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Drivers and barriers shaping the adoption of sustainability labelling in European food supply chains: a systematic review

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Abstract

Sustainability labels (SLs) have emerged as key instruments in promoting sustainable food systems by providing transparent information to consumers about the environmental and social impact of food products. While SLs can nudge companies towards sustainability, their adoption is far from straightforward. Many food producers, processors, and retailers face several obstacles—ranging from economic costs and operational complexity to regulatory uncertainty—that limit their engagement with SLs. This review has a twofold aim: first, to provide a detailed and updated overview of the SLs currently used on food products across EU countries; second, to analyze the main drivers and barriers influencing adoption of SLs from food supply chain stakeholders, with a focus on food firms and retailers. The methodology is based on the PRISMA protocol for systematic reviews. The analysis revealed a highly heterogeneous landscape with over 120 SLs currently in use, often with overlapping information. The analysis also led to the identification of six main factors driving or hindering adoption of SLs, highlighting key differences between food firms and retailers. Overall, the findings provide novel insights to inform policymakers on the harmonization of SLs, as well as to develop strategies aimed at promoting broader and more effective use of SLs in Europe, which are increasingly recognized as key drivers of sustainable food systems.

Introduction

In recent years, the sustainability of the agri-food system has become a central concern for both consumers, firms (including producers and processors) and retailers, particularly within the European Union (EU), where sustainability objectives are increasingly integrated into the food policy framework (European Commission 2022). As global challenges such as climate change, resource depletion, and biodiversity loss intensify, food supply chain actors—from production to consumption—face growing pressure to limit their environmental impact and prioritize sustainability (EEA 2023).

Among the key strategies adopted to promote sustainable practices and sustainable consumption in the food system, the use of sustainability labels (SLs) has gained increasing attention over the past decade. These labels are based on environmental, ethical, and/or social standards, either private or public, that can be voluntarily adopted by food

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firms to certify their sustainability commitments. SLs aim at increasing market transparency by disclosing sustainability-related information that would otherwise remain unknown to consumers. They are expected to enable consumers to recognize sustainable food products, while simultaneously increasing their sustainability awareness.

At the same time, the adoption of SLs pushes firms to align with specific sustainability standards and to improve their sustainability performance (Thøgersen et al. 2010).

Identifying the factors that facilitate or hinder firms' adoption of SLs is key to developing and implementing strategies and food policies geared at promoting sustainability labelling along food supply chains as well as improving their overall effectiveness.

The EU has recently issued a proposal for a harmonized framework on SLs, as part of the Farm to Fork Strategy (European Parliament 2025). The aim of this initiative is to address the current fragmentation of national schemes, reducing the risk of greenwashing, and ensure comparability and transparency for consumers across member states. Central to this initiative is the creation of a standardized, science-based methodology that could contribute to support the EU's broader transition towards a sustainable food system.

In such harmonization process, food firms will be responsible for managing sustainability information along the supply chain, eventually communicating it to consumers. While some of them are open to new standards, others highlight challenges related to methodological complexity and the risk of oversimplifying multidimensional sustainability attributes (Burgess et al. 2024; Prasanna et al. 2025). Understanding the main drivers and barriers of firms' SL adoption is key to designing new sustainability labelling and implementing effective policy strategies geared at facilitating their adoption. However, to date, only a few studies have explored these aspects.

Most of the existing literature on SLs focused on consumers, investigating issues such as trust in sustainability-related information, understanding, and effectiveness in increasing sustainable food consumption (Hanss and Böhm 2012; Bastounis et al. 2021; Cook et al. 2023; Irfan and Bryła 2025). However, studies focusing on the supply-side are scarce.

This review contributes to this field of research in two main ways. Firstly, given the significant proliferation of SLs in the EU food market over the past decade, the review aims to provide an updated overview of existing SLs, classifying them based on their specific characteristics. Secondly, the review aims at (i) identifying and (ii) analyzing the key factors that facilitate or hinder firms' SLs adoption, focusing, among others, on key differences between food firms and retailers.

The findings of this review provide novel insights to inform policymakers towards harmonization of SLs in the EU, as well as to develop strategies aimed at promoting a broader and more effective use of SLs in Europe.

The evolving EU policy landscape for sustainability labelling in food supply chains

SLs in food supply chains play a pivotal role in promoting transparency, accountability, and consistency in sustainable practices. They also serve to verify compliance with sustainability standards and to ensure the application of uniform criteria across sectors (Astill et al. 2019). Furthermore, SLs help to overcome key challenges such as

information asymmetry and the dissemination of misleading information to consumers (Wognum et al. 2011).

However, the current EU landscape for SLs remains highly fragmented due to the proliferation of several public and private standards, at global, EU, and national levels—often with overlapping content and objectives.

To encourage broader SLs adoption and to simplify consumers' understanding of sustainability-related information, the EU took its first concrete step in 2020 through the Farm to Fork Strategy (F2F) (European Commission 2020a, b). This strategy provides a blueprint for the Union's transition towards "a fair, healthy and environmentally friendly food system".

As part of the F2F initiatives, the EU started considering the harmonization of SLs across member states. A major step in this direction was the introduction of the Product Environmental Footprint Category Rules (PEFCRs), a standardized Life Cycle Assessment (LCA) methodology tailored to specific product categories, including food, and designed to assess environmental impacts and support the development of harmonized SLs (European Commission 2013, 2018). Nevertheless, the implementation of such standardized LCA-based methodology is complex. It demands significant investments from the food industry and faces methodological inconsistencies across food categories, which hinder cross-category comparability. Moreover, PEFCR assessment requires advanced LCA expertise and entails costs that limit large-scale application. The lack of standardized criteria leads to consumer confusion and market distortions, as existing labels vary significantly in scope and rigour. By establishing harmonized standards, the EU aims at increasing consumer trust, ensuring fair competition, and fostering improvements in sustainability-related practices.

Methods

Sustainability labels: screening and classification

Given the significant proliferation of SLs in the food market over the past decade, as a first step, we conducted a screening of the existing SLs at the EU level. This screening was aimed at providing a comprehensive and updated overview of the current SL landscape, to highlight key issues and build the grounds for the systematic literature review.

The screening analysis was based on data collected from two primary sources: the Ecolabel Index website (Ecolabel Index 2025), and the Joint Research Centre (JRC) report on food sustainability certifications in the EU (European Commission 2023b).

For the scope of the review, we only considered SLs that are currently adopted in the EU, covering multiple sustainability aspects (e.g. environmental sustainability, animal welfare, social sustainability).

While SLs schemes can be classified according to various criteria (see Prag et al. 2016, and Thøgersen et al. 2024 for a complete overview), in this review, we focused on three main aspects: (i) label type, (ii) information type, and (iii) ownership.

As for the label type, SLs can be either "graded" or "binary". Graded labels, such as the "Green-Score" or the "Planet score" classify products by ranking their relative sustainability performance based on predefined criteria. On the other hand, binary labels such as the "Fairtrade" or the "Marine Stewardship Council" indicate whether a product meets target sustainability standards. Adopting binary labels usually places

a product among the most sustainable on the market for its category, hence acting as a "positive endorsement". Information type refers to the content of information reported in the SLs, which can cover only one or multiple dimensions of sustainability. Lastly, the ownership refers to the standards, specifically whether they are publicly or privately owned (Thøgersen et al. 2024).

