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Sustainability-Driven Legitimacy Through Industry 4.0: Insights From European Agri-Food Giants

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ABSTRACT

Society is undergoing a profound transformation driven by recent social, environmental, and economic shifts. Among the most affected actors are business entities—particularly those in the agri-food sector—due to the substantial sustainability impact of their production activities. In this context, technological advancement offers strategic tools to support the implementation of sustainable practices. This study focuses on the agri-food ecosystem and investigates how European agri-food multinationals are leveraging Industry 4.0 technologies to address social, environmental, and economic sustainability challenges while enhancing corporate legitimacy. A total of 51 GRI-compliant sustainability reports from European agri-food multinationals were analyzed. The study explores the characteristics of the sample, the identification of material topics, and their positioning within materiality matrices. Furthermore, the paper examines the relationship between GRI-defined material topics and the Industry 4.0 technologies employed to implement sustainability practices. This analysis provides insight into how these technologies contribute to building legitimacy within the agri-food sector.

1 | Introduction

In recent years, global social, economic, and environmental disruption—such as the COVID-19 pandemic, geopolitical instability, resource scarcity, and food security concerns—has placed increasing pressure on government, societies, and businesses to respond with resilient and sustainable solutions (Beltrami et al. 2021). Among these actors, businesses play a critical role in driving sustainability transition (Ajwani-Ramchandani et al. 2021; Zhang et al. 2023). As sustainability becomes a central tenet of business strategy (Montiel et al. 2021), many companies have turned to Corporate Sustainability Reporting (CSR) as a means to align corporate behavior with stakeholder expectations and long-term environmental goals (Likitapiwat et al. 2023; Doni et al. 2022).

Sustainability efforts also contribute to the construction of corporate legitimacy—a socially constructed perception of a

company's right to operate. According to legitimacy theory, organizations must align with societal values and norms, complying with both governmental regulation and stakeholders' expectations (De La Plaza Esteban et al. 2014). In this context, sustainability practices serve not only as environmental or ethical imperatives but also as strategic tools to reinforce legitimacy.

This issue is especially salient in sectors with high environmental and social impact, such as the agri-food industry (Abbate et al. 2025). Specifically, multinational companies operating in agriculture and food production (hereinafter agri-food) significantly contribute to CO₂ emissions (e.g., meat production, Kumar et al. 2022) and social concerns (e.g., undeclared labor, Molinero-Gerbeau et al. 2021). These companies face increasing scrutiny from a wide range of stakeholders and are thus compelled to innovate their business models toward more sustainable practices, often through the adoption of emerging technologies.

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One promising avenue is the integration of Industry 4.0 (I4.0) technologies - such as IoT, Big Data Analytics, and RFID—which can support sustainable innovation by optimizing processes, improving traceability, and reducing waste (Beltrami et al. 2021; Ching et al. 2022). These tools also contribute to broader environmental, social, and economic goals (Mukhuty et al. 2022; Srivastava et al. 2022), including the implementation of circular economy strategies (Bag et al. 2021, 2020; Upadhyay et al. 2023). As part of eco-design and eco-innovation frameworks, I4.0 technologies offer new opportunities to align production systems with sustainability objectives while maintaining competitiveness (García-Sánchez et al. 2020).

Although prior research has explored the intersection of I4.0 and sustainability, existing studies remain limited in several ways.

For instance, Tiwari and Khan (2020) and Narula et al. (2021) investigated the role of I4.0 technologies in sustainability practices in India and a global sample, using qualitative and survey methods. These studies proposed mappings between I4.0 tools and material topics but offered limited sector-specific insights. Gladysz et al. (2020), meanwhile, developed a conceptual model integrating RFID to support sustainability measurement.

Despite the presence of these studies and the testimony that the integration of I4.0 technologies in industrial processes enhances the legitimacy of companies (Kamble et al. 2018), several important questions were unanswered—particularly concerning the role of I4.0 in enhancing sustainability within the European agri-food sector, the types of technologies adopted, and their perceived legitimacy-building functions.

This research aims to address these gaps by investigating how European agri-food multinationals (hereafter EAFMs) are using I4.0 technologies to implement sustainability practices and strengthen their legitimacy. Despite growing calls for sustainable innovation, little is known about how EAFMs—facing a complex network of stakeholders and unique environmental pressures—strategically integrate technological tools in their sustainability journeys (Koenig 2012; Borsellino et al. 2020; Del Baldo 2022; Notarnicola et al. 2012). I4.0 presents not only a technological shift but a transformative opportunity to realign business ecosystems around sustainable and ethical objectives (Bansal and Roth 2000; Macassa et al. 2022).

To this end, the study explores the innovation ecosystem of EAFMs through the lens of corporate legitimacy and identifies how I4.0 technologies are leveraged in sustainable strategies. The analysis is guided by three specific sub-objectives (SOs):

- SO1: To explore how EAFMs perceive sustainability issues.
- SO2: To understand EAFMs' sustainability practices and reporting choices.
- SO3: To analyze the role of I4.0 technologies in supporting these sustainability practices.

Although exploratory in nature, this study provides empirical insights into how EAFM are using technology to pursue sustainability objectives. Drawing on a sample of 51 companies and

employing a systematic data collection and analysis framework, the findings contribute to the literature on sustainable innovation and legitimacy. By building upon and extending prior research (e.g., Gladysz et al. 2020; Narula et al. 2021; Tiwari and Khan 2020), the study offers a more focused sectoral and regional perspective. Additionally, it provides actionable recommendations for businesses and policymakers seeking to leverage I4.0 for sustainability, while informing future research on green technological adoption in high-impact industries.

2 | Theoretical Background

2.1 | Sustainability Practices: Issues and Innovation in the Agri-Food Sector

Recent literature has increasingly focused on the impact of food systems on both human health and the environment (Sadraei et al. 2023). Agricultural systems face numerous sustainability challenges daily, including global climate change, excessive energy use, and the depletion of soil and water resources. These issues directly affect environmental quality—contributing to biodiversity loss and the spread of infections—which in turn impacts human well-being (Del Baldo 2022). Ultimately, such challenges jeopardize the planet's capacity to sustain human societies in the short and long term (Borsellino et al. 2020). It is crucial for agri-food businesses to prioritize sustainability, balancing production performance with the protection of the planet's resources (Barth et al. 2017).

Agri-food businesses are therefore compelled to prioritize sustainability, striking a balance between production efficiency and the preservation of natural resources (Barth et al. 2017). Practices that promote sustainability-oriented innovation—capable of generating new knowledge, transforming production processes, and reconfiguring business models—are increasingly vital.

In response to these demands, agri-food enterprises are incorporating circular economy principles, eco-innovation, and open innovation into their business models. This integration has led to improved financial performance as well as environmental and social benefits. These advancements are driven by a heightened awareness of global sustainability issues—accelerated by the COVID-19 pandemic (Barth et al. 2017)—and by the active engagement of internal and external stakeholders, who increasingly influence corporate success in sustainability efforts (Chiambaretto et al. 2020; Schifeling and Soderstrom 2022). Innovation is also occurring across supply chains, where companies are sourcing ingredients sustainably, reducing transportation-related emissions, and adhering to environmental and social standards at each stage (Palazzo and Vollero 2022). Multinational corporations, being major players in global food systems, are especially committed to energy and environmental efficiency, food safety, and food security (Fârte and Obadă 2021). However, their operations are complicated by varying environmental regulations across countries, which can result in inconsistent sustainability practices (Khan et al. 2021). For instance, stricter regulations may require investment in advanced eco-technologies, while more lenient contexts might permit less sustainable approaches.

Multinationals are thus at the forefront of identifying and responding to sustainability challenges. An example of how multinational corporations are addressing sustainability challenges emerges from the findings of an empirical study by (Jindřichovská et al. 2020) focused on the multinational company Cargill. In particular, Cargill, in order to reduce emissions related to maritime transport, has introduced a “parceling” service that allows the shared loading of goods for two clients, thereby offering the possibility to reduce emissions by up to 40%. In the area of health and safety, Cargill pays particular attention to the well-being of seafarers employed on the approximately 600 vessels it charters on average, even though these are not directly under its control. The company considers crew safety—a majority of whom come from developing countries—a priority, and actively promotes vessel maintenance. From an ethical perspective, Cargill has adopted its own Code of Conduct, which sets clear standards regarding legality, integrity, fairness in business management, and respect for human dignity. The company is committed to being a responsible global actor and to proactively addressing any ethical concerns. However, this study is limited to the observation of a single multinational, comparing its commitments and actions in a longitudinal manner. An interesting result also emerges from (Ross et al. 2015), which highlights how American agri-food multinationals are addressing sustainability challenges by integrating environmental, social, and economic practices into their operations. They do so by adhering to various international standards (such as Fairtrade or MSC) and by implementing sustainability directly within production processes—from resource management to food safety. This holistic and certified approach aims to ensure not only environmental responsibility but also fair working conditions and benefits for local communities, reflecting a growing and multidimensional commitment. This study is relevant and almost foundational, although it refers to a specific geographical context that undoubtedly influences the discussion on the topic.

While it is evident that many are innovating toward sustainability (Nylund et al. 2021), limited studies offer in-depth insights into how AFM specifically addresses these issues (Choirun et al. 2020).

These observations lead to the first research question (RQ):

RQ1. *How do multinationals perceive and address specific sustainability issues?*

Answering RQ1 contributes to achieving SO1.

2.2 | Sustainability Reporting: Material Topics and the GRI Framework

The EU’s Non-Financial Reporting Directive (NFRD, 2014/95/EU) and the more recent Corporate Sustainability Reporting Directive (CSRD) require large and listed companies to disclose their environmental and social impacts (Caputo and Leopizzi 2021; Darnall et al. 2022). Over time, various sustainability reporting tools (SRTs) have been developed—including Corporate Social Responsibility (CSR), Sustainable Development (SD), and Environmental, Social, and Governance (ESG) frameworks. While these tools share the goal of enhancing

transparency, they vary in focus and in the types of information they convey (Kumar et al. 2022).

