance, identify gaps, and learn from best practices. Comparative approaches are particularly relevant for entities operating outside the corporate sector, where profit is not the primary driver. It not only helps institutions understand what can be done differently but also fosters innovation and resilience through diverse approaches (De Lima et al., 2016).

Science and Technology Institutes (STIs) represent a critical but underexplored domain for sustainability governance. The Organisation for Economic Cooperation and Development (OECD) describe STIs as organizations that generate scientific and technological knowledge, provide research infrastructure, and act as key nodes in national or international innovation systems (Larrue, P., 2022). Similarly, the United Nations Educational, Scientific and Cultural Organization (UNESCO), defines them as "institutions engaged in the creation, application and dissemination of scientific and technological knowledge to support societal and economic development" (UNESCO, 2015, p.33). As "microcosms of the larger community" (De Lima et al., 2016, p. 146), STIs have a dual responsibility: to minimize their own negative impacts and to model sustainable practices that can be transferred to society at large.

Yet, unlike corporate actors, STIs face unique challenges in adopting comprehensive sustainability reporting. Their governance structures are typically designed to advance scientific objectives rather than respond to market pressures. As a result, their sustainability practices often focus narrowly on environmental compliance, with less emphasis on social or governance dimensions (Barker, 2025). These gaps highlight the need for frameworks that address the specific governance realities of research-driven organizations.

CERN, the European Organization for Nuclear Research, offers a particularly relevant case through which to examine these dynamics. As one of the world's largest and most complex research organizations, CERN operates at the intersection of international collaboration, cutting-edge science and significant environmental and societal impact. Its activities involve thousands of scientists from around the globe, vast research infrastructure and substantial public funding from 25 Member States (CERN, n.d.).

Historically, CERN has published Environmental Reports focusing on energy consumption, emissions management and compliance with Host State regulations (CERN, n.d.). In response to evolving regulatory expectations and the international context, CERN has recognized the need to transition toward a comprehensive Sustainability Report that integrates ESG dimensions into institutional decision-making (Barker, 2025).

In this context, the present thesis first undertakes a comparative analysis of leading sustainability reporting frameworks and standards, including GRI, CSRD, ESRS, EMAS and ISO, to identify their guiding principles, structural differences and complementary elements. This analysis provides a reference point for understanding how various approaches to ESG disclosure influence governance structures and strategic decision-making in organizations.

Using the insights gained from this comparison, the thesis then applies these findings to the case of CERN examining whether CERN's existing reporting practices could benefit from incorporating elements of other standards or whether its current approach already provides a sufficient foundation for comprehensive sustainability governance. This two-step approach aims both to map the strengths and limitations of multiple frameworks and to evaluate their relevance and transferability to the specific context of STIs.

Research Question and Hypotheses

Building on the problem outlined above, this thesis is guided by three central research questions. The first examines the comparative dimension: how different sustainability reporting frameworks (GRI, CSRD, ESRS, EMAS, ISO) conceptualize governance, disclosure requirements, and ESG coverage. This question allows the thesis to establish a systematic basis for comparison, highlighting complementarities as well as divergences that may be particularly relevant for research-driven organizations.

The second addresses the systemic level of research institutions: which ESG dimensions remain underrepresented in research institutions, and how this shapes the capacity of sustainability reporting to operate as a governance tool. This question moves the analysis from the frameworks themselves to their application in non-corporate contexts.

The third question applies to CERN asking whether its current GRI-based reporting is sufficient to underpin comprehensive ESG governance, or whether integrating selected elements from other frameworks would provide added value.

From these questions emerge three hypotheses:

- H1: the selected frameworks vary in scope and prescriptiveness but reveal complementary strengths that, when compared, highlight pathways toward more comprehensive sustainability governance in research institutions.
- H2: research institutions systematically underreport social, and governance dimensions compared to environmental aspects, which limits the effectiveness of sustainability reporting as a governance tool.
- H3: CERN's GRI-based reporting provides a useful foundation but does not fully capture governance and social dimensions; integrating selected elements from other frameworks could enhance its capacity to function as a comprehensive ESG governance instrument.

Methodology

To achieve the objectives of this thesis, a qualitative comparative case study approach is followed, using CERN as the focal organisation. The study unfolds in two stages.

First, it conducts a critical documentary comparison of six sustainability frameworks and standards: GRI Standards, CSRD (and ESRS,) EMAS, ISO 14001 and ISO 26000, selected for their relevance to a Europe-based public scientific institutions and for the contrasting logics they embody (mandatory and voluntary instruments; reporting standards, regulatory requirements, management schemes and guidance). Other widely known standards and initiatives such as ISSB/IFRS-related standards, SASB and TCFD are not included in the core comparison because they are primarily designed for corporate financial disclosure and investor-oriented materiality, which makes their direct transferability to a non-corporate entity like CERN less central for the purposes of this thesis.

In a second stage, the comparative insights are applied to CERN's reporting corpus, focusing on the Environmental Reports from 2017 to 2024, and supported by a contextual benchmark of peer scientific organisations such as the European Space Agency (ESA), International Thermonuclear Experimental Reactor (ITER) and the Max Planck Society (MPS), to identify common patterns of institutionalisation in research settings. This stage is complemented by two semi-structured interviews (see Appendix 1) conducted with CERN staff: the person responsible for environmental reporting at CERN and the Group Leader for Environment, member also of the CERN Environmental Protection Steering (CEPS). These interviews are used to contextualise documentary findings, clarify reporting processes and governance arrangements, and support triangulation when interpreting the applicability of external frameworks to CERN. To preserve confidentiality, interviewees are referred to by role rather than by name. All of them were informed about the purpose of the study, the intended use of their contributions, and the voluntary nature of participation. Prior to the interviews, a consent form was provided and obtained from all interviewees which outlined: (i) the topic to be discussed, (ii) confidentiality conditions and (iii) participants' right to withdraw or request edits to attributed content within a reasonable timeframe. The used consent form is included in Appendix 2. Interview notes and transcripts were handled in a confidential manner and used solely for academic purposes within this thesis.

The analysis is structured through a Framework Comparability Matrix that operationalises comparison across a stable set of dimensions grouped into five analytical blocks: (A) the nature of each framework, (B) materiality and ESG coverage, (C) stakeholder scope and engagement expectations, (D) governance and integration requirements and (E)reporting architecture. The matrix is populated through systematic extraction and synthesis from primary framework texts and official guidance, and is then used to identify convergences and divergences across frameworks, to map these expectations against CERN's current reporting practice, and to derive an applicability assessment of which elements could realistically strengthen CERN's sustainability reporting and ESG governance capacity. The complete comparability matrix can be found in Appendix 3 as Table A.1.

Relevance to the Literature

This research contributes to the growing academic discussion on sustainability governance in non-corporate contexts by integrating two critical dimensions. The first is a comparative evaluation of ESG reporting frameworks that highlights their conceptual and practical differences, creating a basis for assessing their applicability to scientific institutions. The second is an empirical application

of this comparative analysis to a large-scale research organization, providing insights into the governance challenges and opportunities faced by STIs in adopting comprehensive sustainability reporting (Larrue, P., 2022; UNESCO, 2015; Bose, 2020; De Lima et al., 2016).

By situating CERN within this dual framework, the thesis aims to deliver both theoretical and practical contributions. Theoretically, it advances the debate on how sustainability reporting frameworks can be adapted for research institutions, whose objectives differ fundamentally from those of corporate entities. Practically, it offers CERN an evidence-based assessment of whether incorporating elements from CSRD (and ESRS), EMAS or ISO alongside GRI would enhance its ESG governance, or whether refining its existing GRI-based approach can achieve the same outcome.

Statement on the use of Artificial Intelligence (AI)

This thesis made limited and transparent use of AI-based tools to support the writing and organizational process. ChatGPT was primarily used to (i) improve clarity and readability of selected paragraphs, (ii) refine academic wording and transitions, and (iii) generate alternative formulations and outlines that then was reviewed and edited. Google NotebookLM was also used to (i) organize and navigate different source materials, (ii) support notetaking and synthesis of uploaded documents, and (iii) help retrieve key passages and structure summaries of those materials. MeetGeek was also used to transcript the interviews but always without sharing any personal data. AI tools were not used to generate empirical data, fabricate references, or replace the core analytical work. All framework comparisons, selection of evidence, interpretations, and conclusions remain my own responsibility. To mitigate known risks (e.g., factual errors, omissions, or over-generalization), any AI-assisted output was systematically reviewed and, where it implied factual claims, cross-checked against primary sources and the thesis dataset before inclusion. No confidential or personally sensitive information was shared with AI tools.

CHAPTER 1 – THE EMERGENCE AND EVOLUTION OF ESG AND SUSTAINABILITY REPORTING

This chapter sets the conceptual foundations for the thesis by tracing the emergence and evolution of ESG and sustainability reporting, and by clarifying why reporting has become central to contemporary governance expectations. It first situates sustainability reporting within a broader historical trajectory, from early debates on corporate responsibility and sustainable development to more recent frameworks that articulate ecological limits and multidimensional sustainability.

Building on this background, the chapter then conceptualises ESG and sustainability reporting as governance tools rather than purely communicative outputs. It introduces the core principles that underpin credible reporting (materiality, stakeholder engagement, and transparency) and shows how these principles shape what is reported, why it is prioritised, and how accountability is constructed. Finally, the chapter maps the main reporting and management frameworks discussed in this thesis (GRI, CSRD/ESRS, EMAS, ISO 14001 and ISO 26000) and concludes with a comparative synthesis that identifies key points of convergence and divergence across them. This provides the analytical basis for the subsequent chapters, which move from general framework comparison to the institutional case study.

1.2. BACKGROUND AND CONTEXT

In 1950, the economist Howard Bowen in his publication Social Responsibilities of the Businessman coined the term Corporate Social Responsibility (CSR). The concept of corporate responsibility initially focused on the accountability of businesses for their actions in society and their immediate environment (Delgado-Ceballos et al., 2022).

In parallel, in 1972, the publication of *The Limits to Growth* written by the Club of Rome[1] marked another turning point, highlighting the need to change our society's growth patterns to meet human needs within the means of the living planet. This growing concern about the adverse effects of business operations on the natural environment, fuelled the conversation on corporate sustainability, which grew alongside CSR in the 1980s (Delgado-Ceballos et al., 2022).

In this context, the UN introduced the term sustainable development in 1987 through the Brundtland Report. This iconic definition describes sustainability as the ability to "meet the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987, p. 16). As Richard Barker (2015) later noted, this definition carries an implicit message: sustainability is less about "doing good" and more about "doing no harm". It requires leaving future generations with at least the same capacity for well-being and development as current ones.

In the decades that followed, sustainability was increasingly conceptualized as a tri-dimensional construct, encompassing economic integrity, social equity, and environmental resilience. This perspective gave rise to the influential Triple Bottom Line approach, also known as the 3Ps (Profit,

[1] Founded in 1968 by Aurelio Peccei and Alexander King, the Club of Rome is an independent network applying long-term, systemic analysis to interconnected global problems promoting holistic, interdisciplinary and long-range approaches to planetary and societal wellbeing (Clube of Rome, n.d.).

People, and Planet) which became a dominant model for evaluating business and institutional sustainability (Elkington, 1997; Hart & Milstein, 2003, as cited in Delgado-Ceballos et al., 2023).

The launch of the UN Sustainable Development Goals (SDGs) in 2015 further solidified this integrated vision. According to Barker (2015), these goals illustrate two complementary pillars of sustainability: one focused on safeguarding natural capital, and the other on advancing human rights and societal well-being.

In this context, sustainability is no longer simply about mitigating harm or reducing environmental footprints, it is about operating within safe ecological limits to preserve the fundamental life-support systems on which all economic and social systems depend. This also pushed organizations, governments, and institutions to reconsider their governance, measurement tools, and reporting mechanisms. And therefore, to communicate their sustainability efforts in a structured, transparent, and credible way. This gave birth to the field of sustainability reporting, which has rapidly evolved over the last two decades. Starting with voluntary initiatives like the GRI in the late 1990s, the field has expanded to include a wide range of frameworks such as EMAS, ISO 14001/26000, and most recently the CSRD and ESRS.

Building on this logic, the concept of planetary boundaries also provided a scientific framework for understanding the Earth's ecological limits. This framework identifies nine critical earth system processes for which there are quantifiable thresholds. The planetary boundaries framework thus reinforces the Brundtland Commission's principle of intergenerational equity, by making visible the ecological ceilings that constrain human activity.

Initially focused on environmental performance, sustainability reporting now addresses a much broader spectrum of concerns, including human rights, equity, climate risks, biodiversity, and responsible supply chains. As frameworks proliferated, so too did debates around their standardization, credibility, and effectiveness. While some have criticized the "alphabet soup" of overlapping standards, others argue that this diversity reflects the complexity and evolving nature of sustainability itself (Bose, 2022).

In short, the emergence of sustainability reporting reflects not just a technical need for disclosure, but a deeper shift in how institutions are expected to act, be evaluated, and contribute to a liveable future.

1.3. ESG AND SUSTAINABILITY REPORTING AS GOVERNANCE TOOLS

In recent years, ESG and sustainability reporting have moved far beyond their original function as transparency instruments. Sustainability reporting enables not only external accountability but also internal reflection, creating a structured space for organizations to evaluate and improve their performance across ESG dimensions (Barker, 2023; Delgado-Ceballos et al., 2023).

Frameworks such as the ones analysed on this thesis, establish standardized procedures to collect, evaluate, and disclose non-financial information. While these frameworks were initially developed to meet the needs of external stakeholders, they are now used as internal tools to steer risk management, resource allocation, and strategic planning. In doing so, they have become central mechanisms for setting priorities, evaluating trade-offs, and embedding sustainability within the governance architecture of an organization (Farrell & Chater-Lea, 2023; Köster, 2024).

According to Barker (2023), sustainability reports serve as signals of institutional responsibility and intention. They translate abstract values, such as climate action, social equity, or human rights, into measurable and reportable commitments, thereby contributing to internal governance coherence. It reflects a shift from reactive compliance to proactive stewardship.

Moreover, the integration of ESG into corporate and institutional governance is increasingly mandated by law. The CSRD, which represents a significant evolution in European Union (EU) sustainability regulation, not only expands the scope and depth of required disclosures but also obliges companies to report how ESG matters are embedded into their governance structures (European Commission, 2023). As a result, reporting is not an isolated compliance task but a strategic requirement for navigating contemporary governance expectations (Barker, 2023; Delgado-Ceballos et al., 2023).

The landscape of sustainability reporting is becoming more complex. Frameworks are principle-based tools that define what topics should be covered and why, guiding the structure and themes of sustainability disclosure. In contrast, standards are more technical and detailed, specifying how information should be reported through precise metrics and methodologies (Byrne, 2024; Akshay, 2025). For instance, GRI represents a flexible framework that emphasizes broad stakeholder impact and global applicability (GRI, 2023). ESRS, under the CSRD regulation, is the first set of European standards that establishes more prescriptive grounded in the concept of double materiality requiring entities to disclose both how sustainability issues affect them and how they impact society (EFRAG, 2023; Köster, 2024). As will be further elaborated in the following sections, each reporting framework and standard responds to distinct objectives and target audiences within the sustainability landscape (IFC, 2023; Köster, 2024).

Thus, modern sustainability reporting serves dual roles: it functions as a mirror, reflecting an organization's current ESG impacts, internal values, and alignment with stakeholder and societal expectations (Barker, 2023; GRI, 2023); and it operates as a lever, actively driving institutional transformation (Delgado-Ceballos et al., 2023; Farrell & Chater-Lea, 2023). This duality elevates sustainability reporting from a compliance-oriented disclosure practice to a central mechanism for shaping long-term strategy, managing non-financial risks, and enhancing organizational resilience (European Commission, 2023; EFRAG, 2023). It is becoming a core pillar of institutional governance and long-term value creation (IFRS, 2024; Köster, 2024).

Having established sustainability reporting as a governance tool, it becomes critical to define what is reported and why. This leads to the concept of materiality: the cornerstone of credible and effective ESG disclosure.

1.3.1. Materiality and Double Materiality Concepts

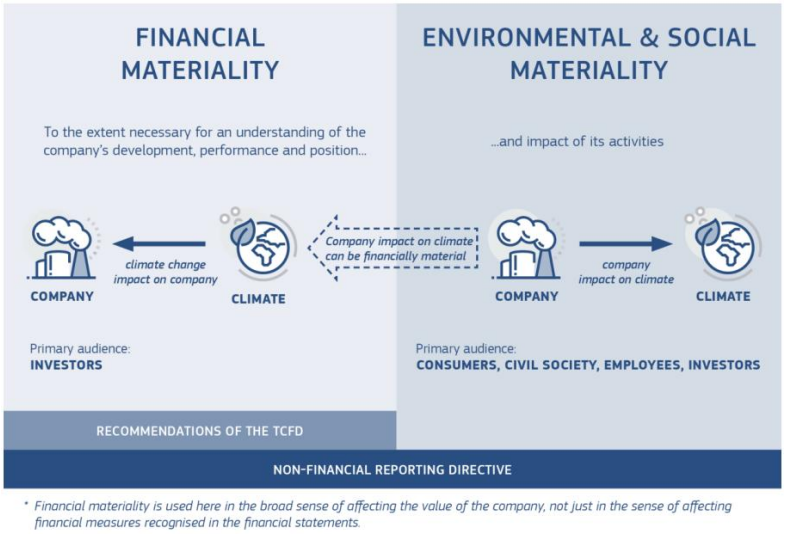
Materiality lies at the heart of all major sustainability frameworks and standards, operating as a filtering mechanism to determine which topics warrant disclosure based on their capacity to influence decision-making or reflect significant impacts (TCFD, 2017; IFRS, 2024). Traditionally, materiality was defined through a financial lens: information is material if its omission, misstatement, or obscuring could reasonably be expected to influence investors' decisions (IFRS, 2024), and misstatements are material when they could alter users' economic decisions (Financial Reporting Council, 2021). This investor-focused interpretation has historically underpinned corporate

financial reporting and continues to guide investor-centric standards such as those developed by SASB and the ISSB.

As sustainability reporting evolved, so too did the concept of materiality. The EU's Non-Financial Reporting Directive (NFRD) and its successor, the CSRD, introduced the concept of double materiality, a model that combines two distinct but complementary perspectives. On one side, financial materiality, which addresses how sustainability issues may affect a company's financial performance and enterprise value. This is often called the "outside-in" perspective. On the other side, impact materiality, or the "inside-out" perspective, which considers the impacts that an organization has on society and the environment (European Commission, 2023).

This expanded model is embedded in the ESRS, developed by the European Financial Reporting Advisory Group (EFRAG). As shown in Figure 1.1., according to EFRAG, material matters include those that reflect significant impacts on people and the environment (impact materiality) as well as sustainability risks and opportunities that may affect the undertaking's financial performance (financial materiality), and these impacts must be considered across upstream and downstream value chains, not just within an organisation's own operations (EFRAG, 2023). Therefore, the materiality assessment process becomes a cornerstone of ESG governance, guiding how relevant topics are selected, justified, and monitored over time (EFRAG, 2023).