Literature review

The review was based on the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework for Systematic Literature Review (SLR). The PRISMA methodology ensures a structured, transparent and reproducible approach to conduct a SLR (Moher et al. 2009). The process followed PRISMA's four-phase flow diagram: identification, screening, eligibility, and inclusion (Page et al. 2021). This systematic approach followed the Population, Interest, Context (PICo) logic (Sayers 2008; Stern et al. 2014) to ensure unbiased and exhaustive coverage of the literature, as follows:

- Population (P): Food value chains, excluding consumers, focusing on business dynamics.
- Interest (I): Drivers and barriers influencing the adoption of environmental SLs.
- Context (C): The EU agri-food sector, considering regulations and market trends.

The following main criteria were applied during the screening process: (i) the article must be published in English, (ii) the publication year must fall within 2000–2024, (iii) peer reviewed, empirical (qualitative, quantitative, mixed, and experimental), reviews, full-text accessible articles were considered. All other publications, such as research notes, editorial comments, readers' comments, and book reviews were excluded as shown in Table 1. The methodology also adheres to text analysis principles (Sahoo et al. 2024), categorizing findings to extract actionable insights. This procedure ensured transparency and replicability in evidence-based research.

Table 1 Inclusion and exclusion criteria adopted in the systematic literature review process

Criteria	Inclusion criteria	Exclusion criteria
Population	Agents of the food supply chains, from agriculture to distribution	Consumers
Phenomena of Interest	Elements that drive companies to use environmental labels and the obstacles they currently encounter in this process	N/A*
Context	The European agri-food landscape	N/A*
Geography	European Union countries	Other countries
Language	English	Other languages
Paper type	Peer reviewed Empirical (qualitative, quantitative, mixed, experimental) Reviews Full-text accessible	Non-peer reviewed Books, book chapters, grey literature, commentaries, editorials, policy and regulation documents Duplicates Full text not accessible
Time limitation	From 2000 to 2024 both included	Before 2000

As a first step, a comprehensive literature search was conducted on Scopus and Web of Science (WOS), using predefined keywords, Boolean operators, and filters to ensure extensive coverage of scientific publications. As shown in Table 2, search strings included terms such as "sustainab* label*," "eco-label*," and "environment*," with the wildcard "*" enhancing the scope by capturing variations of word roots. Keywords were searched in titles, abstracts, and paper keywords, yielding an initial pool of 1,516 articles after duplicates were removed (Aria and Cuccurullo 2017).

Titles and abstracts were then screened against inclusion criteria focused on relevance, peer-reviewed status, and publication dates (2000–2024). Detailed diagram flows are shown in Fig. 1. To ensure methodological rigour and reduce bias, a double independent screening process was performed, following the common best practices in systematic reviews (O'Connor et al. 2019; Medani et al. 2024). During title screening, both reviewers independently assessed all records using a standardized Excel spreadsheet with a traffic-light coding system. Of the 1,516 initial records, 1,402 were excluded by both reviewers, while 51 resulted in an initial disagreement (8 selected by Reviewer 1 but not by Reviewer 2, and 43 selected by Reviewer 2 but not by Reviewer 1). In total, 1,441 records were excluded for not meeting the inclusion criteria: non-food-related topic (66%), not addressing sustainability labelling (30%), not focused on the supply chain perspective (2%), or outside the European context (< 1%). Cohen's kappa coefficient was 0.876, indicating excellent agreement (Gisev et al. 2013). After this first screening stage, 75 studies remained for abstract evaluation. During abstract screening, a total of 57 articles were excluded by both reviewers mainly due to lack of methodological relevance or insufficient focus on SLs adoption, yielding a Cohen's kappa of 0.58, consistent with moderate to substantial agreement thresholds (Gisev et al. 2013). Disagreements were resolved through discussion and consensus.

These articles were then evaluated based on methodological quality, direct relevance to the research question, and criteria such as peer reviewed, English language, empirical methodologies, and accessibility. Excluded publications were documented to ensure transparency. The final set of 18 eligible studies was synthesized to identify

Table 2 Search terms and strings

AND						
	Advantages Disadvantages	**Environment**	**Labelling**	**Food**	**Supply chain**	**Sub-search**[1]
OR	Drivers Barriers Advantage* Disadvantage* Implementation factor* Trade-off* Practice*	Environment* Sustain* Ecolog* Green* Carbon Carbon Footprint Water Footprint Low carbon Environment* protection Water Ecolog* Footprint	Label* Label?ing Claim* Certificat* Standard* Signal* Logo*	Food, Drink*	Supply chain* Industr* Compan* Entreprise*	Environmental product label* Environmental label* Environmental choice label* Green label* Sustainab* label* Voluntary sustainability standard* Ecolabel Eco-label* Eco-logo* Ecologo*

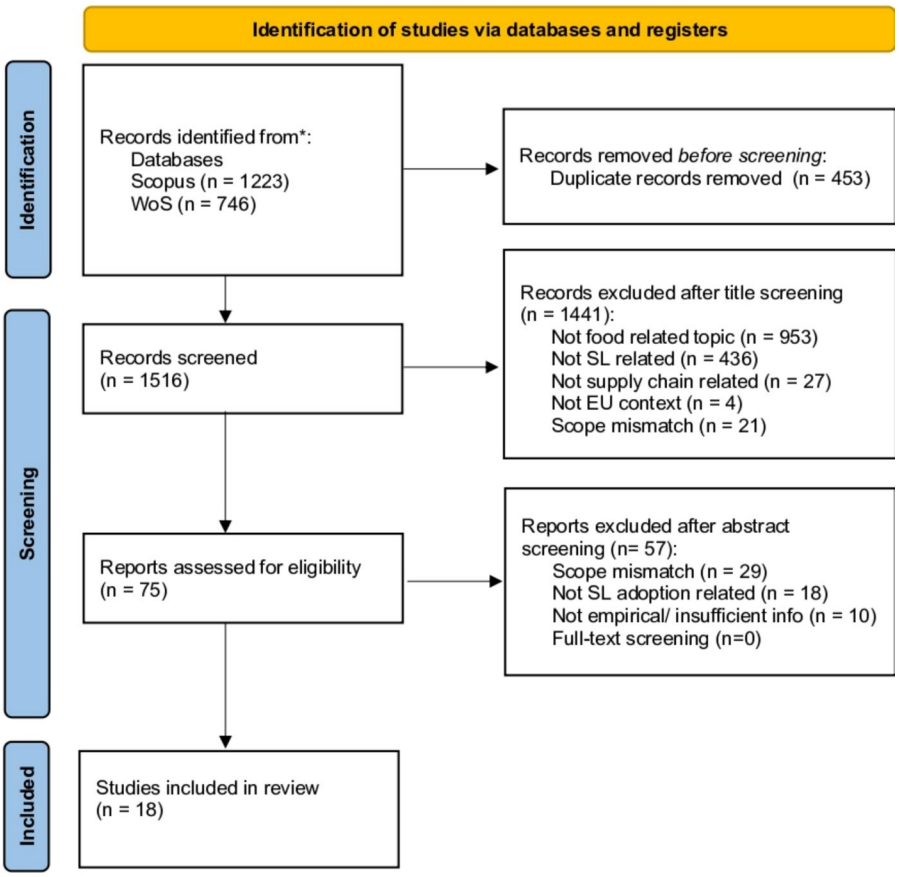

Fig. 1 PRISMA flow diagram detailing the search and inclusion process

key trends, drivers, and barriers influencing the adoption of SLs in the food supply chain. A brief summary of the selected papers is provided in Table 3.

Following the screening and eligibility phases, the articles included in the final sample were analyzed through a systematic qualitative content analysis aimed at identifying the main drivers and barriers influencing firms' adoption of SLs. Both reviewers independently conducted a full-text reading of each study, extracted and coded all relevant text segments referring to factors that facilitate or hinder adoption of SLs at the firm or supply chain level. Relevant factors were first identified directly from the content of the articles and subsequently organized and refined through an iterative coding process based on repeated comparison across studies. Coding decisions and factor definitions were continuously compared between reviewers, and any discrepancies were discussed until consensus was reached. This procedure ensured a transparent, consistent, and replicable identification of the key factors influencing firms' adoption of SLs discussed in the selected literature.

