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# Sustainability Reporting in the Digital Age

Overcoming challenges for SMEs and EMDEs

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**FGV São Paulo Law School**

Viviane Muller Prado

Gabriela de Oliveira Junqueira

**ITS Rio**

Fabro Steibel

Celina Bottino

**ICS**

Maria Netto

Lucca Rizzo

# Sustainability reporting in the digital age: overcoming challenges for SMEs and EMDEs

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## Executive summary

This paper focuses on challenges faced by SMEs and EMDEs to respond to the growing demand of sustainability reporting requirements. The report suggests two main approaches to address the issue: designing proportionate reporting standards for SMEs and EMDEs and leveraging digital technologies.

We also adopt two preliminary hypotheses to suggest how digital tools can support SMEs and EMDEs to implement sustainability reporting. First, technology can decrease the cost of producing information, making reports more accessible for smaller companies and newer markets. Second, technology can increase the value of sustainability data produced, making reports more valuable for small companies and newer markets.

At the end, we focus on five recommendations for jurisdictions and standard-setting bodies to address: (a) Adopting reduced and flexible requirements in standards for SMEs ensure proportionality and avoid unnecessary costs; (b) Capacity building of SMEs for sustainability reporting, including international support for knowledge sharing; (c) Making use of technology to decrease the cost for SMEs and EMDES to generate sustainability reporting data; (d) Making use of technology to increase the value of sustainability reporting data generated by SMEs and EMDEs; (e) Improving sustainability reporting service ecosystem.

## 1. Introduction

The field of sustainability reporting is undergoing great changes as it is increasingly understood as a key tool to promote a transition to a more sustainable economy.

Within the growing momentum for sustainability disclosure, the regulatory agenda is being rapidly transformed (Carrots & Sticks, 2020, 2023) and the field is entering a decisive phase in which key features are being defined (Deloitte, 2024).

**Notably, the debates have been on the move from *whether* to disclose sustainability matters to *how* to make such disclosures.** Furthermore,

the reach of regulatory measures expands, both geographically to Emerging Markets and Developing Economies (EMDEs) and throughout business categories to also include and impact smaller enterprises (commonly referred to as SMEs). These expansions are driven by the institutional developments of disclosure frameworks and standards, which are dedicated to overcoming the many challenges related to standardisation and comparability of data, as well as interoperability between the different tools.

Both the cases of the International Sustainability Standards Board (ISSB) and the European Corporate Sustainability Reporting Directive (CSRD) represent the current dynamics in the field. As a product of convergence between many different sustainability reporting institutions, the ISSB was established to develop a universal set of sustainability reporting standards – consolidating the “alphabet soup” of voluntary initiatives and creating “a truly global baseline of disclosure.” As part of the European Green Deal package, the CSRD has considerably expanded the scope of the previous legislation on non-financial reporting in the EU, triggering the development of the European Sustainability Reporting Standards (ESRS) that will guide the disclosures of over 50.000 companies.

**In those cases, two trends become visible.**

**First, the push for globalising sustainability reporting**, expressed by the international consensus around the ISSB Standards, which were endorsed by the International Organization of Securities Commissions (IOSCO), the Financial Stability Board, the G20 and the G7 Leaders.

**Second, the increasing focus on data requirements related to the reporting entity’s supply chain**, thus extending the demand to many enterprises alongside it. These trends explain the geographic and categorical expansions in the reach of sustainability reporting practices that are raising important issues.

One of the anticipated challenges concerns the likelihood that EMDEs and SMEs will encounter higher compliance burdens (Financial Stability Board, 2023), facing negative impacts in the regulatory arena. Indeed, during the public consultation process of the ISSB Standards, the impact on firms in jurisdictions that need more time to prepare, including SMEs, was stressed, pointing to “the risk of inaccurate emission statements due to inadequate reporting infrastructures, which could have the unintended consequences of driving capital flows away from the countries that need them most” (ISAR, 2022, p. 3).

Addressing such concerns will involve ensuring proportionality of requirements according to each company's size, as well as setting up appropriate transition periods, in acknowledgment of the fact that reporting mandates will have differentiated impacts to specific actors. To add in complexity, the sustainability transition challenges are met by the ones related to the digital transition (European Commission, 2022), which will also have differentiated impacts, representing opportunities and risks for entities that are more or less prepared to adapt to the coming transformations.

Digital technologies play a pivotal role in fostering innovation in sustainability reporting, especially for SMEs and EMDEs. These technologies, encompassing both digitalization (the conversion of information into a digital format) and digital transformation (the integration of digital technology into all areas of a business, fundamentally changing how it operates and delivers value to customers), offer numerous benefits, as well as risks.

**The present study focuses on the specific challenges faced by SMEs to respond to the growing demand of sustainability reporting requirements, and the related digital technologies that may serve as tools to meet these challenges.** To some extent, the reflections can be extrapolated to EMDEs, which, however, also present their own peculiarities and face specific challenges in the evolving scenario described above.

The report suggests two main approaches to address the sustainable reporting challenges faced by SMEs and EMDEs: designing proportionate reporting standards and leveraging digital technologies.

When addressing proportionate reporting, we suggest topics such as: standards that ensure proportionality and avoid unnecessary costs, such as a “building block approach”; and a need for public consultations to design better standards for SMEs and EMDEs.

**We also adopt two preliminary hypotheses to suggest how stock of digital and other tools can support SMEs and EMDEs to implement sustainability reporting. First, technology can greatly decrease the cost of producing information, making reports more accessible to smaller companies. Second, technology can greatly increase the value of data produced, making reports valuable in particular for small companies.**

In other words, if the cost of producing good sustainability reporting is marginal, and if the value of reports produced are weighted as gold,

technology can result in good incentives to make sustainability reporting more fair, and accurate.

The paper was developed through the dialogue between two sets of specialists. On the one hand, Viviane Muller Prado and Gabriela de Oliveira Junqueira focused on the legal and regulatory environment of sustainability reporting, providing the broader context for discussing the role of SMEs in the theme (section 1). On the other hand, and looking at the described context, Fabro Steibel discusses the sustainability reporting solutions related to digitalization (section 2) and the opportunities for more radical digital transformation (section 3).

This multidisciplinary exchange of ideas was coordinated by the Climate and Society Institute, and it sought to promote broader reflections on the risks and potentialities within the growing scope of sustainability reporting. The recommendations presented in section 4 constitute the summary of this joint effort, which we hope will serve as support to the Sustainable Finance Working Group (SFWG) at the G20.

As a final note, we clarify the use of terminologies that might be read differently according to the readers' background. Specifically, we highlight the uses of the terms taxonomy and standards (Timmermans; Epstein, 2010). In our work standards refer to the set up of a collection of rules and procedures that guide the development of sustainability reporting. In the fields of sustainable finance and sustainability reporting, taxonomy refers to a [classification system for defining activities that are in line with a net-zero path](#), while a standard means a defined set of rules that prescribe what and how information on sustainability topics should be disclosed.

In the area of digital reporting, the same terms refer to different things. "Taxonomy" means a "digital taxonomy", i.e., a domain-specific dictionary used in reporting, that defines specific concepts, their attributes, rich metadata, and their interrelationships ([Wagenhofer, 2024](#)).

*Methodology note: this paper was submitted for contributions of 9 experts in the field, and suggestions were incorporated in the final text.*

## 2. Expanding the scope of sustainability reporting

In what follows, the present section further details the institutional context in which sustainability reporting becomes a task extended to SMEs and, to some extent, EMDEs in general. As we attempt to demonstrate, correctly understanding this environment involves distinguishing the direct and indirect obligations created by new regulations, and, in this regard, understanding the strategies and tools that help to overcome the specific challenges.

### 2.1. Direct and indirect sustainability reporting requirements

Through the waves of sustainability reporting, the emergence of legal obligations to disclose sustainability data has interacted with voluntary initiatives (Spiesshofer, 2018), stimulating institutional evolution in the field (Monciardini; Mähönen; Tsagas, 2020). Recent regulatory endeavours such as the EU Taxonomy, the CSRD, the Sustainable Finance Disclosure Regulation (SFDR) have directly imposed sustainability reporting mandates mostly focusing on large and publicly-traded corporations using financial and securities regulation (Eurochambres; SMEunited, 2023).