Figure 1.1. *The double materiality perspective of the NFRD.*



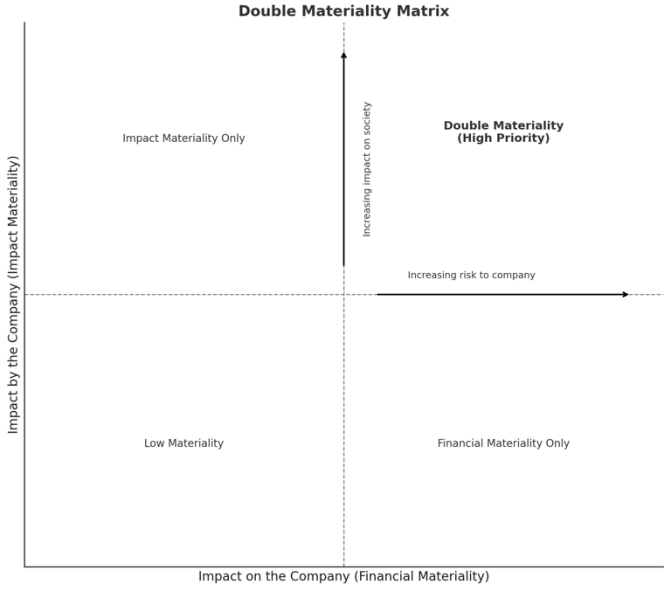
Source: European Commission (2019).

Materiality is also a socio-political construct: in Europe it shifted from predominantly financial interpretations toward double materiality following the adoption of the UN SDGs and the Paris Agreement in 2015, was introduced into Commission guidelines for climate-related disclosures in 2019, and became regulatory with the CSRD (Baumüller & Sopp, 2021). The CSRD further strengthens accountability by requiring disclosure of the materiality assessment process itself while EFRAG has been mandated to develop the ESRS based on this principle, aiming to connect financial and non-financial information within a unified reporting logic (Baumüller & Sopp, 2021; De Cristofaro & Gulluscio, 2023).

To operationalize double materiality, many organizations use a double materiality matrix. As illustrated in Figure 1.2, this tool visually plots ESG issues along two axes: one measuring financial materiality and the other assessing impact materiality. Topics that rank highly on both dimensions

(those found in the upper-right quadrant) are considered the most strategic and are prioritized in both disclosure and governance decision-making. For example, climate change, supply chain impacts, and data ethics often appear in this high-priority zone (GRI, 2023; Köster, 2024). The matrix format not only supports transparency in how priorities are set but also helps communicate governance logic to external audiences.

Figure 1.2. **The Double Materiality Matrix.**



Source: Own contribution based on EFRAG (2023), GRI (2023) and Köster (2024).

A robust materiality assessment process typically involves identifying relevant sustainability issues, engaging with internal and external stakeholders, evaluating the significance of each issue using defined criteria, and integrating the resulting material topics into governance structures and strategic planning. Yet this process is not without its challenges. Adams et al. (2021) highlight that many companies provide inadequate disclosure on how material topics are defined and prioritized. Often, there is little detail on the methods used, the rationale behind including certain issues while excluding others. Additionally, the distinction between financial and sustainability materiality remains ambiguous, and companies may prioritize short-term financial risks over long-term sustainability concerns.

Empirical research by De Cristofaro and Gulluscio (2023) on 58 companies between 2019 and 2021 demonstrates that adoption of double materiality remains limited and inconsistent. Only a minority of companies explicitly referenced the concept, and even among those that did, the level of disclosure and methodological rigor varied widely. While some firms implemented assessments, others provided vague narratives. Furthermore, disclosures often lacked clarity on how the two pillars of materiality were integrated, how stakeholder inputs were weighted, or how thresholds were determined.

As will be demonstrated in the following sections, these differences may be partly explained by the fact that various standards and frameworks conceptualize and apply materiality in distinct ways.

Despite these challenges, double materiality offers clear advantages. It promotes a broader understanding of corporate accountability, encourages dialogue with stakeholders, and aligns corporate strategy with societal expectations and long-term value creation. Ultimately, materiality and

double materiality are foundational to effective and credible sustainability reporting. They help ensure that disclosures are not only aligned with regulatory requirements and investor expectations, but also meaningful in terms of real-world impact. By embedding both financial and impact dimensions into their reporting practices, organizations can also enhance their accountability.

While materiality defines what should be reported, stakeholder engagement and transparency shape how those decisions are made and communicated. The identification of material topics does not occur in a vacuum, it is fundamentally influenced by who is consulted, whose voices are heard, and how information is disclosed. In this sense, stakeholder engagement and transparency are not merely complementary to materiality; they are intrinsic to its credibility and legitimacy. The next section explores these two interconnected pillars.

1.3.2. STAKEHOLDER ENGAGEMENT AND TRANSPARENCY

As sustainability governance evolves, stakeholder engagement and transparency have emerged not only as just procedural requirements but essential mechanisms for enhancing accountability, legitimacy, and societal responsiveness. As outlined in the Brundtland Report, sustainable development requires the active participation of all sectors of society (WCED, 1987), acknowledging that meaningful decisions cannot be made without the input of those directly or indirectly affected by them.

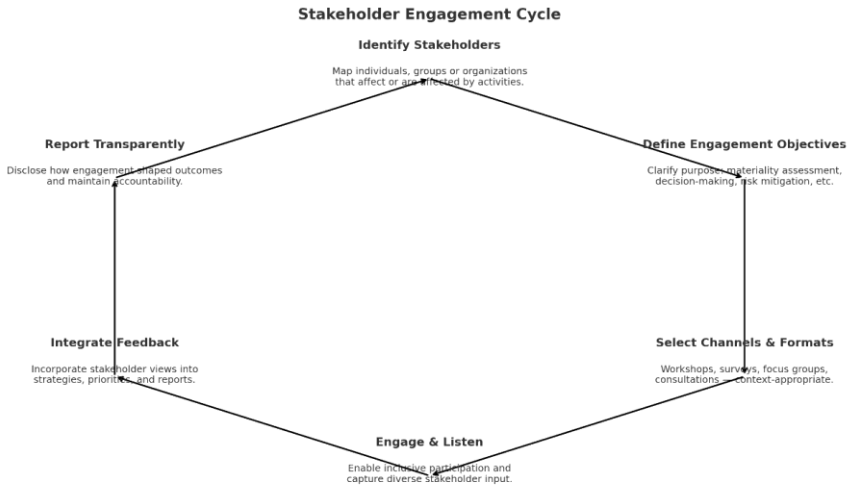
Stakeholder engagement refers to the involvement of individuals, groups, or organizations that affect and/or could be affected by an entity's activities, products, services, and performance. This broad category includes employees, consumers, local communities, non-governmental organizations (NGOs), investors, suppliers, and public institutions (Baumüller & Sopp, 2021). It is grounded in the principle of inclusivity, which holds that people should have a say in the decisions that impact them.

Engaging stakeholders meaningfully brings multiple benefits: it helps identify material topics, enhances the legitimacy of decision-making, fosters accountability, and encourages social and political change. As Adams et al. (2021) emphasize, stakeholder engagement enables companies to capture a wider range of perspectives and to articulate shared priorities in complex sustainability contexts. Furthermore, the Brundtland Report highlights that without widespread consultation and the "incorporation of the opinion of the masses," (WCED, 1987, p. 91) sustainability decisions risk failure or rejection may occur, particularly when imposed top-down.

Stakeholder involvement also contributes to a comprehensive understanding of sustainability, ensuring that governance decisions reflect real-world impacts and the aspirations of affected people. It is especially relevant in the European regulatory context, where directives such as the CSRD require companies to disclose not only what they report, but also how stakeholders were involved in defining those priorities.

Effective engagement is built on appropriate formats, accessible channels, and regular frequency. Tools like surveys, public consultations, interviews, and participatory forums must be selected and adapted based on stakeholder profiles and local context. Critically, the process should be iterative, allowing for continued input as sustainability strategies evolve.

Figure 1.3. *Stakeholder Engagement Cycle*



Source: Own contribution based on principles outlined by the GRI (2023), Adams et al. (2021), and the World Commission on Environment and Development (1987).

Figure 1.3 represents the Stakeholder Engagement Cycle, an iterative process that illustrates how organizations can effectively involve stakeholders in their sustainability governance (GRI, 2023). It begins with identifying relevant individuals, groups, or institutions affected by, or capable of affecting, the organization's activities and decisions (Baumüller & Sopp, 2021). Once stakeholders are mapped, the next step is to define clear engagement objectives, such as informing materiality assessments, managing risks, or shaping sustainability strategies (Adams et al., 2021). Organizations then select appropriate channels and format, such as surveys, interviews, or public consultations, tailored to the context and capacities of different stakeholder groups (WCED, 1987). Through these mechanisms, stakeholders are invited to express their views, enabling the organization to listen actively and gather diverse, and sometimes conflicting, inputs (Adams et al., 2021). These insights are then integrated into strategic planning, the definition of material topics, and governance processes. Finally, the cycle is completed by reporting transparently on how stakeholder feedback influenced outcomes, thereby reinforcing accountability and closing the loop (GRI, 2023; Barker, 2025). The cyclical nature of this process underscores that stakeholder engagement is not a one-time exercise, but a continuous dialogue that evolves in parallel with the organization's sustainability performance.

Closely linked to engagement is the principle of transparency. Transparency entails the full, accurate, and accessible disclosure of material risks, impacts, and governance processes. According to Barker (2025), it must be complete, fair, and truthful, avoiding the selective or manipulative presentation of information. As Bose (2020) explains, transparent sustainability disclosure improves the reliability of data, enhances comparability across firms, and supports better decision-making.

Transparency also plays a critical role in reducing greenwashing. Standardized reporting frameworks such as the ESRS are designed to strengthen the credibility of sustainability data by using specific mechanisms (Wagenhofer, 2023; Barker, 2025). When done well, transparency offers strategic and reputational advantages. It lowers capital costs, improves stakeholder trust, and enables companies to anticipate ESG risks rather than merely respond to them (Bell & Voorhees, 2020). However, transparency is not without challenges: ambiguity in definitions, inconsistent narratives,

underreporting, and report fatigue can all hinder its effectiveness (Baumüller & Sopp, 2021; De Cristofaro & Gulluscio, 2023).

Connecting this point with the previous section, in the EU context, the principle of double materiality represents the intersection of engagement and transparency. By requiring firms to report on both financial and impact materiality, the EU mandates a holistic view that reflects stakeholder expectations and societal impact. Yet, as Adams et al. (2021) note, inadequate disclosure of how material topics are identified and prioritized may undermine the legitimacy of even the most sophisticated reports.

In summary, stakeholder engagement and transparency are interdependent pillars of responsible sustainability governance. Together, they reinforce inclusive decision-making, improve the credibility of disclosures, and help bridge the gap between corporate behaviour and societal expectations.

Having explored the core principles that underpin credible sustainability reporting it is essential to understand how these principles are operationalized in practice: through sustainability frameworks.

1.4. LANDSCAPE OF SUSTAINABILITY FRAMEWORKS: GRI, CSRD (AND ESRS), EMAS AND ISO

The purpose of this section is to provide a structured overview of the main frameworks that have shaped contemporary sustainability reporting and sustainability management in the European context, as already outlined in the previous discussion of reporting complexity and the distinction between "frameworks" and "standards." To ensure clarity and comparability, each instrument is presented separately, because it is grounded in a different underlying logic, ranging from voluntary global reporting standards, to EU regulatory requirements and technical disclosure standards, to environmental management schemes and non-certifiable guidance on social responsibility.

Across the following sub-sections, the discussion focuses consistently on how each instrument frames the purpose of reporting or management, what it prioritises (including how "materiality" or significance is approached), how it treats stakeholders and transparency, and what credibility mechanisms are embedded (such as assurance, verification, or certification). This descriptive mapping is necessary before moving to the comparative synthesis at the end of the chapter, and it establishes the conceptual basis for assessing relevance and applicability in the CERN case study developed in later chapters.

1.4.1. GLOBAL REPORTING INITIATIVE (GRI)

The GRI originated in Boston in 1997 under the initiative of the North American Coalition for Environmentally Responsible Economies and the Tellus Institute, with United Nations Environment Program (UNEP) involvement since 1999 to ensure an international perspective, has the objective of providing "information guidelines to present a clearer vision of the human and ecological impacts of an enterprise. In addition, one of the GRI's main functions is to enable

shareholders and other stakeholders to make well-informed decisions regarding investments" (Marimon et al., 2012, p. 134).

Its early trajectory moved through four guideline generations (G1 (2000), G2 (2002), G3 (2006) and G4 (2013)) before a decisive pivot in 2016 to a codified standards regime. Conceptually, GRI Standards encodes a modular, impact-based architecture that turns a broad normative agenda into reportable, verifiable disclosures

Structurally, the Universal layer was reorganized in 2021 into GRI 1: Foundation 2021, GRI 2: General Disclosures 2021, and GRI 3: Material Topics 2021(GRI, 2021). In practice, GRI 1 sets conditions to report in accordance and quality principles (e.g., accuracy, balance, and verifiability); GRI 2 situates the organization (structure and reporting practices, activities and workers, governance, strategy, policies, practices, stakeholder engagement); and GRI 3 sets out the stepwise method to identify, assess, prioritize and disclose material topics, including how each topic is managed (GRI, 2021).

Sector Standards operationalize completeness at industry level pointing to relevant Topic-Standard disclosures. One crucial point is that "if an applicable Sector Standard is available, an organization is obliged to use it when reporting with the GRI Standards" (GRI, n.d.). Sector Standards, therefore, function as systematic checks against sector-salient blind spots, drawing on multi-stakeholder expertise and intergovernmental instruments (GRI, n.d.). Topic Standards then provide topic-specific scorecards (e.g., Waste, Occupational Health & Safety, Tax) that specify both performance disclosures and management approach, with selection driven by the entity's material topics rather than by a fixed checklist (GRI, n.d.).

GRI ties materiality to traceability through its reporting mechanics. The preferred route is to report in accordance, meaning meeting Universal requirements and covering all material topics and their management. Reporting with reference is permitted where full alignment is not feasible for narrower purposes. In both cases, a GRI content index is mandatory. Since 2016, GRI has evolved both the content and the infrastructure of the system. GRI notes that more than 14,000 organizations around the world use GRI, with the Standards referenced in over 289 public policies across 102 countries (GRI, 2024).

Adoption data reinforce GRI's position as the baseline layer for impact reporting. KPMG's Survey of Sustainability Reporting 2024 (5,800 companies; 58 countries) reports GRI usage at 71% among the N100 and 77% among the G250 (KPMG, 2024).

Finally, GRI frames the Standards as governance infrastructure for producers and users of information alike: they enable any organization to understand their impacts on ESG topics in a credible way (GRI, n.d.). In effect, the Universal–Sector–Topic architecture links material impacts to governance, strategy and management disclosures, while the content index and reasons-for-omission device secure traceability (GRI, n.d.).

1.4.2. CORPORATE SUSTAINABILITY REPORTING DIRECTIVE (CSRD)

The CSRD constitutes the EU legal "container" for sustainability reporting. Adopted as Directive (EU) 2022/2464, it revises the EU corporate reporting architecture by strengthening and expanding sustainability disclosure obligations (European Union, 2022). The European Commission

frames this reform as a means to improve the availability and comparability of sustainability information for stakeholders, and confirms that undertakings subject to the CSRD must report in accordance with the ESRS (European Commission, 2025).

A key structural feature of the CSRD is that sustainability information must be embedded within mainstream corporate reporting: undertakings are required to include sustainability reporting in the management report, and the sustainability information must be clearly identifiable through a dedicated section (European Union, 2022). This design choice is explicitly intended to enhance the connectivity between financial and sustainability information (European Union, 2022).

The CSRD also introduces assurance requirements. The Directive articulates a phased approach whereby sustainability reporting is subject to an assurance engagement, starting with limited assurance, while keeping open a potential move to reasonable assurance once the necessary standards are in place at EU level (European Union, 2022). Importantly, the Directive clarifies that the assurance opinion should cover (i) compliance of sustainability reporting with EU requirements and reporting standards, (ii) the process used to identify the reported information, and (iii) compliance with requirements related to the tagging of sustainability information (European Union, 2022).

Finally, the CSRD places strong emphasis on digital accessibility and machine-readability. It requires undertakings to prepare the management report in the electronic reporting format specified by EU rules on the single electronic reporting format and to mark-up sustainability reporting so that it can be efficiently used and compared by data users (European Union, 2022; European Commission, 2024).

Against this background, the ESRS serve as the technical disclosure standards that operationalize the CSRD's legal requirements by specifying what must be reported and how sustainability statements should be structured (European Union, 2023; European Commission, 2025).

1.4.3. EUROPEAN SUSTAINABILITY REPORTING STANDARDS (ESRS)

The ESRS function as the foundational technical framework designed specifically to implement the legislative requirements outlined in the CSRD (Mays, R. & Daphne, T., 2024). While the CSRD establishes the legal vision, principles, and objectives for sustainability reporting within the EU, the ESRS provide the detailed operational guidelines, identifying the necessary materials, measurements, and processes required for implementation. The primary objective of the ESRS is to standardize sustainability reporting across the EU, integrating sustainability considerations directly into corporate strategy and promoting transparency for consumers and stakeholders (Mays, R. & Daphne, T., 2024). The first set of 12 ESRS standards, covering environmental, social, and governance issues, was formally adopted by the European Commission on July 31, 2023, and was subsequently published in the Official Journal on December 22, 2023 (Mays, R. & Daphne, T., 2024; European Commission, n.d.; Ernst & Young, 2023).

The ESRS reporting obligation applies to a wide range of companies, including all large companies (listed or not) and listed small or medium-sized entities (SMEs), excluding listed micro-companies. The application of the standards is phased: companies already subject to the NFRD apply the rules starting from the financial year 2024; other large companies start in 2025; and listed SMEs start in 2026 (Mays, R. & Daphne, T., 2024).

The framework is constructed around several foundational concepts critical for subsequent comparative analysis with other global frameworks. The most distinguishing concept is double materiality (Mays, R. & Daphne, T., 2024). Furthermore, the ESRS mandate the inclusion of information regarding the entire upstream and downstream value chain, encompassing activities, resources, and relationships beyond the company's own operations (Ernst & Young, 2023). The standards also incorporate the concept of sustainability due diligence, closely aligning reporting requirements with the upcoming Corporate Sustainability Due Diligence Directive, whose aim is "to foster sustainable and responsible corporate behaviour in companies' operations and across their global value chains" (European Commission, n.d., para. 1).

The first set of ESRS consists of 12 standards in total: two mandatory cross-cutting standards (ESRS 1 and ESRS 2) and ten topical standards (Ernst & Young, 2023). These topical standards are crucial because they prescribe the specific disclosure requirements covering ESG matters, more specifically, covering the following four reporting areas: governance, strategy, impact/risk/opportunity management, and metrics and targets, all in relation to the specific topic at hand. The applicability of the majority of disclosures within these topical standards is dependent on the outcome of the double materiality assessment (Mays, R. & Daphne, T., 2024).

As summarised in Table 1.1, the ten ESRS topical standards translate the ESRS architecture into concrete ESG disclosure areas, while still remaining conditional on the outcome of the double materiality assessment for most datapoints (Mays, R. & Daphne, T., 2024; Ernst & Young, 2023). On the environmental side, ESRS E1–E5 cover climate change, pollution, water and marine resources, biodiversity and ecosystems, and resource use/circular economy, thereby framing how undertakings explain impacts and transition-related adaptations in line with EU sustainability objectives (Mays, R. & Daphne, T., 2024; Ernst & Young, 2023). A key comparability feature highlighted in the table is the special status of ESRS E1 (Climate change): even if an undertaking concludes climate change is not material, it must provide a detailed justification and a forward-looking statement, making non-disclosure harder than for other topics (Mays, R. & Daphne, T., 2024). Social requirements are structured through ESRS S1–S4, moving from the undertaking's own workforce to workers in the value chain, affected communities, and consumers/end-users explicitly extending reporting expectations beyond the entity's direct operations and reinforcing the ESRS emphasis on value-chain considerations (Mays, R. & Daphne, T., 2024; Ernst & Young, 2023). Finally, governance disclosures are consolidated in ESRS G1 (Business conduct), focusing on issues such as corporate culture, anti-corruption/anti-bribery, political influence, supplier relationships, and payment practices, which together operationalise "G" in a way that is directly traceable in the sustainability statement structure (Mays, R. & Daphne, T., 2024; Ernst & Young, 2023).