Results and discussion

This section is organized as follows: In Sect. "Sustainability labels in Europe: overview", we present the results of the SLs screening analysis, providing a complete overview of the labels currently in use at the EU level and examining how they were analyzed in the

Table 3 Summary of the resulting papers included in the review (n = 18)

Authors	Year	Objective	Journal	Country	Supply chain stage	Results
Kaiser and Edwards-Jones (2006)	2006	To evaluate the potential and limitations of the Marine Stewardship Council (MSC) ecolabel in promoting sustainable fisheries and increasing participation	Conservation Biology	Non-specific	Fishing methods	While MSC has potential conservation benefits, uptake is limited by low consumer awareness, uncertain financial incentives, monitoring challenges, and lack of property rights in many fisheries. Broader adoption may require structural changes, such as tiered certification, government support, and stronger engagement with retailers
Migone and Howlett (2016)	2016	To review how advanced 'omics' technologies can improve the monitoring and verification of natural resource and agricultural certification schemes	Natural Resources Journal	Non-specific	Supply chain	'Omics' technologies offer promising, cost-effective tools to enhance product origin and purity verification, potentially reducing the need for costly supply chain inspections. However, there are still limitations to their implementation in certification processes
Tzilivakis et al. (2012)	2012	To develop a practical framework for improving the effectiveness and credibility of environmental labels on food products, based on insights from industry and consumer experts	Sustainability Accounting, Management and Policy Journal	Non-specific	Food supply chain	While current science limits the creation of broad outcome-based eco-labels, environmental labelling still plays a valuable role when combined with other sustainability efforts. The proposed framework offers guidelines to enhance the design and evaluation of labelling schemes

Table 3 (continued)

Authors	Year	Objective	Journal	Country	Supply chain stage	Results
Banterle et al. (2013)	2013	To analyze the spread of environmental certification on food products in Italy and Germany and examine how such certification affects the vertical organization of food supply chains	British Food Journal	Italy, Germany	Food supply chain	Environmental certifications are more common on private labels than industrial brands, especially in Germany. These certifications lead to tighter supply chain coordination, reduced product uncertainty, and stronger bilateral dependencies among supply chain actors
Chkanikova and Lehner (2015)	2015	To analyze how retail eco-brands contribute to developing markets for sustainability-certified food products by acting as private institutional arrangements that help retailers govern sustainability throughout the value chain	Journal of Cleaner Production	Western europe	Food retailing	Retailers' eco-brands play key roles in addressing inefficiencies of third-party certifications and serve as proactive tools to promote sustainability in food production and consumption. However, despite their importance, third-party certifications remain valuable for reducing transaction costs and managing risks in supply chain sustainability governance
Miranda-Ackerman and Azzarro-Pantel (2017)	2017	To develop a framework integrating carbon labelling into food supply chain design to improve environmental performance beyond organic labelling	Journal of Environmental Management	Non-specific	Food supply chain	Using a multi-objective optimization, the study shows that minimizing CO2 emissions alongside economic criteria leads to more sustainable supply chains. Carbon labelling can enhance eco-labelling's impact on reducing environmental footprints in the food industry

Table 3 (continued)

Authors	Year	Objective	Journal	Country	Supply chain stage	Results
Chkanikova and Kogg (2018)	2018	To analyze how third-party product sustainability certifications influence supply chain sustainability governance and their role in enabling firms to outsource communication, motivation, and control of sustainability performance upstream in the supply chain, facilitating corporate life cycle management	International Journal of Life Cycle Assessment	Sweden, UK, Denmark	Food supply chain	The study found that third-party certifications can reduce the need for firms to actively coordinate sustainability efforts with suppliers, but this depends on factors like the company's intentions, supply chain context, and certification scheme design. When well-aligned with corporate goals and based on life cycle assessment (LCA), certifications can effectively support corporate Life Cycle Management by allowing companies to manage sustainability through procurement of certified products
Górska-Warsewicz et al. (2018)	2018	To explore how international retailers can gain competitive advantage by introducing organic private labels and promote sustainable food consumption	Sustainability (Switzerland)	Poland	Food retailing	Organic private labels help retailers achieve competitive advantage through pricing, assortment, brand image, and sustainability attributes. They make organic food more accessible and support consumers in adopting healthier, low-impact diets while enhancing the retailer's sustainable image

Table 3 (continued)

Authors	Year	Objective	Journal	Country	Supply chain stage	Results
Autzen and Hegland (2021)	2021	To examine the creation of Denmark's state-led NaturSkånsom ecolabel and analyze how small-scale fisheries responded to the dominance of MSC certification using a political power framework	Marine Policy	Denmark	Fishing methods	The study shows that small-scale fishers, feeling disadvantaged by MSC's market dominance, formed alliances and leveraged political influence to create NaturSkånsom. This case illustrates how less powerful stakeholders can gain influence and reshape ecolabeling dynamics when dominant labels become market norms
Longo et al. (2021)	2021	To explore how eco-certification fosters cooperation to promote sustainable fishing, transparency, and accountability	Frontiers In Ecology and Evolution	Non-specific	Fishing methods	Eco-certification helps reduce illegal, unreported and unregulated fishing by promoting best practices, stronger oversight, and stakeholder cooperation
Stranieri et al. (2022)	2022	To investigate the strategic motivations and transaction-related drivers behind the adoption of the environmentally-friendly VIVA certification in wine supply chains, focusing on managerial perceptions and firm capabilities	Supply Chain Management	Italy	Food industry	Adoption of VIVA certification is mainly seen as a tool to reduce internal risks and manage behavioral uncertainty in the supply chain. High external transaction risks discourage adoption. The certification is not viewed as enhancing operational capabilities but is more likely adopted when it improves supply chain knowledge or fosters better supplier collaboration. Thus, VIVA can act as a resource complementing firm capabilities and supporting dynamic capability development

Table 3 (continued)

Authors	Year	Objective	Journal	Country	Supply chain stage	Results
Malcorps et al. (2021)	2021	To analyze how sustainability certifications, logos, and claims are presented at seafood trade shows across China, Europe, and the USA, and to understand cultural differences in B2B messaging within the seafood supply chain	Sustainability	China, Europe, USA	Supply chain	Seafood trade shows in China emphasize food safety and quality more than sustainability, whereas European and U.S. shows focus more on sustainability messaging. This highlights cultural differences in communicating seafood production and consumption. Effective communication between producers, traders, and consumers requires understanding these cultural messaging strategies to better convey sustainability and product characteristics
Gröfke et al. (2021)	2021	To investigate how different stakeholder groups' attitudes and perceptions affect the adoption of the Traffic Light Index, a meta-sustainability food label aiming to simplify environmental impact information	Sustainability (Switzerland)	Europe	Several actors	Stakeholders show mixed optimistic and skeptical views, perceive various barriers, and propose either entrepreneurial or risk-averse solutions. Their interactions influence attitudes and can either hinder or promote Traffic Light Index adoption. The study offers a framework to guide policy for advancing unified environmental food labelling

Table 3 (continued)