SRTs allow companies to engage with global challenges while improving reputational standing and aligning with the United Nations Sustainable Development Goals (SDGs). Among the available standards, the GRI standard is the most widely adopted worldwide (Manes-Rossi and Nicolo’ 2022; Sandberg et al. 2023). The GRI framework structures sustainability disclosures into 33 topic-specific standards across four categories: core business, economic, environmental, and social. Companies use materiality matrices to identify and prioritize relevant topics based on stakeholder interests.

Although many studies emphasize social sustainability, environmental and economic aspects remain underexplored (see Table A in the Supporting Information). Increasingly, firms view sustainability not only as a moral imperative but also as a strategic approach to enhancing competitiveness (Shahzad et al. 2023). Through SRTs, companies can effectively “certify” their sustainability practices, signaling a commitment to resilience and responsible production.

Empirical findings—such as (Gerber et al. 2024)—show how agri-food multinational corporations concretely prepare non-financial reports in accordance with GRI standards, linking sustainability challenges to business practices by framing them under the umbrella of materiality topics. Starting from their corporate objectives, they aim to improve sustainability performance; for example, through enhanced brand assurance, stakeholder satisfaction, competitive development of certified supply volumes, and dynamic capabilities that contribute to effective, efficient, and timely updates of sustainability practices within the supply chain (Chkanikova and Sroufe 2021). Another example can be found in voluntary certification initiatives for sustainable agri-food products and production processes. These certification initiatives bring with them traceability within supply chains, ensuring the sustainability of the products consumed (Mol and Oosterveer 2015). Furthermore, it emerges that sustainability disclosure by agri-food multinationals has so far received very limited attention from management and organization scholars (Muriel et al. 2025). Relatively little research has been conducted on how agri-food companies or multinationals commit to demonstrating sustainability through the publication of sustainability reports (Muriel et al. 2025). This is despite the importance of communicating with stakeholders, who need such information to evaluate company activities and, consequently, to build legitimacy.

This leads to the second research question:

RQ2. *How do multinationals “certify” practices for addressing specific sustainability issues and thereby build legitimacy?*

Answering to RQ2 contributes to achieving SO2.

2.3 | 14.0 Technologies Serving Sustainability

The fourth industrial revolution has introduced a set of advanced technologies that can support sustainable development

(Ejmsont et al. 2020; Strazzullo et al. 2023). I4.0 and sustainability have gained increased attention in academic, managerial, and policy discussions (Beltrami et al. 2021). The I4.0 paradigm encompasses nine technological pillars that underpin the current wave of industrial transformation (Silvestri et al. 2020; Torres Da Rocha et al. 2022).

Studies linking I4.0 to sustainability present mixed findings. On the positive side: (i) I4.0 can foster sustainable manufacturing (Ching et al. 2022; El Baz et al. 2022), and in some contexts, such as India, tailored roadmaps have been developed to guide sustainable implementation (Pasi et al. 2021); (ii) I4.0 enables circular economy initiatives within supply chains (Bag et al. 2021, 2020; Rajput and Singh 2020; Ünal et al. 2020; Upadhyay et al. 2023); (iii) I4.0 enhances process efficiency, leading to more sustainable resource use (Kiel et al. 2017) and waste reduction (Castiglione et al. 2023; Stock et al. 2018).

However, challenges persist. I4.0 can result in increased electronic waste, higher energy demand (Rajic et al. 2022) and disruption to existing industrial and organizational systems (Lanzolla et al. 2020; Mukhuty et al. 2022; Srivastava et al. 2022). Moreover, barriers such as high implementation costs, resistance to change, and regulatory complexity may hinder its sustainable adoption—particularly in developing countries (Narwane et al. 2021). In the agri-food sector, I4.0 offers promising applications: (i) ensuring food safety and sustainability (Oltra-Mestre et al. 2021); (ii) reducing labor and food waste costs (Aktaş et al. 2021); (iii) promoting green supply chain practices (Dabija et al. 2018); (iv) improving real-time coordination in supply chains (Birkel and Müller 2021); (v) enhancing consumer trust by addressing transparency in food production and logistics (Wu et al. 2021); (vi) supporting regulatory compliance (Härtel 2022). Despite these advantages, barriers remain—particularly financial limitations, resistance to digital transformation, and limited collaboration (Aktaş et al. 2021).

Specifically, from the perspective of actions implemented by agri-food companies and multinationals, empirical studies show that they leverage technologies, gaining advantages also in the field of sustainability (Cricelli et al. 2024). For example, Exposito et al. (2013) found that the use of RFID technology in the traceability of the wine supply chain improves transparency and control along the supply chain, thereby contributing to more responsible resource management and waste reduction. Liang et al. (2015) demonstrated that RFID-based traceability in the beef supply chain can enhance food safety and consumer trust, promoting more ethical and sustainable production in line with the demand for quality and social responsibility. Fan (2019) proposed an IoT system for food logistics that enables real-time monitoring of products, reducing losses along the cold chain, improving energy efficiency, and contributing to the fight against food waste.

The use of technologies to address sustainability challenges is not always a conscious choice by companies, and specifically by multinationals. In fact, many studies show that the decision to rely on technology is often a path taken to simplify actions regardless of the underlying sustainable purpose or objective (Carmela Annosi et al. 2020).

Given the dual nature of I4.0—its promise and its pitfalls—there is a need to better understand how EAFM strategically implements these technologies for sustainability purposes.

This leads to the third research question:

RQ3. *How do multinationals leverage I4.0 technologies to address sustainability issues and build legitimacy?*

Answering RQ3 contributes to achieving SO3.

3 | Theoretical Framework

The lowest common denominator of the previous evidence is the sense of legitimacy that the companies experience by operating ethically—embracing sustainability principles and addressing sustainability challenges through corporate sustainability practices. The issue of legitimacy has become increasingly important in the sustainability domain (De La Plaza Esteban et al. 2014). According to legitimacy theory (Weber 1947), companies establish an “imaginary contract” with society and the planet, compelling them to adopt sustainability-oriented practices in order to gain broad societal approval. Legitimacy theory posits that companies recognize the crucial role of a positive image and reputation (Zeng et al. 2024), and suggests the use of sustainability reporting to enhance legitimacy (Sehgal et al. 2023; Zharfpeykan 2021). This is achieved through both compliance and disclosure mechanisms (Sehgal et al. 2023). Moreover, the quality of sustainability disclosure is crucial in the context of legitimacy theory: firms with superior sustainability performers tend to opt for high-quality, comprehensive reporting to signal their excellence to the market (Hummel and Schlick 2016). As the most inclusive framework for sustainability reporting (Bellantuono et al. 2018), GRI is widely recognized as a valuable tool for enhancing corporate legitimacy by improving the quality and credibility of sustainability disclosure (Gosselin and Berthelot 2024). Beyond reporting, I4.0 technologies have also been highlighted as key enablers in building legitimacy (Bai et al. 2020; Kamble et al. 2018; Kishna et al. 2017). Rooted in the three thematic pillars discussed in Section 2, and using legitimacy theory (Weber 1947) as a theoretical lens, the study’s theoretical framework enables a critical exploration of sustainability practices—investigating how they can be certified through the GRI standard and how they are strengthened by the I4.0 technologies. The connections among legitimacy, GRI standard, and I4.0 technologies are bidirectional and intricately intertwined (Figure 1):

- *from GRI to legitimacy*: By adhering to GRI Standards, companies demonstrate transparency and accountability for their environmental, social, and economic impacts. This structured disclosure builds trust with stakeholders, signals a commitment beyond mere compliance, and allows for comparability, all of which enhance an organization’s reputation and its “social license to operate,” thereby increasing its sustainability-driven legitimacy.
- *from legitimacy to GRI*: In the other direction, the ongoing pursuit of legitimacy—whether to pre-empt regulation,



FIGURE 1 | Interconnected pathways between Legitimacy, GRI reporting, and Industry 4.0 tools (our production).

attract ethically-minded investors, gain competitive advantage, or simply to align with evolving societal values—actively incentivizes companies to adopt globally recognized and credible frameworks like GRI. Companies seek out such robust reporting mechanisms precisely because they are perceived as legitimate tools for demonstrating responsible behavior, thus serving as a strategic response to legitimacy pressures.

- *from I4.0 technologies to legitimacy:* Emerging technologies (such as Artificial Intelligence (AI), IoT, and Big Data Analytics) play a pivotal role by enabling the precise collection, processing, and analysis of vast quantities of sustainability-related data across the supply chain. This technological enablement allows companies to more accurately identify material impacts, track performance against GRI indicators, and generate robust, verifiable data required for comprehensive sustainability reports. By providing such granular and auditable information, I4.0 technologies significantly enhance the credibility and completeness of sustainability reporting, which directly strengthens the foundation of sustainability-driven legitimacy.
- *from legitimacy to I4.0 technologies:* In turn, the increasing pressure for deeper, more verifiable, and real-time sustainability performance (driven by the desire for enhanced legitimacy) compels organizations to invest in and integrate these advanced I4.0 technologies. As stakeholders demand greater transparency and assurance regarding sustainability claims, companies are strategically leveraging technology not just for operational efficiency, but as a critical enabler for demonstrating their commitment and proving their legitimate sustainability efforts. This creates a powerful feedback loop where the quest for legitimacy fuels technological adoption, which, in turn, strengthens legitimate claims.

Therefore, a robust sense of legitimacy, driven by both external pressures (such as regulatory compliance and evolving societal expectations) and internal motivations (including ethical considerations and strategic reputation management), as mentioned by Onkila et al. (2018); Salem et al. (2018) can powerfully compel companies to embrace comprehensive sustainability reporting practices and/or integrate advanced sustainability-enhancing technologies. This adoption serves as a crucial means to formally attest, or “certify” through verifiable reports and data, their commitment to good practices and responsible operations, thereby pursuing sustainability-driven legitimacy. At the same time, the deliberate and transparent adoption of established

sustainability reporting frameworks, coupled with relevant technological advancements, can significantly build and reinforce an organization’s perceived legitimacy (Claus et al. 2021), fundamentally fostering this sustainability-driven legitimacy and creating a virtuous cycle.