Table 1.1. *Overview of ESRS topical standards and their main focus.*

Category	Standards	Main focus
Environmental (E1-E5)	E1 Climate change E2 Pollution	Mandates disclosure of climate transition plans. ESRS E1 is uniquely difficult to omit, requiring detailed

	E3 Water and marine resources E4 Biodiversity and ecosystems E5 Resource use and circular economy	justification and a forwards-looking statement even if deemed immaterial. These standards cover comprehensive environmental objectives related to the European Green Deal.
Social (S1-S4)	S1 Own workforce S2 Workers in the value chain S3 Affected communities S4 Consumers and end-users	Requires extensive human rights and worker well-being disclosures that explicitly extend beyond the undertaking's own operations (S2, S3, S4) to cover the entire value chain.
Governance (G1)	G1 Business conduct	Focuses on corporate culture, anti-corruption, anti-bribery, political influence and management of supplier payment practices.

Source: Own contribution based on the analysis made by Ernst & Young (2023) and Mays, R. & Daphne, T. (2024).

While this first set of 12 standards, the full ESRS architecture also foresees the future publication of sector-specific standards and proportionate standards for SMEs (Ernst & Young, 2023). EFRAG is currently developing draft versions for several high-impact sectors and financial institutions, though this project has been paused pending the outcome of the Omnibus proposal[2] (EFRAG, n.d.). EFRAG is also working to ensure a high level of interoperability between the mandatory ESRS disclosure requirements and other international sustainability reporting frameworks, such as those published by the ISSB and the GRI, aiming to prevent undertakings from having to conduct double disclosure efforts (Ernst & Young, 2023).

1.4.4. ECO-MANAGEMENT AND AUDIT SCHEME (EMAS)

The EMAS is the official environmental management tool established by the EU and governed by the European Commission. Introduced initially in July 1993 by Regulation 1836/93, its purpose was to serve as an environmental policy tool promoting the goal of sustainable development. The current operational framework is set in Regulation No 1221/2009 (Green Progress, n.d.). EMAS's core objective is to drive organizations toward circularity, reduce their environmental impact, and foster the continuous improvement and regular verification of their overall environmental performance (European Commission, n.d.). The scheme is entirely voluntary, yet it maintains a reputation as the highest standard in environmental management within the EU. EMAS is available for voluntary participation by companies, public administrations, and organizations of any size or sector, both within and outside the EU (Green Progress, n.d., European Commission, n.d.).

[2] «The Digital Omnibus proposal includes a set of technical amendments to a large corpus of digital legislation, selected to bring immediate relief to businesses, public administrations, and citizens alike, and to stimulate competitiveness» (European Commission, 2025).

Adopting EMAS commits organizations to achieving continuous improvement in their environmental performance. This commitment is formalized through a detailed process starting with an Environmental Review, which requires organizations to identify their environmental aspects and ensure legal compliance (Department of Climate, Energy and the Environment, 2025). A crucial element that addresses the significance of issues (analogous to the concept of materiality) is the requirement to explicitly identify the organization's direct and indirect environmental impacts and subsequently establish voluntary objectives and targets to reduce them (European Commission, n.d.). The goal is to establish and implement a robust Environmental Management System (EMS) (European Commission, n.d.; Department of Climate, Energy and the Environment, 2025; Green Progress, n.d.). The efforts and compliance of the organization are recognized and validated by an independent, third-party accredited environmental verifier. The scheme also recognizes the importance of active employee involvement and training in achieving its goals (European Commission, n.d.; Department of Climate, Energy and the Environment, 2025; Green Progress, n.d.).

A significant aspect of EMAS for comparative analysis is its relationship with the international standard ISO 14001. The international environmental management system standard ISO 14001:1996 was recognized as a step toward achieving EMAS as early as 1996 (European Commission, n.d.). While EMAS incorporates all requirements of ISO 14001, it extends beyond the scope of that standard in several key areas (European Commission, n.d.).

As highlighted in the article of Green Progress (n.d.), to ensure comparability and systematic evaluation of performance related to their identified impacts, EMAS mandates that registered organizations report on seven core environmental KPIs (Department of Climate, Energy and the Environment, 2025; Green Progress, n.d.). These indicators must be quantifiable, comparable, and validated by the verifier. The required areas for reporting are: Greenhouse gas emissions (Em1), Air pollutant emissions (Em2), Energy efficiency (Em3), Material efficiency (Em4), Water (Em5), Waste (Em6), and Biodiversity (Em7) (Green Progress, n.d.).

In summary, EMAS is positioned as a premium management instrument that balances environmental responsibility with business success (Green Progress, n.d.; European Commission, n.d.). The independent verification and public transparency afforded by EMAS enhance credibility and provide a competitive advantage, particularly in green procurement (Department of Climate, Energy and the Environment, 2025; Green Progress, n.d.).

1.4.5. ISO 14001 AND ISO 26000

ISO 140001 is an EMS standard that provides a structured framework to manage environmental responsibilities and support continual improvement. First published in 1996, it has been revised several times, with the most substantial update in 2015 (ISO, n.d.). Its logic is grounded in the iterative Plan-Do-Check-Act cycle (ISO, n.d.), and it remains one of the most widely adopted management system standards globally (Yin & Schmeidler, 2008).

In terms of ESG coverage, ISO 14001 focuses primarily on the Environmental dimension by specifying the elements needed to implement an effective EMS (Bravi et al., 2020). The intended outcomes include improved environmental performance, fulfilment of compliance obligations, and achievement of environmental objectives (ISO, n.d.). The standard supports environmental protection by preventing or mitigating adverse impacts, addressing environmental conditions that may

affect the organization, and encouraging control or influence across activities, products, and services (ISO, n.d.). However, ISO 14001 is fundamentally a process-based instrument: it requires organizations to establish and maintain a management system but does not prescribe specific performance outcomes (e.g., pollution reduction) and does not necessarily require public disclosure beyond regulatory compliance (Yin & Schmeidler, 2008; Rondinelli & Vastag, 2000).

Regarding governance, the 2015 revision follows the High Level Structure, facilitating alignment with other ISO management system standards (ISO, n.d.). The standard strengthens the role of top management, requiring leadership to integrate environmental management into business processes, strategic direction, and decision-making (ISO, n.d.).

Materiality and risk are addressed through understanding the organization's context and planning. Organizations must identify relevant internal and external issues, as well as the needs and expectations of interested parties (ISO, n.d.). This contextual analysis supports identifying environmental conditions that may affect, or be affected by, the organization's activities (Alzate-Ibañez et al., 2018). ISO 14001 also explicitly requires consideration of risk and opportunities linked to environmental aspects and compliance obligations (ISO, n.d.; Alzate-Ibañez et al., 2018). A key novelty of the 2015 version is the explicit requirement to adopt a life cycle perspective when determining environmental aspects (ISO, n.d.; Alzate-Ibañez et al., 2018).

Stakeholder engagement is framed through the identification and management of "interested parties" (ISO, n.d.), including regulators, communities, customers, suppliers, NGOs, investors, and employees. Adoption is often influenced by external pressures and legitimacy concerns, such as customer requirements or regulatory expectations, with certification sometimes used to signal environmental commitment and enhance market access (Yin & Schmeidler, 2008; Bravi et al., 2020).

As summarized in Table 1.2., a key issue in practice is the heterogeneity of outcomes: organizations may adopt the same standardized tool but implement it differently depending on resources, capabilities, and organizational norms (Yin & Schmeidler, 2008). Implementation can become symbolic, focusing on documentation and audit readiness rather than operational change. By contrast, more substantive implementation, integrated into daily routines and accompanied by performance management, has been associated with greater reported improvements and stronger attribution of gains to certification (Yin & Schmeidler, 2008).

Table 1.2. *Impact of ISO 14001 depending on the organizational strategy employed.*

Implementation Strategy	Characteristics	Environmental Outcome
Substantive / Integrated	Actively integrate ISO standards into daily operations;	More likely to report greater environmental performance improvement;

	Involve employees and production managers; Include performance management elements.	Higher attribution of improvement ot certification.
Symbolic / Ceremonial	Focus on superficial implementation (paperwork); Doing the bare minimum necessary to gain certification.	Environmental improvement is limited; Perceived risk of "symbolic" adoption without substantial environmental commitment.

Source: Own contribution based on the analysis made by Yin and Schmeidler (2008) and Bravi et al. (2020).

Bravi et al., (2020) also pointed out some practical barriers, particularly impacting smaller firms, such as the increase in bureaucracy and the onerous costs. Additionally, the vague nature of the standard regarding the measurement of actual environmental impacts and difficulty in measuring the standard's overall efficiency.

After presenting ISO 14001 as a certifiable, largely process-based environmental management standard (ISO, n.d.), the discussion now turns to ISO 26000, a guidance standard on social responsibility (ISO, 2010).

The ISO 26000 represents a unique international standard designed in 2010 to assist organizations in contributing to sustainable development by translating principles into effective actions (Popa & Dabija, 2018). Unlike traditional management standards such as ISO 14001, ISO 26000 is explicitly non-certifiable and does not contain requirements, serving instead as a voluntary guidance document applicable to all types of organizations regardless of their size or location (Pojasek, 2011; ISO, 2010). In terms of ESG coverage, the standard provides a holistic framework through seven core subjects: organizational governance, human rights, labour practices, the environment, fair operating practices, consumer issues, and community involvement and development (ISO, 2010).

ISO 26000 places organizational governance at the centre of the framework, viewing it as the most crucial core subject because it provides the system through which an organization makes and implements decisions to achieve its objectives (ISO, 2010; Popa & Dabija, 2018). Effective governance enables action on all other core subjects and should reflect the principles of social responsibility, such as accountability and transparency, within the organization's culture, strategy, and daily activities. For materiality, the standard adopts a process of determining relevance and significance rather than using the specific term "materiality" found in frameworks like the ESRS (Pojasek, 2011). This process requires organizations to identify which issues are pertinent through a systematic review of their direct and indirect impacts on society and the environment (ISO, 2010). As highlighted by ISO (2010) and Pojasek (2011) a key component of this is due diligence, described as a proactive process to identify, avoid, and mitigate negative social, environmental, and economic impacts throughout the life cycle of a project or activity. Related to that, organizations are encouraged to address issues within their sphere of influence, which encompasses relationships through which they have the capacity to affect the decisions or activities of others, such as suppliers or partners.

Stakeholder engagement is fundamental to the ISO 26000 philosophy and is defined as the creation of opportunities for dialogue between an organization and those who have an interest in its

decisions (ISO, 2010). This engagement is not merely a communication exercise but a practice to provide a grounded basis for organizational decisions (ISO, 2010). Respect for stakeholder interests is one of the seven underlying principles of the standard, alongside accountability, transparency, and ethical behaviour (Popa & Dabija, 2018). However, Popa & Dabija (2018) and Pojasek (2011) also showed that the standard is often criticized for its broad scope. For a large scientific research organization, the standard's strength lies in its ability to promote a common international understanding of social responsibility and its integration with existing management systems to enhance credibility and stakeholder trust.

1.5. COMPARATIVE SYNTHESIS ACROSS FRAMEWORKS

As this thesis has highlighted in the previous sections, the recent "alphabet soup" of sustainability instruments reflects not only a proliferation of labels, but also a diversification of underlying purposes: some instruments are primarily designed to structure public disclosure, others to institutionalise management routines, and others to provide guidance on organisational responsibility.

A first clear divergence concerns the nature of the instrument and its degree of legal force. The CSRD functions as the EU legal container for sustainability reporting and explicitly embeds sustainability information into the management report, thereby integrating sustainability disclosure within mainstream reporting rather than treating it as a stand-alone communication product. In this regulated approach, the ESRS operate as the technical disclosure standards that implement the CSRD's requirements by specifying what must be reported and how sustainability statements should be structured. By contrast, GRI has a modular architecture (Universal, Sector, Topic) that organizations can apply to report their impacts in a structured and transparent manner, but without the same legal anchoring described for the CSRD regime. EMAS and ISO 14001 are framed differently again, as environmental management instruments that prioritise systematisation, internal routines, and continuous improvement, with EMAS adding a stronger public transparency and verification logic through its validated environmental statement. ISO 26000, finally, is explicitly described as non-certifiable guidance aimed at translating social responsibility principles into organisational practice rather than imposing auditable requirements.

A second major divergence relates to how each instrument defines what should be prioritised, and how scope is constructed. GRI's architecture links reporting to a materiality process oriented toward identifying significant impacts and translating these into topic-specific disclosures and management approaches. The CSRD/ESRS approach is anchored in double materiality and makes the materiality assessment process itself an explicit part of what organisations must explain, thereby pushing transparency not only on what is reported but also on how topics were selected and justified. EMAS and ISO 14001, although not framed through the same reporting-centric materiality language, address prioritisation through the identification of significant environmental aspects/impacts and compliance obligations within an environmental management system logic. ISO 26000 is presented as using a relevance and significance approach rather than the specific term materiality, encouraging organisations to prioritise issues based on impacts and stakeholder concerns across a broad set of social responsibility subjects. Across these instruments, the chapter therefore points to different "entry points" into sustainability: disclosure-led prioritisation (GRI and ESRS within CSRD), management-system prioritisation (EMAS and ISO 14001), and principles-based prioritisation (ISO 26000).

The chapter's earlier emphasis on stakeholder engagement and transparency also helps clarify how frameworks differ in their stakeholder logic and in the extent to which engagement is formalised. In the framework sections, these ideas reappear in different forms but with the same purpose: GRI is described as oriented toward a broad stakeholder base and includes explicit reporting expectations on stakeholder engagement and the traceability of disclosures via the content index and reasons-for-omission mechanism. ESRS, as described in the chapter, distinguishes between affected stakeholders and users of sustainability reporting and integrates stakeholder-related expectations through the double materiality assessment and topical disclosure structure. EMAS embeds public transparency through the publication of an externally validated environmental statement, linking engagement to the credibility of disclosed environmental performance, and explicitly emphasises employee involvement as part of the scheme's functioning. ISO 14001 frames stakeholders through the category of "interested parties," connecting engagement primarily to the environmental management system's context analysis, compliance logic, and communication needs. ISO 26000, in turn, is portrayed as placing stakeholder engagement at the core of social responsibility, defining it as dialogue that grounds organisational decisions, but doing so as guidance rather than auditable requirements.

A fourth axis of divergence concerns the frameworks' governance and integration logic, which is central to this thesis's framing of sustainability reporting as a governance tool. As described in the CSRD section, the EU regulatory architecture strengthens the link between reporting and formal governance structures by positioning sustainability reporting within the management report and by requiring assurance over compliance and the process used to identify reported information. The ESRS further reinforce this integration through a disclosure model that covers governance, strategy, impact/risk/opportunity management, and metrics and targets across topical standards, thereby making the connectivity between governance arrangements and reported sustainability information more explicit. GRI also requires contextual disclosures on governance, strategy, policies, and stakeholder engagement (through GRI 2), and it connects material topics to management approach disclosures (through GRI 3 and topic standards), yet the logic remains primarily disclosure-oriented rather than management-system oriented. EMAS and ISO 14001, by contrast, are explicitly designed to institutionalise environmental governance through system requirements, audit cycles, management review, and continual improvement. ISO 26000 is presented as centring organisational governance as a core subject that enables action across all other responsibility domains and encourages integration into culture, strategy, and daily activities, though without certification.

The final major contrast lies in reporting architecture, indicators, and assurance/verification mechanisms, which shape both comparability and credibility. As presented in the CSRD section, assurance is built into the regime (starting with limited assurance) and is tied to compliance with reporting requirements and tagging expectations, while digital accessibility and machine readability are explicit design features. ESRS are described as prescriptive standards that specify disclosure requirements across ESG topics, including value-chain considerations. GRI, while described as structured and modular, is presented as allowing staged implementation (reporting "in accordance" or "with reference") but requiring traceability through the content index and justified reasons for omissions. EMAS, as described, couples' transparency with external validation and also specifies reporting on core environmental KPIs that must be quantifiable, comparable, and verified. ISO 14001 is presented as certifiable and process-based, supporting environmental performance improvement through management routines rather than requiring public reporting in the manner of disclosure standards, while ISO 26000 is explicitly non-certifiable guidance and therefore relies on

organisational uptake and transparency choices rather than external verification mechanisms. As highlighted in the ISO 14001 discussion, the chapter also notes that implementation strategies can range from substantive integration to more symbolic adoption, implying that assurance and certification mechanisms do not automatically translate into comparable outcomes without meaningful organisational embedding.

Table 1.3. *Visual snapshot: Comparability across sustainability frameworks and standards.*

Framework / standard	Nature and legal force	Materiality / prioritisation and scope	Stakeholders and engagement	Governance and integration	Reporting design and credibility
GRI Standards	Voluntary global reporting standards	Impact materiality; broad esg scope	Broad stakeholder orientation; engagement informs material topics	Disclosure-led; links topics to "management approach" disclosures	Structured disclosures; traceability through content index and justified omissions; external assurance optional
CSRD	EU regulatory regime for sustainability reporting	Double materiality (operationalised through esrs); broad esg scope	Embedded in a formal accountability context	Integrates sustainability reporting into the management report	Assurance expected as part of the regime (initially limited assurance)
ESRS	Mandatory disclosure standards under csrd	Double materiality; broad esg scope	Distinguishes affected stakeholders and users of reporting; linked to materiality and topical disclosures	Makes governance–strategy–management–metrics connectivity explicit	Highly prescriptive disclosure architecture; credibility linked to csrd assurance expectations
EMAS	Voluntary eu environmental management and reporting scheme (registration)	Prioritisation based on significant environmental aspects/impacts; environmental scope	Transparency strengthened through a validated environmental statement; emphasis on internal involvement	Management-system oriented; systematisation and continuous improvement	Public environmental statement; external verification/validation built into the scheme
ISO 14001	Voluntary certifiable environmental management system standard	Prioritisation based on significant environmental aspects and compliance obligations; environmental scope	Focus on "interested parties" within the management system context	Strong internal governance through pdca cycle, audits, management review, continual improvement	Certification possible; not primarily a public reporting standard
ISO 26000	Voluntary guidance on social responsibility (non-certifiable)	Prioritisation through relevance and significance of impacts and stakeholder concerns; broad	Stakeholder engagement positioned as central, as guidance	Encourages integration into culture, strategy and daily practices (non-auditable)	Guidance-oriented; no certification or assurance mechanism by design

	social responsibility scope

Source: Own contribution based on the own produced Framework Comparability Matrix (see Appendix 3).

Taken together, the comparison developed across the previous sections supports one overarching conclusion for the thesis's analytical strategy: these instruments are most coherently understood through functional differentiation and potential complementarity**,** rather than as mutually exclusive substitutes.