Authors	Year	Objective	Journal	Country	Supply chain stage	Results
Chkanikova and Sroufe (2021)	2021	To examine how retail-driven sustainability certification schemes are designed and function from a corporate perspective, focusing on three types—unilateral (Tesco Nurture), collaborative (GlobalGAP), and multi-stakeholder (UTZ)—and their role in improving supply chain sustainability	Journal of Cleaner Production	Non-specific	Food retailing	Retail-driven certifications align with business goals to enhance sustainability performance, strengthen brand assurance, satisfy stakeholders, and build dynamic capabilities for faster, more efficient supply chain upgrades. The study highlights key factors influencing certification design, including trade-offs, collective bargaining challenges, and capability development. It also finds that the coexistence of multiple certifications ("standards multiplicity") can be beneficial, fostering competitive advantage and sustainable supply chain management
Ingrassia et al. (2022)	2022	To assess producers' and consumers' views on the SOStain sustainability certification in the Sicilian wine sector, focusing on motivations, challenges, costs, and willingness to support ethical and sustainable choices	Sustainability	Italy	Food industry	Ethical values influence consumers' willingness to pay more for SOStain-certified wine, despite taste preferences. Producers face cost and communication challenges in the green transition, highlighting the need for better outreach and support

Table 3 (continued)

Authors	Year	Objective	Journal	Country	Supply chain stage	Results
Yu et al. (2022)	2022	To analyze how organic certification and branding affect supplier-retailer interactions and pricing strategies in an organic food supply chain, particularly focusing on the trade-offs small suppliers face due to certification costs	Annals of Operations Research	Non-specific	Agricultural production and retail	When suppliers adopt different certification strategies, retailers prefer to procure products with organic labels. Suppliers without strong brand recognition benefit more from organic certification, often gaining higher profits than branded rivals. However, if both suppliers certify, they may enter a prisoner's dilemma, especially when the health value of the organic label is perceived as low and certification costs are high
Deconinck et al. (2023)	2023	To examine the growing demand and supply of quantified environmental impact information in food systems, focusing on its economic implications and potential challenges	European Review of Agricultural Economics	Non-specific	Several actors	The rapid expansion of environmental impact reporting risks creating a fragmented system and may disproportionately burden poorer producers. The paper highlights key drivers, impacts, and open questions for future research and policy development

Table 3 (continued)

Authors	Year	Objective	Journal	Country	Supply chain stage	Results
Schulze et al. (2024)	2024	To explore how ecosystem services information can be integrated into a European food labeling framework aligned with the EU's Farm to Fork Strategy, by capturing the perspectives of food industry experts	Ecological Economics	Germany, Poland, Spain, Sweden	Food supply chain	The study identifies broad support for new labels that incentivize farmers to provide ecosystem services like biodiversity. It proposes three label prototypes: (1) producer-driven ecosystem services label, (2) consumer-oriented information label, and (3) a new EU sustainable food label. These prototypes reflect diverse stakeholder views and country-specific preferences, suggesting that a successful EU labeling framework should incorporate all three to accommodate varied actor perspectives

literature. In Sect. "Drivers and barriers influencing firms 'adoption of sustainability labels" and the following subsections, we report the results of the SLR. The analysis of the selected papers led to the identification of six main factors influencing SL adoption, namely, the economic issues, the supply chain relationships, the role of institutions, the characteristics of SLs, the role of consumers, and the environmental concern. These subsections explain in detail how these factors were identified and how they affect SL adoption, acting as drivers and/or barriers.

Sustainability labels in Europe: overview

The analysis of the Ecolabel Index website and the JRC report on food sustainability certifications in the EU allowed the identification of 125 SLs, currently adopted in the EU food market and covering different aspects of sustainability. A graphic representation of their presence across EU countries is illustrated in Fig. 2.

SLs differ in terms of label type (e.g. graded vs binary), information type (e.g. single sustainability dimension vs multidimension), and ownership (e.g. public vs private). A detailed description, along with the number of SLs identified, is reported in Table 4.

Out of the 125 SLs, only about one-third appear in the selected academic literature. This highlights a strong thematic and sectorial concentration, with only a limited number of labels and specific supply chains receiving most of the scholarly attention. A substantial share of the reviewed studies focused on fisheries and aquaculture certifications, particularly the Marine Stewardship Council, Aquaculture Stewardship Council, and related ecolabels such as Friend of the Sea, NaturSkånsom, and Dolphin Safe (Banterle et al. 2013; Kaiser and Edwards-Jones 2006; Autzen and Hegland 2021; Malcorps et al. 2021; Longo et al. 2021; Migone and Howlett 2016). These certifications are among the most established and internationally recognized schemes in the seafood sector. Their prevalence in research reflects both their maturity and visibility, as well as the availability of measurable environmental indicators within supply chains (Malcorps et al. 2021; Longo et al. 2021). The long-standing policy relevance of marine ecolabels, especially in relation to illegal, unreported, and unregulated fishing, has further intensified institutional attention (Kaiser and Edwards-Jones 2006; Autzen and Hegland 2021).

Organic certifications and organic private labels constitute the second most frequently examined labels. More than 30% of existing SLs refer to organic agriculture (39 out of 125), highlighting both firms' growing commitment to sustainability and consumers' rising interest in organic food. Organic labelling is among the oldest sustainability certifications, spreading in the EU in the early 90's. Since their introduction, organic labels were intended as a response to emerging public environmental concerns associated with intensive agriculture, soil degradation, water contamination from agrochemicals, and biodiversity loss (European Commission 2007). Yet, the number of organic labels remains unexpectedly high, especially considering the "EU-leaf" introduced in 2010 to harmonize organic certification. A comparison of the standards behind the EU-leaf and other private organic labels adopted at national level revealed that private ones often have stricter standards than the EU scheme. While this may be an additional guarantee on product quality and sustainability, they may cause confusion among consumers and undermine harmonization efforts.

