State of the art analysis of LCA-based ecolabelling schemes in Europe

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The growing environmental footprint of agrifood production demands changes in both demand and supply. Demand-side efforts encourage eco-friendly behaviours, such as adopting more environmental-friendly diets and reducing food waste, while supply-side strategies focus on sustainable production and supply chains. Life Cycle Assessment (LCA)-based ecolabels are pivotal in this shift. However, there are still challenges to address around harmonisation of various ecolabelling schemes that have rapidly emerged. This study, part of the Eco Food Choice project, analyses 16 LCA-based ecolabels from public and private sectors against 40 criteria to assess their credibility, consistency, and transparency. Findings highlight the need and critical success factors for a harmonised European ecolabelling system to enhance trust and support the sustainable food transition. While public (PEF-based) schemes present greater harmonisation, private labels using ISO or GHG protocols vary more in their methodologies.

Key words: LCA-based ecolabelling schemes, harmonised ecolabelling, comparing ecolabels, scope 3 reporting, overview ecolabels, eco-rating food products, sustainable food production, sustainable food consumption, state-of-the-art analysis ecolabels

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Contents

Preface

This study 'Overview of LCA-based ecolabelling schemes in Europe' was conducted by Wageningen Economic Research and was commissioned in the framework of the ECO FOOD CHOICE project. It was funded by the European Commission, through the LIFE programme (the granted authority *The European Climate, Infrastructure and Environment Executive Agency (CINEA)* and co-funding has taken place via the Dutch Ministry LVVN (The Ministry of Agriculture, Fisheries, Food Security and Nature). The authors would like to thank all the members of the Eco Food Choice consortium, and in particular the reviewers Coen van Wagenberg and Birgit de Vos as well as owners of the LCA-based ecolabelling schemes included in this study, for their support, transparency and collaboration during the data collection, validation and review process.

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Summary

S.1 What is the state of the art of LCA-based ecolabelling schemes in Europe?

As the environmental footprint of agrifood production and consumption grows, addressing these challenges requires changes on both the demand and supply sides. Along with traditional certification labels, a key approach to meeting these needs will be the use of Life Cycle Assessment (LCA)-based labelling of food products to inform consumers about their environmental impact. The use of LCA for assigning ecolabels has rapidly expanded across Europe, with numerous public and private schemes being implemented by retailers and the food service sector. With the rise of sustainability labelling, EU policies and regulations, notably the 'Green Claims Initiative' are responding by implementing stricter standards and promoting standardisation. This rapid rise of both traditional (certification based) and LCA-based ecolabels in the European agrifood sector over the last decade has led to concerns regarding the credibility, quality, and clarity of some labels, creating confusion and mistrust among consumers and companies. In light of these there is an urgent need of a harmonised and reliable LCA-based ecolabelling methodology within Europe that will address environmental challenges and requirements the industries are facing to comply with ever increasing consumer demand, awareness, and regulations on environmental reporting requirements.

To address this, the Eco Food Choice project was proposed to introduce a European harmonised LCA-based ecolabel system. This harmonised system could benefit from the methodological work that has already been done by other schemes and the lessons learned during implementation. As part of this project, the main research objective of this study is to analyse the state of the art on LCA-based ecolabelling schemes, to help building on the strengths of existing systems and avoid duplicating efforts. One of our objectives is also to identify key success factors, sources of inspiration, as well as the challenges and opportunities that remain. The report concludes with insights into the critical success factors and the necessary steps to achieve harmonisation in ecolabelling. Finally, we illustrate a vision for a unified EU-wide LCA-based ecolabelling scheme.

S.2 Current schemes are promising, but methodologies, data sources and governance are not harmonised

What is the state of the art on LCA-based ecolabelling schemes for food products across the EU?
The analysis of LCA-based labelling schemes highlights both similarities and notable differences in their methodologies, governance, and labelling systems. PEF-based schemes show greater harmonisation, especially in areas such as impact category selection, functional units, system boundaries, data verification, data quality, database usage, and impact assessment methods. On the other hand, private schemes that follow ISO or GHG protocol standards display more variability and less consistency across these criteria, while often demonstrating innovative and agile implementation practices.