The chapter also shows that the differences between frameworks are not only about "what to report," but about how accountability is organised, sustainability frameworks are best understood as instruments with different governance effects, rather than as interchangeable substitutes. Some instruments mainly structure disclosure (what information is expected and how it should be presented), while others are designed to strengthen internal routines and continuous improvement through management-system requirements. At the same time, although materiality, stakeholder engagement, and transparency are presented as the pillars of credible reporting, the comparison makes clear that these pillars are applied in different ways, with implications for scope, prioritisation, and reporting boundaries. Finally, the chapter highlights that credibility can be supported through different mechanisms, such as assurance requirements, external validation, certification, or traceability tools within reporting standards, and that these mechanisms do not automatically guarantee substantive integration if implementation remains largely symbolic.

On this basis, this chapter has established the conceptual foundations needed for the thesis's comparative and case-based analysis. This sets the stage for the next chapters, which move from the conceptual and cross-framework level to the institutional level by examining CERN's current reporting practice (Chapter 2) and assessing which elements across instruments could be most applicable and meaningful in that specific context (Chapter 3).

CHAPTER 2 – SUSTAINABILITY REPORTING IN SCIENTIFIC AND RESEARCH INSTITUTIONS: CERN'S CASE

This chapter examines how sustainability and environmental reporting is implemented in large scientific and research institutions, with a focus on CERN. Building on the conceptual foundations established in Chapter 1, it first outlines CERN's mission, organisational structure and governance context, and explains why these features matter for environmental governance and reporting (2.1). It then establishes CERN's reporting baseline through an overview of its biennial Environment Reports (2.2). Finally, it benchmarks CERN against peer institutions (ESA, ITER and MPS) to compare how accountability is organised and communicated in comparable research settings, and it closes with a cross-cutting observation on ESG coverage, highlighting how ESG dimensions tend to become visible through different institutional reporting and governance formats (2.3).

2.1. CERN: MISSION AND ORGANIZATIONAL STRUCTURE

CERN is an intergovernmental organization that operates the world's largest particle-physics laboratory on the Franco-Swiss border near Geneva. Its core mandate is to advance fundamental knowledge about the basic constituents of matter and the laws that govern their interactions, by designing, building and operating large-scale accelerator and detector infrastructures that are beyond the reach of individual states or universities (CERN, n.d.).

The Organization's formal mission statement highlights four closely related pillars: performing world-class research in fundamental physics; providing a unique range of particle-accelerator facilities that enable research at the forefront of human knowledge in an environmentally responsible and sustainable way; uniting people from all over the world to push the frontiers of science and technology for the benefit of all; and training new generations of physicists, engineers and technicians while engaging wider society in science and its values (CERN, n.d.). These elements link the scientific mandate to a broader societal role that includes education, capacity-building and international cooperation.

CERN is governed by its Member States and each of them appoints two delegates to the CERN Council, one representing the national government and one representing the scientific community. The Council is the supreme decision-making authority of the Organization: it sets overall policy, approves the scientific programme, adopts the budget and reviews expenditure, and oversees the Laboratory's activities in scientific, technical and administrative matters (CERN, n.d.). It is assisted by standing committees, notably the Scientific Policy Committee and the Finance Committee, which provide expert advice on scientific priorities and financial management respectively (CERN, n.d.). Operational management of the Laboratory is entrusted to the Director General (DG), who is appointed by the Council, usually for a five-year term (CERN, n.d.; CERN, 2007). The DG is supported by a directorate and a structure of sectors and departments responsible for accelerators and technology, research and computing, finance and human resources, and site-related activities. Throughout the period covered by this thesis (2017–2024), CERN has been led by Director General Fabiola Gianotti, who has served two consecutive mandates. Her last mandate (2020-2025) included a strong emphasis on environmentally responsible research and transparent environmental reporting (CERN, n.d.).

The environmental protection dimension is therefore not external to CERN's mission but explicitly embedded in it. High-energy physics relies on very large, energy-intensive infrastructures with long lifetimes and cross-border physical footprints. The Organization's mission to provide accelerator facilities in an environmentally responsible and sustainable way (CERN, n.d.) implies a dual responsibility: to minimise the environmental impacts associated with the construction and operation of these facilities, and to leverage CERN's technological capabilities to contribute solutions that can support environmental protection more broadly (CERN, n.d.).

The management's objectives for 2021–2025 further reinforce this link. Alongside delivering world-class scientific results and increasing the return to Member and Associate Member States, CERN explicitly commits to strengthening its impact on society. Environment and sustainability are identified as one of three priority domains, with objectives that include minimising the Laboratory's environmental footprint, improving energy efficiency and recovery, and developing CERN technologies that may help mitigate society's environmental impacts (CERN, n.d.).

Of particular relevance for environmental governance is the position of the Occupational Health & Safety and Environmental Protection (HSE) function within CERN's structure. Since a management reorganization in 2016, HSE has been established as a dedicated unit attached directly to the DG and since 2026 HSE has been included in the Site Operations Sector but maintaining the nature of reporting directly to the DG (CERN, 2020; CERN, n.d.). This positioning reflects the cross-cutting nature of safety and environmental protection: HSE is mandated to drive CERN's Safety Policy, act as the organization's centre of competence on both conventional and radiological safety and support all departments in meeting safety and environmental objectives (CERN, n.d.).

Environmental governance is further structured through dedicated bodies and processes. The CEPS board coordinates work across eleven high-priority environmental domains. On the origins of this governance architecture, CERN'S Environment Group Leader and CEPS member stated that she proposed to set up this committee. She argued that within other existing committees, it was difficult to handle these environmental topics given time constraints and the breadth of issues, which motivated a dedicated cross-departmental structure for coordination and follow-up. The Energy Management Panel oversees energy-efficiency and energy-recovery initiatives across the accelerator complex and sites. Together with HSE, these bodies provide the institutional backbone for developing environmental strategies, setting objectives, and generating the data and analysis that feed into CERN's environmental reporting.

Ultimately, responsibility for environmental performance and for the publication of environmental reports is shared: HSE coordinates the technical content, but the DG and the Council retain overall accountability by endorsing strategic objectives, approving resource allocations for environmental measures and, where relevant, taking note of public reports and Host State commitments.

Several structural characteristics of CERN are particularly relevant for environmental governance and, by extension, for sustainability reporting.

First, CERN's legal status as an intergovernmental organization with multiple Member and Associate Member States and two Host States creates a complex regulatory and stakeholder landscape. CERN enjoys certain privileges and immunities under its Convention and Host State agreements, but it also commits to comply with Host State environmental legislation and to work closely with national and local authorities on issues such as land-use planning, environmental impact assessments and emergency preparedness (CERN, 2007).

Second, CERN's physical infrastructure is extensive, heterogeneous and long-lived. The accelerator complex includes the 27 kilometre Large Hadron Collider (LHC) ring and multiple injector accelerators, together with experimental caverns, surface buildings, cooling and ventilation systems, cryogenic plants, data centres and support facilities distributed across several sites (CERN, n.d..

Third, CERN's user-facility model means that a significant proportion of the scientific work is carried out by an international community of around 13,000 users affiliated with universities and institutes worldwide, in addition to CERN's own employed staff (CERN, n.d.). This leads to a wide and diverse stakeholder base and therefore, environmental reporting must respond to multiple expectations: transparency towards governments and Host State regulators, accountability to the public in the region, and communication of CERN's environmental commitments and performance to the global scientific community.

Finally, CERN's strategic orientation towards maximising its impact on society reinforces the importance of environmental transparency. The management's objectives document emphasises minimising the Laboratory's own environmental footprint, implementing energy-saving and energy-recovery projects, and identifying CERN technologies that can contribute to environmental solutions in areas such as renewable energy, efficient power electronics and low-loss power transmission (CERN, n.d.).

As discussed in Chapter 1, credible sustainability reporting rests on materiality, stakeholder engagement and transparency, and can function as a governance tool. In CERN's case, these dimensions are closely linked to the Organisation's institutional set-up: a complex stakeholder environment, large-scale infrastructures, and governance bodies that coordinate environmental priorities and data production. Therefore, CERN's mission, governance structure and organizational features create both challenges and opportunities for environmental reporting. The following sections examine CERN's reporting practice not only as a communication and transparency output, but as an institutional arrangement that shapes boundaries, priorities, and accountability mechanisms.

2.2. Overview of CERN's Environmental Reports (2017–2024)

CERN's current environmental reporting practices reflect its institutional commitment to operate environmentally responsible research (CERN, 2020), embedding environmental protection as an explicit goal within the Organization's framework. As Fabiola Gianotti (2020, p.4) noted in the first environmental report published by the Organization, this commitment stems from the belief that "science's flag-bearers need to demonstrate their relevance, their engagement, and their integration into society as a whole," leading to the introduction of the first environment report explicitly titled "A role model for environmentally responsible research" (CERN, 2020, p.4). This strategic focus has pushed CERN's community to define ambitious yet realistic environmental objectives, and the Organization continues to strive to be a role model while committed to minimizing its environmental impact.

The cornerstone of CERN's public environmental communication is the production of biennial environment reports, which the Organization prepares in accordance with the GRI Standards (CERN, 2020; CERN, 2021). When investigating why CERN relies on GRI Standards as its baseline, the CERN Environmental Reporting Coordinator explained that GRI was chosen because it is internationally recognized and a flexible and voluntary tool. CERN's Environment Group Leader

shared this perspective and added that this framework fits CERN's intergovernmental context and its Member States outside of the European Union and community. She added that this choice was strongly driven by communication leadership and supported by external advice, with the environment team acting as a technical counterpart in the process.

The reporting cycle has generated reports covering the following periods: 2017–2018, 2019–2020, 2021–2022 and 2023–2024. As CERN's Environment Group Leader recalled, a series of environmental incidents between 2012 and 2016 increased public visibility and strengthened the internal momentum for formalised environmental reporting. She noted that early, CERN's DG stated that the organization should become a role model for an environmentally aware research laboratory, which helped bring environmental performance and public disclosure into the institutional spotlight. In all environmental management aspects, CERN consistently applies the precautionary principle, taking action to prevent significant environmental harm even when scientific certainty of the risk is lacking. For future transparency, CERN is currently exploring the feasibility of evolving its next report (for the 2025–2026 period) into a complete ESG report.

The definition of what constitutes a priority for reporting is driven by a periodic materiality analysis based on consultation with internal and external stakeholders, focusing on topics deemed of high significance to CERN's sustainable development. The core material topics consistently addressed include: energy consumption, emissions, ionising radiation, noise, waste, water and effluents, and biodiversity. As described by CERN'S Environmental Reporting Coordinator, CERN's environmental reporting functions as a routinised cross-departmental production process: domain experts are interviewed and review successive drafts, followed by group-leader and department-head validation, and final sign-off at the level of the HSE Head and Director-General.

As CERN noted in its first (2020), second (2021), third (2023) and fourth (2025) environmental reports, regarding the reporting scope, the presented environmental data exclusively covers the impact of CERN's facilities in the Geneva region, including only the facilities that CERN owns or operates. Notably, the impacts arising from the large international user community are explicitly excluded from CERN's direct reporting boundaries, as these activities are largely outside the Organization's control or financial oversight. CERN maintains transparency and compliance through close collaboration with its Host States, France and Switzerland. This collaboration is formalized through two mechanisms: the Tripartite Committee for the Environment, addressing non-radiological issues, and a separate Tripartite Agreement on Radiation Protection and Radiation Safety, which provides a legal framework for discussing radiation-related matters. Within this context, CERN reports quarterly to Host State authorities on environmental issues, including radiation measurements, and the authorities also conduct independent monitoring of CERN's water, radiation, and noise emissions.

CERN's Environment Group Leader also suggested that internalisation of environmental reporting has progressed primarily through departments rather than being automatically 'top-down'. 'Department heads have to be convinced and have to be committed themselves' (CERN's Environment Group Leader, 2026), and that the diffusion of reporting-related practices tends to occur stepwise as departments translate the message to units. This helps interpret CERN's reporting baseline as not only a communication product but also an ongoing coordination mechanism across departmental structures, particularly relevant as CERN moves toward broader sustainability reporting.

This section establishes CERN's current reporting baseline in terms of scope and boundaries, materiality process, stakeholder interface, governance arrangements, and credibility mechanisms, which will later be used for the framework comparability assessment set out in Chapter 3.

2.2.1. REPORT 1: 2017–2018 (THE FOUNDATIONAL BASELINE)

The first public environment report, published in 2020, covered the years 2017 and 2018 and served to establish CERN's official reporting framework and set concrete goals for the immediate future. This report solidified the Organization's vision to operate as a "role model for environmentally responsible research" (CERN, 2020, p.4).

The initial materiality analysis, based on internal and external stakeholder interviews, identified topics such as energy consumption, emissions, waste, and water as high significance topics for the report. In this regard, CERN's Environment Group Leader and CEPS member emphasised that the reporting exercise itself 'pushed us really to fix these objectives' (CERN's Environment Group Leader, interview, 2026), moving 'not only to speak about general commitments, but to scale, to assess, to provide numbers' (CERN's Environment Group Leader, 2026). She explained that this dynamic supported the formal endorsement process for Horizon 2025 objectives, later mirrored for Horizon 2030. In 2018, baseline electricity consumption was recorded at 1251 GWh, and CERN committed to limiting any increase to 5% up to the scheduled end of Run 3 in 2024 (CERN, 2020).

Regarding emissions, Scope 1 (direct) Green House Gas (GHG) emissions totalled 192,100 tCO2e in 2018, primarily from fluorinated gases, and a core target was set to achieve a 28% reduction in Scope 1 emissions by the end of 2024 (CERN, 2020). Water consumption was 3477 ML in 2018, with a corresponding goal to keep the increase below 5% until 2024 (CERN, 2020).

In terms of governance and credibility, the report links disclosure to formal environmental structures (notably the CEPS and EMP) and to operational monitoring practices.

2.2.2. REPORT 2: 2019–2020 (THE SHUTDOWN AND INITIAL SCOPE 3 REPORT)

The second report covered a period heavily influenced by the second Long Shutdown (LS2) of the accelerator complex and the COVID-19 pandemic, and explicitly reinforces the idea of "turning words into action" (CERN, 2020, p.4) as Fabiola Gianotti pointed out. It also situates CERN's reporting in a broader policy context, including the European Strategy for Particle Physics in 2020, which requires environmental impact planning to be treated as an integral component of major projects (CERN, 2021, p.4). Due to LS2, electricity consumption dropped dramatically to 428 GWh in 2019, reflecting a 64% reduction compared to operational years (CERN, 2021).

Emissions reductions reflected the shutdown period, with Scope 1 emissions falling to 78,169 tCO2e in 2019. Critically, this report included the first quantification of Scope 3 emissions, reporting 12,098 tCO2e in 2019 from sources including business travel, personnel commutes, catering, waste treatment, and water purification (CERN, 2020). Water consumption dropped significantly to 2006 ML in 2019 due to reduced cooling needs (CERN, 2021).

In terms of integration into practice, the report documents concrete prevention and mitigation measures (including retention infrastructure for runoff and pollution prevention) and notes progress on energy recovery initiatives (CERN, 2021).

2.2.3. REPORT 3: 2021–2022 (RUN 3 AND PROCUREMENT INTEGRATION)

This report marked the completion of the LS2 and the subsequent ramp-up to Run 3 of the LHC, officially launched in July 2022, and it is framed with CERN's formal response to the global energy crisis and the full integration of indirect supply chain impacts into reporting. The updated materiality analysis in 2022 confirmed the focus on energy and emissions and prioritized the reporting of materials and procurement (CERN, 2023). As operations resumed, electricity consumption increased to 1215 GWh in 2022, remaining below the target maximum of 1314 GWh (CERN, 2023).

Governance and integration are strengthened through steps to formalise energy management, including the start of the ISO 50001 certification process in 2022 and the publication of an Energy Policy in October 2022 (CERN, 2023). Scope 1 emissions rebounded to 184,173 tCO2e in 2022, with CERN still aiming for the 28% reduction target by the end of Run 3 (now rescheduled for 2025/2026) (CERN, 2023). A central reporting shift is the introduction of procurement-related Scope 3 emissions for the first time; procurement is identified as representing approximately 92% of CERN's total Scope 3 emissions (CERN, 2023). In response, the CERN Environmentally Responsible Procurement Policy Project was launched in September 2021 to align procurement progressively with ISO 20400 guidance (CERN, 2023). Water consumption stood at 3234 ML in 2022 (below the maximum target of 3651 ML) (CERN, 2023). Furthermore, the CERN Innovation Programme on Environmental Applications (CIPEA) was launched in 2022 to fund projects that transfer CERN technologies to environmental applications (CERN, 2023).

2.2.4. REPORT 4: 2023–2024 (CERTIFICATION AND 2030 GOAL SETTING)

The most recent report covers two full operation years and places strong emphasis on formalisation and long-term orientation through certification and target-setting. CERN successfully achieved ISO 50001 certification in February 2023, covering all sites, activities, and energy profiles, marking a formal commitment to continuous energy performance improvement (CERN, 2025). Governance is further reinforced through the adoption of the Environmentally Responsible Procurement Policy in June 2023 and the establishment of the Sustainable Accelerator Panel in 2023, aiming to integrate lifecycle sustainability early in future projects (CERN, 2025).

In January 2024, the Directorate approved comprehensive environmental objectives for 2030 (CERN, 2025). Electricity consumption reached 1290 GWh in 2024, and the new objectives include limiting electricity consumption to 1.5 TWh/year, covering 10% of electricity needs, and aiming for a 60% reduction in gas consumption compared to 2018 (CERN, 2025). Scope 1 emissions were 170,024 tCO2e in 2024, with a 2030 objective of a 50% reduction compared to 2018 (CERN, 2025). Scope 3 emissions from procurement were 102,730 tCO2e in 2024 (CERN, 2025). Water consumption was 2895 ML in 2024, with objectives including keeping consumption below 3600 ML (CERN, 2025). Non-hazardous waste recycling reached 76% in 2024, with the 2030 objective focused on maintaining a recovery rate above 70% and increasing total reuse by 10% (CERN, 2025).

Based on the evidence presented across the four reporting cycles, and as summarised in Table 2.1, the evolution of CERN's GRI-based environmental reporting can be captured along three main lines: an expansion of scope, the maturation of governance and objective-setting. Over time, the institutional approach moves from relying primarily on internal governance arrangements (notably CEPS and EMP) towards greater formalisation through external standards, culminating in ISO 50001 certification.

Table 2.1. *Evolution of CERN's environmental reporting practices across four reporting cycles (2017–2024)*

Reporting cycle	Expansion of scope	Governance maturation	Objective setting
2017–2018	Scope and boundaries explicitly defined (Geneva sites under CERN control).	Reporting anchored in internal structures (CEPS/EMP) and monitoring practices.	Targets framed as operational and short-term, aligned with Run scheduling.
2019–2020	Reporting begins to extend beyond direct operations through first Scope 3 quantification.	Implementation narrative strengthened in the context of LS2/COVID; preventive measures documented.	Targets remain mainly operational; reporting reflects a "transition" phase.
2021–2022	Scope expands substantially by introducing procurement-related Scope 3 and supply-chain relevance.	Governance becomes more formalised, including the start of ISO 50001 certification work and new policies/roadmaps.	Targets still partly tied to Run planning, but with clearer longer-term direction emerging.
2023–2024	Scope consolidation: indirect impacts (procurement and mobility) positioned within a longer-term horizon.	External standardisation reached through ISO 50001 certification; governance instruments broaden.	Clear step-change: comprehensive 2030 environmental objectives approved by the Directorate.

Source: Own contribution based on CERN Environment Reports (2017–2018; 2019–2020; 2021–2022; 2023–2024).