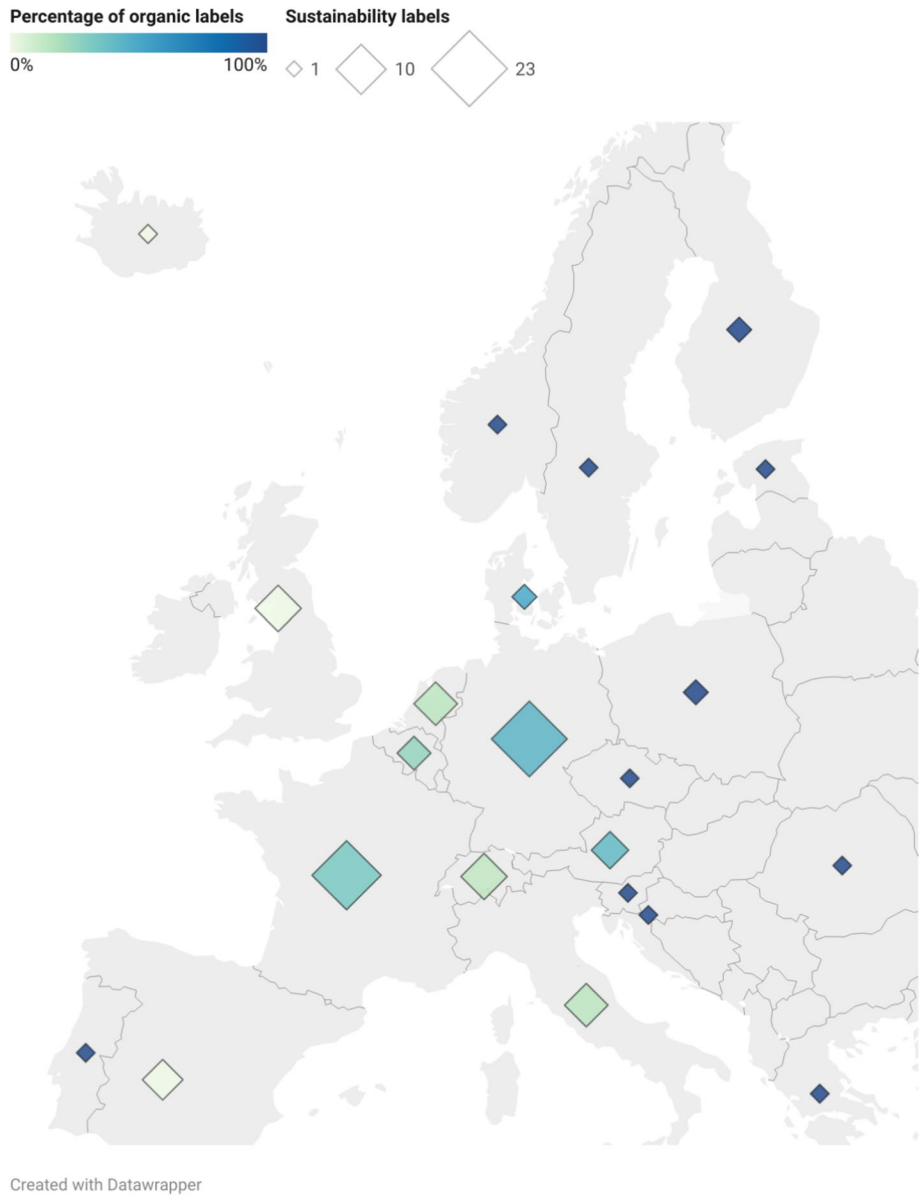

Fig. 2 Graphic representation of geographic distribution of SLs across Europe. The graphic provides a comparative overview of the number of SLs per country (represented by marker size) and the relative share attributed to organic certifications (represented by colour gradient)

A third cluster of studies focuses on multidimensional sustainability certifications such as Fairtrade, Rainforest Alliance, and UTZ Certified (Banterle et al. 2013; Chkanikova and Kogg 2018; Chkanikova and Sroufe 2021). These standards, usually managed by multi-stakeholder platforms, play a prominent role in the governance of global value chains. They are often discussed in relation to both economic barriers—such as certification costs and market inequalities—and institutional drivers, such as stakeholder collaboration and reputation gains (Chkanikova and Sroufe 2021; Chkanikova and Kogg 2018; Deconinck et al. 2023).

Table 4 SL characteristics

Dimension	Categories	Description	Examples	N. of SL
Label type	Graded	Provides a ranking of products according to relative sustainability performance based on predefined criteria. Allows comparison among products	Green-Score, Planet-Score	8
	Binary (positive endorsement)	Indicates whether a product meets specific sustainability standards (*yes/no*). Typically acts as a "positive endorsement" for products meeting high standards	Fairtrade, Marine Stewardship Council (MSC), EU Organic	109
	Mixed typology	Combines binary and graded components, offering both certification and performance scoring	Beter Leven (Better Life)	4
	Brand labels	Proprietary sustainability labels developed by retailers or brands, often combining internal standards and communication strategies	Demeter, Carrefour Eco-Planet	4
Information type	Single dimension	Focuses on one aspect of sustainability (e.g. environmental, social, or animal welfare)	Carbon Trust Label, Rainforest Alliance (environmental focus)	43 (2 social, 17 animal welfare, 24, environmental)
	Multi-dimension	Covers multiple dimensions (environmental, social, economic, ethical, etc.), providing a more holistic assessment	Planet-Score, Fairtrade	43
	Organic certifications	Based on regulated organic farming standards; treated separately due to their prevalence and regulatory specificity	EU Organic, AB France, Bio-Siegel	39
Ownership	Public	Standards defined and managed by public institutions or intergovernmental bodies	EU Organic	21
	Private	Developed and managed by private organizations, NGOs, or consortia	Fairtrade, MSC, Rainforest Alliance,	101
	Public/ private	Hybrid governance models combining public regulation and private standard-setting	Planet-Score, AMA-Gütesiegel	3

Finally, brand-owned and retailer-driven sustainability labels are rarely analyzed, despite their growing relevance in shaping corporate sustainability (Chkanikova and Lehner 2015; Chkanikova and Sroufe 2021; Górska-Warsewicz et al. 2018). Their underrepresentation may derive from limited data transparency and the private nature of brand standards (Autzen and Hegland 2021; Ingrassia et al. 2022). Overall, the literature on SLs is predominantly consumer-focused, emphasizing perception, awareness, and trust (Chkanikova and Kogg 2018; Górska-Warsewicz et al. 2018; Gröfke et al. 2021; Schulze et al. 2024), while supply-side drivers—such as firms' motivations and barriers—are less explored (Banterle et al. 2013; Stranieri et al. 2022; Ingrassia et al. 2022). This reflects both the greater availability of consumer data as well as opacity of sustainability management along food supply chain. In fact, more established and widespread schemes dominate the literature due to clearer governance, measurable indicators, and accessible data, whereas newer or less diffused labels remain understudied because of limited documentation and inconsistent implementation.

Drivers and barriers influencing firms 'adoption of sustainability labels

Based on the qualitative coding procedure described in Sect. "Literature review", the full-text analysis of the selected studies led to the identification of six recurrent factors influencing firms' adoption of sustainability labels. These are: economic issues, supply chain relationships, the role of institutions, the characteristics of sustainability labels, the role of consumers, and environmental concern. The frequency with which the six factors were discussed in the selected studies, as well as the directionality of their effect (i.e. whether they act as drivers or barriers) is illustrated in Table 5.

Overall, the analysis revealed substantial variation in how these six factors are analyzed and weighed across studies: in most cases, the identified factors are reported to act as both drivers and barriers, depending on the context and the analysis.

Table 6 provides the aggregated counts and percentages of studies reporting each factor as a driver or barrier, offering an overview of the relative prominence and ambivalence of the six factors in the literature.

A detailed discussion on how the six factors influence firms' SL adoption follows in the next subsections.

Economic issues

Over the past years, firms' (including producers and processors) and retailers' internal expertise in environmental and sustainability management has grown rapidly, together with their interest in SLs, also due to several policy initiatives launched at the national and international levels (Deconinck et al. 2023). However, the adoption of SLs represents a difficult trade-off between potential advantages and financial outlays required for implementation and management (Tzilivakis et al. 2012). Businesses weigh the benefits of certification against the high costs of coordination, compliance, and stakeholder negotiations, which can be complex and expensive.

SLs are increasingly recognized as a strategic tool for achieving competitive advantage in the food market, where product differentiation is key. Their adoption enhances firms' and retailers' ability to highlight distinctive characteristics, improving market positioning and financial performance (Chkanikova and Lehner 2015; Stranieri et al. 2022;

Table 5 Detailed mapping of each study against the six factors (Driver/Barrier/–)

Reference paper	Role of consumer	Economic perspective	Label characteristics	Role of institutions	Supply chain relationship	Environmental concern
Banterle et al. (2013)	–	Barrier	–	–	Barrier	–
Autzen and Hegland (2021)	Barrier	Both	Barrier	Both	Both	–
Longo et al. (2021)	Driver	–	Both	Driver	Both	Driver
Schulze et al. (2024)	Both	Both	Both	Driver	Both	Driver
Chkanikova and Kogg (2018)	Driver	Driver	Both	–	Both	–
Gröfke et al. (2021)	Both	Both	Both	Both	Barrier	Driver
Górska-Warsewicz et al. (2018)	Both	Both	Both	–	Driver	–
Ingrassia et al. (2022)	Both	Barrier	–	Both	Both	Driver
Deconinck et al. (2023)	Both	Both	Both	Driver	Both	Both
Kaiser and Edwards-Jones (2006)	Barrier	Barrier	Barrier	Driver	–	Driver
Malcorps et al. (2021)	Both	–	–	–	Driver	Driver
Migone and Howlett (2016)	Both	–	Barrier	–	Barrier	Barrier
Miranda-Ackerman and Azzarro-Pantel (2017)	Driver	–	–	–	Both	–
Chkanikova and Sroufe (2021)	Both	Both	Both	Both	Both	–
Chkanikova and Lehner (2015)	Both	Both	–	–	Both	–
Stranieri et al. (2022)	Driver	Both	–	Driver	Both	Driver
Tzillivakis et al. (2012)	Barrier	Barrier	Barrier	–	–	–
Yu et al. (2022)	–	–	–	–	Driver	–