It can be concluded with this study that while current LCA-based ecolabelling schemes are promising and innovative in how they calculate and report the environmental footprints of products, there is an urgent need to improve, operationalise and harmonise methodologies and data sources. While PEF is a first step to harmonisation, it does not fully answer the needs of an ecolabel. We observed that most PEF-based ecolabelling schemes considered that some adaptations were needed for ecolabelling, leading further to a fragmented landscape.

While public (PEF-based) schemes offer more consistency in areas such as impact categories and data verification, private schemes following ISO or GHG protocols are more varied but offer faster and more agile implementation.

What are the current barriers towards harmonisation among these LCA-based ecolabelling schemes in the EU?
The main barriers to harmonisation include differing methodologies, high data collection costs, data access, national regulations, industry resistance, and the complexity of creating consumer-friendly labels.

What are the key factors for success and the challenges associated with recently launched LCA-based ecolabelling schemes for food products in the EU?
Key factors for success at methodological level include balancing the administrative burden with accurate measurements, operationality, ensuring data accessibility and quality, and preventing trade-offs between environmental impacts. Effective harmonisation at operational level requires broad stakeholder engagement, transparency and data accessibility, prevention of proliferation and alignment with political dynamics and consumer awareness and education.

What could a potential harmonised EU LCA-based ecolabelling scheme look like?
A potential harmonised EU ecolabelling system could include six key elements: standardised LCA methods, clear primary data requirements, a consistent secondary database, consumer-friendly labels, verification processes, and uniform label design. This would be overseen by a governance platform involving EU bodies, ecolabelling schemes, and stakeholders, with opportunities for private sector involvement in data collection and verification. This potential vision and associated elements could aid The Eco Food Choice project towards a unified, sustainable food ecolabelling system across Europe.

S.3 Methodology

The methodology in conducting this study was as follow. A general literature review was done to set the context on the problem and current situation around the ecolabelling of agrifood products. The initial list of 25 ecolabelling schemes was narrowed down to 16 schemes based on specific criteria to ensure the study’s relevance and focus. The study established 40 criteria to assess the selected ecolabels, focusing on operational and methodological factors critical for a harmonised and robust LCA-based ecolabelling scheme for food products. Initial data were gathered from publicly available sources such as scheme websites and methodology factsheets. When available information was insufficient to fully evaluate the schemes’ methodologies, governance, or label designs, one-on-one meetings with ecolabelling scheme owners were held. After compiling the initial data, they were sent back to the ecolabelling schemes representatives for verification and validation, ensuring accuracy before publication. Once validated, the data were analysed to identify commonalities, differences, and best practices across the ecolabels. This process helped to draw conclusions on the critical success factors for a robust and effective LCA-based ecolabelling scheme and as well as illustration of a potential vision for a harmonised and unified labelling methodology in Europe.

1 Introduction

1.1 Numerous ecolabels employing various methodologies

The Food and Agriculture Organisation FAO (FAO, 2018) estimates that the global environmental footprint of food production is immense, with agriculture occupying 40% of land, consuming 70% of global water resources, and contributing over 25% of worldwide greenhouse gas emissions. It is predicted that between 2010 and 2050, due to anticipated population growth and rising incomes, the environmental impact of the food system could increase by 50–90%. Without technological advancements, this impact could surpass levels that are considered safe for human existence (Richardson et al., 2023).