2.3. REPORTING PRACTICES IN PEER INSTITUTIONS: ESA, ITER AND MPS

This section provides a brief peer benchmark to contextualise CERN's environmental reporting practices within the reporting and accountability approaches of comparable public research institutions. The aim is not to evaluate overall performance, but to compare how accountability is organised and communicated, particularly in terms of reporting formats, scope and boundaries, governance signals, and credibility mechanisms.

Although CERN's environmental reporting is shaped by its specific governance setting and operational footprint, it is not alone in facing growing expectations around transparency, accountability, and environmental responsibility. A brief benchmark against ESA, ITER, and MPS is useful because these organisations share structural features with CERN: they are publicly oriented research institutions operating large-scale scientific and technical infrastructures, they depend on broad stakeholder legitimacy, and they face increasing pressure to demonstrate responsible environmental performance alongside scientific excellence. ESA explicitly frames its sustainability strategy as both an internal footprint-reduction effort and a way to "lead and inspire" the wider sector, anchored in European policy reference points such as the Paris Climate Agreement and the

European Green Deal (European Space Agency, n.d.). MPS positions climate neutrality as part of a wider responsibility narrative for research organisations, pairing long-term targets with institution-wide implementation arrangements (Max Planck Society, 2024).

ESA's reporting approach is organised around periodic "Responsibility & Sustainability" reporting that is explicitly broader than environment only disclosure. ESA notes that it has published Corporate Responsibility and Sustainability reports "regularly" over a long period, positioning the 2022–2023 report as part of an ongoing institutional reporting practice (European Space Agency, 2024). Within that report, accountability is framed through a materiality process explicitly aligned with the European concept of double materiality, producing an ESG-oriented narrative that combines governance framing with quantified indicators, including structured GHG accounting and target-setting (European Space Agency, 2024).

ITER's public reporting is more modular than ESA's, relying on a set of distinct institutional reports and formal policy documents rather than a single integrated sustainability report. Its Annual Report presents governance and oversight arrangements, while the Financial Report embeds external credibility mechanisms through an independent auditor's opinion on the financial statements (ITER, 2024). The Human Resources report documents organisational and social dimensions, including formalised corporate values (ITER, 2024). This architecture is complemented by a policy instrument that places safety, security, quality and environmental protection within an explicit priority hierarchy, framing environmental protection as part of a broader safeguarding system rather than a stand-alone reporting domain (ITER, 2025).

MPS provides a third model, where the strongest public accountability signal is carried by strategy, targets, and implementation instruments rather than a single consolidated sustainability report. The Climate Action Plan states an intention to operate climate-neutrally by 2035 and frames this as an evolving instrument tied to implementation arrangements (Max Planck Society, 2024, p. 1–2). It operationalises climate governance through Scope 1–3 framing, intermediate target-setting (including halving Scope 1 and 2 emissions by 2029 compared to 2019), and explicit acknowledgement of data gaps for specific impact areas (Max Planck Society, 2024). In parallel, the Guidelines for Sustainable Planning and Building translate climate objectives into binding institutional requirements for construction and refurbishment, including climate-neutral building operation by 2035 (Max Planck Society, 2025).

2.3.1. Cross-cutting observation: ESG coverage in research institutions

Across these peer cases, a cross-cutting pattern concerns how ESG coverage becomes visible in research-institution settings.

Environmental content tends to be the most structured and continuous reporting stream. In CERN's case, as established in Section 2.2, the environment reports are explicitly organised around environmental material topics and defined boundaries, prioritising impacts within CERN's operational control while excluding broader impacts that sit largely outside its direct oversight. In the peer cases, similar dynamics are visible even where the reporting vehicle differs: environmental accountability is anchored either in consolidated reporting products (as in ESA's Responsibility &

Sustainability reporting) or in strategy and implementation tools focused on climate and energy transition (as in MPS's climate planning and building guidance).

By contrast, social and governance dimensions tend to be less consolidated within a single sustainability narrative. This does not necessarily mean they are absent; rather, they are often communicated through separate institutional artefacts such as annual governance reporting, audited financial accountability, HR reporting, or overarching safeguarding and policy instruments. ITER illustrates this "distributed" accountability architecture particularly clearly, while MPS demonstrates a strong governance signal through targets and binding implementation instruments without relying on an integrated sustainability report as the primary disclosure vehicle. ESA sits somewhat differently within this pattern, as it's reporting explicitly adopts a broader ESG framing and uses a materiality process aligned with double materiality to integrate priorities into a single reporting product.

This benchmark therefore suggests that, in research institutions, ESG coverage is shaped not only by "what matters," but also by how accountability is organised. Where accountability is channelled primarily through environment-focused reporting, disclosure can be strong on boundaries, indicators and environmental governance routines, while remaining comparatively thinner on social and governance dimensions as part of a unified ESG account. Where accountability is distributed across institutional reports and governance instruments, social and governance information can be visible but fragmented, making overall sustainability priorities less legible as one coherent system of commitments, performance and controls.

Taking this together, this chapter has established the empirical baseline for the comparative assessment that follows by identifying four main findings.

First, CERN's environmental reporting is strongly shaped by its institutional context: its intergovernmental status, cross-border footprint and Host State interfaces influence reporting boundaries, stakeholder expectations and the credibility conditions under which environmental information is disclosed.

Second, the overview of CERN's biennial, GRI-based environment reports (2017–2024) shows a stable reporting architecture centred on defined scope and boundaries, materiality-informed prioritisation of environmental topics, and identifiable governance and credibility arrangements. Across the reporting cycles, three developments stand out: an expansion of scope, most visibly through the inclusion of procurement-related Scope 3 emissions, greater formalisation of environmental governance (culminating in ISO 50001 certification), and a shift from short-term operational targets linked to accelerator cycles towards more comprehensive 2030 environmental objectives.

Third, the peer benchmark indicates that comparable research institutions organise sustainability accountability through different architectures. While ESA relies on a consolidated Responsibility & Sustainability reporting product with explicit materiality structuring, ITER and MPS communicate sustainability through a portfolio of institutional reports and governance instruments rather than a single sustainability report per se.

Fourth, a cross-cutting pattern across peers is that environmental performance tends to be the most structured and continuous reporting stream, whereas social and governance dimensions are

often less consolidated within one disclosure narrative and become visible through separate institutional channels.

Overall, Chapter 2 has showed how environmental accountability is organised at CERN through defined boundaries, materiality-informed prioritisation and identifiable credibility arrangements. It has also demonstrated that peer institutions make sustainability accountability visible through different reporting architectures, ranging from consolidated reporting products to portfolios of reports, policies and implementation instruments, and that this affects how ESG dimensions appear in practice. Chapter 3 therefore applies the A–E comparability lens to position CERN's current approach in relation to framework logics and peer models, identifying what the baseline already makes visible and what additional elements would be foregrounded under other accountability designs.

CHAPTER 3 – COMPARATIVE ASSESSMENT: CERN'S REPORTING IN RELATION TO FRAMEWORKS AND PEERS

Building on the conceptual synthesis developed in Chapter 1 and the institutional baseline established in Chapter 2, this chapter provides a comparative assessment of CERN's current reporting approach in relation to selected sustainability frameworks and peer institutions. The purpose is not to evaluate performance or to identify a single "best" instrument, but to position CERN's reporting practice within a landscape of distinct accountability logics, disclosure-oriented, management-system-oriented, and principles-based, and to clarify what each logic makes visible in practice.

The chapter proceeds in two steps. Section 3.1 sets out the assessment criteria and introduces the A-to–E comparability lens, operationalised through the Framework Comparability Matrix (see Appendix 3). Section 3.2 then applies this lens to CERN: it maps CERN's reporting baseline to A-to–E, identifies elements already covered relative to framework expectations, clarifies which elements are emphasised by other instruments but fall outside CERN's current environment-centred baseline, and articulates potential integration as functional complementarity rather than as prescriptive recommendations. The chapter closes by positioning CERN against ESA, ITER and MPS to highlight how different accountability architectures operate in comparable research settings and to establish the analytical basis for the thesis conclusions.

3.1. ASSESSMENT CRITERIA AND FRAMEWORK LOGICS

Building on the comparative synthesis developed in Chapter 1, this section clarifies the criteria used to assess sustainability frameworks and to position CERN's current reporting practice in comparative perspective. Rather than treating GRI, CSRD/ESRS, EMAS and ISO as interchangeable substitutes, the analysis follows the premise established earlier in the thesis: these instruments are best understood through functional differentiation, since they organise accountability through different combinations of disclosure requirements, internal governance routines, and credibility mechanisms.

To operationalise this comparison in a consistent way, the thesis uses a Framework Comparability Matrix (see Appendix 3), which structures the assessment across a stable set of dimensions grouped into five analytical blocks. These blocks are used throughout Chapter 3 as a common "comparability lens" for examining both frameworks and institutional practices, and they are referred to here as A-to–E for analytical clarity: (A) nature of the instrument (type, legal force, purpose and audience), (B) materiality and ESG coverage (including boundaries), (C) stakeholder scope and engagement expectations, (D) governance and integration requirements (accountability and continuous improvement), and (E) reporting architecture and credibility mechanisms (level of prescription, indicators, assurance/verification logic). A complete table with the questions I have taken into account when analysing each element included in each of the aforementioned blocks can be found in the Appendix 3 under Table A.2.

Using this shared grid makes it possible to compare instruments that differ substantially in form and intent. The thesis does not seek to rank frameworks as "better" or "worse"; instead, it treats them as different ways of organising sustainability accountability. Some instruments mainly structure public disclosure (i.e., what is reported and how it should be presented; for example, GRI and ESRS). Others focus on internal management routines and continuous improvement (i.e., what

processes, responsibilities and controls an organisation should put in place to manage impacts over time; for example, ISO 14001 and EMAS). Finally, some operate as principles-based guidance (i.e., what values and responsibilities should guide organisational behaviour, without prescribing indicators or certification; for example, ISO 26000). Framed in this way, "alignment" for CERN can be assessed in functional terms, namely, whether CERN's current approach is primarily disclosure-oriented, management-system-oriented, or principles-oriented, and where elements of these logics may complement each other in a research-institution context.

In practical terms, the assessment in Chapter 3 therefore distinguishes between (i) scope and coverage effects (what ESG dimensions are brought into view and where reporting boundaries are drawn), (ii) governance and integration effects (whether and how responsibilities, routines, and continuous improvement expectations are institutionalised), and (iii) credibility effects (how transparency and reliability are reinforced through mechanisms such as assurance expectations, validation, certification, traceability tools, or formal oversight). This also connects directly to the baseline established in Chapter 2: CERN's current GRI-based reporting already includes defined boundaries, a materiality-informed prioritisation logic, and identifiable governance and credibility arrangements, but these elements have evolved unevenly across reporting cycles and remain shaped by CERN's specific organisational and Host State context.

3.2. CERN IN COMPARATIVE PERSPECTIVE: ALIGNMENT, GAPS AND POTENTIAL INTEGRATION

This section shifts from the assessment criteria introduced in Section 3.1 to their application to CERN. The aim is to make explicit what CERN's current GRI-based, environment-centred reporting approach renders visible as an accountability instrument, and what would become more salient if it were viewed through other framework logics, most notably the comprehensive disclosure orientation of ESRS/CSRD, the management-system logic of EMAS and ISO standards, and the principles-based responsibility framing of ISO 26000. Framed in this way, the analysis does not ask whether CERN "should" adopt other instruments, but uses them to clarify CERN's relative positioning, the limits of its current baseline, and the types of complementarities that could be analytically relevant in a research-institution context.

3.2.1. CERN MAPPED TO A-TO-E

Applying the A-to-E assessment criteria to CERN's current reporting practice provides an analytical map of how accountability is organised through the Organisation's GRI-based Environment Reports and associated governance arrangements. This mapping does not restate the descriptive baseline established in Chapter 2; rather, it re-frames that baseline through the comparability lens in order to enable systematic comparison with the framework logics discussed in Chapter 1 and the peer accountability architectures reviewed in Chapter 2.

Under A (nature of the instruments), CERN's reporting practice is best characterised as a consolidated, disclosure-oriented accountability instrument. CERN publishes biennial environment reports structured in line with internationally recognised reporting standards. In institutional terms, the reporting vehicle is voluntary rather than legally mandated, but it operates within a strong public-accountability context shaped by CERN's intergovernmental governance structure and host-

state interfaces, which reinforce expectations of transparency and monitoring beyond what would typically be expected from a purely voluntary corporate report. Interpreted through the Chapter 1 framework logics, this positions CERN primarily within a disclosure-oriented accountability model (GRI-like, and partially comparable to ESRS at the level of reporting architecture), rather than within a management-system reporting model.

Under B (materiality and ESG coverage, including boundaries), CERN's reporting baseline reflects a clearly bounded, predominantly environmental scope. The reporting content is structured around environmental material topics and environmental objectives, and the reporting boundaries are explicitly defined around CERN-owned or operated facilities in the Geneva region. The baseline also shows that, while CERN reports comprehensively on environmental impacts under its operational control, it draws a clear boundary around impacts that are largely outside its direct oversight (notably those associated with the wider international user community and external partner institutes). As CERN's Environmental Reporting Coordinator (2025) pointed out, reporting boundaries are shaped by practical traceability constraints: 'currently we do not report on waste that's generated by contractors because tracing such waste is a complex task', illustrating how data control and availability affect disclosure perimeters. Within the environmental domain, the reporting scope has expanded over time, notably through the inclusion of procurement-related Scope 3 emissions, indicating a growing acknowledgement of indirect impacts and supply-chain relevance even within an environment-focused reporting model. In A-to-E terms, this is a clear strength on B (boundary transparency), but it also signals that any comparison with ESG-comprehensive instruments will hinge less on environmental depth and more on how far ESG breadth and boundary choices can be extended beyond the environmental perimeter.

Under C (stakeholder scope and engagement expectations), CERN's stakeholder interface is characterised by a combination of internal consultation mechanisms and formalised external interfaces. Reporting priorities are informed by periodic materiality processes that involve consultation, while CERN's external stakeholder environment is shaped in particular by its relationship with its Host States, France and Switzerland. CERN's Environmental Reporting Coordinator (2025) specified that materiality assessments include both internal and external stakeholders, including 'associations that have been quite vocal in their opposition to a potential Future Circular Collider (FCC)', which were invited to participate to understand expectations and concerns. In practice, this creates an accountability pattern in which stakeholder engagement is not limited to reputational responsiveness but is also institutionalised through structured dialogue and monitoring arrangements with public authorities. This configuration is distinctive for a research institution operating transnationally: it embeds reporting within a broader system of external scrutiny, even where the reporting instrument itself remains voluntary. This implies that stakeholder engagement at CERN should be read primarily through an institutional-legitimacy lens rather than a corporate investor-facing logic, which matters when interpreting stakeholder expectations across frameworks.

Under D (governance and integration requirements), CERN's reporting is supported by identifiable organisational structures and routines rather than being a stand-alone communications exercise. Environmental governance is anchored in the HSE function and supported through internal coordination bodies that structure environmental management and reporting processes. Over time, this governance has become more formalised, with a progression from internal working arrangements towards stronger integration through externally recognised management-system validation, most visibly through the adoption of ISO 50001 certification. The baseline also indicates a maturing

planning logic: reporting evolves from short-term operational targets linked to accelerator cycles towards more comprehensive longer-term objectives, signalling a shift from reporting as retrospective disclosure toward reporting as part of organisational steering. Analytically, this suggests that CERN's reporting is not only disclosure-based but increasingly "governance-anchored," creating practical hooks for complementarity with management-system logics (such as ISO and EMAS) in later integration pathways.

Finally, under E (reporting architecture and credibility mechanisms), CERN's reporting displays relatively high transparency and traceability within its defined environmental scope, with a structured presentation of topics, indicators and performance narratives consistent with a disclosure-oriented logic. Credibility is reinforced through multiple mechanisms that go beyond the report itself. These include the disciplined use of established reporting standards, the existence of external monitoring and reporting routines with Host State authorities, and the increasing role of certified management systems as signals of internal control and continuous improvement capacity. As described by CERN's Environmental Reporting Coordinator (2025), credibility is reinforced procedurally through a staged validation chain (experts → group leaders → department heads → management) and through timeline 'reverse engineering' from the publication date, which structures internal accountability and contingency planning. At the same time, the baseline suggests that credibility is primarily anchored in environmental monitoring, governance routines and external interfaces, rather than in a comprehensive ESG assurance model typical of corporate sustainability reporting under mandatory regimes. In E terms, credibility is reinforced mainly through monitoring/oversight arrangements and management-system validation signals rather than ESG-wide assurance, which becomes a key point of contrast with the CSRD/ESRS credibility model in the sections that follow.

Taken together, this A-to-E mapping positions CERN as an institution with a comparatively mature and structured environmental reporting baseline, strong boundary-setting and monitoring-linked credibility cues, and an evolving governance and objective-setting logic. At the same time, it also makes visible the functional limits of an environment-centred disclosure instrument when evaluated against broader ESG governance expectations, an issue that is examined more explicitly in the sections that follow on stronger alignment, gaps, and potential complementarity across framework logics.

3.2.2. Elements Already Covered by CERN's Baseline (relative to framework expectations)

Viewed through the framework logics outlined in Section 3.1, CERN's current reporting practice already reflects several core expectations associated with disclosure-oriented accountability instruments, particularly transparency through a stable reporting architecture and explicit boundary-setting.

First, CERN aligns closely with disclosure frameworks such as GRI and, at the level of reporting architecture, with the general logic of ESRS: its environment reports follow a consistent structure with recurring environmental topics and indicators, enabling traceability and comparability across reporting cycles within the chosen scope. In A-to-E terms, this represents a clear strength on A (instrument purpose as a disclosure vehicle) and E (reporting architecture and traceability).

Second, CERN's approach covers the boundary clarity that is central to credible reporting in both GRI and ESRS/CSRD-style disclosure regimes. CERN explicitly defines what is inside the reporting perimeter and what is excluded, thereby clarifying the interpretive limits of the disclosed information. While these choices constrain coverage, their explicitness strengthens transparency by making the reporting perimeter legible to the reader. In A-to-E terms, this reinforces B (scope and boundaries) and supports E (interpretability and credibility conditions for disclosure).

Third, CERN shows meaningful convergence with the materiality-based structuring expected in disclosure frameworks such as GRI (and, conceptually, in the ESRS logic), insofar as reporting priorities are organised through a periodic prioritisation process rather than being presented as a purely descriptive inventory. Even within an environment-centred report, this materiality-informed structuring matters because it connects reported topics to a rationale for prioritisation and supports coherence between stated priorities, objectives and performance narratives. In A-to-E terms, this strengthens B (prioritisation logic and topic coverage) and provides a bridge to C where materiality is linked to stakeholder expectations.

Finally, CERN's baseline also reflects elements that resonate with management-system-oriented instruments such as ISO 14001 and EMAS, even though CERN's reporting vehicle is not itself a management-system statement. The progressive formalisation of environmental governance routines and the presence of externally validated management-system signals (notably ISO 50001) indicate internal control capacity and a continuous-improvement orientation, which are central to the governance effect that management-system standards are designed to produce. In A-to-E terms, this contributes primarily to D (governance integration and routinisation) and E (credibility cues), even if credibility is not structured around ESG-wide assurance.

Taken together, these elements indicate that CERN's current approach provides a robust foundation for environmental accountability within a disclosure-oriented logic: it is reporting-structured, explicit on boundaries, materiality-informed, and increasingly supported by governance routines that are compatible with continuous-improvement expectations. This provides a clear baseline for the next subsection, which identifies which additional accountability elements are foregrounded by other framework logics but remain outside CERN's current environment-centred reporting architecture.