Table 6 Aggregated number and percentage of studies identifying each factor as a driver or a barrier of SL adoption, based on the qualitative coding results

	Factor	Driver	Barrier	Driver (%)	Barrier (%)
1	Role of consumers	13	12	72	67
2	Economic perspective	9	12	50	67
3	Label characteristics	7	11	39	61
4	Role of institutions	9	4	50	22
5	Supply chain relationship	13	13	72	72
6	Environmental concern	8	2	44	11

Schulze et al. 2024). The economic rationale for SLs adoption lies in the opportunity to develop a better management of resources (which translates into cost savings) and to increase competitive advantage over non-certified competitors by signalling quality and sustainability commitment (Chkanikova and Sroufe 2021; Schulze et al. 2024). Such competitive advantage is linked to consumers' trust, brand loyalty, reputational gain and allows firms to obtain price premiums, especially targeting environmentally sensitive consumers (Górska-Warsewicz et al. 2018; Gröfke et al. 2021; Yu et al. 2022; Chkanikova and Kogg 2018; Schulze et al. 2024).

Despite these expected benefits, SLs adoption may be limited due to economic barriers. High implementation costs, compliance requirements, and supply chain adaptation, as well as sanctioning frameworks in case of non-compliance, represent significant challenges (Chkanikova and Sroufe 2021; Ingrassia et al. 2022; Stranieri et al. 2022). The so defined "type of swords" (i.e. how stringent are the certification standards) play a key role in firms' and retailers' decision to adopt SLs. Stricter certification standards, often referred to as "strong swords", can enhance firms' reputation and strengthen stakeholder trust. However, their rigorous requirements may deter companies from participating, as compliance can be costly and demanding (Chkanikova and Sroufe 2021; Malcorps et al. 2021).

When supply chains are global, managing sustainability and ensuring compliance with the standards is even more complex. Differences in national regulations, traceability systems, reporting standards, and methodologies further increase SLs' implementation costs and negatively affect market transparency (Deconinck et al. 2023; Gröfke et al. 2021; Tzilivakis et al. 2012). The lack of a harmonized approach generates uncertainty among stakeholders that advocate for more standardized protocols (Deconinck et al. 2023; Gröfke et al. 2021). As suggested by Tzilivakis et al. (2012), to ensure that labelling schemes can effectively leverage sustainability practices, it is crucial to use scientifically sound, rigorous and harmonized measurement and monitoring methods. This would also contribute to protecting the credibility and efficiency of the certification system.

Supply chain relationships

The adoption of SLs can profoundly affect the organization of food supply chains and the relationships among stakeholders. The agri-food system is characterized by dense and often international supply chains that involve different sectors, from agriculture to distribution, with several differences in their operational activities, market structure, and organization (Migone and Howlett 2016; Chkanikova and Kogg 2018). This inherent complexity may negatively affect collaborative relationships among stakeholders and hinder the information flow along the chain. This may undermine SLs adoption, as the process requires coordinated action across stakeholders (Gröfke et al. 2021; Chkanikova and Sroufe 2021).

In fact, ensuring compliance with SLs requirements requires continuous data collection and monitoring, which, in most cases, involve multiple phases of the production process (Migone and Howlett 2016; Chkanikova and Kogg 2018; Autzen and Hegland 2021). Moreover, continuous monitoring practices increase transaction costs and introduce liability risks in case of non-compliance (Chkanikova and Kogg 2018; Chkanikova and Sroufe 2021).

When firms do not perceive the collective benefits deriving from SLs and/or are uncertain about the return on investment, they may decide not to adopt SLs (Tzilivakis et al. 2012; Banterle et al. 2013; Chkanikova and Sroufe 2021). In addition, SLs imply administrative burdens, which increase the costs. Disparities in economic capacity and organizational resources between large and small firms play a key role (Stranieri et al. 2022), with small-scale firms struggling to meet and comply with SLs standards (Chkanikova and Kogg 2018; Autzen and Hegland 2021; Ingrassia et al. 2022; Yu et al. 2022; Stranieri et al. 2022). Especially for small firms, profitability is a precondition when deciding to implement sustainability-oriented actions (Górska-Warsewicz et al. 2018; Longo et al. 2021; Ingrassia et al. 2022; Yu et al. 2022).

Moreover, key differences are evident in the adoption of SLs between food firms and retailers, with the latter playing a pivotal role due to their strategic position between producers and consumers.

While food firms often struggle to cover the costs of SLs through price premiums and only a small increase in market shares, retailers are in an advantageous position (Chkanikova and Sroufe 2021; Górska-Warsewicz et al. 2018).

For instance, retailers have extensive market knowledge, including insights into consumption trends, labelling preferences, market size, competition, and product differentiation (Chkanikova and Lehner 2015; Schulze et al. 2024). They can leverage this market power to set sustainability standards and require suppliers (i.e. food firms) to comply with them. Often, retailers adopt private sustainability standards and require their suppliers to adapt, sometimes involving third-party audits and certifications (Chkanikova and Kogg 2018; Chkanikova and Sroufe 2021; Autzen and Hegland 2021; Yu et al. 2022). By doing so, they strengthen their relationship with the suppliers and reduce reputational and legal risks associated with supply chain misconduct or non-compliance. In addition, by ensuring the availability and variety of products that fulfil sustainability standards, they increase their brand image, as well as consumers' loyalty. For these reasons, as remarked by Schulze et al. (2024), retailers can be considered the "gatekeepers to crucial food system changes" (Schulze et al. 2024), capable of directing and reshaping supply chain trajectories towards sustainability goals. In essence, the role of retailers is fundamental in firms' decision to adopt SLs because this may facilitate their inclusion in the supply chains of influential retailers, thus increasing their opportunities to establish long-term partnerships (Chkanikova and Sroufe 2021; Yu et al. 2022; Schulze et al. 2024).

The role of institutions

Institutions, both public and private, can play a pivotal role in promoting and facilitating the adoption of SLs, while ensuring market transparency and avoiding opportunistic behaviours.

Public institutions can leverage their regulatory power through dedicated regulations at national and international levels. Such initiatives are essential for establishing the structural framework to support and enforce the adoption of SLs (Kaiser and Edwards-Jones 2006; Chkanikova and Sroufe 2021). For instance, targeted policy measures, such as those that prioritize certified products in green public procurement programmes or offer tax reductions and subsidies for low-impact goods, may stimulate large-scale adoption of sustainability standards, making sustainability-oriented efforts more

economically feasible (Ingrassia et al. 2022). Requiring companies to monitor and periodically report their environmental performance is another way to stimulate continuous efforts, while ensuring transparent information flow along the supply chain (Deconinck et al. 2023). In fact, environmental reporting requirements in the agri-food system are expected to intensify in the coming years, pushed by the EU commitment to achieve zero net emissions by 2050. This intensification might increase the demand for sustainably labelled products. At the same time, to comply with reporting requirements, firms usually need substantial data collection practices: these same data can also be used to obtain SLs. This overlap in data requirements along the supply chain may reduce costs, time, and efforts (Deconinck et al. 2023).