As pointed out by Deconinck et al. (2022), to meet these environmental challenges facing food systems, changes are needed on both supply and demand sides. On the demand side, key drivers include rising consumer awareness of the environmental impacts of food systems, the increasing sophistication of methodologies and datasets, and a growing focus on 'results-based' approaches to reduce the environmental footprint of food systems. These efforts complement the traditional 'practice-based' approaches that have been in use (Deconinck et al., 2023). Supply-side changes require adapting product offerings, such as developing new supply chains, redesigning products, innovating recipes, and modifying production processes and distribution methods (Hélias et al., 2022).

Following these challenges and drivers, there are the growing regulatory and market pressures from schemes such as the Paris Climate Agreement, the EU Corporate Social Reporting Standards, and Science based targets initiative both for GHG and Nature (Biodiversity). All these regulatory drivers within EU are demanding more transparency and transitioning to more sustainable food production and consumption methods. The Green Claim directive proposal (European Commission, 2023a) also pushes for more science- and data-driven communication, acknowledging both the need for an LCA-based approach but also addressing some of its limitations, in particular in the agri-food sector. This global trend is driving all stakeholders within the agrifood industry to calculate the GHG emissions of their whole value chain and establish targets to reduce their environmental impact. Altogether, there has been an growing demand, need and awareness both for producers and consumers for information regarding the ecological and social impacts of food products (Teufer et al., 2023).

In response to these needs and challenges, in recent years, various traditional certification-based and LCA-based labelling systems for food have emerged to evaluate and communicate the environmental impact of food products referred to as ecolabels (See Chapter 2.1 for differences between these two ecolabelling systems). The development of these schemes has challenges related to inconsistent methodologies and frameworks, leading to discrepancies in product-level impact assessments. As a result, there is currently no universally accepted, comprehensive, and harmonised methodology for assessing the environmental impact of food products within Europe or globally.

1.1.1 Recent EU directives aiming towards more credibility and harmonisation; yet uncertainty remains

A recent study done for the European Commission cites that over 50% of environmental claims on the performance of products are misleading, vague or unsubstantiated (McGuinn et al., 2023). In response to this fact, several frameworks and directives have been proposed by the European Commission.

In 2015, the European Commission raised concerns about the credibility of ecolabels, describing them as being at a critical crossroads if no consolidation efforts were made (European Commission, 2021). Following this, it introduced the first circular economy action plan, aiming to address deceptive green claims and examine the potential use of an EU-wide approach, known as the Product Environmental Footprint (PEF), for conveying environmental information.

In the release of the Farm to Fork Strategy in May, 2020, the European Commission set plans to develop a sustainable labelling framework that covers the nutritional, environmental, and social aspects of food products (Bunge et al., 2021). More recently, the Group of Chief Scientific Advisors has highlighted the importance of more systemic actions to address the whole food environment.(Joint Research Centre: European Commission, 2024). In their report, they recommend various areas for EU policy action to reduce barriers that prevent consumers of making more sustainable food choices.

On 22 March 2023, the EU Commission proposed a directive, known as the 'Green claims directive', aiming to regulate the substantiation and communication of environmental claims in business-to-consumer practices. This directive sets minimum requirements for voluntary environmental claims and labelling, while acknowledging existing EU legislation for specific products or sectors. It also proposes mandates that environmental claims must be substantiated by recognised scientific evidence and state of the art technical knowledge, and considering impacts across the product's lifecycle. It limits the communication of aggregated results until several conditions met which also includes the missing issues and limitations in PEF to be completed and improved. (i.e., extensive farming practices, biodiversity and animal welfare), in particular related to the agrifood sector (Directorate-General for Environment, 2023).

Limitations of PEF
PEF is increasingly applied in various public LCA-based schemes at the European level, and is recognised in policy schemes across different industry sectors as the leading environmental footprint methodology. However, within the agrifood sector, several (civil society) organisations criticise PEF as a 'biased' approach, arguing it primarily measures efficiency (e.g. through yield) and favours intensive production systems. This criticism also suggests that PEF is inadequate for fair comparisons between agrifood products, and particularly production systems with different levels of intensity. LCA often rewards more intensive practices without sufficiently considering other crucial aspects of long-term sustainability, such as soil quality, (local) biodiversity, ecosystem (services), and animal welfare (Lanzoni et al., 2023).