In this dynamic landscape, the GRI standards occupy a uniquely central position. Their prominence stems from their comprehensiveness, global applicability, and a strong stakeholder-centric approach (Mohanty et al. 2024). Unlike other sustainability reporting frameworks that may predominantly focus on financially material aspects (e.g., SASB¹, often investor-focused) or specific thematic areas (e.g., TCFD², addressing climate-related financial disclosures), GRI provides a holistic framework for reporting on an organization’s most significant impacts—economic, environmental, and social—across its entire value chain. This broad scope inherently aligns with the diverse expectations of a wide array of stakeholders, from employees and local communities to NGOs and customers, making it fundamental for achieving broader societal legitimacy and fostering sustainability-driven legitimacy (Suchman 1995).

GRI actively supports the process of building sustainability-driven legitimacy through several key mechanisms:

- *Enhanced transparency and accountability:* GRI’s detailed disclosure requirements compel organizations to be transparent about their performance and impacts. By consistently reporting on specific indicators, companies demonstrate accountability for their actions to a wide audience, thereby cultivating trust and signaling a commitment beyond mere regulatory compliance, which is essential for sustainability-driven legitimacy. The role of emerging technologies, such as AI, for data processing in sustainable practices can further enhance this transparency and accountability (Yadav et al. 2024), enabling more informed sustainability decision-making and better reporting (Chen et al. 2024).
- *Facilitated stakeholder engagement:* A core principle of GRI is stakeholder inclusiveness. The standards guide organizations in identifying their key stakeholders and engaging in dialogue to determine material topics for reporting. This active responsiveness to stakeholder concerns is vital for establishing and maintaining a “social license to operate”, which directly underpins sustainability-driven legitimacy (Scherer and Palazzo 2007). To fully appreciate how GRI actively supports sustainability-driven legitimacy, it is crucial to understand the intricate interplay between stakeholder salience, materiality, and the very concept of legitimacy

itself. Organizations operate within a complex web of stakeholders, each possessing varying degrees of power, urgency, and perceived legitimacy concerning their claims (Mitchell et al. 1997). The process of identifying these “salient” stakeholders—those whose concerns are most pressing and impactful—and understanding their legitimate expectations is therefore fundamental. GRI’s rigorous approach to materiality directly addresses this by guiding organizations to determine the most significant economic, environmental, and social impacts based on structured stakeholder dialogue and their own operational context. By concentrating reporting efforts on these material issues—which are, by definition, most important to their salient stakeholders—companies can strategically manage stakeholder expectations, demonstrate active responsiveness, and align their practices with societal norms and values. This systematic engagement with material topics, driven by salient stakeholder concerns, serves as a powerful mechanism for cultivating and maintaining their legitimacy (Suchman 1995), moving beyond mere compliance towards genuine sustainability-driven acceptance.

- *Credibility through comparability*: While achieving complete comparability across all reports remains a challenge, the structured nature of GRI Standards provides a common language and methodology. This enables stakeholders to better understand and, to some extent, compare the sustainability performance of different organizations, enhancing

the credibility of reported data and the sustainability-driven legitimacy derived from it (Korca et al. 2023).

- *Global recognition and authority*: As the most widely adopted global standard for sustainability reporting, adherence to GRI carries substantial weight. It signifies to international markets, investors, and civil society that an organization is committed to globally recognized best practices in transparency and accountability, thereby bolstering its sustainability-driven legitimacy on a global scale (Bais et al. 2024).

Furthermore, I4.0 technologies (such as AI, IoT, and Big Data Analytics) are increasingly pivotal in this process. They facilitate the precise collection, processing, and analysis of vast quantities of sustainability-related data across the supply chain (Badar et al. 2025). This technological enablement allows companies to more accurately identify their material impacts, track performance against GRI indicators, and generate the robust, verifiable data required for comprehensive sustainability reports. By providing the granular information essential for detailed GRI disclosures, I4.0 technologies can significantly enhance the credibility and completeness of sustainability reporting, thereby strengthening the very foundation of sustainability-driven legitimacy.

Figure 2 shows the links among the overall objective, related SOs, and RQs, thematic pillars, and the theoretical lens of the study.

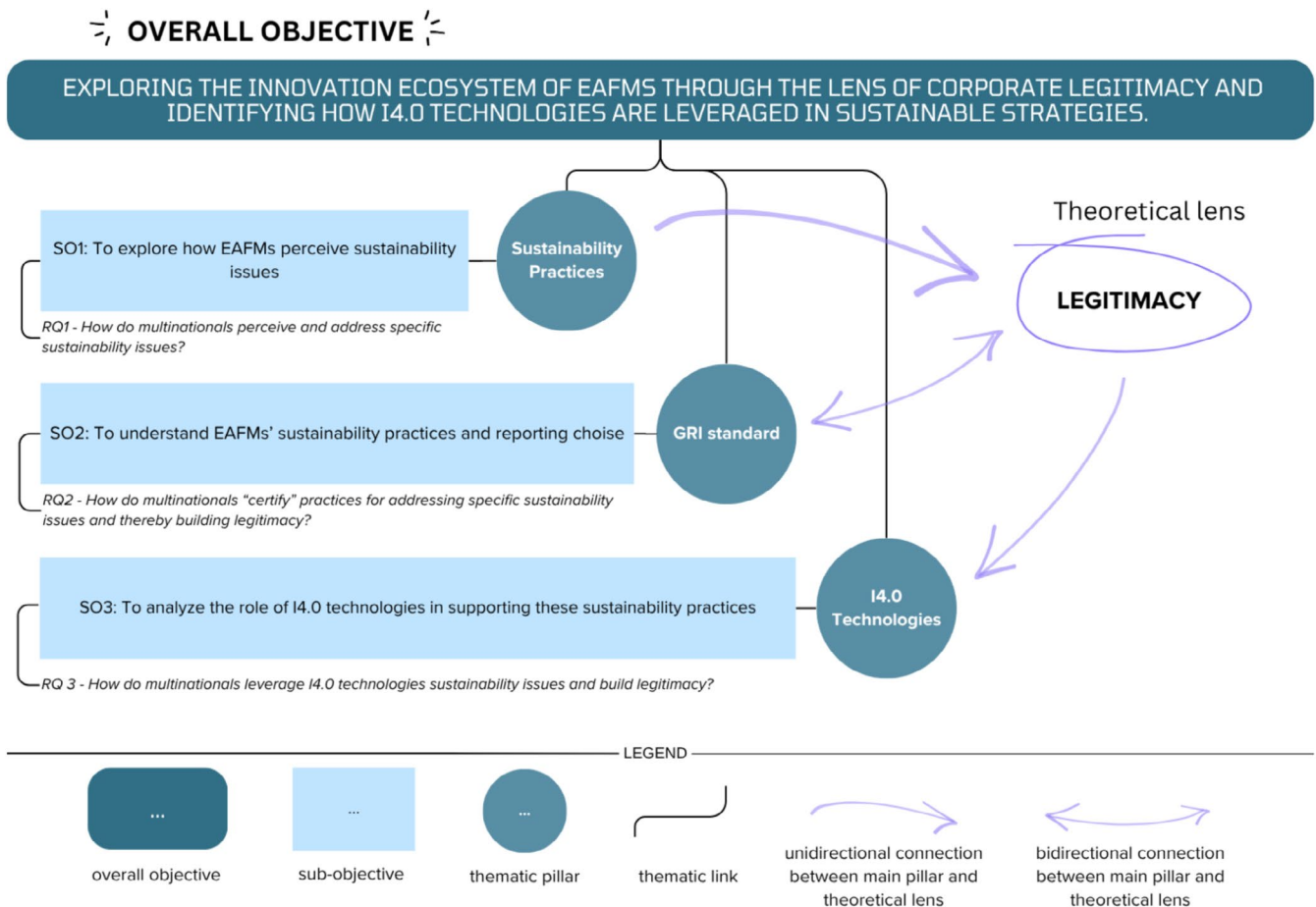


FIGURE 2 | The theoretical framework of the study (our production).

4 | Research Methodology

This study adopts a qualitative document analysis approach, consistent with an interpretivist paradigm and an inductive logic of inquiry, whereby the researcher constructs meaning from empirical evidence (Crotty 1998). Among various qualitative methods (e.g., interviews, observation, audiovisual data), document analysis was chosen for its ability to offer objective, reproducible data while minimizing response bias common in self-reported methods (Alshenqeeti 2014). To investigate how EAFMs address sustainability through I4.0 technologies and reporting practices, we analyzed sustainability reports prepared in accordance with the GRI standards. These documents were selected as they typically contain detailed, structured, and standardized disclosures on environmental, social, and governance (ESG) performance, including the use of technologies, stakeholder-relevant material topics, and strategic sustainability actions. The methodology follows a three-phase protocol: data collection, data analysis, and validation.

4.1 | Data Collection

The data collection procedure involved gathering sustainability reports compliant with GRI Standards, a widely adopted approach supported by recent studies in the field (e.g., (Kassier 2024; León and Salesa 2023)), which demonstrate the methodological robustness and relevance of using GRI-based disclosures for sustainability research. Specifically, our data collection was performed in December 2021 and was focused on identifying and selecting GRI-compliant sustainability reports published between January 2018 and December 2021, a period corresponding to the most recent GRI Standards update. Reports were retrieved from the official GRI Sustainability Disclosure Database, which enables filtering by industry, geography, and GRI version³.

The inclusion criteria were as follows (see Table B in the Supporting Information):

- i. Industry: companies operating in the primary sector (agriculture, livestock, fisheries) and food industry (processing, distribution, retail and catering);
- ii. Geography areas of the continent: Europe;
- iii. Reporting Format: GRI—Standards (latest version).

The initial screening yielded 107 reports. After excluding reports with incomplete or inaccessible data, the final sample consisted of 51 sustainability reports from multinational companies. All documents were downloaded in HTML format to facilitate text extraction and analysis.

4.2 | Data Analysis

The analytical strategy combined qualitative content analysis with descriptive quantitative techniques, following frameworks applied in recent sustainable management studies (e.g., Kassier 2024). All textual data were extracted and systematized into a structured Excel matrix, designed to capture: general company information (e.g., size, sector, country); material

topics (i.e., issues deemed significant by both the company and its stakeholders, as prioritized through the GRI materiality matrix); referenced GRI topic-specific standards (organized by the GRI series: economic, environmental, social); I4.0 technologies, categorized according to the nine I4.0 pillars (Silvestri et al. 2020): Additive Manufacturing, Augmented Reality, Autonomous Robots, Big Data & Analytics, Cloud Computing, Cybersecurity, Horizontal and Vertical Integration, Internet of Things (IoT), and Simulation.