Notably, the initiatives have resulted from and pushed for changes in the information demands of investors and financial regulators, who have moved to perceive issues such as climate change through the lenses of financial risks and opportunities (UNEP Finance Initiative, 2019; Bolton et al., 2020). The growing investor demand for data has fuelled calls for greater harmonisation and reduced complexity in sustainability reporting (Adams; Abhayawansa, 2022). In alignment with this context, the global baseline provided by the ISSB Standards are “investor-focused” (de Villiers; La Torra; Molinari, 2022), i.e., they “are designed to meet the needs of existing and potential investors, lenders and other creditors.”<sup>1</sup>

**The exception to this general focus on large corporations by the legal disclosure mandates is the inclusion of listed SMEs in the scope of the CSRD.**

From 2026, the new European Directive will extend sustainability reporting requirements to SMEs that are listed on regulated European markets and meet at least two of the following criteria: (i) balance sheet

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1. IFRS. *Introduction to ISSB and IFRS Sustainability Disclosure Standards.* Available at: <https://www.ifrs.org/sustainability/knowledge-hub/introduction-to-issb-and-ifrs-sustainability-disclosure-standards/>

total of EUR 5 million or above; (ii) net turnover of EUR 10 million or above; and (iii) average of 50 or more employees during the financial year.<sup>2</sup> As it will be detailed below, listed SMEs' obligations will, however, be guided by a specific standard that derogates the application of ESRS in light of the principle of proportionality.

In any case, even if not within the direct scope of most regulatory measures, SMEs in general are already feeling the pressure of the growth in prevalence and sophistication of sustainability reporting (Shields; Shelleman, 2017) as they increasingly receive requests for information "from customers, banks, investors or other stakeholders" (European Commission, 2023). While from the legal point of view sustainability reporting may appear as optional for SMEs, "they may be forced to do so, in order to meet the reporting requirements of financial institutions and significant clients in their value chain." (European Commission, 2022, p. 81).

**By employing concepts such as "indirect effect" (Allgeier; Feldmann, 2023), "spillover effect" (Huq et al., 2023) or even "trickle-down effect" (Eurochambres; SMEUnited, 2023), different actors attempt to stress the impact of sustainability reporting mandates on SMEs considering the requirements on supply-chain data and their status as suppliers of large companies as well as their access to credit needs, through bank loans.**

In the CSRD, for instance, Article 19a para. (2) point (f) (ii) states that among the disclosed information, it shall be included a description of "the principal actual or potential adverse impacts connected with the undertaking's own operations and with its value chain, including its products and services, its business relationships and its supply chain, actions taken to identify and monitor those impacts, and other adverse impacts which the undertaking is required to identify pursuant to other Union requirements on undertakings to conduct a due diligence process."

Together with the [emerging breed of due diligence laws](#), the new sustainability reporting mandates' focus on supply-chain data are fuelling the trend of legislations that aim to govern "sustainable supply chains" (Sarfaty, 2015; LeBaron; Rühmkorf, 2017). Using the lead firm as a regulatory target, these "supply chain laws" constitute a new legal field that usually presents transnational effects (Salminen; Rajavuori, 2019) as it seeks to increase corporate accountability across supply chains (Schilling-Vacaflor, 2021). As it is being documented, business leaders

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<sup>2</sup> Listed micro-enterprises are exempt from the scope of the CSRD.



across the globe are reporting moderate to very high pressures to advance on supply chain sustainability (Correll; Betts, 2023).

As regards financial institutions, their own obligations to assess the sustainability of their portfolio and to disclose it (e.g., in the EU, Regulation n. 2019/2088) are driving the push to passing on reporting requirements to their clients, impacting many loan-dependent SMEs. As explained, “good ESG performance will be a prerequisite to access (more affordable) financing” (Leempoel, 2023), and this is becoming an important factor in understanding sustainability as a competitive advantage among SMEs.

The issue of accessing funding is particularly relevant, as sustainable finance requirements are increasingly being adopted and those unable to fulfil data requirements may suffer the consequences of a higher cost of capital. EMDEs are vulnerable to these capacity gaps for data and disclosure of non-financial information, which constitutes a relevant bottleneck to investments for achieving the sustainable development goals (OECD, 2023).

**In the above scenario, where there is a great demand to collect a big amount of data from SMEs in a company's value chain or in a financial institution's portfolio, there is a proliferation of mechanisms being used to request information to SMEs, including different supplier sustainability self-assessment questionnaires** (Fraser; Müller; Schwarzkopf, 2020). **This can be overwhelming**, considering that “[t]he process of sustainability data gathering can be extremely challenging and costly for SMEs, which often face limited financial, technical and human resources, due to the complexity of existing private reporting frameworks, involving a huge array of KPIs and competing requests from financial institutions, investors, large enterprises and other stakeholder in the supply chain.” (European Commission, 2022, p. 81).

The observed expansion of scope for sustainability reporting with the inclusion of SMEs is indeed relevant, considering their share in economic affairs (Galli; Torelli; Caccialanza, 2023). However, there are substantial challenges that must be recognized, considering the scarcity of resources that characterise many SMEs (Shields; Shelleman, 2017), and the fact that “much of the support and guidelines available for sustainability reporting do not cater to the needs of SMEs” (CDP, 2021, p. 4).

## **2.2. Facing the challenges: simplified standards and new digital tools**

Beyond efforts of capacity building as sustainability reporting expands its scope, the debates around the topic revolve around questions on how to ensure proportionality in the requirements.

The emerging routes to address such issues comprise two interrelated dimensions: an intentional effort to simplify reporting standards that would be applicable to SMEs and, at the same time, an increased use and promotion of digital technologies that may also work to lower the burden of reporting. For analytical purposes, we examine these dimensions separately.

On the issue of developing “SME-proportionate standards”, the Carbon Disclosure Project’s framework for climate disclosures focused on SMEs offers an illustrative example, as it attempted “to strike a balance between comprehensive climate disclosure and reduced reporting burden” (CDP, 2021, p. 20). Recognizing the lack of reference, CDP’s framework relied on a modular design whose adoption could be stretched throughout a three-year time frame that aimed to ensure enough flexibility for reporting SMEs.

Beyond the case of the CDP, the evolving landscape in the implementation of the EU CSRD offers an illustrative example of sensitivity towards SMEs’ capacities in the field of sustainability reporting. Beyond mandating the development of specific standards for SMEs, the new EU regulation explicitly recognizes the growing pressures and provides for a “cap” in the data requests regarding the value chain, stating that “[s]ustainability reporting standards shall not specify disclosures that would require undertakings to obtain information from small and medium-sized undertakings in their value chain that exceeds the information to be disclosed pursuant to the sustainability reporting standards for small and medium-sized undertakings” (CSRD, Article 29b, 4).

Regarding the specific standards, the CSRD acknowledges the challenges and resource constraints faced by SMEs, with its Recital 21 stating that listed SMEs and SMEs outside the scope of the CSRD should be given the possibility of reporting in accordance with proportionate standards, and Article 29c providing for the development of SME-proportionate standards. The European Commission delegated the development of the two additional sets of standards to EFRAG.

One of the standards is dedicated to Listed SMES (LSME),<sup>3</sup> which fall under the scope of the CSRD and thus have a direct obligation to report, and the other is dedicated to non-listed SMEs, outside of the regulatory scope, but facing reporting demands within their value chains and credit relations and encouraged to adopt the so-called Voluntary ESRS for SMES (VSME)<sup>4</sup>. These will complement the ESRS which was primarily tailored for large companies under the scope of the CSRD.

The exposure drafts of both LSME and VSME state that the standards establish sustainability reporting requirements for SMEs “that are proportionate and relevant to their capacities and characteristics and to the scale and complexity of their activities” (EFRAG, 2024a, p. 9), being “based upon the key concept of proportionality” and therefore taking into account SME’s “fundamental characteristics” (EFRAG, 2024b, p. 5).

The LSME draft results from an extensive simplification effort departing from the ESRS, which significantly reduced the data points that must be reported by the undertakings under its scope (i.e., listed SMEs). Beyond eliminating some reporting requirements, the LSME turned others voluntary. Unlike the ESRS, all sections in the LSME are sector-agnostic, “meaning that they apply to all undertakings regardless of the sector or sectors they operate in” (EFRAG, 2024a, p. 10).

The VSME draft, in its turn, was developed as a standalone document, based on other ESG questionnaires applied to SMEs, but following a conceptual coherence with ESRS. Its main objectives are to support SMEs in (a) contributing to a more sustainable and inclusive economy; (b) improving the management of the sustainability issues they face; (c) providing information that will help satisfy data demand from lenders/credit providers and investors; and (d) providing information that will help satisfy the data demand needs of large undertakings requesting sustainability information from their suppliers (EFRAG, 2024b).