This criticism also was echoed within the most recent Green Claims Initiative proposal. The proposal restricts communication of aggregated results, as can be done using the EF method. Additionally, it addresses missing issues and limitations in the PEF methodology, such as extensive farming practices, biodiversity, and animal welfare, particularly in the agrifood sector (European Commission, 2023).

On the other hand, this lack of comprehensiveness should be viewed as an opportunity to enhance LCA, making it more suitable for assessing agricultural systems in the future. With respect to this aspect, European Commission's Agricultural Working Group is working on addressing and improving some of these limitations, in particular on biodiversity, and will introduce a new updated methodology and database by 2026.

Thus, uncertainty remains regarding the mandates of the prospected directive on ecolabelling and whether the PEF methodology will be mandated as the sole framework for LCA-based environmental product labelling across the European Union. This lack of an agreed harmonised ecolabelling methodology, in turn creates confusion and proliferation around the LCA-based eco labelling schemes.

1.2 One harmonised LCA-based ecolabeling scheme in the EU for agrifood products

To overcome these issues, the European Commission strives for having one harmonised LCA-based ecolabelling scheme in the EU (European Commission, 2023). Existing schemes could offer insights and lessons as a starting point in the process to develop such a harmonised LCA-based ecolabelling scheme.

Therefore, the objective of this study is to analyse the state of the art of LCA-based ecolabelling schemes used in Europe for agrifood products, allowing to build on the strengths of existing schemes and avoiding the need to reinvent the wheel. Our overview analyses and evaluates recently launched LCA-based ecolabelling systems for food products across Europe against predefined criteria related to governance, methodology, scoring, and label design. It examines both public (national) and private schemes. Our goal is to identify the key factors for success and inspiration, as well as the remaining opportunities and challenges. We will conclude the report with insights into critical success factors and the steps needed to make the harmonisation of ecolabelling a success, driving sustainable food production and consumption. Additionally we will illustrate a potential vision for an harmonised EU LCA-based ecolabelling scheme.

This particular study is part of the work packages involved within the Eco food Choice Project. Eco Food Choice project was initiated on the shared ambition of researchers to develop and harmonise LCA-based environmental labelling on a European scale. The project, financed by the LIFE program, brings together 8 European partners from France, Spain, Germany and the Netherlands, with researchers and companies who are experts in their fields: agricultural production, data, LCA, consumer sciences, etc. The intention of this project is to set a standard methodology that will lead to best results in practice and gain as much support as possible from all the relevant stakeholders.

It should be noted that, although main conclusion do not change, this overview is a snapshot of the current situation only. All schemes are constantly changing and updating their methodology and labelling systems as the market and regulatory demands evolve.

1.3 Main research question of this study

The main research question of our study was:
1. What is the state the art on LCA-based ecolabeling schemes for food products across the EU?

Sub-research questions were:
1. What are the current barriers towards harmonisation among these LCA-based ecolabelling schemes in the EU?
2. What are the key factors for success and the challenges associated with recently launched LCA-based ecolabelling schemes for food products in the EU?
3. How could a potential harmonised EU LCA-based ecolabeling scheme look like?

1.4 Report Outline

This report is organised into 7 chapters, beginning with the problem statement on current situation around ecolabelling and objectives of the study. Chapter 2 introduces the role of ecolabels to date, exploring the differences between the types of ecolabels and the challenges associated in harmonising ecolabeling methodologies for agrifood products. Chapter 3 outlines the methodology used for selecting, analysing, and interpreting the LCA-based ecolabelling schemes included in this study. Chapter 4 presents a detailed examination of the study’s results, discussing each criterion used to assess the 16 LCA-based ecolabeling schemes. Chapter 5 discusses critical success factors and strategies for harmonising ecolabelling schemes. Following that Chapter 6 illustrates a potential vision for an harmonised EU LCA-based ecolabeling system. Chapter 7, the final chapter, summarises the findings of the report towards the harmonisation of a LCA-based ecolabelling schemes and concludes.