4.2.1 | Coding and Reliability

The dataset was organized and made available in the same format for the researchers, who independently coded the reports using a manual open-coding process, based on a shared codebook developed in an initial pilot round. To ensure inter-coder reliability, Cohen's Kappa was calculated on a 10-report subsample, achieving an average agreement score of 0.81, indicating substantial agreement (Landis and Koch 1977). Any disagreements were resolved through consensus discussions. This qualitative coding strategy allows a subsequent descriptive quantitative strategy.

4.2.2 | Use of Software

Coding was performed manually using Excel to maintain transparency and flexibility in capturing multidimensional relationships between material topics, technologies, and standards. While dedicated CAQDAS (e.g., NVivo) was considered, its emphasis on automated organization may introduce unnecessary complexity. As Moncada (2025) notes, Excel is compatible, lightweight, and supports nuanced narrative analysis; similarly, the NHS Evaluation guide⁴ demonstrates Excel's suitability for structured qualitative coding.

4.2.3 | Analytical Steps

The data analysis followed six key steps (Figure 3), each aligned with the research objectives. First, we conducted a materiality mapping, which involved counting the material topics reported by each company and assessing their relevance based on the prioritization differences between stakeholders and the companies themselves, as shown in the GRI materiality matrices. Next, we examined sustainability practices by performing a frequency analysis of the topic-specific disclosures within the GRI standards, further grouping these disclosures into the main GRI categories: economic, environmental, and social. Finally, we analyzed the integration of Industry 4.0 technologies by identifying and counting the specific I4.0 technologies mentioned in the companies' sustainability actions and cross-tabulating these technological pillars with the material topics they addressed.

4.2.4 | Validation Through Focus Group

To triangulate findings and reduce bias, preliminary results were discussed in a focus group (Galdas 2017) involving both academic experts in sustainability and industry practitioners from the agri-food sector ($n = 4$ participants each). The session

lasted ~90 min and followed a semi-structured discussion guide. Participants helped validate the coding scheme, interpret ambiguous cases, and refine conceptual linkages. Their feedback was incorporated into the final analysis.

4.3 | Sample Overview

The final dataset comprises 51 EAFM with different characteristics (see Figure 4), including representation across capital size, marketing, dimensions, and geographic locations within Europe.

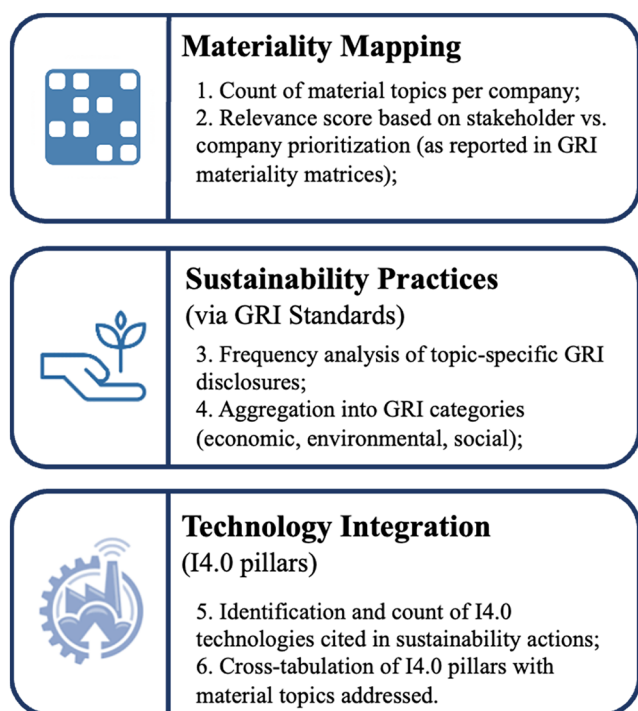


FIGURE 3 | Six key steps in data analysis.

5 | Results

5.1 | Assessing Material Topics for EAFM Sustainability Goals

The material topics considered by the EAFM in our sample are shown in Figure 5. Specifically, the most frequent material topics are related to:

- Environmental actions: “water management” (frequency = 32, hereafter f), “energy management” ($f=29$) and “waste management” ($f=28$);
- Social actions: “human capital, occupation resource well growth” ($f=50$), “food and beverage safety” ($f=30$) and “local community wellbeing” ($f=27$);
- Economic actions: “financial and economic performance” ($f=24$), “traceability and transparency” ($f=20$) and “anti-corruption” ($f=13$).

Figure 6 shows the materiality matrix, where the material topics are positioned according to their relevance for the stakeholders (horizontal axis) and for the multinationals (vertical axis). The positioning was determined as the weighted average of the rankings assigned to each material topic across the various sustainability reports. It is worth noting that most material topics fall within the medium-to-high relevance quadrant. Only four topics appear in the medium-low relevance quadrant: “local community wellbeing”, “product transport”, “technology implementation” and “procurement practices”.

5.2 | Implementing Sustainable Practices Through GRIs in the EAFM

The sustainability reports of the multinationals sample were published in 2021 in 50.9% of cases, followed by 23.6% in 2020, 21.8% in 2019, and 1.8% in 2018 and 2022.

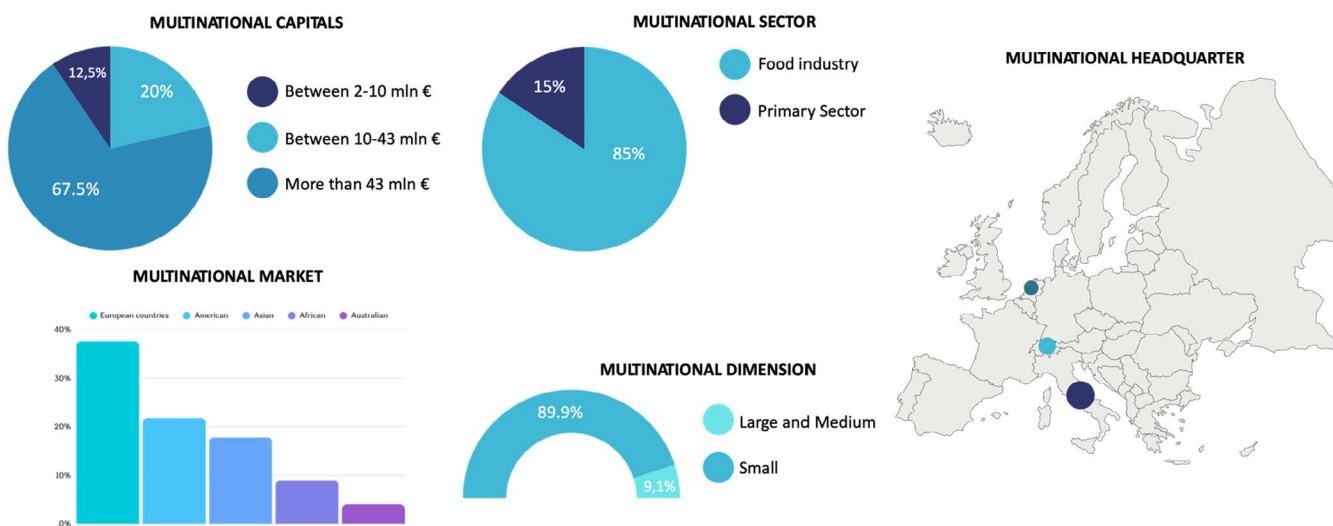


FIGURE 4 | Infographic based on main features of sample (our production).

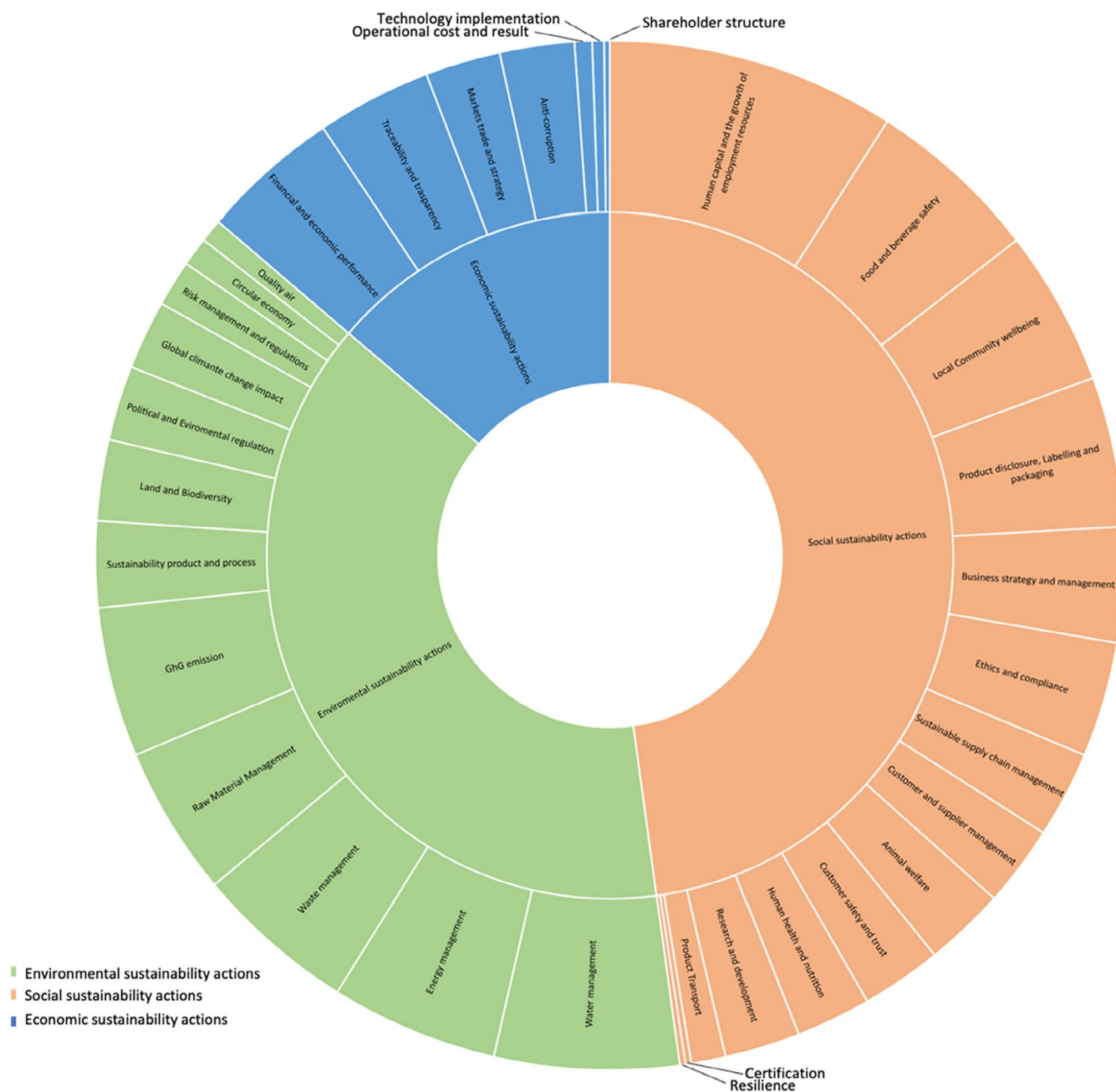


FIGURE 5 | Material topics (our production).