The VSME adopts simplified language and it includes three modules that can be used in the preparation of the sustainability report: the basic module; the narrative-policies, actions, and targets module; and the business partners module. The latter, i.e., the “Business Partner Modules”, sets data points to be reported that are likely to be included in data requests from lenders, investors, and corporate clients. Through this module, the VSME aims to replace the many questionnaires currently

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<sup>3</sup> For an overview of the draft, see <<https://www.greenomy.io/blog/simplified-esrs-smes-under-csrd-what-you-need-to-know>>.

<sup>4</sup> For an overview of the draft, see <<https://www.greenomy.io/blog/non-listed-sme-reporting-guide-vsme-esrs>>.

used in the market that channel uncoordinated data requests to many SMEs, and this is why it is described as “a much needed protection for SMEs from ad-hoc-requests by large companies, which are expected to rise significantly due to the extensive supply-chain-reporting required by the CSRD.” (Allgeier; Feldmann, 2023).

In the ISSB arena, there has been some demand for a type of SME-proportionate standard, or a “ISSB for SMEs” (ISAR, 2022, 3). In this sense, a representative from the insurance industry encouraged the ISSB to “consider further action to take account of the distinct needs of users of smaller non-listed entity disclosures and the cost to these entities of full ISSB disclosure.” (Saporta; Walker, 2023, p. 2–3).

The present view, however, is that the released ISSB standards provide enough flexibility in themselves to allow for a tailored filling of the data points, assessing the materiality where relevant. Instead of developing new specific standards, the position is that the focus now should be on capacity building among SMEs and EMDEs as the ISSB standards are adopted globally.

Other initiatives to establish a common denominator among companies not directly subject to legal reporting obligations are exemplified by the [ESG Integrated Disclosure Project](#) (ESG IDP), an initiative of lenders to improve transparency by borrowers in private credit and syndicated loan transactions. The ESG IDP Template is a reporting tool “that represents a proportionate set of questions that are designed to solicit a global baseline of information from private companies.” As explained in their overview, the ISG IDP followed three guidelines in building their disclosure template: proportionality, credit-materiality, and harmonisation (ESG IDP, [n.d.]).

In alignment with the efforts of simplification, many initiatives are dedicated to using digital technologies that could contribute to overcome resource scarcity among SMEs. The use of digital tools is broadly revolutionising the field of sustainability reporting, with, for instance, digital taxonomies being discussed to define tagging rules both within the ESRS (EFRAG, 2024c) and the ISSB (IFRS Foundation, 2023). These transformations can assume particular meanings when discussing reporting requirements for SMEs, in light of the discussed above.

For instance, the alliance of “Bankers for Net Zero” and Icebreaker One are developing [Project Perseus](#), aimed at automating GHG emissions reporting for SMEs in the UK. In Brazil, the Ethos Institute, together with Sebrae, developed simplified reporting standards for micro and small enterprises that can be used within an online platform that is freely available and that simplifies data collection. Another similar framework is

the Impact Scoring Platform (ISP), an [collaborative effort by Finance&Invest.Brussels and Greenomy](#) to streamline ESG reporting for SMEs.

Most notably, GRI, the most used sustainability reporting standard among the world's largest companies (de Villiers; La Torra; Molinari, 2022) "is currently developing a new SME reporting tool that will enable multinationals to directly engage their supply chains in the reporting process." Described as an "innovative and unique reporting tool", the GRI online platform is being developed within the [Corporate Sustainability and Reporting for Competitive Business program](#). As described in one of the project's reports, "[t]he implementation of the program in Peru has taken sustainability reporting from a niche practice among big companies to a critical and essential one adopted by companies of different sizes and sectors around the country." (Global Reporting Initiative, 2021).

Overall, the above assessment of the landscape of sustainability reporting revealed the surrounding context of value chains and credit relations that are pressuring SMEs to report on sustainability matters, even if not legally obligated. As we argue, this brief investigation offers important takeaways to reflect on the coming challenges and the way digital tools may be used to overcome them. They can be summarised in four main points:

- There is the need of ensuring proportionality in the applicable standards to SMEs through reduced and flexible requirements, reported in a simplified manner;
- Relatedly, the path forward must avoid unnecessary costs, that may go in the opposite way of promoting sustainability as a competitive advantage;
- It is necessary to promote capacity building of SME for sustainability reporting; and
- A promising mechanism is to ensure appropriate transition periods that can be combined with a modularity approach to the standards.

### 3. The role of digitalization

In order to support the SFWG with a set of recommendations addressing sustainability reporting challenges for SMEs and EMDEs, we now review a set of existing digital tools that can enhance the value of sustainability reporting. This is of key importance, considering that we expect to see a wide adoption of digital devices in the near future, with disruptive impacts on financial and sustainable markets (Pizzi et al, 2023).

**The main argument of this section is that sustainability reporting digitalization can generate increased value when combining different digital tools at once, either by decreasing the cost to generate sustainability information, or increasing the value of information once generated.**

For instance, in the case of the “[Ethos-Sebrae Indicators for sustainable and responsible business](#)” initiative mentioned above, the use of digital tools increases the accessibility of sustainability reporting, and aids in reducing management costs. Nonetheless, we can illustrate how the indicators could have increased value when making use of a broader range of digital solutions.

If the indicators made use of open formats (on top of the existing generated textual PDF), imputed data could also be reused by other software solutions or cloud digital repositories. The same is true if data was provided with clear metadata information disclosure, as well as simple APIs (*Application Programming Interface*) to increase the level of interoperability of information provided.

#### 3.1. The digitalization of sustainability reporting

In the current environment, almost all human activities are open to digitalisation. For businesses, from interaction with stakeholders to compliance, digitalisation is creating opportunities for increasing convenience, efficiency, as well as risks (Park, 2021). In one way or another, digital innovations are able to change the structure of industries and be largely disruptive (Christensen and Raynor, 2003).

Nonetheless, only a few studies have considered the role of digital transformation in sustainability reporting practices (Lombardi & Secundo, 2020; Schmitz & Leoni, 2019). At the same time, we know that adoption of digital tools is not evenly distributed across the ecosystem.

It is set, for example, that the adoption of digital tools is highly dependent on how small businesses approach digital transformation strategically (Quinton et al., 2018).

Also, there is a growing need to standardise sustainability information, generating a clear incentive for the development of new reporting tools to enhance the reliability of the information disclosed (George & Schillebeeckx, 2022). Such paths reduce potential shortcomings of standardisation, such as the lack of comparability and reliability, and at the same time improve the delivery time and information verification (Leitner-Hanetseder & Lehner, 2022).

One good illustration of how digital tools can enhance sustainability reporting is to look at the extensible business reporting language (XBRL).

XBRL is an international digital business reporting standard managed by a global not-for-profit consortium (XBRL), that allows both human-readable and structured, machine-readable data to be provided in a single document. The standard makes use of extensive markup language (XML) that enhances comparability with other standards, including well-established financial reports, and promotes a common language to disclose information (Troshani & Rowbottom, 2022). Expected results of XBRL adoption include enhancement of accessibility, availability, administrative burden reduction, and usefulness (Bartolacci et al., 2021).

XBRL is an example of digitalization, a process related to converting tasks made originally without computers into a digital format. This is the case of turning printed reports into PDFs, publishing reports online in multiple venues, or making use of digital tools to collect, analyse and evaluate information.

### **3.2. Sets of digitalization tools**

This section addresses the role of digitalization in promoting SMEs and EMDEs adoption of sustainability reporting. Most of the tools addressed are promoted by the XBRL and GRI reporting standards, although other standards are also sources of research, such as EU CSRD, IFRS, and TNFD. Illustration of use cases come from the ecosystem of services offered to organisations to produce sustainability reporting, in special those that offer open and accessible solutions.

## **Open vs. closed standards**

Setting standards for sustainability reporting naturally drives digitalization, although as seen in the previous sections it remains a challenge how they are adopted by small and medium-sized enterprises (SMEs). This is primarily because standards provide a framework that guides the reporting process, ensuring that it is structured, consistent, and comparable across different entities and sectors. By doing so, standards can also facilitate the adoption of digital tools and platforms that support the efficient collection, analysis, and disclosure of sustainability data (Trum, 2020).