3.2.3. Areas Not Covered by CERN's Current Reporting Baseline (relative to framework expectations)

While CERN's reporting is coherent within its stated purpose and its GRI-based architecture, comparing it to other framework logics helps identify which disclosure and governance elements remain outside the current baseline. In this thesis, this comparative step is used to clarify what CERN's current environment-centred reporting model captures well, and what would become more salient if CERN were assessed through frameworks designed for comprehensive ESG accountability.

A first element that remains largely outside CERN's current baseline concerns the systematic visibility of social and governance dimensions within one reporting architecture. CERN's reporting vehicle is explicitly an environment report and, accordingly, its material topics and performance narrative remain predominantly environmental. By contrast, ESG-oriented instruments, most notably the ESRS within the CSRD logic, and broader responsibility guidance such as ISO 26000, are

explicitly designed to make social and governance responsibilities more visible and more systematically addressed alongside environmental topics. When CERN's reporting is viewed through that lens, the key observation is that social and governance accountability is not organised as part of the environment report's disclosure architecture, which limits the extent to which the report can function as a single, comprehensive ESG governance account.

A second element concerns materiality framing across ESG domains. CERN's prioritisation logic is materiality-informed, but it is applied primarily within an environmental perimeter. In contrast, the ESRS/CSRD approach operationalises double materiality as a structuring device intended to organise priorities across environmental, social and governance impacts and risks. The difference matters for comparative interpretation: CERN's current baseline supports prioritisation within environment-focused reporting, but it does not provide an integrated framework for explaining prioritisation and trade-offs across ESG domains within one disclosure narrative.

Third, other frameworks place stronger emphasis on a predefined disclosure architecture that extends beyond performance topics into governance, strategy and management disclosures. CERN's reporting is systematic and transparent within its environmental scope, but it remains a voluntary reporting product rather than a sustainability statement organised around an extensive set of required governance and management disclosures across ESG topics. In the ESRS logic, for example, the reporting architecture is designed to cover both topical impacts and the governance and management arrangements that structure organisational accountability. From this perspective, the comparative lens highlights that CERN's baseline is primarily organised around environmental topics and indicators, rather than around a more comprehensive reporting architecture that also standardises how governance and management disclosures are presented.

A fourth element relates to credibility mechanisms as defined in mandatory reporting regimes. CERN's credibility signals are strong in environmental monitoring and institutional oversight, particularly through host-state interfaces and increasingly formalised management routines. However, in regimes such as the CSRD/ESRS model, credibility is also reinforced through formal assurance expectations over sustainability information as part of a structured reporting system. CERN's current baseline is not organised around this assurance logic. This does not imply lower credibility overall; rather, it indicates that CERN's credibility architecture is anchored in different mechanisms (monitoring interfaces, external scrutiny, and management-system validation) than those prioritised in corporate-style mandatory ESG reporting models.

Finally, CERN's explicit boundary logic, while a strength for interpretability, also defines what remains outside the reporting account when compared to frameworks that increasingly foreground value-chain or broader upstream/downstream impacts. The inclusion of procurement-related Scope 3 emissions represents a significant step towards recognising indirect impacts, yet CERN's reporting still draws a clear line around major impact sources that sit outside its direct operational control. Under framework logics that emphasise extended boundary accountability, this boundary choice becomes a key constraint that shapes what the reporting baseline can reasonably claim to represent.

In sum, CERN's reporting is comparatively mature as an environment-centred disclosure instrument, but the comparative lens shows that frameworks designed for comprehensive ESG accountability would bring additional elements into view, particularly regarding the systematic visibility of social and governance dimensions, the use of double materiality as an organising device

across ESG domains, and assurance-style credibility mechanisms. The next subsection therefore considers potential integration as an analytical question of complementarity: which elements from other framework logics would be relevant if CERN chose to broaden the visibility of ESG governance beyond its current environmental baseline.

To make this contrast explicit, Table 3.1. summarises, in a condensed format, which accountability elements are already visible within CERN's current baseline and which are foregrounded by other framework logics, providing a bridge to the potential integration pathways discussed in Section 3.2.4.

Table 3.1. *What CERN's current baseline makes visible vs what other frameworks logic foreground.*

Accountability element (what is at stake)	**CERN baseline visibility (within environment report logic)**	**Framework logic where this element is foregrounded**
Structured, traceable disclosure architecture (what is reported and how)	Yes – stable reporting structure and recurring environmental indicators	GRI; ESRS
Clear scope and boundary setting	Yes – explicit inclusions/exclusions and reporting perimeter	GRI; ESRS/CSRD
Materiality-based prioritisation	Yes (within e scope) – priorities organised through materiality but mainly environmental	GRI; ESRS/CSRD
ESG breadth (systematic social + governance visibility in one account)	No / limited – largely outside an environment-only reporting architecture	ESRS/CSRD; ISO 26000
Double materiality framing across ESG impacts and risks	Not explicit – prioritisation remains mainly within environmental perimeter	ESRS/CSRD
Management-system routines made explicit (pdca, controls, corrective action visibility)	Partly – present through governance routines/certification signals but not fully "reported as system"	ISO 14001; EMAS
Credibility through sustainability assurance expectations	Not central – credibility anchored in monitoring/oversight and validation, not ESG assurance	CSRD/ESRS
Responsibility framing beyond environment (values, organisational conduct, stakeholder responsibilities)	Limited – not structured as a social responsibility account	ISO 26000

Source: Own contribution based on Chapter 2, Chapter 3 and the framework logics outlined in Chapter 1.

3.2.4. POTENTIAL INTEGRATION

The purpose of this subsection is to articulate, in analytical terms, what "potential integration" could mean if CERN sought to increase alignment with specific framework logics beyond its current GRI-based environmental reporting baseline. Because the instruments discussed in Chapter 1 organise accountability in different ways, "integration" should be understood primarily as functional complementarity: adding selected elements that make additional aspects of accountability visible (disclosure), strengthening routines that institutionalise accountability (management systems), or expanding the responsibility framing that guides organisational behaviour (principles-based guidance).

If the objective were to increase alignment with the ESRS/CSRD disclosure logic, the most relevant integration would concern the reporting architecture rather than the environmental indicators themselves. This could involve adopting a clearer structure for linking impacts, risks and opportunities to governance and strategy disclosures, and using a more explicit materiality framing that can, in principle, organise prioritisation across ESG dimensions rather than within the environmental perimeter alone. In practical terms, this would mean moving from an environment-only disclosure product towards a reporting architecture that explains how priorities are determined, how responsibilities are assigned, and how performance information connects to management approach and oversight. Such an approach would bring CERN's reporting closer to the logic of comprehensive sustainability statements where governance and management disclosures are integral parts of transparency.

If the objective were to increase alignment with management-system-oriented instruments such as ISO 14001 and EMAS, the relevant integration would lie less in adding new disclosure topics and more in strengthening the visibility and traceability of internal routines. For example, reporting could more explicitly reflect the presence of structured cycles of planning, implementation, monitoring and corrective action, and clarify how responsibilities, controls and continuous improvement expectations are embedded across environmental domains. Where CERN already shows movement in this direction through formalisation and certification (e.g., ISO 50001), potential integration could consist of making these routines more legible in the reporting narrative, showing, for instance, how objectives are operationalised through procedures, internal review, and improvement loops, and how compliance obligations and environmental risk management are managed systematically. This would increase alignment with the governance effect that management-system standards are designed to produce: institutionalised accountability through continuous improvement capacity.

If the objective were to increase alignment with ISO 26000's principles-based guidance, the relevant integration would primarily concern the visibility of social responsibility and governance considerations that sit alongside environmental performance but are not captured by an environment-only reporting architecture. This could take the form of articulating more explicitly how stakeholder responsibilities are defined and governed (beyond consultation), and how organisational conduct, accountability and social implications are addressed within CERN's broader responsibility narrative. In analytical terms, this is less about prescribing indicators and more about clarifying how CERN frames its responsibilities and decision-making in areas that may not naturally appear in an environmental performance report, but that become salient when sustainability reporting is treated as a governance tool.

Across these potential integration paths, two clarifications are important for the thesis. First, "integration" does not imply that CERN should adopt each framework in full; rather, it highlights that those different instruments offer different add-on elements that correspond to different accountability logics. Second, the most meaningful integration opportunities are those that match CERN's institutional nature and existing reporting foundation: CERN already has a relatively mature environmental disclosure baseline, defined boundaries, and strong external accountability interfaces. Potential integration, therefore, is best framed as a selective broadening of what becomes visible through reporting, either by adopting a more ESG-comprehensive disclosure architecture (ESRS/CSRD logic), by making internal continuous-improvement routines more explicit and traceable (ISO/EMAS logic), or by strengthening the articulation of organisational responsibility and stakeholder-related governance beyond environmental performance (ISO 26000 logic). The final subsection of this chapter section positions CERN against peer institutions to show how these different integration logics are already reflected, implicitly or explicitly, in comparable research settings.

3.2.5. CERN vs Peers

Placing CERN alongside ESA, ITER and the Max Planck Society highlights that comparable research institutions "align" with sustainability expectations through different accountability architectures, not through one uniform model. This matters in particular in settings where sustainability reporting is also tied to institutional legitimacy and a stated ambition to lead by example. As discussed in Chapter 2, CERN frames its environmental responsibility in "role model" terms; ESA and MPS similarly use a leadership-oriented responsibility narrative. Against that backdrop, the form and visibility of public accountability become part of how these organisations demonstrate responsible performance alongside scientific excellence.

In this peer set, CERN stands out for relying on a relatively consolidated and framework-shaped reporting product: its biennial environment reports resemble the logic of structured sustainability disclosure more closely than the more distributed approaches observed at ITER and MPS. In that sense, CERN is comparatively advanced in the format of public environmental accountability, particularly when compared to institutions whose sustainability-related information is communicated primarily through portfolios of institutional reports, policies, or thematic instruments rather than a single recurring reporting vehicle.

At the same time, ESA illustrates what a more explicitly ESG-oriented, disclosure-centred model can look like in a research-institution setting. Relative to CERN's environment-centred report, ESA's Responsibility & Sustainability reporting provides a consolidated disclosure architecture that is framed more explicitly through materiality (including double materiality), and therefore offers a clearer template for making governance framing and cross-domain prioritisation visible within one reporting product. In comparative terms, this positions CERN closer to ESA in its reliance on a consolidated reporting vehicle, but closer to ITER and MPS in the sense that its primary reporting scope remains focused on environmental performance rather than on an integrated ESG account.

ITER and MPS, by contrast, show how sustainability accountability can be organised without a single sustainability report "per se." As developed above, ITER distributes accountability across an Annual Report, audited financial reporting, HR reporting and overarching safeguarding policies, which makes governance and social dimensions visible but not necessarily integrated with

environmental performance into a single sustainability narrative. MPS foregrounds targets and binding implementation instruments (such as climate planning and sustainable building requirements), which produces a strong governance signal through steering tools, even if the disclosure architecture is less standardised as a recurring ESG reporting product. For CERN, these peer models are analytically relevant because they suggest that "integration" can take different forms: it can mean broadening disclosure within a consolidated reporting architecture (closer to ESA), strengthening the visibility of governance and oversight arrangements that sit around reporting (closer to ITER's accountability portfolio), or reinforcing steering capacity through explicit targets and binding implementation instruments (closer to MPS's strategy-led approach). This comparative positioning therefore provides a pragmatic reference point for interpreting CERN's current baseline: CERN already demonstrates a relatively mature environmental reporting format, while the peer landscape illustrates alternative ways in which broader ESG governance visibility can be organised in research institutions.

Taking this together, this chapter has positioned CERN's current reporting approach in comparative perspective by applying a consistent A-to-E lens across frameworks and peer accountability architectures. Three main findings emerge. First, CERN's biennial environment reports constitute a comparatively mature, disclosure-structured environmental accountability instrument: they are clear on boundaries, organised through a materiality-informed prioritisation logic, and supported by credibility cues rooted in monitoring interfaces and increasingly formalised governance routines. In comparative terms, this places CERN strongly within the disclosure-oriented logic associated with GRI, while also showing meaningful resonance with management-system expectations where governance formalisation and continuous-improvement signals are visible.

Second, the comparative lens clarifies that the key issue is not the quality of CERN's environmental disclosure within its stated scope, but the visibility limits of an environment-centred baseline when viewed through frameworks designed for comprehensive ESG accountability. Instruments such as ESRS/CSRD and ISO 26000 foreground additional elements, systematic social and governance coverage, cross-domain prioritisation through double materiality, and assurance-style credibility mechanisms, that are largely outside CERN's current reporting architecture. Importantly, these differences reflect distinct accountability designs rather than a single normative benchmark: frameworks make different aspects of organisational responsibility visible, and CERN's current model makes environmental accountability visible particularly well.

Third, the chapter has framed "potential integration" as functional complementarity rather than as prescriptive recommendations. It has shown how different integration paths would correspond to different accountability effects: an ESRS/CSRD-type path would primarily expand reporting architecture and ESG visibility; an ISO/EMAS-type path would strengthen the explicitness and traceability of internal routines and improvement cycles; and an ISO 26000-type path would broaden the articulation of responsibility and governance considerations beyond environmental performance. The peer comparison reinforces that multiple accountability architectures are viable in research settings: CERN is comparatively advanced in the existence of a consolidated reporting product, while peers illustrate alternative ways of organising governance visibility through portfolios of reports, audited oversight arrangements, targets, and binding implementation instruments. Together, these results establish the analytical basis for the conclusions chapter, where the implications for the thesis argument are synthesised and linked back to the overall research objective.

CONCLUSION

This thesis set out to clarify how sustainability reporting frameworks differ in the way they organise accountability, and what this implies for large scientific and research institutions. Building on a comparative analysis of GRI, CSRD/ESRS, EMAS and ISO (14001/26000), the study applied a consistent A-to-E comparability lens to CERN's Environment Reports (2017–2024) and to a brief peer benchmark (ESA, ITER, and MPS). The aim was to assess whether CERN's current GRI-based baseline is sufficient to underpin comprehensive ESG governance, or whether selected elements from other framework logics would add value through functional complementarity rather than substitution.

In response to the first research question, the analysis confirms that the selected instruments encode distinct accountability logics. GRI functions primarily as a disclosure-oriented standard designed to structure impact reporting through material topics and traceable disclosures. CSRD/ESRS represent a regulatory and prescriptive disclosure regime that makes governance–strategy–risk/impact management–metrics connectivity explicit and formalises credibility through assurance expectations. EMAS and ISO 14001 are better understood as management-system instruments that institutionalise routines of planning, monitoring, corrective action and continual improvement, with EMAS adding public transparency through validated statements. ISO 26000 operates as principles-based guidance, foregrounding social responsibility, stakeholder dialogue, and organisational conduct without certification. This confirms H1, namely that the selected frameworks vary in scope and prescriptiveness but reveal complementary strengths that, when compared, highlight pathways toward more comprehensive sustainability governance in research institutions.

Regarding the second research question, the CERN case and the peer benchmark converge on a consistent institutional pattern: environmental reporting tends to be the most structured, continuous, and measurable stream, while social and governance dimensions are often less consolidated within a single sustainability narrative and become visible through separate organisational artefacts. This does not imply an absence of social and governance commitments; rather, it indicates a different architecture of visibility in which what becomes legible depends on how accountability is organised internally and communicated publicly. ITER illustrates particularly clearly how accountability can be distributed across modular reports and formal policy instruments, while MPS demonstrates strong governance signalling through targets and binding implementation tools without relying on one consolidated sustainability report. ESA sits somewhat differently, as it adopts a broader ESG framing and uses a materiality process aligned with double materiality to integrate priorities into one reporting product. This supports H2, namely that research institutions systematically underreport social and governance dimensions compared to environmental aspects, which limits the effectiveness of sustainability reporting as a governance tool, especially when assessed through ESG-wide disclosure logics.

With respect to the third research question, the findings suggest that CERN's current GRI-based reporting provides a strong foundation for environmental accountability. Across the four reporting cycles, CERN's reporting architecture is stable, with explicit boundaries, materiality-informed prioritisation of environmental topics, and identifiable governance and credibility arrangements that have matured over time. The reporting evolution can be summarised along three main lines: scope expansion, governance formalisation, and longer-term objective setting. Over time, indirect impact visibility expands most clearly through procurement-related Scope 3 emissions,

governance becomes more formalised through external standards and policies, and strategic planning shifts from short-term targets linked to accelerator cycles towards comprehensive 2030 environmental objectives. At the same time, when assessed against ESG-comprehensive logics, most notably the CSRD/ESRS architecture and the broader responsibility framing of ISO 26000, CERN's baseline remains environment-centred: social and governance responsibilities are not yet organised within one coherent ESG reporting architecture, and credibility mechanisms are anchored mainly in environmental monitoring, oversight and management-system signals rather than ESG-wide assurance. This confirms H3, namely that CERN's GRI-based reporting provides a useful foundation but does not fully capture governance and social dimensions; integrating selected elements from other frameworks could enhance its capacity to function as a comprehensive ESG governance instrument, best framed as complementarity rather than replacement.

If CERN's objective is to remain GRI-consistent while becoming more closely aligned with other framework logics, the thesis indicates a small set of shifts that would most clearly broaden its reporting from an environment-centred baseline to a more explicit ESG accountability architecture. Moving closer to the CSRD/ESRS logic would require making the materiality process more explicit and traceable in double-materiality terms, strengthening the structured linkage between governance, strategy, impact/risk/opportunity management and metrics/targets across ESG topics, and progressively expanding value-chain coverage where material, beyond the current emphasis on procurement. Aligning more strongly with EMAS/ISO 14001 would mean complementing disclosure with a clearer organisation-wide environmental management-system logic, including systematic identification of significant aspects and compliance obligations, routinised review and management evaluation, and, if pursued, stronger public validation features associated with EMAS. Finally, closer alignment with ISO 26000 would mainly involve making social-responsibility governance legible rather than adding indicators: clarifying due diligence processes for social and human-rights-related impacts, formalising stakeholder dialogue channels, and integrating these social and governance commitments into the same accountability narrative instead of leaving them dispersed across separate institutional artefacts. Read as complementarity, these moves do not replace CERN's current reporting baseline; they specify what would need to be foregrounded for the baseline to function more fully as an ESG governance instrument.

Beyond the research questions, the thesis yields three broader conclusions about sustainability reporting in research-institution contexts. First, reporting operates as governance rather than solely as communication: in CERN's case, the reporting process functions as a routinised mechanism that coordinates actors, stabilises indicators, structures internal validation chains, and supports the production of comparable performance information over time. Second, boundaries are a core governance choice and a major driver of what becomes visible: CERN's reporting strength in clearly defining scope enhances interpretability, but it also delimits what can plausibly be claimed as an ESG account, especially regarding impacts associated with user communities and external partners. Third, the peer benchmark indicates that multiple accountability architectures are viable in research institutions, but they shape ESG visibility differently; across cases, environmental accountability is most consistently channelled into recurring reporting streams, whereas social and governance dimensions are frequently distributed across separate institutional channels, which can make overall sustainability priorities less legible as one coherent system of commitments, performance and controls.

In terms of contribution, this thesis reinforces a governance-tool perspective by showing that sustainability disclosure does not simply reflect organisational reality but helps constitute it by shaping routines, priorities, and accountability relations. It also advances a functional differentiation reading of sustainability instruments: frameworks should be interpreted less as competing labels and more as tools that foreground different governance effects, including disclosure architectures, management routines, and principles of responsibility. Empirically, the thesis provides a structured A-to-E mapping of CERN's reporting baseline and its evolution over 2017–2024, and it identifies a cross-institutional pattern, environmental dominance with more dispersed social and governance visibility, that helps explain why many research institutions appear strong on environmental performance disclosure while remaining comparatively fragmented on ESG-wide reporting.