2 Introduction to Ecolabelling

Over the past three decades, ecolabels have become a vital means of communicating environmental sustainability information about consumer products, highlighting those that have reduced environmental impact. During this period, ecolabels have proliferated globally, reflecting a diversification in both their types and applications (Iraldo et al., 2020).

In Europe, environmental sustainability claims and labels have seen a steady rise, with their presence on newly introduced products growing at an average rate of 2.83% annually between 2005 and 2021 (Tiboni-Oschilewski et al., 2024). This growing trend is accompanied by the development of various standards, such as the Greenhouse Gas (GHG) Protocol, ISO, and PEF methodologies, which provide guidelines for calculating carbon and environmental footprints at various levels. Furthermore, tools such as the GHG Protocol's Agricultural Guidance and simplified farm-level calculators are making it easier to estimate environmental impacts. The availability of primary research data and comprehensive databases on food production also further enhances the accuracy and depth of these assessments (Deconinck et al., 2023). Accounting standards are also evolving, particularly through schemes such as those from the International Sustainability Standards Board (ISSB), which now include sustainability reporting requirements such as Scope 3 GHG emissions for all industries.

Building on these developments, businesses are likely to face increasing pressure to disclose detailed, quantitative data on their environmental impacts. Whether through standard practice or legal mandates, this will include product-level and company-level disclosures, as well as the environmental impacts of other entities within their supply chains. Such data will likely form the backbone of future public and private schemes, including environmental impact labelling on food products, green public procurement policies, and carbon pricing mechanisms (Deconinck et al., 2023). This shift will mark a significant step toward more transparent and accountable sustainability practices across industries.

2.1 Key differences between traditional certification-based ecolabelling and LCA-based ecolabelling schemes

In this report, we distinguish between two types of environmental labels: traditional certification-based ecolabels and LCA-based ecolabels, with a focus on highlighting the advantages of the latter.

Traditional certification-based Ecolabels
Traditional certification-based ecolabels have been around for many years, serving as certifications that communicate a product's environmental or sustainability attributes. These schemes rely on clearly defined and standardised criteria but typically focus on specific aspects of sustainability, such as organic farming, fair trade practices, or animal welfare. While these labels are awarded when a product meets the requirements of a certification programme, they often concentrate on single or limited impact areas. For example, standards may be set for organic practices or social responsibility, but they do not provide a comprehensive assessment of a product's overall environmental performance. Furthermore, traditional certification-based ecolabels are applied to a limited range of products, resulting in low penetration rates, many products still lack reliable traditional labels altogether.

Emergence of LCA-based Ecolabels
In recent years, a new category of ecolabels, known as environmental rating ecolabels, has emerged to complement traditional labels. These schemes utilise (LCA) methodologies to quantify and present the environmental impact of a product, typically summarised in a final score. Driven by regulatory and market pressures, such as the Corporate Sustainability Reporting Directive (CSRD) and the Science Based Targets initiative (SBTi), these ratings are gaining traction as industry and policymakers respond to consumer

demand for clearer sustainability information. However, the coexistence of different labelling types can contribute to confusion among consumers and producers alike.

Advantages of LCA Methodology

LCA serves as a robust methodological framework that offers greater structure than traditional ecolabelling. It addresses the processes involved in product production, transformation, and distribution, along with their associated impacts. Despite some limitations, LCA allows for the estimation of pollutant emissions and resource utilisation across a product's entire life cycle. This comprehensive approach enables various applications, such as product and organisational level reporting, hotspot analysis, and more effective ecolabelling.