For SMEs, this means accessing affordable or even open-source solutions that can simplify the process of collecting and reporting sustainability data, thus reducing the burden and costs associated with manual data handling and reporting (Han and Kühnen, 2013). Standards can also streamline the compliance process, making it easier for SMEs and EMDEs to adhere to legal and regulatory requirements without extensive additional resources.

Nonetheless, there is a key advantage gap when comparing the adoption of closed to open standards.

Open Standards are standards that are publicly available and are freely licensed to anyone seeking to use the standard (fsfe, 2024). They are generally free or low-cost, making them accessible to organisations with limited resources such as SMEs and EMDEs. Secondly, open standards encourage innovation and competition among software developers to create diverse digital tools and solutions that adhere to these standards, offering SMEs a wide range of options to choose from based on their specific needs and capabilities.

Open standards are also related to the definition of a digital public good. According to the UN Secretary General's Roadmap for Digital Cooperation, digital public goods are "open-source software, open standards, open data, open AI systems, and open content collections that adhere to privacy and other applicable best practices, do no harm, and are of high relevance for the attainment of the United Nations 2030 Sustainable Development Goals (SDGs)" (UN, 2024).

Closed standards, in a different direction, are standards that are proprietary and controlled by specific entities [source]. While they can ensure a high level of specificity and potentially offer advanced features, their adoption might be limited to organisations that can afford the associated costs. For SMEs, closed standards might pose a barrier to entry due to the higher costs of acquiring the necessary software



licences or tools. Moreover, the lack of alternatives could hinder the organisation's ability to find a solution that perfectly matches its unique reporting needs and constraints.

One example of an open standard that drives digitalization is XBRL. XBRL is an open international standard for digital business reporting, managed by a global not-for-profit consortium, XBRL International, used in more than 50 countries, by more than 600 member organisations, from both the private and public sectors (XBRL, 2024). At early stages, XBRL provides a common language that can be used to represent the contents of reporting statements. At later stages, XBRL offers open digitalization tools that can be adopted by others, enhancing confidence in publishing reports and interoperability between different information systems, even in entirely different organisations.

Open standards also increase the value of sustainability reporting within a range of different stakeholders, which is of major benefit for large corporations (but not necessarily to small ones, due to their comparatively reduced size of relevant actors). For regulators, for example, it simplifies the analysis of complex performance and risk information (e.g., or harmonising reporting obligations; For companies, there is easy noise in the exchange of information in the supply chains; For reporting service ecosystems, it increases available information for setting new and more diverse types of solutions, and a wider range of software from vendors large and small.

Lastly, open standards incentivize markers that are platform-independent, in a vendor-neutral way. The standard can be adopted and adjusted by a large number of solution providers, and even supported by not-for-profit or government-funded solutions.

## **Taxonomies**

Taxonomies (i.e. digital taxonomies) are domain-specific dictionaries used in reporting, that define specific concepts (e.g. “net profit”), their attributes, rich metadata, and their interrelationships (Wagenhofer, 2024)<sup>5</sup>. Characteristics of a good taxonomy include the capacity to be unique, useful, independent, concise, and consistent . They support standardisation by increasing documentation (incentivizing free use of a rule, guideline, or definition), repeatability (leading to consistent quality in output), and acceptance (increasing convergence of acceptance amongst different actors) (Lucarelli et al, 2020).

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<sup>5</sup> We use "taxonomy" as "digital taxonomy". For an extended explanation of the term in other fields of knowledge, please see the introduction.

Taxonomies - when designed - require a **decision-making process** that includes defining the object of reporting (e.g. scope or rationale), the roles involved in the reporting (e.g. who reports, who decides, who collaborates), functional requirements (e.g. data requirement, data hierarchy, data expected uses), technical requirements (e.g. data modelling and testing), and lifecycle management (e.g. versioning, notification, communication). As such, taxonomy moves beyond low methods of data gathering, towards a mixture of information and digitalization tools.

Designing taxonomy is a complex and diverse effort, which is challenging from SMEs and EMDEs (Allen & Overly, 2024). More likely, those are organisations who consume taxonomies defined by others, raising alerts about the need to adjust expectations that can be met both by large to small and medium size organisations. Considering the role of voluntary reporting when SMEs and EMDEs are part of a larger supply chain, taxonomies require additional adjustments to avoid reducing access of organisations from the reporting process.

One key characteristic of taxonomy is the use of **metadata**, information designed mostly for computer-based reading. Metadata includes multi-language labels, links to authoritative definitions, and validation rules, amongst others. Metadata is usually not visualised directly in the report, but when associated with reporting data allows enhanced reuse of data, and external modelling and validation. For SMEs and EMDEs, the use of metadata greatly enhances the reuse of their produced data over other data processing processes.

Another characteristic of taxonomy is **versioning** (Ramanan, 2023). Taxonomies are released as part of regular update cycles, and can be required to correct errors (e.g. typos), formatting issues (e.g. data mask format), or also change of context (e.g. reinterpretation of taxonomy use), or conflict resolution (e.g. clarification of different taxonomies overlap). Due to that, taxonomy is always associated with a certain date of release. A similar situation happens when one taxonomy is used to create new ones, reusing existing components as an alternative to replicating or redoing modelling when an acceptable solution has already been developed. This increases data interoperability, and improves compatibility

Taxonomy can also carry **attributes of mandatory or optional information**, which is directly related to the issue of modularity discussed in the above section. Mandatory fields occur when they are required for calculation and validation, and can be set to stop data submission if missing. Some taxonomy can be manually filled (e.g. total

assets) or automatically generated (e.g. submission date). Voluntary fields carry additional information that can aid calculation checks. In one direction, mandatory taxonomies increase process complexity, and reduce a solution's applicability. In another direction, voluntary fields reduce data comparability, and increase reporting costs and complexity.

Another important point is that taxonomies make use of customised software processes, or **Extensible Markup Language (XML)**, that adopts international standards (e.g. W3C1 standards) to provide not only a vocabulary but also a means of unambiguously representing the semantics of the information being reported [source] Adoption of XML, especially when internationally standardised, can lead to cleaner data, increase of data accuracy, and reduction of reporting time (Bonsón et al, 2009). There are however different technical formats of XML, which leads to an increased need for technical assistance to select which format best fits one organisation's needs (source).

Lastly, taxonomies are the base for design systems that provide both human-readable and structured, machine-readable data, or inline solutions. The advantages of this tool is to make it simple for humans to validate imputed data (e.g. by providing an easy-to-read layout of verifiable information), and at the same time allow instant automated calculation, validation, and chart generation.

### **Digital input methods**

Collecting, inserting and analysing data of sustainability reports can be achieved in different ways, some more friendly than others to SMEs and EMDEs.

For those with limited internal resources, the most attractive alternative is to make use of **online forms-based approaches**, such as the ones designed by regulators or third parties [see e.g. source]. One advantage of this method is a straightforward approach to data input, as well as simplified comparability of end results. Another advantage is the ease of testing imputed data for errors. A disadvantage of this method is customization, being a "one solution fits all" method of data collection. Another disadvantage is the low level of interoperability between systems, which leads to an increase in rekeying and copy-paste manual effort, which is time-consuming, costly, and error-prone.

Other more flexible methods are to design **intermediary data-gathering solutions**. These can be created in-house, from existing software, as well as contracted as outsourced production. One related solution is to adopt "bolt-on tools", add ons that interact with common software

adopted in companies, such as mainstream data and word editors (e.g. FactsConverter, Arkk XBRL Adapter, Firesys.de, Toppanmerrill). Advantages related to this method are a higher level of customization, and the large availability of "common off-the-shelf" solutions that can be hired, especially by small and medium size organisations. Disadvantages include a higher requirement of human and financial resources to produce standard information, as well as the potential vendor-lock of closed adopted solutions in the long term.

Examples of data-gathering solutions available for hire are:

- Solutions for regulatory and statistical reporting, including data collection, validation, and preparation for the submission of quantitative and qualitative reports, as well as risk calculation and controlling regulatory KPIs and templates (e.g. regnology.net, Amana, Amelkis, Calcbench, MDD Platform, UBPartner).
- Sector-specific solutions, such as those designed for insurance (e.g. FactsConverter, parseport), banking and finance (e.g. aSISSt, ParsePort XBRL Finance, Vizor), tax reporting (e.g. SmartTaxBalance)
- Collaborative solutions for supply chain collaboration (e.g. IRIS FinX, IRIS Carbon) or even consumer participation (e.g. Ez-XBRL Solutions)

## **Data ledgers**

Data ledgers refer to digital databases that use advanced technology, such as blockchain, to record information in a secure, immutable, and transparent manner. These ledgers can capture a wide variety of data, including financial transactions, asset ownership, and in the context of sustainability reporting, detailed records of a company's environmental, social, and governance (ESG) activities.