This study has limitations. It is a single-case design centred on CERN, which constrains generalisation. It relies primarily on documentary evidence complemented by a limited number of interviews, which supports process understanding and triangulation but does not capture all internal decision-making dynamics or the full range of stakeholder perspectives. The framework comparison is also necessarily selective and anchored in an EU-influenced institutional environment. Future research could extend this work by comparing multiple research institutions using the same A-to-E comparative lens, expanding interviews across governance, procurement, Human Resources, scientific departments and external stakeholders, and following CERN's next reporting cycle to examine empirically how an ESG-oriented transition reshapes boundaries, materiality and credibility mechanisms in practice.

CERN's ambition to operate as a role model for environmentally responsible research points to a broader implication of this thesis: in high-visibility, infrastructure-intensive scientific institutions, reporting is one of the main mechanisms through which responsibility is made legible, negotiated, and governed. The thesis has shown that what sustainability reporting "is" depends on the accountability logic embedded in the chosen instruments and organisational architecture. Understanding these logics as complementary rather than competing provides a more realistic and institutionally sensitive basis for strengthening transparency and governance in research institutions while remaining aligned with their distinctive mandates, constraints, and public responsibilities.

REFERENCES

Adams, C. A., Alhamood, A., He, X., Tian, J., Wang, L., & Wang, Y. (2021). The double-materiality concept. Application and issues. Queen's University Belfast. https://pure.qub.ac.uk/en/publications/the-double-materiality-concept-application-and-issues/.

Alzate, A., Ramírez, J. & Alzate, S. (2018). Modelo de gestión ambiental ISO 14001: evolución y aporte a la sostenibilidad organizacional. Revista chilenad e economia y sociedad. https://rches.utem.cl/wp-content/uploads/sites/8/2018/07/revista-CHES-vol12-n1-2018-A.Alzate-Iban%CC%83ez-Ramirez-S.Alzate-Iban%CC%83ez.pdf.

Akshay. (2025). Standard vs Framework vs Laws vs Regulations: 6 Key differences. TrustCommunity. https://community.trustcloud.ai/docs/grc-launchpad/grc-101/compliance/standard-vs-framework-vs-laws-vs-regulations/.

Barker, R. (2025). Corporate sustainability reporting. Journal of Accounting and Public Policy, 49, 107280. https://doi.org/10.1016/j.jaccpubpol.2024.107280.

Baumüller, J., & Sopp, K. (2021). Double materiality and the shift from non-financial to European sustainability reporting: review, outlook and implications. Journal of Applied Accounting Research, 23(1), 8–28. https://doi.org/10.1108/jaar-04-2021-0114.

Bell, C., & Voorhees, J. (2020). Using Standards as a Framework for Environmental and Social Governance. Natural Resources & Environment, 35(2), 41–45. https://www.jstor.org/stable/27010671.

Bravi, L., Santos, G., Pagano, A., & Murmura, F. (2020). Environmental management system according to ISO14001:2015 as a driver to sustainable development. Corporate Social Responsibility and Environmental Management, 27(6), 2599–2614. https://doi.org/10.1002/csr.1985.

Byrne, D. (2024). What's the difference between ESG reporting standards and frameworks? The Corporate Governance Institute. https://www.thecorporategovernanceinstitute.com/insights/guides/whats-the-difference-between-esg-reporting-standards-and-frameworks/.

CERN (n.d.). Contribute to society. Our Impact. About. CERN. https://home.cern/about/what-we-do/our-impact.

CERN (n.d.). CERN's Main Objectives for the period 2021-2025. CERN. https://home.cern/sites/default/files/2022-01/CERNS%20Main%20Objectives_0.pdf.

CERN (2020). Director-General Office Sector (DG), 2009 – Present. CERN Scientific Information Service. CERN. https://library.cern/archives/history_CERN/internal_organisation/DG?utm.

CERN (n.d.). Environmental Protection. HSE unit at CERN. Services & Support. CERN. https://hse.cern/services-support/environmental-protection.

CERN (n.d.). Our mission. About. CERN. https://home.cern/about/who-we-are/our-mission.

CERN (n.d.). Our Member States. About. CERN. https://home.cern/about/who-we-are/our-governance/member-states.

CERN (2020). Vol. 1 (2020): CERN Environment Report—Rapport sur l'environnement 2017–2018. Archives. CERN. https://doi.org/10.25325/cern-environment-2020-001.

CERN (2021). Vol. 2 (2021): CERN Environment Report—Rapport sur l'environnement 2019–2020. Archives. CERN. https://doi.org/10.25325/CERN-Environment-2021-002.

CERN (2023). Vol. 3 (2023): CERN Environment Report—Rapport sur l'environnement 2021–2022. Archives. CERN. https://doi.org/10.25325/CERN-Environment-2023-003.

CERN (2025). Vol. 4 (2025): CERN Environment Report—Rapport sur l'environnement 2023–2024. Archives. CERN. https://doi.org/10.25325/CERN-Environment-2025-004.

Cook, A. (2025). CERN sets new environmental objectives for 2030. News. Topic : At CERN. CERN. https://home.cern/news/news/cern/cern-sets-new-environmental-objectives-2030.

De Cristofaro, T., & Gulluscio, C. (2023). In search of Double Materiality in Non-Financial Reports: First Empirical evidence. Sustainability, 15(2), 924. https://doi.org/10.3390/su15020924.

Delgado-Ceballos, J., Ortiz-De-Mandojana, N., Antolín-López, R., & Montiel, I. (2022). Connecting the Sustainable Development Goals to firm-level sustainability and ESG factors: The need for double materiality. BRQ Business Research Quarterly, 26(1), 2-10. https://doi.org/10.1177/23409444221140919.

De Lima, R. G., Lins, H. N., Pfitscher, E. D., Garcia, J., Suni, A., De Andrade Guerra, J. B. S. O., & Delle, F. C. R. (2016). A sustainability evaluation framework for Science and Technology Institutes: an international comparative analysis. Journal of Cleaner Production, 125, 145–158. https://doi.org/10.1016/j.jclepro.2016.03.028.

Department of Climate, Energy and the Environment (2025). Eco-Management and Audit Scheme (EMAS). Government of Ireland. https://www.gov.ie/en/department-of-climate-energy-and-the-environment/publications/eco-management-and-audit-scheme-emas/.

Down, H. (2025). ESG reporting frameworks and standards – understanding the difference. EcoOnline. https://www.ecoonline.com/blog/esg-reporting-frameworks-and-standards-understanding-the-difference/.

EFRAG (n.d.). About us. EFRAG. https://www.efrag.org/en/about-us#missionstatement.

EFRAG. (2023). European Sustainability Reporting Standards (ESRS). https://www.efrag.org/en.

EFRAG (n.d.). Sector-specific ESRS. ESRS workstreams. Sustainability Reporting. https://www.efrag.org/en/sustainability-reporting/esrs-workstreams/sectorspecific-esrs.

Ernst & Young (2023). European Sustainability Reporting Standards (ESRS). EU Sustainability Developments. EY. https://www.ey.com/content/dam/ey-unified-site/ey-com/en-gl/technical/ifrs-technical-resources/documents/ey-pov-esrs-august-2023.pdf.

European Commission (n.d.). About EMAS. Green Business. Green Forum. Energy, Climate change, Environment. https://green-forum.ec.europa.eu/green-business/emas/about-emas_en.

European Commission (n.d.). Corporate sustainability due diligence. European Commission. https://commission.europa.eu/business-economy-euro/doing-business-eu/sustainability-due-diligence-responsible-business/corporate-sustainability-due-diligence_en.

European Comission (n.d.). Corporate sustainability reporting. Company reporting and auditing. Finance. European Comission. https://finance.ec.europa.eu/capital-markets-union-and-financial-markets/company-reporting-and-auditing/company-reporting/corporate-sustainability-reporting_en.

European Commission. (2023). Corporate Sustainability Reporting Directive (CSRD). https://finance.ec.europa.eu/index_en.

European Commission (n.d.). Digital Omnibus Regulation Proposal. Shaping Europe's Digital Future. https://digital-strategy.ec.europa.eu/en/library/digital-omnibus-regulation-proposal.

European Commission (n.d.). Eco-Management and Audit Scheme (EMAS). Green business. Green forum. Energy, Climate change, Environment. https://green-forum.ec.europa.eu/green-business/emas_en.

European Commission. (2019). Guidelines on reporting climate-related information [Report]. European Commission. https://ec.europa.eu/finance/docs/policy/190618-climate-related-information-reporting-guidelines_en.pdf.

European Space Agency (n.d.), ESA's Commitment to Sustainability. About us. The European Space Agency. https://www.esa.int/About_Us/Climate_and_Sustainability.

European Space Agency (2024). ESA Responsibility & Sustainability Report 2022-23. The European Space Agency. https://esamultimedia.esa.int/docs/corporate/CSR_REPORT_2022-23-digital.pdf.

Farrell, S., & Chater-Lea, A. (2023). The rising tide of sustainability reporting: Navigating the new era of corporate transparency. https://www.deloitte.com/uk/en/services/audit-assurance/blogs/2024/the-rising-tide-of-sustainability-reporting.html

Green Progress (n.d.). Eco Management and Audit Schem (EMAS): Complete Guide. https://evaluaciondeimpactoambiental.com/eco-management-and-audit-scheme/.

GRI (n.d.). A Short Introduction to the GRI Standards. https://www.globalreporting.org/media/wtaf14tw/a-short-introduction-to-the-gri-standards.pdf.

GRI (n.d.). Global Reporting Initiative Standards. https://www.globalreporting.org/.

GRI (n.d.). GRI Standards. https://www.globalreporting.org/media/s4cp0oth/gri-gristandards-visuals-fig1_family-2021-print-v19-01.png.

GRI (n.d.). GRI - Vision, mission and history. https://www.globalreporting.org/about-gri/vision-mission-and-history/.

GRI (n.d.). How to use the GRI Standards. https://www.globalreporting.org/how-to-use-the-gri-standards/.

IFC (2023). Understanding the Global Reporting Frameworks. https://www.ifcbeyondthebalancesheet.org/.

IFRS (n.d.). IFRS Sustainability Standards. https://www.ifrs.org/.

ISO (n.d.). ISO 14001:2015(en) Environmental management systems — Requirements with guidance for use. Online Browsing Platfrom (OBP). https://www.iso.org/obp/ui/en/#iso:std:iso:14001:ed-3:v1:en.

ISO (n.d.). ISO 26000:2010(es) Guía de responsabilidad social Online Browsing Platfrom (OBP). https://www.iso.org/obp/ui#iso:std:iso:26000:ed-1:v1:es.

ITER (2025). Annual Report ITER Organization 2024. ITER. https://www.iter.org/sites/default/files/media/2025-11/exe-ra-2024-ok-web.pdf.

ITER (2025). Financial Report ITER Organization 2024. ITER. https://www.iter.org/sites/default/files/media/2025-11/rapport-financier-iter-2024-web.pdf.

ITER (n.d.). ITER Policy on Safety, Security, Quality and Environment Protection. ITER. https://www.iter.org/sites/default/files/media/2025-12/iter-policy-on-safety-security-quality-and-environment-protection_43ujn7_v4.0_signed-002.pdf.

ITER (2025). Report on Human Resources ITER Organization 2024. ITER. https://www.iter.org/sites/default/files/media/2025-09/rh-2024-web_2.pdf.

Köster, J. (2024). Navigating the interplay of GRI standards and ESRS. Sunhat. https://www.getsunhat.com/blog/gri-esrs.

Marimon, F., et al. (2012). The worldwide diffusion of the global reporting initiative: what is the point? Journal of Cleaner Production, 33, 132–144. https://doi.org/10.1016/j.jclepro.2012.04.017.

Max Planck Society (2025). Guidelines for Sustainable planning and building. https://www.mpg.de/25928145/mpg-guidelines-for-sustainable-planning-and-building.pdf.

Max Planck Society (n.d.). Sustainability in the Max Planck Society. About Us. https://www.mpg.de/21497470/sustainability-in-the-mps.

Max Planck Society (2025). JAHRESBERICHT Annual Report 2024. https://www.mpg.de/24877983/mpg-annual-report-2024.pdf.

Max Planck Society (2024). Max Planck Climate Action Plan. https://www.mpg.de/21703326/climate-action-plan-en.pdf.

Max Planck Society (2023). More Biodiversity at Max Planck Institutes A Guide. Sustainability at the Max Planck Society. https://www.mpg.de/21501878/biodiversity-at-max-planck-institutes.pdf.

Max Planck Sustainability Network (n.d.). The Max Planck Sustainability Network. Max Planck Society. https://www.nachhaltigkeitsnetzwerk.mpg.de/.

Mays, R. & Daphne, T. (2024). The European Sustainability Reporting Standards explained (ESRS). Circularise. https://www.circularise.com/blogs/the-european-sustainability-reporting-standards-explained-esrs.

Montecalvo, M., Farneti, F. & De Villiers, C. 2018. The potential of integrated reporting to enhance sustainability reporting in the public sector, Public Money & Management, 38(5), 365-374. https://doi.org/10.1080/09540962.2018.1477675.

OECD (2019). Reference framework for assessing the scientific and socio-economic impact of research infrastructures. In OECD science, technology and industry policy papers. https://www.oecd.org/content/dam/oecd/en/publications/reports/2019/03/reference-framework-for-assessing-the-scientific-and-socio-economic-impact-of-research-infrastructures_5215b703/3ffee43b-en.pdf

Larrue, P., Strauka, O., & OECD Directorate for Science, Technology and Innovation. (2022). The contribution of RTOs to Socio-Economic recovery, resilience and transitions. In OECD Science, Technology and Industry Policy Papers (pp. 2–5) [Report]. OECD. https://www.oecd.org/content/dam/oecd/en/publications/reports/2022/05/the-contribution-of-rtos-to-socio-economic-recovery-resilience-and-transitions_d27dd621/ae93dc1d-en.pdf.

Pojasek, R. B. (2011). ISO 26000 guidance on social responsibility. Environmental Quality Management, 20(3), 85-93. https://doi.org/10.1002/tqem.20292.

Popa, D.I., Dabija, DC. (2019). ISO 26000: A Brief Literature Review. In: Idowu, S.O., Sitnikov, C., Moratis, L. (eds) ISO 26000 - A Standardized View on Corporate Social Responsibility. CSR, Sustainability, Ethics & Governance. Springer, Cham. https://doi.org/10.1007/978-3-319-92651-3_6.

Reyes, S. (2004). Archives of Relations with Member and Non-Member States Service. CERN Scientific Information Service. CERN. https://scientific-info.cern/archives/CERN_archive/guide/management/directorate/isadsudo?utm.

Rondinelli, D., & Vastag, G. (2000). Panacea, common sense, or just a label? European Management Journal, 18(5), 499–510. https://doi.org/10.1016/s0263-2373(00)00039-6.

SASB (n.d.). SASB Standards Overview. Sustainability Accounting Standards Board Framework. https://sasb.ifrs.org/standards/.

TCFD. (2012). Task Force on Climate-related Financial Disclosures Overview. https://assets.bbhub.io/company/sites/60/2022/12/tcfd-2022-overview-booklet.pdf.

Tompson, M. (2025). CERN management structure for 2026–2030, part 3. CERN. https://home.cern/news/opinion/cern/cern-management-structure-2026-2030-part-3? .

UNESCO. (2015). UNESCO Science Report: Towards 2030. Paris: UNESCO Publishing. https://unctad.org/system/files/official-document/dtlstict20163_en.pdf.

Wagenhofer, A. (2023). Sustainability Reporting: A Financial Reporting perspective. Accounting in Europe, 21(1), 1-13. https://doi.org/10.1080/17449480.2023.2218398.

WCED (1987). Our common future. Oxford University Press. World Commission on Environment and Development. https://sustainabledevelopment.un.org/content/documents/5987our-common-future.pdf.

The Club of Rome. (2026). History - Club of Rome. Club Of Rome. https://www.clubofrome.org/about-us/history/.

Yin, H., & Schmeidler, P. J. (2008). Why do standardized ISO 14001 environmental management systems lead to heterogeneous environmental outcomes? Business Strategy and the Environment, 18(7), 469–486. https://doi.org/10.1002/bse.629.

APPENDICES

APPENDIX 1: INTERVIEW TEMPLATES

CERN's Group Leader Environment & Member of CEPS Interview

Opening

First of all, thank you very much for taking the time to speak with me today.

As you know, I am working on my Master's thesis in Sustainable Societies and Social Change at the Uniersity of Geneva. My thesis looks at how different sustainability reporting frameworks – such as GRI, CSRD, EMAS and ISO – can be used to support environmental governance at CERN.

The goal of this interview is to better understand your perspective and experience regarding environmental reporting at CERN.

The interview should take around 30 to 45 minutes. With your permission, I would like to record our conversation so that I can focus on listening and later transcribe it accurately. The recording and transcript will be used only for academic purposes, and any quotes in my thesis can be anonymised or attributed by role, depending on what you prefer. You are of course free to skip any question or stop the interview at any time.

Before we start: Do you have any questions for me before we begin?

If not, I'll start with the first question.

Questions

1. Could you briefly describe your role in relation to CERN's environmental reporting? For instance, which parts of the process you contribute to or coordinate, where you sit in the organisation, and who your main internal counterparts are.

2. CERN published its first Environment Report covering 2017–2018 (released in 2020). Were you involved around that time?
   If yes, could you walk me through how the idea to start reporting emerged—what triggered it, who pushed for it, and what the main objectives were at the beginning?

3. How has CERN's environmental reporting evolved since then, in terms of scope, level of detail, and expectations, both internally (management) and externally (host states, partners, scientific community, local stakeholders)?

4. Today the Environmental Report is structured using GRI. Do you recall how the decision to use GRI was made?
   If you were involved, could you describe the process, who was consulted, what criteria were used (credibility, comparability, feasibility, stakeholder expectations), and what alternatives (if any) were considered?

5. In your view today, what is the report primarily for: external transparency, internal management/steering, or both? Who is the "real" audience?

6. When an environmental topic needs a decision, how does it move from "issue identified" to "decision taken"? Where does CEPS intervene, and what typically happens before/after CEPS?

7. Can you share one recent example where an environmental consideration materially influenced an outcome? What was the key piece of evidence or signal?

8. In practice, what makes an environmental signal "strong enough" to trigger action at CERN? (thresholds, trends, incidents/audits, benchmarking, host-state expectations, scenario analysis…)

9. In the last reporting cycle, CERN moved toward longer-term objective-setting, including the Directorate's approval of 2030 environmental objectives. Could you walk me through how these objectives were developed and agreed?
   a. *What was CEPS's role versus other bodies (e.g., EMP, Directorate)?*
   b. *What kinds of evidence or constraints mattered most (technical feasibility, costs, operational needs, host-state expectations)?*
   c. *How is progress tracked and revisited*

10. Looking ahead to the next few years, which 3–5 environmental metrics matter most to CERN's leadership – and why (e.g. risk, impact, comparability, external expectations)? *(By metrics I mean indicators such as electricity use, scope 1–2 emissions, water consumption, waste generated, incident rate, etc.).*

Closing

That was all from my side in terms of questions. Thank you very much for your time and for sharing your experience .

Before we finish,

11. Is there anything important about CERN's environmental reporting practice that we haven't covered, but that you think is crucial to understand its strengths and limitations?