The sustainability-related activities disclosed by multinationals were categorized according to the GRIs standards. As shown in Figure 7, the most frequently cited GRI standards are:

- GRI 102 ($f=45$), related to general disclosures, such as company strategy, governance, stakeholder engagement initiatives, ethics, and integrity.
- GRI 103 ($f=43$), related to the management approach, which includes the significance, boundaries, and impacts of material topics.
- GRI 302 ($f=42$), related to energy management.
- GRI 403 ($f=45$), related to occupational health and safety, including management systems, harm reduction, and health promotion.

Referring to the GRI series defined by the Global Reporting Initiative standards (Figure 8), the most frequently reported topics belong to the Social series ($f=416$), followed by the Environmental series ($f=248$), the Economic series ($f=147$), and the Universal Standard series ($f=97$).

Figure 9 shows the GRI standard used by EAFM for each of the implemented material topics.

5.3 | Adopting I4.0 Technologies in the Sustainability Practices of EAFM

The multinationals in the sample were involved in the adoption of various technologies (Figure 10). To provide a more

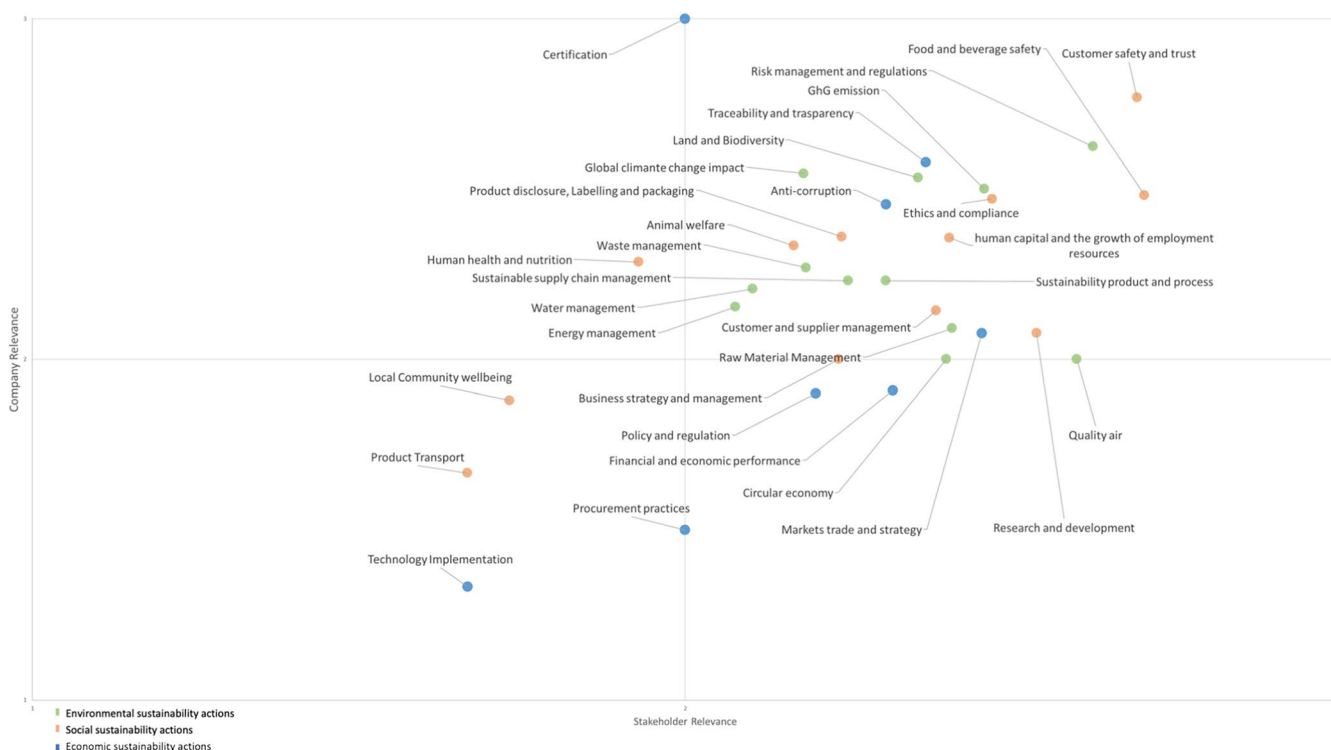


FIGURE 6 | Relevance matrix of material topics for multinationals and stakeholders (our production).

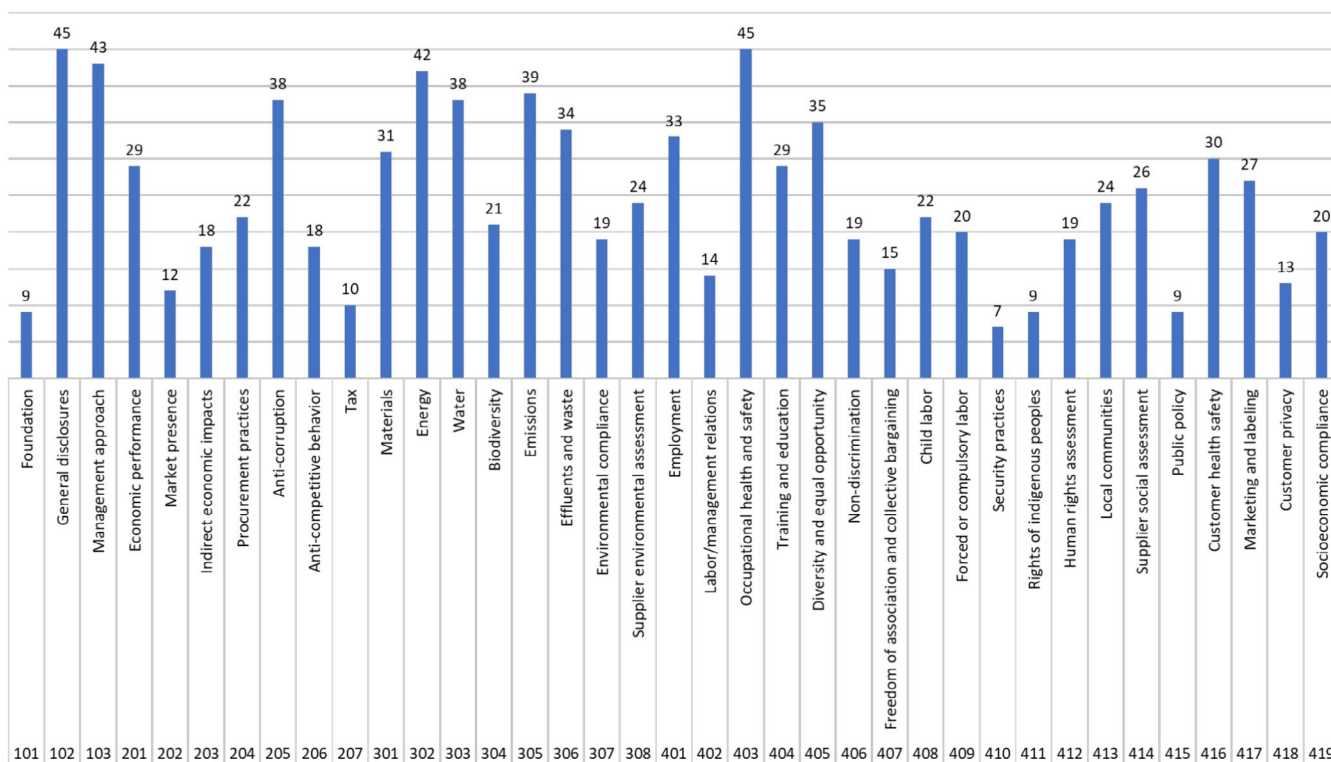


FIGURE 7 | GRI frequency (our production).

structured and comprehensive overview of the technologies integrated into sustainability practices, we categorize them according to the nine pillars of I4.0, as outlined in the Background section (2.3 Industry 4.0 at the service of sustainability). Among the analyzed companies, there is a clear

preference for technologies related to IoT (35.1%), followed by Big Data Analytics (18.9%) and Advanced Robotics (18.9%) (Figure 11). For instance, a multinational agricultural production company adopted IoT-based sensors to monitor production processes, enhancing water management capabilities