One of the main advantages offered by data ledgers is gains in **transparency and trust**. These tools provide a transparent record of transactions and data entries, visible to all permitted participants, allowing stakeholders to more promptly trust the accuracy of the sustainability information reported by a company, as once data is entered into the ledger, it cannot be altered without notation or publicity.

Another advantage is the **immutability**, considering that by default when information is recorded on a data ledger it is associated with content and time validation. Such records of immutability ensure the integrity of the data over time, making it an ideal platform for documenting and verifying sustainability claims.

Data ledgers can also increase efficiency and **automation**. First, they can operate on a decentralised network, distributing the data across multiple nodes (computers). This decentralisation reduces the risk of data manipulation, loss, or tampering, as no single entity has control over the entire network. It also enhances data security and resilience against cyber attacks. Secondly, it simplifies to automate the collection and reporting of sustainability data through smart contracts, which are self-executing contracts with the terms of the agreement directly written into code. This automation can significantly reduce the administrative burden and costs associated with manual data collection and reporting processes, making sustainability reporting more accessible and manageable, especially for SMEs.

One example of an open data ledger is the XBRL Global Ledger (XBRL, 2024), a specialised ledger to capture, archive, transmit, and aggregate information contained in the original ledgers, working as a standardised way to store operational data and data definitions. Ledgers can assist and automate audit review, facilitate data consolidation, facilitate transfer of transactional accounting data from system to system, and due to their open format, work with advanced levels of interoperability with other solutions.

Data ledgers also can work with integrated **APIs** (Application Programming Interfaces), allowing computer-computer communication in a simple form. APIs are based on a set of protocols, routines, and tools for building software applications, allowing applications to communicate with each other. In the context of enhancing reporting with data ledgers, APIs play a crucial role in streamlining the integration of ledger technologies with existing business systems and processes, and facilitating real-time access to data stored on the ledger, enabling organisations to include up-to-date sustainability information in their reports. This capability is particularly valuable for dynamic and rapidly changing metrics, such as energy consumption or carbon emissions, where timely data is crucial for accurate reporting.

APIs can also be designed with robust **security measures**, such as encryption and authentication protocols, to ensure that data transfer between the ledger and reporting systems is secure, which is key when communicating sensitive sustainability data and maintaining stakeholder trust. Organisations also use APIs to develop custom reporting tools and dashboards that meet their specific needs, highlighting key sustainability metrics and insights that are most relevant to their stakeholders.

## 4. The role of digital transformation

We can draw a line on how digital technologies impact organisations, namely splitting transformation in two major categories: digitalisation and digital transformation (Collin et al., 2015).

Digitalization, addressed in the section above, refers to the process of converting tasks made originally without computers into a digital format. This is the case of turning printed reports into PDFs, publishing reports online in multiple venues, or making use of digital tools to collect, analyse and evaluate information. However, better uses of technology aim to provide not only digitalization, but also digital transformation.

**Digital transformation refers to the use of technological principles and advantages to transform how processes are produced and used.**

This is the case for example of promoting the adoption of DPIs and DPGs, where DPIs (Digital Public infrastructures) refer to a digital solution that enables basic functions essential for public and private service delivery, promoting people's access to private and public services, and DPGs (Digital Public Goods) promote digital infrastructures that make use of open standards when designing DPIs. [FONTES]. Other examples of technologies related to digital transformation are digital platforms [FONTE], assets tokenization [FONTE] or data interoperability [FONTE].

And why does digital transformation matter for sustainability reporting?

According to the Oslo Manual (OECD, 2018), innovation refers to "a new or improved product or process (or combination thereof) that differs significantly from the unit's previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process)". Moreover, the OECD Business Innovation Indicators (OECD, 2023) shows that the innovation gap between the most and least innovation-intensive sectors is large, ranging from between 40 and 50% depending on the indicator measured. In the same direction, reporting at least one innovation with environmental benefits is present in over one-third of innovative firms.

Within this framework, technology plays a key role, where the emergence of new information technologies and how they influence new business models is directly related to the role of global value chains, the growing importance of knowledge-based capital, and economic impact.

Adoption of innovation can diffuse faster or slower (Rogers, 1962), being an individual process of how the adopting organisation becomes aware of an innovation, takes interest in the innovation, evaluates the innovation, tries the innovation, and finally adopts or rejects the innovation (Park, 2020). Digitality is strategic for companies (Quinton et al. 2018; Ukko et al. 2019), although it is dangerous for small business owners to assume that new technologies will automatically provide their businesses with a competitive edge (Thompson et al., 2013). Even so, corporate reporting over time has increased the amount of information provided, first to shareholders, then to potential investors (Gilmore and Willmott 1992), and lastly to wider audiences (Crowther, 2012).

The potential benefits of digital innovation are wide. According to Bini (Bini, 2019), positive trends include enhancing ability to track progress against specific targets, facilitating the implementation of the environmental strategy, enjoying reputational benefits, cost savings identification, increased efficiency, and enhancing staff morale. At the same time, the reasons to avoid digital innovation include doubts about the advantages to the organisation, customers not interested, cost, and difficulty to gather consistent data from all operations and to select correct indicators (Bini, 2019).

All those arguments in favour or against digital innovation are even challenging considering the universe of SMEs and EMDEs (Pizza, 2023). In this regard, despite recent data released by leading consulting firms highlighting that many international companies adopted new accountability tools, only a few pieces of evidence have been collected about the adoption of digital devices in sustainability reporting (EY, 2022; KPMG, 2020). Particular issues related to small companies include challenges for institutional governance, smaller market sizes, and parallel regulatory burdens.

#### **4.1. Sets of digital transformation tools**

##### **Asset tokenization**

Asset tokenization refers to the process of converting rights to an asset into a digital token on a decentralised ledger, such as those supported by blockchain technology. This approach provides a secure and efficient method of representing ownership of physical or intangible assets in a digital form. Blockchain's ledgers, in particular, can secure decentralised

and immutable asset tokenization, allowing more transparent, tamper-proof record-keeping, while enhancing trust and reducing fraud.

To illustrate how asset tokenization can aid sustainability reporting, we can review a key difference between crypto assets (such as Bitcoin) and normal assets (such as national currencies). When we report on national currencies in a bank account, we always report on the total amount of fungible assets available (e.g. the bank account balance), and never on the individual assets that were used to calculate the overall balance.

In a different direction, when we report on Bitcoin assets, we always report the individual assets available, even if the "coins" are potentially fungible. As such, the "account balance" of assets that have been tokenized are the end product of individual assets, but each asset can be accounted individually. In other words, tokenization allows reporting on total sums of fungible assets, or the identification of each asset alone. Traditional accounting methodologies, however, allow reporting only on a fungible asset total, being individual assets information not available for use.

For sustainability reporting, the main benefit of asset tokenization is the possibility to report assets (fungible or not) in a granular level as well as in a generalisation level. Considering the digital nature of tokenized assets, this means that each asset can be used for implementing off-chain (e.g. legal contracts) rules.

By June 2022, 12 countries had regulated tokenization (Kumat, 2022), which led to a significantly diverse ecosystem. Some for and non-profit solutions related to that are DexStar<sup>6</sup> (i.e. tokenize debt positions in sustainable projects), Cashlink<sup>7</sup> (i.e. provides supply chain crypto securities register, compliant to local regulatory compliance), Agrotoken<sup>8</sup> (i.e. transforms grains into digital asset, store/exchange for inputs, services, other assets), Moss<sup>9</sup> (i.e. offer NFTs representing ownership of Amazon rainforest land), CarbonMark<sup>10</sup> (i.e. open-source carbon credit marketplace), Regen<sup>11</sup> (i.e. unite stakeholders to govern ecological outcomes, and rewarding verified ecological outcomes), EthicHub<sup>12</sup> (i.e. connecting unbanked smallholder farmers with global lenders), amongst others.