As next steps, I will transcribe the interview and as agreed, I'll send you the transcript once it's done and you'll have 2 days to review it, in case I don't receive any edits or clarifications, I'll proceed with the integration of the insights into my thesis.

If after our conversation you remember something, you would like to add please feel free to email me.

Thank you again for your time and support.

CERN's Environmental Reporting Responsible Interview

Opening

First of all, thank you very much for taking the time to speak with me today.

As you know, I am working on my Master's thesis in Sustainable Societies and Social Change at the Uniersity of Geneva. My thesis looks at how different sustainability reporting frameworks –

such as GRI, CSRD, EMAS and ISO – can be used to support environmental governance at CERN.

The goal of this interview is to better understand your perspective and experience regarding environmental reporting at CERN.

The interview should take around 30 to 45 minutes. With your permission, I would like to record our conversation so that I can focus on listening and later transcribe it accurately. The recording and transcript will be used only for academic purposes, and any quotes in my thesis can be anonymised or attributed by role, depending on what you prefer. You are of course free to skip any question or stop the interview at any time.

Before we start: Do you have any questions for me before we begin?

If not, I'll start with the first question.

Questions

1. Could you briefly describe your role in relation to CERN's environmental reporting? For example: which parts of the process you coordinate, where you sit in the organisation, and who your main internal counterparts are.
2. How has CERN's environmental reporting evolved over the last few years, in terms of scope, level of detail and expectations? Any key milestones or turning points you would highlight?
3. Which reporting frameworks or guidelines currently shape CERN's environmental report (e.g. GRI, ISO-based systems, host state requirements), and how do they influence what is included or excluded?
4. How are the "material" environmental topics for CERN identified? Who is involved, what criteria are used, how often is this revisited and which is the tipical workflow when doing a materiality assessment?
5. If we take 2–3 key indicators (for example electricity use, scope 1–2 emissions, waste generated), could you walk me through the end-to-end process from raw data to the final published figure? Main data sources, frequency, tools/systems, checks, and approvals.
6. In your experience, which indicators tend to generate the most issues (data quality, access, duplication, timing), and what are the usual root causes?
7. Once the environmental data and narratives are ready, how are they validated and discussed at management level? Which bodies are involved, and what kind of questions do they typically ask?
8. To what extent do current reporting requirements influence which indicators and analyses you prioritise? Do you see any gaps between what is most useful for internal decisions and what is emphasised in the external report?
9. Are there any environmental aspects that, in your experience, tend to be under-seen or under-signaled and where external expectations (scientific community, host states, partners) are rising and therefore, they are gaining more significance within CERN?

10. Looking at the next 1–2 reporting cycles, what concrete improvements would you personally prioritise in the environmental reporting process (data, tools, coordination, narrative)?

Closing

That was all from my side in terms of questions. Thank you very much for your time and for sharing your experience – this is extremely helpful for my thesis.

Before we finish,

11. Is there anything important about CERN's environmental reporting practice that we haven't covered, but that you think is crucial to understand its strengths and limitations?

As next steps, I will transcribe the interview and as agreed, I'll send you the transcript once it's done and you'll have 2 days to review it, in case I don't receive any edits or clarifications, I'll proceed with the integration of the insights into my thesis.

If after our conversation you remember something you would like to add please feel free to email me.

Thank you again for your time and support.

APPENDIX 2: CONSENT FORM FOR INTERVIEW PARTICIPANT

(Name of participant), you are invited to participate in an interview part of the Master's Thesis of Sofia Gil Mora, student of the Master in Sustainable Societies and Social Change imparted in the University of Geneva. You were selected because of your experience at CERN. This consent form is designed to ensure that you fully understand the nature of the interview, your role in it, and your rights as a participant. Please take your time to read through the following information carefully. If you have any questions or concerns, feel free to ask before agreeing to participate.

I. Investigators

This research project is being done by Sofia Gil Mora (sofia.gil-mora@etu.unige.ch) in a partner with the University of Geneva.

II. Purpose of the Study

This project aims to bridge and compare key sustainability reporting frameworks in order to assess how they conceptualize governance, materiality, stakeholder engagement and ESG coverage, and how suitable they are for large scientific research organizations. Using CERN as a case study, I seek to identify complementarities and gaps between these frameworks, determine which ESG dimensions tend to remain underrepresented in research institutions and evaluate whether CERN's current GRI-based reporting could be strengthened by selectively integrating elements from other frameworks.

It is important to note that the specific research questions may evolve over time as discussions progress and new insights emerge. Your input will be key for the analysis performed during this research.

III. Description of Research Process

If you opt to take part in this research, you'll be invited to a 45-minute interview conducted by the main researcher. To express your interest in participating, please contact Sofia Gil Mora using the contact details provided. She will then get in touch with you to arrange the interview. Prior to the interview, you will go through a verbal consent process. Following the interview, a transcript of your interview will be provided to you. You will have 2 days to review the transcript and request any edits, clarifications, or additions. This step is crucial for ensuring the transcript accurately reflects your language, intentions, and beliefs. If no revisions are received within the 2-day period, the research team will proceed with the analysis of the transcript.

IV. Study Results

Findings may be shared with the CERN team in charge of sustainability reporting.

V. Confidentiality and anonymization of Data

To build a confident space, we want to note that you do not have to answer any questions if you do not want to. Therefore, we will ensure that information you share is kept confidential in our reports. Any information shared during the interview and the discussion will be anonymized if you prefer it to protect the privacy of all the participants. With your permission, we will email you all research outputs we have created related to the research you participated in.

Please, click the box according to your preferences:

☐ I want to be anonymized, and I do not give permission to show my role within CERN in the final report.

☐ I want to be anonymized, but I give permission to show my role within CERN in the final report.

☐ I do not want to be anonymized in the final report.

VI. Who can you talk to?

If you have any questions or concerns about anything during the research, please contact Sofia Gil Mora. Her contact details are listed at the beginning of this form. If you cannot reach the research team, you want to talk to someone besides the research team or you have questions about your rights as a research subject please contact the University of Geneva (secretariat-sociologie@unige.ch).

VII. Participant Consent and Signature

By signing this form, you acknowledge that you have read and understood the information provided above. You agree to participate voluntarily in our collaborative climate action planning project. You consent to have us retain your email to send you our research outputs.

Participant Signature: **Researcher Signature:**

_____ _____

Date: _____

Thank you for your commitment to making a positive impact on your community's environmental future. Your participation is invaluable to the success of this project.

APPENDIX 3: FRAMEWORK COMPARABILITY MATRIX AND CONSIDERED QUESTIONS

Table A.1. *Framework Comparability Matrix.*

	Block A: Nature of framework			Block B: Materiality and ESG coverage			Block C: Stakeholders		Block D: Governance and integration			Block E: Reporting architecture, indicators and assurance		
	Framework Type and legal force	**Primary purpose**	**Target Audience**	**Materiality concept**	**ESG scope**	**Organizational boundary**	**Stakeholders scope and salience**	**Stakeholder engagement requirements**	**Governance and accountability requirements**	**Integration with strategy and core processes**	**Reflexivity and continuous improvement**	**Reporting structure and level of prescription**	**Indicators and measurability**	**Assurance, certification and verification expectations**
GRI Standards	Voluntary, global sustainability reporting standards (modular: Universal / Sector / Topic).	Public reporting of an organization's impacts on economy, environment and people; transparency + reporting principles and disclosures.	Broad stakeholder audience (shareholders/investors + wider stakeholders, policymakers, civil society).	Impact materiality: stepwise method to identify/prioritise material topics (GRI 3).	Broad sustainability/ESG coverage (economic, environmental, social; some topic standards include governance-related issues).	Flexible boundary defined by the organisation; selection driven by material topics; partial claims permitted were full alignment not feasible.	Broad stakeholder concept ("shareholders and other stakeholders").	Requires disclosure of stakeholder engagement approach (GRI 2) and its role in identifying material topics (GRI 3).	Disclosure of governance, strategy, policies, practices; topic standards may specify governance/control elements for issues (e.g., tax).	Disclosure-oriented: explains how material topics are managed and linked to strategy; does not prescribe a management system.	No explicit PDCA; relies on periodic reporting and management approach disclosures.	Highly structured architecture (Universal/Sector/Topic); guidance is detailed but topic selection remains materiality driven.	Topic standards specify performance disclosures + management approach; aims at comparability (incl. digital taxonomy work).	Verifiability is a quality principle; external assurance is optional/not required in the Draft.
CSRD	EU Directive setting legally binding sustainability reporting requirements for in-scope entities; implemented via ESRS.	Mandate comparable sustainability reporting and embed sustainability information in the management report.	Regulators and market participants; consumers and broader stakeholders (users of sustainability statements).	Double materiality operationalised through ESRS (impact + financial materiality).	ESG coverage via ESRS topical standards (E, S and G).	Value-chain information required via ESRS (upstream/downstream beyond own operations).	Broad stakeholder framing (consumers and stakeholders explicitly referenced).	Entity-level engagement requirements not detailed in Draft; implied through materiality/due diligence processes under ESRS.	Governance disclosures required as part of the management report under CSRD (via ESRS cross-cutting requirements).	Explicit aim to integrate sustainability considerations into strategy and governance through regulated reporting.	Annual reporting cycle with mandatory assurance; potential progression from limited to reasonable assurance.	Reporting required in management report; detailed content requirements provided by ESRS.	Standardised datapoints and metrics/targets via ESRS.	Mandatory third-party verification (assurance): limited assurance initially; possible move to reasonable assurance.
ESRS	Mandatory EU reporting standards implementing CSRD (technical standards adopted by the European Commission).	Standardize sustainability reporting across the EU; embed sustainability into strategy and increase transparency/accountability.	Users of sustainability statements incl. investors, regulators, consumers and broader stakeholders.	Double materiality (impact + financial materiality) as the core reporting logic.	Full ESG: cross-cutting ESRS 1–2 + topical standards (E1–E5, S1–S4, G1).	Explicit upstream and downstream value-chain coverage beyond own operations.	Explicit stakeholder groups (e.g., own workforce, workers in value chain, affected communities, consumers/end-users).	Requires disclosures connected to due diligence and (in S4) stakeholder engagement topics; materiality assessment determines applicable disclosures.	Cross-cutting ESRS 2 requires governance disclosures (roles/oversight) related to sustainability matters.	Strong link to strategy and management of impacts, risks and opportunities (IRO), with metrics and targets.	Not PDCA, but iterative through ongoing reporting, target tracking and periodic materiality reassessment.	Highly prescriptive, datapoint-driven disclosures; crosscutting + topical standards, subject to materiality.	Strong measurability: detailed metrics/targets and disclosure requirements across ESG topics.	Mandatory third-party assurance under CSRD/ESRS regime (limited assurance initially; potential move to reasonable).
EMAS	Voluntary EU environmental management scheme under EU Regulation (current framework: Reg. No 1221/2009).	Improve environmental performance via EMS, legal compliance, continuous improvement and public validated reporting.	Organizations, competent authorities and the public/stakeholders (transparency focus).	Significance of environmental aspects: identify direct/indirect impacts; set criteria for significance; ensure legal compliance.	Environmental only.	Primarily organisational operations but explicitly includes direct and indirect environmental impacts.	Recognises employees and public stakeholders; scheme involves EC, competent authorities, accreditation bodies and verifiers.	Publishes verified environmental statement; promotes open dialogue with public/stakeholders and active employee involvement/training.	Requires environmental policy, objectives, responsibilities and verified statement prior to registration; oversight via EMS processes.	Management-system oriented: integrates environmental objectives and performance monitoring into organisational processes.	Strong continuous improvement and regular verification; includes ISO 14001 requirements and extends beyond them.	Prescriptive EMS steps (environmental review → programme → audits → statement) and more demanding reporting than ISO 14001.	Requires reporting on seven core environmental KPIs (quantifiable, comparable, validated by verifier).	Independent accredited environmental verifier required; registration in the EMAS register.
ISO 14001	Voluntary international ISO Environmental Management System (EMS) standard; certifiable via third-party audits.	Provide a structured EMS to manage environmental responsibilities and support continual improvement; improve environmental performance, meet compliance obligations and environmental objectives.	Organisations implementing an EMS; auditors and certification bodies; used as a legitimacy/market access signal for external parties.	Not framed as 'materiality'; focuses on identifying significant environmental aspects/impacts and compliance obligations, informed by organisational context and risks/opportunities; includes a life-cycle perspective.	Primarily Environmental (E) scope (process-based), with governance elements (leadership, roles, accountability) to enable environmental performance.	Activities, products and services within organisational control and influence; considers upstream/downstream impacts via life-cycle perspective when determining environmental aspects.	Considers needs/expectations of 'interested parties' (e.g., regulators, communities, customers, suppliers, NGOs, investors, employees) as inputs to EMS planning; no formal taxonomy beyond this concept.	No explicit broad stakeholder engagement process; requires determining relevant interested parties and managing communications where relevant; adoption often driven by external pressures/legitimacy concerns.	Strengthened top-management leadership (especially in 2015 revision); requires environmental policy, assigned responsibilities and accountability within the EMS.	Requires integration of environmental management into business processes: context analysis, planning, operational control, monitoring/evaluation and setting measurable objectives.	Explicit continual improvement logic grounded in PDCA (Plan–Do–Check–Act), supported by internal audits, management review and corrective action.	Not a reporting standard; prescribes management system requirements and documented information but does not prescribe public reporting templates or specific performance outcomes.	No prescribed KPI set; organisations define objectives, metrics and monitoring approaches appropriate to their aspects and risks; performance management influences outcomes.	Third-party certification is possible (conformity of the EMS to the standard); assurance relates to certification audits rather than assurance of public sustainability disclosures.
ISO 26000	Voluntary international guidance standard on social responsibility; explicitly non-certifiable (no requirements).	Guide organizations in contributing to sustainable development by translating social responsibility principles into effective actions and integrating responsibility into decision-making and practices.	All types of organizations (any size/location/sector) seeking guidance on social responsibility; also useful for stakeholders assessing organizational responsibility approaches.	Does not use 'materiality' terminology; relies on determining issue 'relevance and significance' based on direct/indirect impacts; emphasizes due diligence to identify, prevent and mitigate adverse impacts and acting within a 'sphere of influence'.	Holistic ESG-relevant coverage via seven core subjects: organisational governance; human rights; labour practices; environment; fair operating practices; consumer issues; community involvement and development.	Addresses impact across activities and relationships, including indirect impacts; encourages action beyond own operations through 'sphere of influence' (e.g., suppliers/partners) and across the life-cycle of projects/activities.	Broad stakeholder scope: respect for stakeholder interests is a core principle; focuses on those affected by or interested in decisions and impacts.	Stakeholder engagement is fundamental: create opportunities for dialogue to ground decisions and priorities; engagement is positioned as more than communication.	Places organisational governance at the centre as the enabling 'core subject'; stresses accountability, transparency and ethical behaviour embedded in culture, strategy and daily activities.	Designed to integrate with existing management systems and organisational processes (e.g., can complement ISO 14001) to broaden from environmental management to integrated sustainability/social responsibility.	Encourages learning and improvement through guidance-based review of impacts and practices (not a PDCA requirement standard), supporting progressive integration over time.	Guidance document (principles + recommended practices); not a prescriptive reporting framework and does not provide mandatory disclosure templates.	No prescribed indicators or measurement methodology; implementation can be resource-intensive due to breadth; users may operationalise through other frameworks/standards.	No certification/verification mechanism (non-certifiable); credibility typically comes from transparent communication/self-declaration or pairing with certifiable standards and external assessments.
CERN current practice	Current practice: biennial Environment Reports prepared in accordance with GRI Standards; complemented by formal management systems (e.g., ISO 50001 for energy).	Public transparency + internal management: position CERN as a role model for environmentally responsible research; set objectives (incl. 2030).	CERN community, Member/Host States, regulators and general public/stakeholders.	Material topics identified via internal & external stakeholder interviews; consistent focus on high-significance environmental topics (e.g., energy, emissions, waste, water).	Primarily environmental; increasing attention to indirect impacts (e.g., Scope 3 procurement).	Reported data mainly covers Geneva-region facilities owned/operated; excludes user travel/collaborating institutes; Scope 3 procurement included since 2021–2022.	Key stakeholders include Host States (France/Switzerland), Member States, users/scientists, staff, suppliers and local communities/public.	Stakeholder interviews for materiality; close collaboration with Host States; supplier engagement (e.g., surveys) for procurement emissions.	Environmental governance through HSE (attached to DG), CEPS board (11 domains) and Energy Management Panel; data/analysis feed reporting.	Environmental protection framed as a management priority; objectives/policies integrated into management processes (2030 objectives; procurement policy; energy policy).	Iterative reporting cycle with updated objectives; movement toward externally validated systems (ISO 50001 certification).	GRI-based report architecture organised around material topics; exploring evolution toward broader sustainability reporting in future cycles.	Quantitative indicators on key topics (energy, emissions, etc.) and targets/objectives reported (incl. 2030 objectives).	No report-level assurance described in Draft; external certification achieved for energy management (ISO 50001).

Source: Own contribution based on what GRI, CSRD/ESRS, EMAS & ISO 14001/26000 frameworks and CERN's Environmental Reporting include.

Table A.2. *Considered questions when doing the Framework Comparability Matrix.*

Block A: **Nature of framework**	Framework type	Is it voluntary standards, a law/regulation or a management system? Is it legally binding for CERN?
	Primary Purpose	What is the main purpose (reporting, management, continuous improvement, communication, certification?
	Target audience	Who is it mainly written for (investors, regulators, general stakeholders, management systems professionals, companies)?
Block B: **Materiality and ESG coverage**	Materiality concept	Which materiality logic does it use? Financial only, impact materiality, double, other (significance to stakeholders/environmental significance)
	ESG scope	Does it cover E, S, and G equally or is it manly environmental?
	Organisation boundary	Does it extend to the value chain (upstream/downstream) or mainly the organization's own operations?
Block C: **Stakeholders**	Stakeholder scope and salience	Which stakeholders are explicitly recognised (investors, employees, communities, regulators, future generations, etc)? Is the concept of "stakeholder" broad or narrow?
	Stakeholder engagement requirements	Does the framework formally require stakeholder engagement to define material topics or evaluate impacts? Are there prescribed processes (consultations, surveys, dialogue, etc.) or just general recommendations?
Block D: **Governance and integration**	Governance and accountability requirements	What does the framework ask organizations to disclose or set up regarding governance (roles, responsibilities, oversight bodies, board involvements, top management responsibilities)?
	Integration with strategy and core processes	Does the framework link sustainability issues to strategy, risk management, decision-making and core management systems? Or is it mainly a reporting/compliance exercise detached from day-to-day governance?
	Reflexivity and level of prescription	Does it include explicit requirements for review, evaluation, audits, management review, or learning cycles? Is there a built-in logic of "plan-do-check-at" / improvement?
Block E: **Reporting architecture, indicators, and assurance**	Reporting structure and level of prescription	How structured and prescriptive is it? Does it provide detailed disclosure requirements and templates, or more high-level guidance? Are there sector-specific add-ons?
	Indicators and measurability	What type of information does it emphasize (quantitative KPIs, qualitative narratives, both)? Does it provide

		standardized indicators that allow comparability across organizations?
	Assurance, certification and verification expectations	Does the framework require or strongly suggest external assurance/verification or certification? Is there an official registration system (e.g., EMAS) or accredited certification (e.g., ISO 14001)?

Source: Own contribution based on what GRI, CSRD/ESRS, EMAS and ISO 14001/26000 frameworks include.