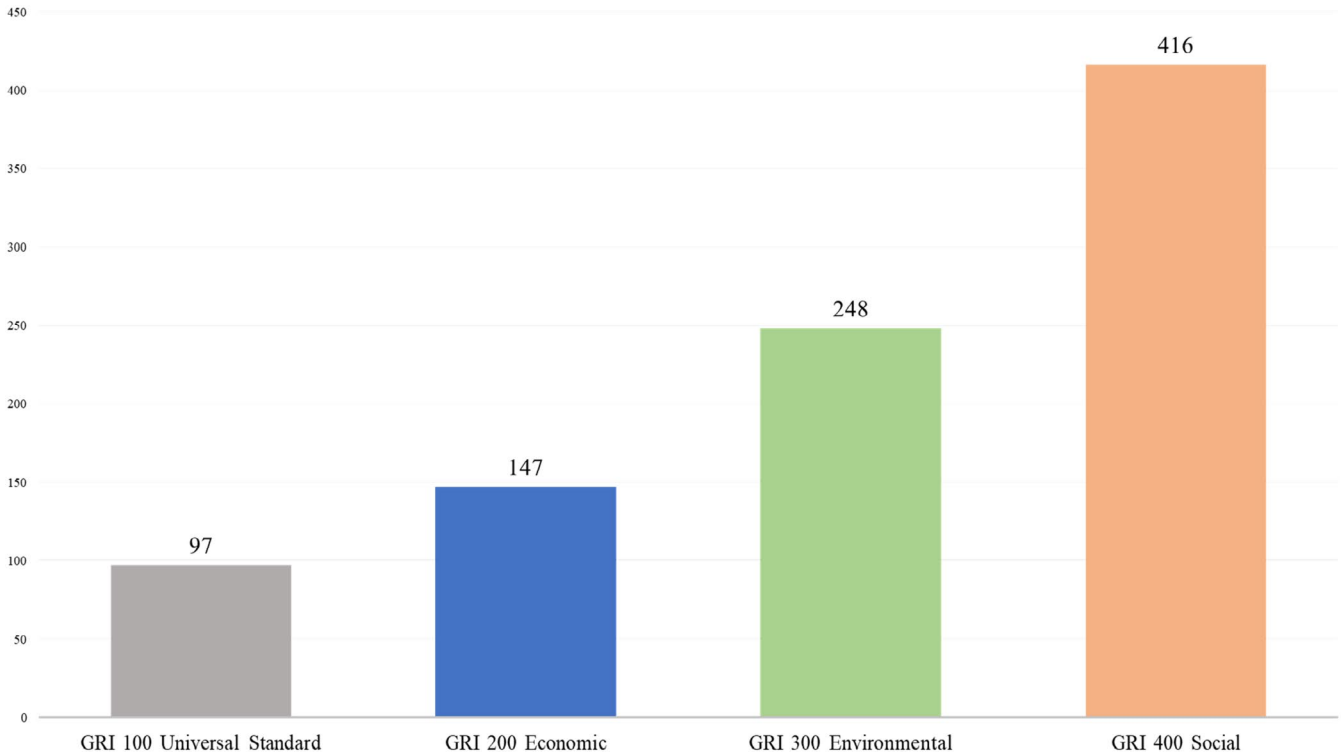


FIGURE 8 | Aggregated GRI frequency (our production).



FIGURE 9 | GRI and material topic matrix (our production).

(addressing the water saving material topic) and collecting valuable data to ensure product quality and safety (traceability and transparency material topic). Another example comes from a company in the chocolate and packaged confectionery

sector, which synergistically employed IoT and Big Data Analytics to map data from farms and sourcing areas, gaining insights into location, size, and productivity. This information helped improve efficiency in product certification and

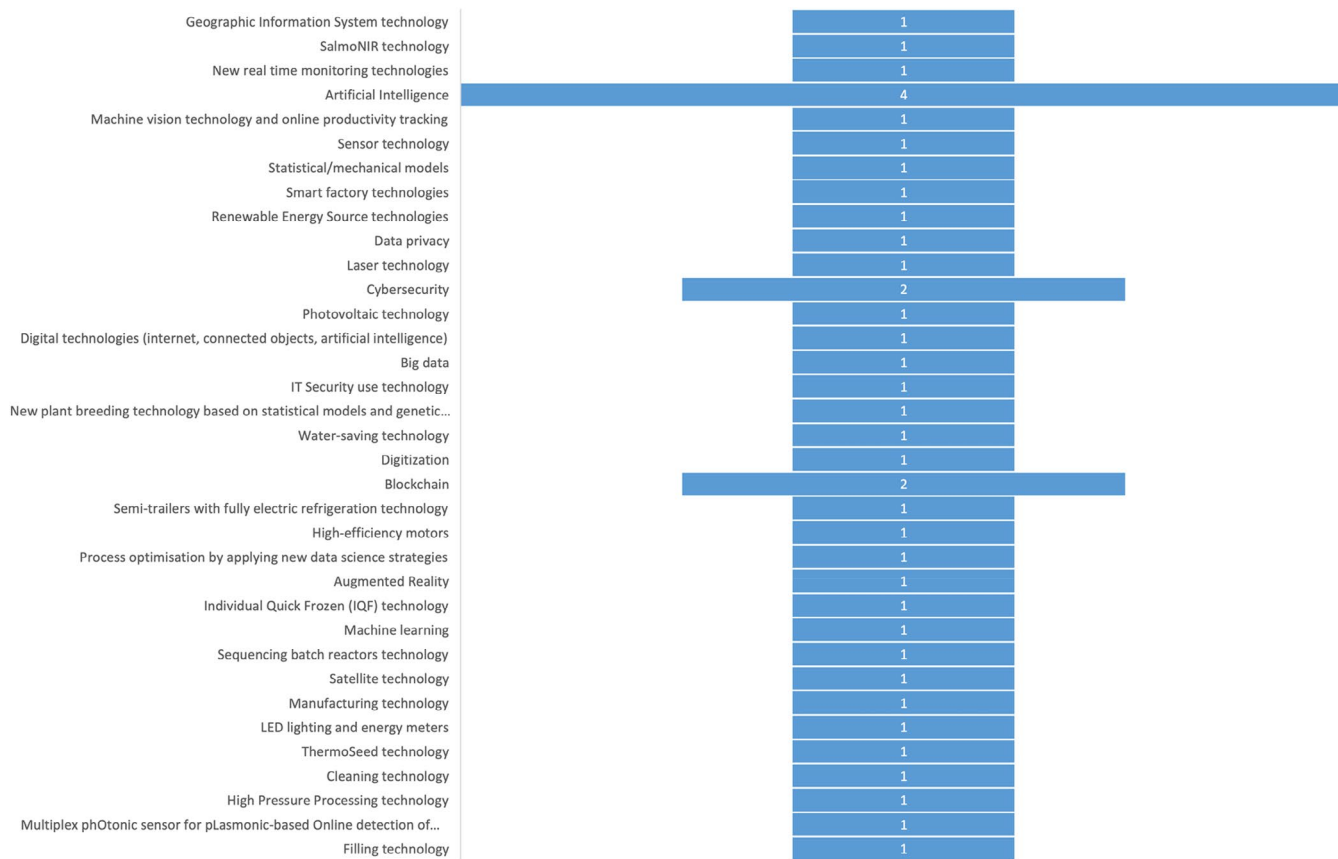


FIGURE 10 | Technology frequencies (our production).

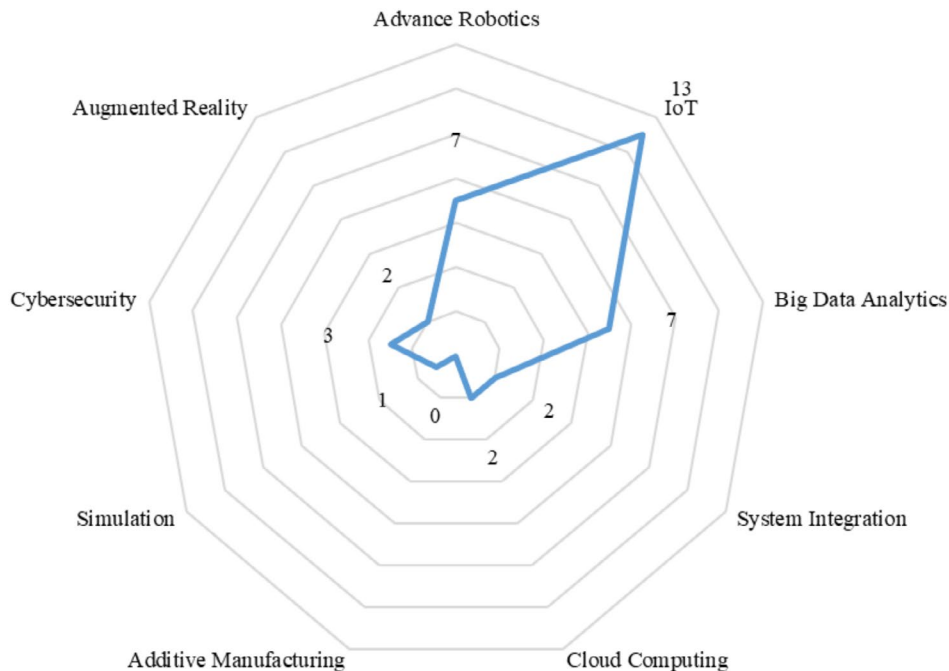


FIGURE 11 | Most frequent pillars of I4.0 (our production).

traceability. Finally, a leading company in wholesale food and non-food trade implemented advanced robotics for product handling within plants and throughout the distribution chain, thereby increasing both operational efficiency and employee safety.

Finally, Figure 12 illustrates the technologies adopted by EAFM in each sustainability action. It is interesting to note that our data confirm the use of Big Data Analytics in waste management and IoT in supply chain management, as respectively declared by Ciccullo et al. (2021) and Gawusu et al. (2022).

6 | Discussion and Implications

This study provides empirical evidence on how I4.0 technologies are used by EAFM to implement environmental, social, and economic sustainability practices, with the ultimate aim of building corporate legitimacy. By focusing on the nine technological pillars of I4.0, this study offers a novel contribution to existing literature that traditionally investigates sustainability goals in agri-food (e.g., Aké and Boiral 2022; Klychova et al. 2019) and broadens the geographical scope, which has been primarily centered on developing countries such as India (Narula et al. 2021; Tiwari and Khan 2020) and without an integrated theoretical framework such as legitimacy theory.