Unlike traditional certification-based ecolabels, LCA-based ecolabels provide a quantitative measure of environmental impact, making it easier to compare the sustainability of different foods, regardless of certification status ((Clark et al., 2022). While traditional ecolabels may increase consumer demand, they often lack evolving standards, once a product meets initial certification requirements, there is little incentive for producers to improve their environmental or social practices. In contrast, LCA-based labelling systems are recognised as essential for promoting sustainability in food production and consumption across Europe (Boone et al., 2023, Deconinck et al., 2023).

Currently, there is increasing urgency among retailers and food service companies in the EU to comply with science-based targets on carbon emissions and report their scope 3 emissions, which include their entire supply chain. While many LCA-based schemes primarily consider climate and carbon as key environmental indicators, there is a growing trend to incorporate additional metrics, such as biodiversity indicators and Science-Based Targets for Nature. This shift positions LCA as a valuable tool for comprehensive environmental impact reporting.

Overall, LCA-based ecolabelling has two main objectives: to stimulate consumer behaviour towards more sustainable diets by enabling comparisons between product categories, and to incentivise and encourage producers to adopt more sustainable production practices. By providing a more comprehensive, transparent, and quantifiable assessment of environmental impacts, LCA-based ecolabels represent a significant advancement in promoting sustainability in the food sector.

Addressing Market Confusion and Administrative Burden

The proliferation of different labelling schemes enhances awareness of the environmental footprint of products but can also lead to market confusion for consumers (ISO, 2019, Boone et al., 2023). For producers, this creates a larger administrative burden, as different schemes have varying criteria and data needs. For example, a farmer may be required to obtain certification from multiple schemes to satisfy the demands of different clients.

In this overview, we focus exclusively on LCA-based ecolabelling schemes for food products. LCA-based eco (rating) labels facilitate the evaluation and communication of the environmental impact of all food items. They diverge from traditional labels—such as fair trade, organic, or environmentally friendly—in two significant ways: first, they aim to assess the sustainability of all food products, rather than solely those certified under specific schemes, second, they rely on quantifying impacts such as greenhouse gas emissions and water usage, as opposed to the process-oriented metrics typically associated with traditional labels (Boone et al., 2023). This quantitative approach also includes harder-to-quantify aspects, such as biodiversity impact.

3 Methodology of the analysis

3.1 Scope: LCA-based ecolabels covering the food, beverage and agrifood sector

Scope of this ecolabelling analysis covers LCA-based ecolabelling schemes that are covering specifically the food, beverage and agrifood sector both public (national-country level) schemes and private sector schemes (across borders within Europe). These schemes are either under development, pilot testing or officially in use by various retailers, and/or food service industries in various countries within Europe.

3.2 Criteria used in selection of assessed labelling schemes in Europe

An initial list of 25 LCA-based labelling schemes were identified through meetings with experts and stakeholders, market analysis, announcements communicated within agrifood sector and retailers and media in Europe. A large number of LCA-based ecolabels emerged on agrifood products in the last 10 years within Europe. Some of these ecolabels lack the quality, credibility and clarity which is leading to miscommunication and distrust among consumers and companies (EIT Food Consumer Observatory and IPSOS, 2023). Given the limited capacity we had available for this research and the level of detail that is needed to make a useful analysis of ecolabels, we wanted to focus only on the most promising schemes with the highest chance of adoption. Therefore we used four criteria to select the most relevant schemes for the objectives of this study. All ecolabels on the initial list were analyzed on each of the four criteria. Failing to meet one criterion does not necessarily mean that an ecolabel was not selected; instead, it may have been compensated by stronger performance/representation in other criteria.

- Transparency and accessibility of the methodology used. We targeted schemes that are mostly transparent and open in sharing their methodology.
- Operational and used within Europe: The analysis targeted the labelling schemes that are operational and/or developed in Europe. Ideally used or tested by more than one retailer, brand or food service company.
- Scalability towards a large scale application and harmonisation. The analysis targeted the labelling schemes that are scalable to European level.