Chkanikova and Sroufe (2021) highlight that "institutional entrepreneurship" is another key factor in building the foundations for SLs harmonization. This concept refers to the proactive efforts of non-market actors (such as NGOs, advocacy groups, or industry associations) who perceive limitations in existing certification systems and work to improve or reshape them to advance their own objectives and public interests. By actively initiating and guiding institutional change, these actors can help create the conditions needed to encourage companies to adopt more collaborative approaches to standard-setting and compliance (Chkanikova and Sroufe 2021).

Institutions, both public and private, can also use financial means to promote SLs. They can provide grants, offer various forms of support (financial, organizational, etc.), and promote capacity-building initiatives to help firms develop the competence required to manage sustainability and ensure compliance with sustainability standards. Indeed, many sustainability standards demand investments in traceability systems, sustainable technologies, organizational changes, and training. In this regard, public support can significantly lower entry barriers (Chkanikova and Sroufe 2021; Ingrassia et al. 2022). Furthermore, financial incentives such as subsidies, innovation grants, and training initiatives help offset the risks of adopting certified sustainability standards, enhancing their economic viability. While large firms and retailers are better equipped to absorb these costs, small firms would benefit from such initiatives (Ingrassia et al. 2022; Yu et al. 2022). As highlighted in previous studies, firms argue that initial investments should be shared between industries and governments to facilitate data availability and certification development (Górska-Warsewicz et al. 2018; Gröfke et al. 2021).

Institutions also play a key role in stimulating market demand for sustainable products. This can be achieved by increasing consumer awareness regarding environmental issues and the importance of environmental certifications. Information campaigns and/or targeted initiatives could increase public environmental awareness and, in turn, boost consumer demand for sustainable food products. This would represent a strategic opportunity for firms to expand their market shares and obtain higher price premiums (Deconinck et al. 2023).

Characteristics of sustainability labels

The characteristics of SLs play a crucial role in facilitating their adoption and effectiveness. There are several factors that can facilitate or hinder firms' and retailers' adoption of SLs, which include: the format of information provided (i.e. graded vs. binary), the type of ownership (i.e. private or public), the scale of application (e.g. local, national,

international) of the certification itself, which can affect how broadly it can be implemented; and label multiplicity, that is, the number of available SLs that refer to the same sustainability dimension (Gröfke et al. 2021; Chkanikova and Sroufe 2021).

SLs can be classified as either binary labels or graded labels. Binary labels follow a practice-based approach, as they simply indicate whether a company meets predefined standards, essentially showing whether the product is certified or not. Typically, once a certification is obtained (especially when the ownership is private), firms and retailers have no incentives or obligations to improve further or to exceed the minimum required standards. This makes binary labels the easiest choice for firms but limits their sustainability commitment in the long run (Gröfke et al. 2021; Chkanikova and Sroufe 2021).

In contrast, graded labels adopt an outcome-based format that provides an overall assessment of sustainability performance and encourages firms and retailers to improve and communicate their progress to final consumers. Different from binary labels, which refer to predefined standards to comply with, graded sustainability labels allow firms greater flexibility in deciding how to achieve higher sustainability performance, enabling them to choose the most cost-effective and context-appropriate strategies (Deconinck et al. 2023). Increasing the number of outcome-based graded labels would substantially stimulate sustainability commitment to the benefit of the agri-food system and consumers (Deconinck et al. 2023; Schulze et al. 2024). However, this approach is challenging for firms and implies considerable organizational and financial efforts.

While most SLs are private, some schemes are jointly developed and implemented by groups of stakeholders (which may include firms, public entities, NGOs, etc.). Such multi-stakeholder certifications generally impose more stringent sustainability requirements compared to private ones and have greater credibility. However, monitoring these certifications may be costly and require organizational, procedural, and financial investments, as well as coordinated action among all participants. For these reasons, multi-stakeholder SLs are less used (Gröfke et al. 2021; Chkanikova and Sroufe 2021). To mitigate these challenges, many initiatives instead rely on certification systems operated by independent bodies. Such external, third-party certifications provide a single, widely recognized reference framework, thereby simplifying compliance procedures and reducing the need for firms to negotiate standards and document their sustainability performance for each individual buyer or stakeholder. This shared framework not only minimizes administrative burdens and uncertainty but also enables firms to implement uniform practices across multiple markets (Chkanikova and Kogg 2018; Autzen and Hegland 2021).

As for the scale of application of SLs, universal schemes (such as the Fair-Trade certification) are based on highly standardized parameters intended to be broadly applicable across industries, countries, or product categories. Universal schemes may not always be attractive to firms because they can limit competitive advantages (Chkanikova and Lehner 2015; Gröfke et al. 2021). Moreover, stakeholders believe that a universal label could face strong opposition from producers, who perceive it as a threat to their financial stability and reputation. As a result, the adoption of such labels is unlikely due to resistance from powerful market players who lack motivation to support it (Gröfke et al. 2021). However, when certification schemes operate on a limited scale (either targeting a narrow market segment or involving only a small number of certified suppliers), the

resulting low volume of certified products can struggle to generate sufficient consumer demand. In such cases, the high costs associated with meeting advanced sustainability requirements may outweigh the commercial benefits, reducing the incentive for suppliers to participate (Chkanikova and Sroufe 2021).

Label multiplicity is an additional factor influencing SL adoption. On one hand, the variety of existing SLs, often referring to the same sustainability dimension, provides greater flexibility in addressing diverse market demands and operational complexities (Chkanikova and Sroufe 2021). Label multiplicity is especially evident for organic products, with numerous labels and schemes coexisting at national and EU levels (such as the EU Leaf, national organic standards, and private labels), all aiming to certify similar sustainability attributes related to organic products and production. Such label multiplicity creates opportunities for product differentiation but also generates information overload and confusion for consumers approaching the organic market (Deconinck et al. 2023).

The proliferation of SLs is sometimes interpreted as a market failure; specifically, a failure to coordinate collective efforts towards shared sustainability goals (Chkanikova and Sroufe 2021). When too many overlapping or inconsistent certification schemes exist, it can lead to confusion among consumers (Gröfke et al. 2021; Chkanikova and Sroufe 2021), reduce trust in sustainability claims (Chkanikova and Sroufe 2021; Autzen and Hegland 2021), and fragment efforts that could otherwise have greater collective impact.

The role of consumers

Consumer demand for sustainable food products has increased remarkably over the last decade (Górska-Warsewicz et al. 2018), driven by rising environmental awareness and concern. However, increased interest in sustainability does not always translate into sustainable food choices. Sustainable food purchasing decisions are influenced by several (often interrelated) factors, such as the product's geographical origin, product type, the perceived utility of the certification, and the understanding of the label (Deconinck et al. 2023; Malcorps et al. 2021; Stranieri et al. 2022).

Another key variable is the product price, as sustainable products are generally more expensive. This limits accessibility to more affluent consumers and contributes to a persistent attitude–behaviour gap (Górska-Warsewicz et al. 2018; Ingrassia et al. 2022; Deconinck et al. 2023).

SLs not only enable consumers to differentiate products based on environmental performance but also serve as indicators of trust, particularly when backed by third-party verification (Chkanikova and Lehner 2015; Miranda-Ackerman and Azzaro-Pantel 2017; Yu et al. 2022). Digital communication tools, such as QR codes, further enhance consumer engagement by reducing information asymmetry, thereby facilitating informed purchasing decisions (Schulze et al. 2024). Nonetheless, consumers' understanding of SLs may be challenging. First, label multiplicity may overwhelm consumers, making it difficult to distinguish differences across products. Second, the label format plays a key role. While graded labels, less widespread, might be easier to interpret (as they refer to an overall evaluation of product sustainability performance), binary labels sometimes refer to very narrow sustainability dimensions, and consumers may lack the knowledge required to understand their meaning (Autzen and Hegland 2021; Schulze et al. 2024). Taken together with consumers' price sensitivity, these barriers—label multiplicity and

limited understanding—may significantly constrain effective demand for sustainability-labelled products (Autzen and Hegland 2021; Schulze et al. 2024).