6.1 | EAFM'S Perception of Sustainability and Stakeholder Expectations

Our findings show that EAFM are engaged in various best practices addressing sustainability challenges, incorporating elements of social, environmental, and economic sustainability into their operations. These practices, identified through material topics for their relevance for both stakeholders and companies (Koenig 2012), show a market emphasis on social and environmental dimensions. This finding supports the ongoing debate on the urgency of addressing social and environmental challenges in the agri-food sector discussed in Section 2.1 (e.g., Borsellino et al. (2020); Del Baldo (2022); Notarnicola et al. (2012)). Moreover, the identification of best practices through material topics inherently involves understanding the legitimate expectations of diverse stakeholders, aligning with the importance of identifying “salient” ones—those whose concerns are most pressing and influential—as highlighted by stakeholder theory (Mitchell et al. 1997). Focusing on such material issues is crucial

for strategically managing expectations and maintaining organizational legitimacy (Suchman 1995).

In the social dimension, many multinationals focus on human capital (e.g., employee development), consumer protection (e.g., food and beverage safety, labelling, and customer trust), and societal well-being (e.g., local community support, health and nutrition, ethics, animal welfare). This focus on “human capital, growth of employment resources and local community well-being” is reflected in the Europe Sustainable Development Report 2022⁵ (ESDR), which emphasizes the need to address “inequalities within countries” and promote “Education and skills for sustainable development”. Although the “welfare of the local community” was in the section of low relevance for EAFM, the ESDR report places a wide focus on social inclusion and the principle of “leaving no one behind”, suggesting that this topic has a significant general relevance in the European context, although it may be less of a priority for individual companies. From the legitimacy theory perspective, this focus reflects efforts by multinationals to align with societal values and expectations, thereby maintaining or enhancing their legitimacy (Onkila et al. 2018). These initiatives also respond to increasing consumer demands for transparency and ethical behavior, showing a proactive role in building trust. However, actions related to certification and resilience remain marginal. This may reflect current debates and controversies regarding certification systems (Alonso González et al. 2022; Balogh et al. 2016; Garavaglia and Mariani 2017), as well as high costs and limited stakeholder pressure in this area.

From an environmental perspective, EAFM emphasize resources management (water, energy, raw material management) and pollution control (waste and emission). The ESDR confirms the relevance of these themes. The report stresses that “the EU is tackling its major challenges in the areas of

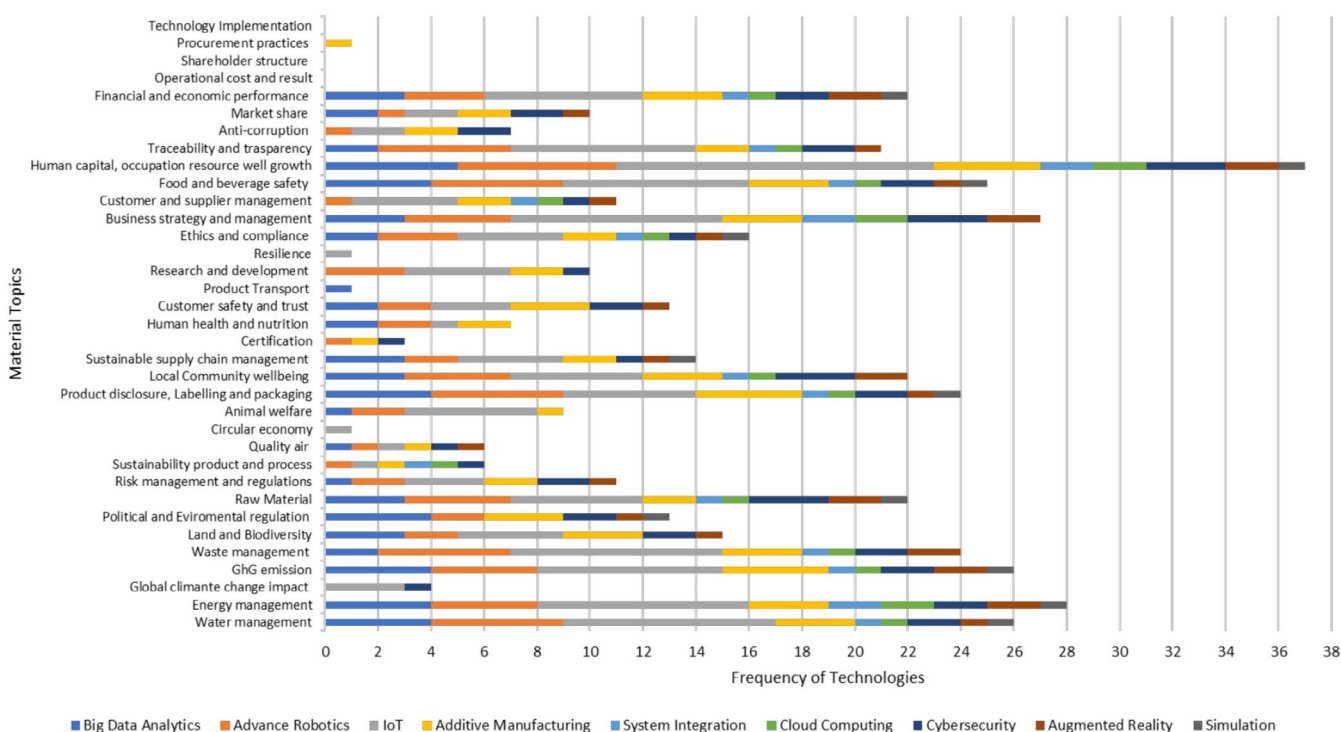


FIGURE 12 | Link between material topics and technologies (our production).

responsible consumption and production and sustainable food systems (SDG 2 and SDG 12-15)". This is fully in line with the EAFM's emphasis on environmental management, given their nature as agri-food companies. Transformation 4 of the ESDR report, "Sustainable food production, healthy diets and biodiversity protection", reinforces the importance of the food sector in Europe for sustainability.

Yet circular economy practices—despite growing international attention (Bag et al. 2021, 2020; Rajput and Singh 2020; Ůnal et al. 2020; Upadhyay et al. 2023)—appear to be marginally adopted. This may result from limited awareness or high implementation costs (Ejmont et al. 2020). From a stakeholder perspective, the market and regulatory bodies play a crucial role here. For instance, stronger policy incentives and clearer guidelines from public institutions could shift perceptions of circular economy practices from optional to strategic.

In the economic dimension, EAFM prioritizes financial performance, traceability, transparency, market strategy, and anti-corruption. According to legitimacy theory, such emphasis reflects the need to maintain investor confidence and regulatory compliance (Spence and Rinaldi 2014). However, the technological implementation topic appears to receive limited attention, possibly due to the substantial economic investment required. Interestingly, some discrepancies emerge between the frequency of actions taken and their perceived relevance in the materiality matrix. For example, while local community well-being and financial performance are frequently addressed in practice, they are not ranked as highly relevant. This suggests a strategic prioritization of consumer—and environment—related topics, in line with the needs to meet evolving customer expectations (Dabija et al. 2018) and comply with environmental regulations (Montiel et al. 2021).

6.2 | EAFM Sustainable Practices and Certification Choices

The findings reveal that EAFM relies on GRI standards and I4.0 technologies to implement and communicate sustainability practices discussed above. The widespread use of GRIs—especially in the Social (GRI400) and Environmental (GRI300) domains—demonstrates their effectiveness in aligning company practices with regulatory and societal expectations (Ika et al. 2021). These results confirm the principles of legitimacy theory, according to which legitimacy is achieved through a "social contract" with the environment and society.

Although the ESDR focuses on the SDGs and does not explicitly mention the GRI, it implicitly supports the need for structured and comprehensive reporting. The report highlights the importance of "quantified targets for many SDG indicators" and an "integrated and comprehensive approach to implementing SDGs". The strong recognized adoption of GRI standards by EAFM aligns with this need for transparency and measurability of sustainability performance. The "The ESG Imperative, Ipsos Foundational Perspectives"⁶ IPSOS' report further reinforces this point, underlining the importance of pursuing the ESG pillars in an integrated way and avoiding considering them in silos, an approach that GRI reporting facilitates. Moreover,

GRI-based reporting serves not only to "certify" sustainability practices but also to enhance transparency and stakeholder engagement, contributing to a more favorable public perception (Sehgal et al. 2023; Zeng et al. 2024; Zharfpeykan 2021). However, while the alignment between material topics and GRI indicators is evident, the connection between material topics and I4.0 technologies appears weaker. This result challenges holistic models such as that of Gladysz et al. (2020), which argue for a tight integration between digital technologies and sustainability measurement.

6.3 | The Role of I4.0 Technologies in EAFM Sustainable Practices

The diversity of technologies adopted by EAFM is likely driven by the heterogeneity of companies in terms of size, revenue, and geographical scope. The analysis shows that the adoption of I4.0 pillars is uneven, with IoT, advanced robotics, and big data analytics being the most frequently employed. These technologies support a broad range of sustainability initiatives across all three dimensions and confirm trends highlighted in previous studies (Gladysz et al. 2020; Narula et al. 2021). Concrete examples include the use of sensors for process monitoring (Zhu et al. 2022), robotic systems for safety and logistics (Gorjian et al. 2021; Camar ena 2020), and big data for farm-level decision-making and traceability (Misra et al. 2022). These cases show that I4.0 can foster transparency, efficiency, and responsiveness to stakeholder expectations. For research institutions and technology developers, this highlights the importance of designing sector-specific technological solutions that align with sustainability goals and can be adopted by companies of different scales. The ESDR provides a European-wide framework for the adoption of these technologies. The report includes a section on "Digitization for a just transition" (Transformation 6) and stresses that "new technologies, R&D and innovation can help the EU to increase its strategic autonomy and achieve sustainable development". It also mentions the need for investments in cutting-edge technologies and skills and the existence of an EU action plan to digitize its energy system. This confirms that EAFM's investment in IoT, Big Data and Robotics is not an isolated case but part of a broader European strategy to harness technology for sustainability and efficiency goals.