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6 <https://dexstar.io/>

7 <https://cashlink.de/en/>

8 <https://www.agrotoken.com/en/home>

9 <https://www.rwa.world/rwa/moss>

10 <https://www.carbonmark.com/>

11 <https://www.regen.network/>

12 <https://www.ethichub.com/>



Examples of asset tokenization related to sustainability reporting include:

- *Tokenization of Carbon Credits*: Companies can tokenize carbon credits, representing a reduction in carbon emissions, which can then be traded on blockchain platforms. This approach improves the transparency and traceability of carbon trading, encouraging more businesses to offset their carbon footprint. If sustainability reporting taxonomies include carbon credits, it is possible to track the movement of each credit, or to associate a specific carbon credit to a specific rule.
- *Tokenization of Sustainable Real Estate*: Tokenizing shares in green buildings or sustainable real estate projects allows investors to own a fraction of an environmentally friendly property. This approach lowers the barrier to entry for investors interested in green real estate, promoting the development of more sustainable building projects. If reports list real estate assets in a standardised way, reports can be used to increase trust and reduce risk of financial transactions.
- *Waste Management Tokens*: Blockchain can be used to tokenize the recycling process, where tokens are awarded to individuals or companies based on the amount of waste they recycle. These tokens could then be used to claim rewards or discounts, incentivizing sustainable waste management practices. If sustainability reporting lists waste management practices, the supply-chain of recycling materials can be individually tracked.
- *Sustainable Supply Chain Tokens*: Companies can tokenize their supply chains to ensure transparency and sustainability from production to delivery. Tokens can represent compliance with environmental standards at each step of the supply chain. Consumers can then verify the sustainability of their purchases, encouraging companies to adopt greener practices. If sustainability reporting from SMEs make use of tokenization, later supply chain actors can reuse the produced information, even at a granular level.

In Brazil, a clear path towards asset tokenization is being carried out by the Central Bank, with the project "Digital Real", officially branded as Drex. Drex is a decentralised ledger system, with the potential use of smart contracts, that goes beyond programmable central bank-issued digital currencies (CBDCs), improving the security and efficiency of digital payments and ensuring the functioning of the payment system (Boar and Wehrli, 2021).

Drex has different levels of programmability. Currently, as a pilot phase, it consists of APIs that allow other applications to access it in a standardised way. Considering the topics addressed in the previous section, it is a case of digitalization (not digital transformation). Nonetheless, the next phases of Drex includes the ability to link token ownership to smart contracts, enabling monetary or non-monetary information (such as those report on taxonomies) to be associated with decision-making (if/then) commands (LIFT, 2024).

## **Platformization**

The "platform effect" refers to the economic and strategic advantages generated by digital platforms that facilitate direct interactions between multiple groups of users, such as consumers, service providers, and producers. Platforms are solutions that focus on producing value amongst actors outside the solution itself (Parker, 2016).

Unlike linear production value systems, where value creation follows a straight path from producer to consumer, platforms create value by enabling these various groups to interact, share, and transact directly, often in a many-to-many fashion. This model leverages network effects, where the value of the platform increases as more users join and interact, significantly enhancing scalability and efficiency. By doing so, it employs The move to platforms involves three key shifts: (1) resource orchestration, producing producers and consumers as the chief asset; (2) external interaction, facilitating interactions between external producers and consumers; (3) ecosystem value focus, by maximising the total value of an expanding ecosystem in a circular, iterative, feedback-driven process (Sarkar, 2016).

Platformization has significant implications for SMEs, offering both advantages and challenges (Cenamor, 2019), being digital transformation competencies key to profit from the opportunity (Min, 2021).

In the positive light, platforms increase the value of SMEs' product or service as it grows the number of networked users. Also, as the network expands, the cost of servicing each additional user typically decreases, allowing SMEs to benefit from economies of scale. For EMDEs, there are additional opportunities for newcomers to capitalise on network effects and achieve a dominant position in their market.

At the same time, creating platforms requires large capital investments, which is resource-intensive for SMEs. SMEs can also become

increasingly dependent on network effects, which can rapidly shrink. Several big techs are usually associated with the platform effects, including those focused on logistics (e.g. drivers or deliveries services), asset loans (e.g. housing and second-hand goods), marketplaces (e.g. consumer or business business intermediary), amongst others.

Examples of platform effects related to sustainability reporting include:

- **Sustainability-driven Marketplaces:** Platforms that connect consumers with sustainable products can see increased value for all users as the number of participants grows, enhancing the range and quality of available sustainable options. This increases the potential reputational gains of investing and publishing voluntary sustainability reporting.
- **Lowered Barriers to Entry** External small producers or service providers of sustainability reporting services can more easily gain access to new markets, bypassing traditional intermediaries. Also, platforms can match supply with demand more efficiently, reducing entry-level costs for market segmentation, and sectorial service design. This increases the offer of products and services available for SMEs to hire services, and better deliver sustainability reports.
- **Improved data utilisation:** Platforms can lead to better utilisation of resources, increase data return over data production investment. The collaborative nature of platforms is associated with fostering innovation, and platforms facilitate the sharing of sustainable technologies and best practices across industries and consumers.
- **Sustainability-driven supply chain platforms:** Platforms that provide transparency into the supply chain, or that are designed around the principles of the circular economy, can help stakeholders to make informed choices about the sustainability of SMEs. For example, platforms can be used to trace reported lifecycle of a product from raw materials to disposal, increasing access to data on carbon footprint, water usage, and labour practices across the supply chain. Platforms can facilitate the exchange, reuse, and recycling of sustainability data

A key debate around platformization and platform effects is the role played by large platforms, such as those defined by European Law as "gatekeepers". Under the Digital Markets Act (DMA), platform gatekeepers refer to large online platforms and digital services that serve as critical access points between businesses and consumers. These are typically major tech companies that control significant market power and user access. The DMA specifically targets these gatekeepers

by imposing a set of rules designed to ensure fair competition, promote innovation, and prevent market abuse (Beems, 2022). The goal is to create a more level playing field for smaller businesses and to enhance consumer protections in the digital space.

Platform solutions specifically designed for sustainability reporting are at early stages. Some all-in-one software solutions already available for SMEs offer digitalization facilities, but they do not foster a platform network effect. Instead, they introduce closed infrastructures, where last-mile product and service consumption is the most expected behaviour.

Even so, current digital solutions provide services such as data collection, data management, emissions reporting, stakeholder facilitation, information distribution, and more. Due to that, existing solutions can foster platformization, and circular economy (Eastwod, 2023), either as connecting knowledge as on and off-line platforms (e.g. Be.Brussels<sup>13</sup>), enhancing community links (e.g. PeaceCircular<sup>14</sup>), reusing sustainability reporting data for monitoring (e.g. Circular Economy Platform<sup>15</sup>), amplifying sustainability credentials (e.g. Provenance<sup>16</sup>), or reporting on circular economy food chain (e.g. IBM Food Trust<sup>17</sup>), and others.

## **Artificial intelligence**

Artificial Intelligence (AI) refers to the development of computer systems capable of performing tasks that typically require human intelligence. These tasks include learning, reasoning, problem-solving, perception, and language understanding. According to the OECD, "an AI system is a machine-based system that, for explicit or implicit objectives, infers, from the input it receives, how to generate outputs such as predictions, content, recommendations, or decisions that can influence physical or virtual environments" (OECD, 2024).

AI solutions can be broadly categorised into two types based on functionality: descriptive AI and predictive AI.

Descriptive AI was the one to become popular, and focuses on analysing historical data to understand patterns, trends, and relationships. It does not predict future outcomes but rather provides insights into what has

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13 <https://www.circulareconomy.brussels/?lang=en>

14 <https://pacecircular.org/>

15 <https://www.cep-americas.com/>

16 <https://www.provenance.org/>

17 <https://www.ibm.com/products/supply-chain-intelligence-suite/food-trust>

happened in the past, hence the "descriptive" label. An example related to sustainability is the use of AI to analyse energy consumption patterns in a facility over time, identifying periods of high usage and potential inefficiencies. Examples of that are the SustainLab<sup>18</sup> (i.e. combines 500+ sustainability reports for visualisation and informed actions), Nasdaq Sustainable Lens<sup>19</sup> (i.e. on-demand data-driven insights to over 9,000 companies), Greenomi<sup>20</sup> (i.e. evaluates compliance CSRD and EU Taxonomy), amongst others.

Predictive AI methodologies forecast outcomes based on past trends, and are largely known due to the applications of Natural language processing (NLP), and LLMs (Large Language Models). LLMs are trained on vast amounts of text, visual or audio data, to generate look-like data that mimics human-like understanding of language. Several companies offer closed solutions of LLMs (see e.g. most of global big techs) and a large number of open models of AI are also available (Solaimna, 2023).