Recent SLR and meta-analyses provide robust evidence that consumers are, on average, willing to pay price premiums for sustainability-labelled foods (Li and Kallas 2021; Bastounis et al. 2021; Piracci et al. 2024). However, such willingness-to-pay (WTP) is highly heterogeneous across label types, product categories, and varies across countries (Bastounis et al. 2021; Li and Kallas 2021). Recently, Piracci et al. (2024) distinguish between environmental and social SLs, reporting that consumers tend to value environmental information more, and that broad sustainability claims perform comparably to more specific ones.

From a supply-side perspective, these findings indicate that consumer interest in sustainability can act as a market signal encouraging firms and retailers to adopt SLs. Yet, the magnitude and variability of consumers' WTP introduces uncertainty, especially for labels addressing social dimensions, where consumer valuation remains weak.

While consumer preferences create incentives for firms' SL adoption, the credibility, standardization, and communication of labels determine whether this demand can be effectively translated into incentives to adopt SLs along the supply chain.

Environmental concern

Emerging environmental challenges have been, and still are, a primary driver behind the development and implementation of SLs. For instance, the continuous decline in wild fish stocks and growing concerns over illegal fishing inspired the creation of the Marine Stewardship Council back in 1997 (Kaiser and Edwards-Jones 2006; Malcorps et al. 2021). Another example is the Forest Stewardship Council (FSC) label, established in the early 1990s, designed in response to intensive deforestation (Chkanikova and Lehner 2015). Another, more recent example comes from the wine industry, where firms affiliated with the SOStain Foundation in Sicily (Italy) decided to commit to sustainability not merely for compliance purposes, but to safeguarding environmental and social resilience in a region highly vulnerable to extreme climate conditions and resource scarcity (Gröfke et al. 2021; Ingrassia et al. 2022).

In such context, organic certifications are probably the most representative example. Organic labels appeared in the EU at the beginning of 1990 in response to emerging environmental concerns associated with intensive conventional agriculture, soil degradation, water contamination from agrochemicals, and biodiversity loss (European Commission 2007). Increasing societal concern about environmental sustainability -as well as health-related concerns about possible effects of chemicals use in agriculture—further increased the proliferation of organic labels (Górska-Warsewicz et al. 2018; Yu et al. 2022).

Today, climate change has become the most pressing environmental and socioeconomic challenge and is once again acting as a catalyst for new forms of sustainability labelling. For instance, climate change was the main driver behind the creation of new labels such as the Planet Score, which aims to convey a multidimensional assessment of products' sustainability by including aspects like carbon emissions, biodiversity, and pesticide use.

At the EU level, there is growing effort to develop harmonized labels aimed at communicating the overall sustainability performance of a product, rather than single sustainability dimensions. Harmonized scientific-based labelling schemes that encompass multiple dimensions of sustainability are increasingly seen as essential tools to provide consumers and supply chain actors with complete and trustworthy information that can support a transition towards climate-resilient food systems (Gröfke et al. 2021; Chkanikova and Sroufe 2021; Deconinck et al. 2023). However, when designing these new systems, it is essential to consider that food supply chain stakeholders tend to prioritize operational flexibility over adherence to rigid certification standards (Stranieri et al. 2022; Deconinck et al. 2023). Committing to fixed requirements may limit their capacity to adapt to unforeseen events, while more flexible schemes can facilitate adoption and maintain competitiveness (Tzilivakis et al. 2012; Gröfke et al. 2021; Stranieri et al. 2022; Deconinck et al. 2023). In this regard, integrating climate-resilience metrics or adaptation strategies into certification systems could enhance their relevance and uptake.

Concluding remarks

This SLR provides a comprehensive overview of the main drivers and barriers influencing firms' adoption of SLs. The results highlight key issues that should be taken into consideration by EU policy makers to achieve an effective harmonization of the use of SLs in the agri-food system.

The results highlight that the dynamics underlying firms' and retailers' adoption of SLs are far from homogeneous. The firm size plays a decisive role, since small and medium enterprises face more challenges than larger companies in complying with sustainability standards, monitoring, and reporting procedures. All these imply organizational and economic burdens, which small firms cannot absorb as easily as large companies and retailers do (Chkanikova and Kogg 2018; Stranieri et al. 2022). Moreover, retailers hold a strategic position between producers and consumers, have greater bargaining power, access to market information, as well as greater capacity to internalize certification costs. In fact, they have a leading role in spreading private sustainability standards, while many suppliers adopt SLs mainly to maintain access to retail distribution channels (Yu et al. 2022; Schulze et al. 2024).

The SLR also highlighted a high degree of fragmentation characterizing the current EU sustainability-labelling landscape. The coexistence of multiple labels, often referring to the same sustainability dimension but relying on different standards, is problematic (Thøgersen et al. 2010; Sörqvist et al. 2015). On the one hand, this multiplicity of labels allows firms to select those that best suit their operational needs, capacities, and market strategies. On the other hand, such proliferation generates information overload for consumers and increases the risk of confusion, scepticism, and declining trust in sustainability claims (Horne 2009; Annunziata et al. 2019). Furthermore, the predominance of binary, practice-based schemes limits incentives for continuous improvement. Graded, outcome-based labels, would be more effective in stimulating progress, but are more expensive and more complex to implement (Asioli et al. 2020).

This study has some limitations that must be acknowledged. Firstly, this SLR resulted in a relatively small number of studies included in the final sample. While this reflects the current scarcity of supply-side research on sustainability labelling in

the European agri-food system, the resulting corpus of 18 articles is relatively small. The selection process was rigorous and strictly guided by inclusion and exclusion criteria, but the limited sample size constrains the generalizability of the findings. Secondly, the results reflect a strong polarization of literature, as the majority of studies focus on fisheries, aquaculture, and organic food supply chains, while other relevant sectors remain underrepresented. As a result, the identification of the drivers and barriers may reflect sector-specific dynamics rather than more general patterns applicable across the entire agri-food system.

Despite these limitations, this SLR contributes to extend knowledge by providing a supply-side perspective on the adoption of SLs, a field that is still underexplored in the literature. Overall, the findings indicate that the European Union's proposal to harmonize sustainability labelling is timely and well-justified. A common label, based on a sound scientific methodology and able to aggregate several sustainability dimensions into a single interpretable indicator, could increase market transparency and improve consumer understanding and trust in sustainability-related information (Grunert et al. 2014; Deconinck et al. 2023; Schulze et al. 2024).

In addition, harmonization could lower transaction costs for firms, improve information flows along supply chains, and foster more coordinated stakeholder collaboration.

However, the development and implementation of an EU-wide harmonized sustainability label scheme is nontrivial. The fraction of overly stringent requirements or excessively complex methodologies, such as those based on LCA, might disproportionately burden the smaller firms and therefore widen their competitive gap against larger firms and retailers. According to Stranieri et al. (2022) and Deconinck et al. (2023), harmonization needs to be pursued with enough flexibility to consider the varieties of supply chain realities and avoid unintended negative effects for both firms' and consumers.

Abbreviations

EU	European Union
SL	Sustainability label
F2F	Farm to Fork
PEFCRs	Product environmental footprint category rules
LCA	Life Cycle Assessment
WTP	Willingness to pay

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Data availability
Data sharing is not applicable to this article as no datasets were generated or analyzed during the current study.

Declarations

Competing interests
The authors declare no competing interests.

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