By contrast, the remaining six pillars of I4.0 (augmented reality, cybersecurity, simulation, cloud computing, system integration, additive manufacturing) are rarely implemented, despite their recognized potential (Ejmont et al. 2020). The limited use of cybersecurity technology, for example, is particularly noteworthy given the increasing risks of cyber-attacks in the agri-food sector (Manning 2019; Bonell et al. 2018; Spink and Moyer 2011). Paradoxically, while the adoption of IoT and Big Data Analytics aims to improve the transparency and veracity of sustainability data, the simultaneous and limited implementation of critical pillars such as cybersecurity can undermine the confidence that these reports intend to build. The trust of consumers and stakeholders is not only based on the quantity and granularity of information provided, but also on its integrity and security. In a sector such as agri-food, where product traceability and safety are paramount, perceived vulnerabilities to cyber-attacks or data manipulation can frustrate advocacy efforts based on

sustainability reports. This gap between advanced data collection (via IoT/Big Data) and their protection (lack of cybersecurity) creates a “trust gap”. A sustainability report that presents detailed data on emissions or water management, but is not supported by robust cybersecurity guarantees for the supply chain or consumer data, may raise doubts about its overall reliability. Modern stakeholders are increasingly aware of the risks associated with data privacy and information security, and neglect in these areas, although not directly linked to specific environmental or social metrics, can erode the credibility of the company as a whole. From the perspective of legitimacy theory, an unbalanced adoption of I4.0 technologies could lead to a “legitimacy deficit”. Companies may appear to be at the forefront of data collection, but lagging behind in protection, compromising their social acceptance. Public institutions and policymakers should consider incentives or regulations to encourage the adoption of protective digital technologies, helping companies overcome the high investment costs discussed by Ejsmont et al. (2020).

The absence of additive manufacturing applications (e.g., 3D food printing, smart packaging, equipment manufacturing) is also surprising, given the growing interest in this field (e.g., Lipton et al. 2015; Javaid and Haleem 2019). This might reflect the early stage of development or the lack of specific demand from current stakeholders such as consumers or distributors.

Summarizing, using a database of GRI-compliant sustainability reports, this study highlights how GRIs and I4.0 technologies can work together to build company legitimacy. GRIs provide companies with a way to certify and communicate their sustainability efforts, enhancing their credibility in the eyes of stakeholders (Salem et al. 2018). Meanwhile, I4.0 technologies—particularly IoT, big data, and analytics—offer powerful tools for implementing and managing sustainability initiatives, improving stakeholder engagement, and addressing societal and market expectations more effectively (Chiambaretto et al. 2020).

In conclusion, adopting a multi-stakeholder perspective—such as those from regulators, research institutions, consumers, and civil society—can lead to more comprehensive sustainability strategies. These perspectives are essential not only for understanding the impact of EAFM’s current practices, but also for identifying areas where technology adoption and reporting mechanisms could be improved to strengthen legitimacy across the board.

6.4 | Implications

Our results lead to the following theoretical and practical implications. As a result of their discussion, a series of future research directions has been proposed.

6.4.1 | Theoretical Implications

The results of this study offer meaningful theoretical contributions to the fields of sustainability and digital transformation. They may support researchers, academics, and practitioners in reflecting on the concrete potential of I4.0 technologies to enhance businesses sustainability practices and generate

innovation that benefits entire ecosystems. To the best of our knowledge, this is the first study to assess the use of I4.0 technologies to implement sustainability practices in the context of EAFM, while also applying legitimacy theory as a lens to interpret how digital tools support the creation of sustainability-driven legitimacy. Our analysis highlights the synergistic value of combining GRI standards and I4.0 technologies to build sustainable innovation ecosystems. Specifically, this synergy demonstrates how the integration of advanced digital tools with established reporting frameworks can strengthen a company’s legitimacy in the eyes of its stakeholders. These insights suggest that legitimacy theory should increasingly consider the influence of digitalization in shaping corporate legitimacy dynamics. The study also contributes to advancing the current body of knowledge on sustainability practices and technology integration, expanding on the work of Gladysz et al. (2020), Narula et al. (2021) and Tiwari and Khan (2020).

6.4.2 | Practical Implications

From a practical perspective, EAFM, governments, policymakers, and broader societies may benefit from this study as a guide to understanding how I4.0 technologies can support the development of a sustainable innovation ecosystem. Specifically, companies are offered an example of how to “certify” and communicate their sustainability efforts through the integration of GRIs and digital tools, thereby strengthening their position in the ecosystem. As also stated by Zeng et al. (2024), companies that effectively combine GRI reporting with advanced technologies can emerge as leaders in transparency and innovation, attracting socially responsible investors and increasing their market competitiveness. This integration enhances their capacity to monitor and communicate sustainability efforts and proactively address stakeholder concerns, ultimately reinforcing their legitimate standing. Therefore, based on our findings, companies can recognize that among various technologies, I4.0 tools such as IoT, big data, and analytics are particularly effective in enhancing legitimacy—especially when applied to support sustainability objectives. Furthermore, this study provides a list of best practices in sustainability, offering practical insights into how GRI standards and I4.0 technologies can be leveraged to implement a wide range of material topics. For instance, we identified evidence of the use of blockchain, AI, and laser inspection technologies to support sustainability practices such as anti-corruption, traceability, and transparency, and strategic management, ultimately driving innovation across the entire ecosystem.

Multinational companies can benchmark their own material topics and relevance rankings with the European averages provided in this study, gaining insights into how to reduce environmental and social impacts and build trust within the ecosystem.

Governments and policymakers may find valuable indications regarding the alignment between corporate sustainability practices and strategic regulations, helping to identify areas that need further investments and to reflect on policies (e.g., incentives, training, tax relief) to foster sustainable, technology-based ecosystems. To further enhance the applicability of our findings, we suggest that policymakers develop

targeted governance frameworks that actively support the integration of I4.0 technologies within sustainability strategies. In particular, governments could promote a multi-stakeholder approach by facilitating dialogue platforms that bring together companies, civil society organizations, academic institutions, and regulatory bodies. These platforms could guide the co-design of standards and best practices for digital sustainability reporting, fostering transparency and inclusiveness. Moreover, tailored policy actions—such as funding schemes, digital infrastructure support, and capacity-building initiatives—could help reduce disparities among firms in adopting digital tools for sustainability, ensuring that even smaller players in the ecosystem benefit from the digital transition. In this way, institutions can play a proactive role in shaping a sustainability-oriented innovation ecosystem that reflects shared legitimacy across diverse stakeholder groups.

Finally, consumers and society at large can better understand how EAFM are evolving toward more sustainable models, using this knowledge to inform their consumption choices.

6.5 | Directions for Future Research

Given the exploratory nature of this study, several future research directions emerge:

- Expanding the sample to include more companies and different agri-food sectors or countries could provide broader generalizability of our results;
- Exploring the results from a comparative perspective across other sectors or other counties, with the aim of identifying sector-or regional-specific constraints and benefits;
- Longitudinal studies may help assess how the adoption of I4.0 technologies in sustainability reporting evolves over time;
- Applying alternative theoretical frameworks (e.g., stakeholder theory) may offer complementary insights into the motivations behind sustainability strategies;
- Investigating under-implemented material topics, such as certification or circular economy, could uncover barriers to adoption and highlight innovation opportunities;
- Exploring strategies to overcome resistance to technological change—in companies of different size (from SMEs to multinationals)—may identify low-cost solutions that increase I4.0 adoption.

These directions aim to deepen understanding of how I4.0 technologies can shape sustainability practices and corporate legitimacy in an increasingly digital and environmentally conscious business environment.

7 | Closing Remarks, Limitations and Follow-Up

Although exploratory in nature, this study assesses how I4.0 technologies are currently used by the EAFM to implement

Limitations	Future Research
Our research relies on the sample of the multinationals composed by only 51 companies	In future studies could increase the dimensionality to provide more evidence on the results, confirming or not the insights coming from our preliminary exploration.
Our research relies on sustainability reports data, we did not directly survey the multinationals with relevant interpretation bias	In future studies could be addressed by interviewing managers of the EAFM of our sample, combining their answers with data available in sustainability reports and using tool of analysis capable of overcome the limits of researchers' interpretation
Our research relies on sustainability reports data, we did not directly survey the multinationals with relevant interpretation bias	In future studies could consider other theoretical lens (for example stakeholder theory) or selecting other industries or other type of business (i.e., SME) to conduct a multi-industry or a multi-business type analysis to increase the generalization of our findings.
Our research relies on GRI-report and Industry 4.0 models	In future studies could consider selecting other models in sustainability reporting and/or in technologies classification open to Industry 5.0 paradigm

FIGURE 13 | Table of limitations and future research avenues.

sustainability practices and enhance legitimacy within sustainable innovation ecosystems.

We found that EAFM primarily implements social sustainability actions, with particular attention given to employees, consumer safety, and societal well-being. Conversely, limited attention is devoted to certification and resilience initiatives. Regarding environmental sustainability, the main issues addressed by our sample include pollution and waste management, the sustainability of production processes, biodiversity, and the impact of production on climate change. Despite the growing relevance of the circular economy in the international research landscape (Bag et al. 2021, 2020; Upadhyay et al. 2023), our study reveals that the implementation of related actions remains weak. Our findings also show that the nine pillars of I4.0 are not equally employed in sustainability

strategies, confirming the evidence gathered in our previous studies⁷. Specifically, only technologies related to IoT, advanced robotics, and big data analytics are widely adopted by EAFM to pursue sustainability goals. Legitimacy theory provided a valuable lens to understand how GRI standards and I4.0 technologies can synergistically support companies in their sustainability efforts, while also maintaining brand identity and market reputation.

As the first study to explicitly examine the adoption of I4.0 technologies in the sustainability practices of EAFM—through the lens of legitimacy theory—this research is not without limitations, which offer promising avenues for future investigation, as summarized in Figure 13.

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Endnotes

¹ <https://sasb.ifrs.org>.

² <https://www.fsb-tcdf.org>.

³ <https://www.globalreporting.org/>.

⁴ <https://nhsevaluationtoolkit.net/resources/content-analysis-quick-guide-using-excel/>.

⁵ <https://s3.amazonaws.com/sustainabledevelopment.report/2022/europe-sustainable-development-report-2022.pdf>.

⁶ https://www.ipsos.com/sites/default/files/ct/publication/documents/2023-05/TheESGImperative_IpsosFoundationalPerspectives.pdf.

⁷ citation omitted to preserve anonymity.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section. **Data S1:** Supporting Information.