LLMs can enhance sustainability reporting, for example, with reporting data highlighting key sustainability performance indicators, navigating through complex landscapes of sustainability regulations and standards, tailor sustainability reports to the interests and concerns of different stakeholders, or even creating interactive Q&A tools that allow stakeholders to ask specific questions about an organisation's sustainability practices. They can also reveal a sound grasp of language nuance, as well as a strong appreciation of the audience in reports, when compared to human-only generated reports (Villers, 2024).

There is nonetheless a risk of bias against smaller actors. According to OECD (2023), AI provides a new tool for investors to harness big data to align investment standards. However, the use of AI in automatised portfolio allocations could exclude developing countries on the basis of a lack of quality data needed for sustainability reporting.

For SMEs, in particular, designing their own solution of AI is a major challenge. Training AI from scratch is very costly, and requires datasets that are frequently larger than one small or medium enterprise alone. It is possible nonetheless to hire as a service previously trained AIs, as well as it is already cheap to fine tune models for one organisations' need. Some solutions require simple tasks, such as giving access to organisations' reports, while others require more programming intensive tasks, but can deliver tailor compliance checks, or thematic vocabulary refinement.

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18 <https://sustainlab.co/>

19 <https://www.nasdaq.com/solutions/corporate-esg-solutions/resources/fact-sheets/esg-ai>

20 <https://www.greenomy.io/>

At the same time, AI for sustainability is challenged by (1) overreliance on historical data in machine learning models, (2) uncertain human behavioural responses to AI-based interventions, (3) increased cybersecurity risks, (4) adverse impacts of AI applications, and (5) difficulties in measuring effects of intervention strategies (Nishant, 2020). Another challenge is the reality that most data used for AI training come from large organisations, leaving SMEs data underrepresented in training data (Chan, 2013). The technology also struggles to distinguish inputs coming from different sources with varying levels of reliability (Ferreira, 2009).

### **Interoperability and digital public infrastructures**

Data interoperability refers to the ability of different information systems, devices, or applications to access, exchange, integrate, and cooperatively use data in a coordinated manner. Interoperability goes beyond data-only aspects, such as portability or integration of data, to include for example data governance, data standards, data markets and more (source).

Interoperability can be used for example to integrate reporting across diverse data sources, including those coming from IoT devices, regulatory databases, and third-party sustainability metrics. Interoperable data also enables organisations to benchmark their sustainability performance against industry standards or competitors, and allows organisations to more efficiently compile, analyse, and report data in compliance with government bodies and sustainability rating agencies. It also facilitates stakeholders to engage with more transparent and accessible information, supporting better governance, innovation, and transparency (source).

Interoperability empowers more environmental actions in businesses (Mora-Rodriguez, 2016), and the XBRL is an illustrative case of how to use interoperability to provide both an inside-out and an outside-in perspective on sustainability reporting and management. Recent literature review argues, nonetheless, that although integrated reporting is a major trend in the industry and is growing quickly, the use of the technology is in its infancy year. Also, interoperability is associated with conflicts of interest for companies, leading to Greenwash-pitfalls and under-enforcement sustainability and transparency practices (Seele, 2016).

A different approach for interoperability can be seen when we look at digital public infrastructures (DPIs). DPIs refers to a set of digital

systems, tools, and platforms that provide public goods or services through digital means. The definition of DPIs can vary depending on the context, focusing on the infrastructure's purpose (e.g., financial inclusion, access to information), the technologies it encompasses (e.g., digital identity systems, payment platforms), or its governance and operational models. Also, when the definition focuses on the openness of solutions provided, they can also be defined as DPGs (Digital Public Goods), a path towards greater interoperability of data, suppliers and information (DPGA, 2024).

DPIs are designed to be beneficial to the public at large, often underpinning critical aspects of society such as governance, economy, and social welfare. Main sectors where DPIs have been used include digital identity systems, digital public records (such as land registries), healthcare services and electronic access to health records.

Specifically tackling environmental challenges and climate change, one illustrative area is deforestation (Attah, 2024). MapBiomas, for example, is addressing sustainable land-use mapping. As a collaborative initiative, they provide open ultra-detailed maps of Brazil, addressing issues such as deforestation, water levels, crop cover, and ecosystem restoration. Planet Labs<sup>21</sup> follows a similar path, sharing millions of satellite images regularly, allowing governments and NGOs to track areas being deforested in near-real time. Sustainability reporting data, if properly tokenized and digitally managed, can make it easier for organisations to make use of relevant satellite images.

A promising area that connects sustainability reporting and DPGs is the growing need for open and accessible weather, climate, and hydrological data (DPGA, 2022). Although open data is more commonly available, innovative data infrastructure is required to unlock the access to a greater diversity of actors in the ecosystem (Farooqi, 2023). Moja Global<sup>22</sup>, for example, can collect, analyse, and share sustainability reporting data to identify areas of high environmental impact and support the development of mitigation strategies, measuring, reporting, and verifying greenhouse gas emissions and removals from agriculture and forestry. In Armenia, all automatic meteorological stations across the country were connected to provide weather forecasts and meteorological monitoring in a free, open and accessible way (Sakahayan, 2022).

There are also reasons to connect current DPI components, such as digital identity, digital payments and data exchange, to environmental

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21 <https://www.planet.com/>

22 <https://moja.global/>

challenges (Sandman & Wood, 2024). For example, digital payments, when connected to social protection systems, can facilitate anticipatory cash assistance that send targeted funds to affected populations before an extreme weather event.

An illustrative list of how DPIs and data exchange systems can enhance sustainability reporting data is listed by a UN Environment Programme report on the matter (2024):

DPI as a data exchange system for sustainability-related data	
Technology innovation	Desired outcome
Data markets for environmental sustainability-related data	Real-time monitoring of deforestation with data readily available for stakeholders by creating incentives for collecting and sharing. This process is expected to bring about consistent and reliable data across the board
Open data discovery for environmental sustainability	Facilitate identification of relevant data
Privacy enhancing technologies to enable flow of environmental sustainability information	Addressing the barriers for data sharing without compromising privacy
Using Large Language Models to "speak" with green and circular economy policy	Improved compliance with environmental standards across all company sizes due to better understanding and easier policy interpretation
Computational law and data integration of green and circular economy policy measures	Streamlined MRV frameworks that reduce redundancy and confusion among stakeholders
Data markets for environmental sustainability-related data	Data-driven policy making by creating incentives for data collecting and generation
Open data discovery for environmental sustainability	Facilitate identification of relevant data
Data markets for environmental sustainability-related data and tools and techniques for human-centred artificial intelligence in environmental sustainability decision-making	A more inclusive data environment that represents diverse groups and allows for user-friendly interaction with data-generating and collection tools

For SMEs, DPIs and DPGs can greatly reduce entry-barriers to access other services, at a fast pace. We can illustrate this with Pix, a case from Brazil. This digital payment DPI reduced costs for users and promoted financial inclusion, and in little over a year it was already used by 67% of adults in the country. SMEs in this process are serviced by public owned and public oriented services, being in the particular case a key requirement for its success the central bank's dual role as infrastructure provider and rule setter (Duarte, 2022), as well as the fostered collaboration between the public and the private sector (Wilkins, 2022).

It is also relevant to consider that governments are making data interoperability more mandatory, specially in face of limited results of



voluntary arrangements. The EU Data Act, for example, defines the rights to access and use data generated in the EU across all economic sectors, making it easier to share data, in particular industrial data, while the EU Interoperable Act creates a network of digital public administrations that stimulates public sector innovation and public-private partnerships (European Commission, 2024).

## 5. Recommendations

### A. Adopting reduced and flexible requirements in standards for SMEs to ensure proportionality and avoid unnecessary costs.

*Considering that:*

- Increasing complexity of financial reporting standards represents a challenging scenario for SMEs, and the introduction of mandatory sustainability reporting associated with financial reports tends to increase the compliance gap.
- There is a need to ensure proportionality in the application of standards to SMEs.
- International standards worldwide are in early-stages of addressing how to adjust requirements to SMEs and EMDEs' needs.

*Recommendations:*

- ***Public consultations must be carried out, by international organisations and governments, to gather information about SMEs' sustainability reporting needs.*** Moreover, there is a need for a proactive approach to support SMEs to participate in the process.
- ***Designing standards for SMEs must reduce the complexity and costs of sustainability reporting, through flexible requirements, reported in a simplified manner.*** Smaller companies allocate fewer resources to generating sustainability data, and without adjusting complexity accordingly we reduce the quality of data collected and the competitive advantage of SMEs
- ***The use of a building block approach can function as a way to create viable flexible requirements, depending on the particularities of each SME.***

### B. Capacity building of SMEs and EMDEs for sustainability reporting, including international support for knowledge sharing.