Assessing the various LCA-based Ecolabelling schemes that fit into the criteria given above, we have identified 16 LCA-based Ecolabelling schemes to include in our analysis (See Table 3.1.)

Table 3.1 *Selected LCA-based ecolabelling schemes.*

National (Public) Initiatives/ Schemes a)	Private schemes
• France (ADEME- French Ecolabelling initiative) • Netherlands (Dutch Ecolabelling initiative) • UK (IGD) b) • Denmark (Danish Climate label initiative)	• Carbon Cloud • Dayrize • Eco-score • Eco-impact/Foundation Earth • Enviroscore • Eco-score by Beelong • Eaternity • Inoqo • Mondra • M-check • HowGood • Planet-score

a) National (Public) initiatives have no formal names yet but they are being developed under the national governments lead;
b) IGD is a non profit private party, informing UK government DEFRA on LCA-based ecolabelling methodology.

3.3 Definition of final criteria list in the analysis of ecolabels

To establish a solid assessment framework to analyse the selected 16 LCA-based ecolabelling schemes, we identified the key criteria essential for defining and implementing a robust and harmonised LCA-based ecolabel. These criteria not only facilitate the assessment but also cover the essential operational and methodological factors necessary for the implementation and functionality of an LCA-based ecolabel for food products. To achieve this, we reviewed literature, consumer studies, and market trends related to LCA-based ecolabelling methodologies, focusing on comparability, credibility, consistency, and label design and scoring. Additionally, interviews with food ecolabelling owners, users, and experts were crucial in identifying relevant differences and areas to pay attention in between ecolabels. Lastly, the first detailed screening study of the ecolabels led to small adaptations in our criteria list on wording, methods and terms used. From this comprehensive process, we established 40 criteria to analyse the selected 16 schemes. Below is the table listing the key criteria that each scheme was analysed for.

Table 3.2 *Criteria list to analyse the 16 LCA-based ecolabelling schemes.*

Criteria		Explanation of the criteria
Generic information	**Country of origin**	**Where is the scheme/initiative founded?**
	The year of initiation	When was the scheme/initiative started/founded?
	Country of application	In which country(ies) is the scheme being tested, piloted, or actively operational currently?
	Current status and operationality of the ecolabel	Is the scheme 1) Under development 2) Under development with consumer testing started 3) Pilot testing (temporary) at retailers 4) Methodology is operational but not yet tested/implemented at any retail/industry 5) Officially in use and operational by retailers and brands?
	Use of label/score as part of Scope 3 reporting and CSRD	Is the scheme/eco-label (also) used for the purpose of scope 3 reporting and if so does it include the right level of assurance for CSRD?
	Custom made application	Can the ecolabelling LCA methodology be tailor made according to the client needs and wants? For example, change of system boundary, indicator selection etc. (Yes/No/Partly)
Governance	Stakeholders involved	Main parties involved in decision making/methodology development. (i.e Public, private, public and private, NGO)
	Third party assurance or verification of data	Is the secondary data used being verified by a third party?
		Is the primary data used verified by a third party? If yes, which primary data is verified?
	Scalability of the scheme	Can the scheme/system be applied in other regions and/or worldwide?
Methodology	System boundary	To what extent are the life cycle stages considered: cradle-to-farm gate, cradle-to-factory gate, cradle-to-retail, cradle-to-grave?
	Functional Unit	Per what unit is the impact expressed?
	LCA-based Environmental Impact categories considered	What LCA environmental impact categories are covered?
	Non-LCA environmental impact categories	What non-LCA environmental impact categories are covered?
	Additional Social-LCA/Social impact themes	Are there additional social impact indicators included?
	LCA methodology used	Is the LCA methodology based on PEF? If not what kind of approach or methodology is applied? Answer options: PEF based with adaptations, PEF based, PEF Compliant, ISO14044-67 standards, or equivalent, GHG protocol?
	Life cycle Impact assessment methods	General Impact assessment method applied for respective impact categories selected.
	Normalisation and weighting	Are weighting and normalisation factors applied? If yes, the method and factors used? (e.g., PEF Weighting, PEF with adaptations)?
	Additional steps applied in scoring and weighting for additional indicators.	Is there an additional step (s) in scoring of the indicators on top of normalisation and weighting? For example, bonus/malus approach and/or other (non)-LCA method/steps/adjustments?