*Considering that:*

- For a variety of reasons, SMEs and EMDEs are lagging behind in the development of sustainability reporting and, as a result, do not benefit from its value-enhancing features.

- SMEs and EMDEs have reduced access to expert staff in matters of sustainability reporting, which have been complexified in recent years and represent a high implementation cost.
- The lack of adequate sustainability reporting can hinder SMEs and EMDEs' access to needed sources of sustainable finance.

*Recommendations:*

- **National economies should focus on programs that aim to build the capacity of its SMEs to properly generate sustainability data.** This will enhance competitiveness of these actors across global value chains.
- **International efforts and technical cooperation programs should promote capacity building across EMDEs.** These efforts will help in reducing identified bottlenecks in access to sustainable development funding.
- **Lead firms shall play an important role in providing qualification throughout their value chains.** Making use of its structures, lead companies are in strategic places to connect players, promote the capacities of different actors, and contribute to alleviating the burden of SMEs and EMDEs in sustainability reporting.

### **C. Making use of technology to decrease the cost for SMEs and EMDES to generate sustainability reporting data.**

*Considering that:*

- Standardised processes ensure that reported data is better structured, consistent, and comparable across different sectors, and that standards facilitate the efficient collection, analysis, and disclosure of good sustainability data.
- Standards platforms and taxonomies simplify the process of collecting and reporting sustainability data, reducing costs associated with manual data handling and reporting.
- That XBRL is a good case to illustrate how international standard taxonomies can be used to lower costs of gathering information, eventhat such cost might be higher for SMEs.

*Recommendations:*

- **Promoting open taxonomies offer a beneficial path for reducing costs and promoting a healthy ecosystem for sustainability reporting.** Open taxonomies provide a common language that can be adopted by many, enhancing interoperability between different information systems, even in entirely different organisations.
- **Large-scale and low-cost digital input methods reduce the cost of SMEs to adopt digital sustainability reporting solutions, up to a certain level.** Although costs for reporting data can be lowered, investments related to understanding the data, the organisational strategy, and the meaning of sustainability reporting remain challenging steps for SMEs.
- **Data ledgers reduce the cost of republishing data, especially when there is a need to report comparable data in different jurisdictions or sectors.** Data ledgers can be used to grow data lakes or data spaces, making data more easily used for compliance requirements. However, data ledgers require high-levels of understanding of digital taxonomies, something that SMEs have more difficulty to achieve.
- **Platformization can drastically reduce the cost of data generation, especially when related to foundational digital public infrastructures (DPIs), such as digital identity or digital payments.** Several stages of sustainability reporting require common processes to be completed, such as keeping track of authorship, information access permission, and tracking payments. These can be streamlined with national large DPIs, making governments the main supplier of DPIs of this type for sustainability reporting.
- **The adoption of PETs (privacy enhancing technologies) can reduce costs of controlling commercially sensitive information, increasing trust in sharing data.** By allowing data to be exchanged between known and unknown peers, without disclosing its content except with proper access permission, PETs can protect sensitive information on transit, increasing trust in the system, which leads to more information being shared in the value chain data.
- **AI, in particular generative AI and LLMs, can greatly reduce costs of understanding and generating sustainability reporting data.** AI can help change the way SMEs interpret and respond to policy measures, by improving policy comprehension and allowing users to query policy data. LLMs can for example lower the cost of applying sector specific formats, or help to navigate through large and complex groups of policies and procedures. This makes it easier for

SMEs to make queries, assess data quality, generate insights, and receive tailor-made assistance.

#### **D. Making use of technology to increase the value of sustainability reporting data generated by SMEs and EMDEs.**

*Considering that:*

- Large actors are more likely to profit from sustainability reporting data, due to their larger capacity to make use of large amounts of data, and their privileged position at the top of data value chains.
- There are economic incentives for SMEs to profit from sustainability reporting data, such as access to sustainability funding, reduced insurance costs, direct profit from carbon markets, or even indirect increases in competitiveness. Those activities, nonetheless, are heavily data dependent, which is a burden for SMEs.
- The use of new digital technologies have increased value of data in other sectors, including the financial sector (see e.g. the role of crypto assets), supply chain (see e.g. the role of AI in optimising process), and public service (see e.g. the role of digital ID for reducing bureaucracy).
- The use of data ledgers provides transparency and trust in data sharing. When delivered with distributed technologies, it increases the use of data immutability, automation, and APIs (Application Programming Interfaces), allowing computer-computer communication in a simple form.

*Recommendations:*

- **Asset tokenization can increase the traceability of granular and material data published in sustainability reports.** If SMEs have easy access to tokenizing valuable information in their reports, they can profit beyond the report as a whole, increasing the opportunities for received value. Also, if assets of reports are tokenized, the growth of public and free information increases access to data demanding opportunities, such as green funding and affordable insurance.
- **Asset tokenization can also increase the value of sustainability reporting in the data value chain.** If reports are tokenized, they can be negotiated with larger companies as paid information. With the use of wallets and smart contracts, the reuse of their data can lead to later profitability, as happens with "royalties" or "copyright", that

fund the early value chain actor that pays to generate an information, but it is later on paid back for their actions.

- **Asset tokenization can create middle-markets of sustainability revenues for SMEs.** For example, tokenizing shares of a sustainable real estate project allows investors to own a fraction of an asset, lowering the entry barrier for investors interested in green agenda opportunities.
- **Asset tokenization can increase the consumer perceived value of sustainability reporting.** Companies can tokenize their supply chains to ensure transparency and sustainability. Once made public and accessible, consumers can verify the sustainability of their purchases, increasing the brand or product value. This is particularly profitable in contexts where it is mandatory to publish data in news venues, a format that has no data interoperability and very low use for asset tokenization.
- **Data interoperability can foster the creation of data spaces, data polls or data lakes, technical repositories of data that incentivize the responsible and profitable reuse of data by third-parties.** By scraping the web, several sustainability reports can be grouped and analysed. Scraped data, however, breaks the link between data producer and data user, removing incentives for data producers to publish their data with granularity and completeness beyond legal obligations. New models of data repositories can include rules and governance systems that maintain the link between data producer-user stability.
- **The use of data interoperability with smart contracts can streamline consented third-party access to data made available only to companies.** Electricity or gas bills, for example, have valuable information for sustainability reporting, and are largely provided to companies by service providers in digital format. If end-users of data value chains, such as banks, want to have access to this information in real time, smart contracts can allow companies to give or revoke consent for the operation, protect sensitive information in data transference, and set up payments and other forms of retributions related to data use.

## **E. Improving sustainability reporting service ecosystem**

*Considering that:*

- Data input systems, data ledgers and other technologies are costly to develop and maintain, and SMEs lack the capacity of funding access to creating these technologies alone.
- A diverse and inclusive reporting services market is a must for different sectors and different company sizes to generate sustainability data.
- There are currently few free or open solutions for SMEs and EMDEs to deliver sustainability reporting, and at the same time the paid solutions that exist need to scale up in order to keep providing digital services.

*Recommendations:*

- **There is a need to provide free and open technologies for sustainability reporting SMEs' needs.** The most promising investments at the moment are open standards and taxonomies, but digital input methods for all data reporting phases are required for full benefit of sustainability data markets by companies. Open standards incentivize markers that are platform-independent, in a vendor-neutral way. Open solutions are also related to the digital public good (DPG) concept, supported by the UN Secretary General's Roadmap for Digital Cooperation.
- **Digital public infrastructure can support private and non-profit business models for sustainability reporting services.** By making it easier for intermediaries to use digital ID and digital payments systems, those service providers can focus on their core business and a more diverse range of clients.
- **Large companies should contribute back for SMEs data produced along the data value chain.** In general, there are no incentives for large actors to pay or incentivize smaller actors data gathering. However, if we set up a compulsory incentive for reuse of sustainability data in the supply chain, we create revenue to fund a richer intermediary ecosystem.
- **AI infrastructure, such as public LLM topic-enhanced solutions, can foster the availability of "AI reporting as a service".** Open AI layers fine tuned for sustainability reporting can foster reporting services that make data gathering and data reporting more accessible to SMEs.

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