Criteria		Explanation of the criteria
		How is the additional step ((non)-LCA and/or the bonus/malus approach) applied?
	Primary data integration and inclusion in different life cycle stages.	Which primary data are used to change the outcome of the LCA via bonus/malus or other complementary measures?
		Which primary LCA data is (can be) included (either mandatory or voluntarily) and at which stage of the life cycle?
	Product or ingredient level secondary LCA database	Is the secondary LCA database used modelled at product level (assuming an average set of ingredients) or is it modelled at ingredient level(ingredients database using recipes of actual food products).
	Regional coverage of the database	Does the secondary LCA database contain scores based on average production regions for consumption in one particular country (such as Agribalyse for France) or does it include separate values for separate production regions so the real country of production can be used for the calculation of the score of an individual product?
	Granularity of the database	What is the number of ingredients, products, countries for which specific data is available?
	Secondary LCA databases used	Specify the database(s) used to create representative country specific, European, generic (average) database worldwide?
	Methodology applied for databases used	Method of harmonisation applied in databases for secondary data to address the consistency and comparability of the results.
	Comparability (between and within product categories)	Can the given scores be used to compare within and between product categories?
	Data quality management	Is there a mechanism/system in place to 1) measure data accuracy, completeness, and consistency. (E.g PEF based DQR), and/or 2) Prevent errors in data inventory process (including matching a product with right quantities of ingredients etc.)?
	Accessibility of the calculation tool or footprint database.	Some schemes allow open access to their footprint database/tools (maybe limited) for public to test and explore the product footprints for internal use.
Label design	Label design	Is the label descriptive with numerical, letter and or color graded?
	Scoring system	What is the final scoring system (Aggregated Single score, Individual score per impact category, or combined (LCA and non-LCA)
	Additional themes/indicators reported separately?	Are the additional indicators/themes included in the label separately? Which ones?
	QR Code availability(for more details)	A QR code is placed to give more detailed information on the footprint of the product
Additional items	Link to website	
	Software used	The type and nature of the software/tool used in exchange of (primary) data and calculation of scores.
	Retailers testing/using the label	Which retailers are testing or using (operational) the label
	Additional remarks	Any additional feature/highlight specific for the respective scheme?
	Product coverage so far	The size of product/dataset coverage on food products

In the subsequent Chapter 4, on results of the assessment, for each of the criteria we will explain in more detail the description and the reason why that particular criterion was selected.

3.4 Data collection methods

3.4.1 Literature review, analysis of documents and webpages of the LCA-based ecolabelling schemes

We collected the initial data on the 40 criteria items on LCA-based ecolabelling schemes through publicly available information provided in each scheme’s websites, other publications (e.g. other comparisons of ecolabels) or documents that were shared with us by the owners of the schemes. To set the context on the problem and current dynamics around ecolabelling of agrifood products, we relied on the existing literature and regulations documents at European context.

3.4.2 Interviews and Oral discussions with LCA-based ecolabelling representatives

In some cases, the publicly available information in the respective schemes' websites or methodology papers was not sufficient to draw conclusions on the methodology, governance or label design. In that case, we drew conclusions from the face-to-face meetings with ecolabelling scheme representatives from January 2023 to May 2024. It should be noted that these conservations during this period were not all focused on evaluating the 40 criteria specifically. They also occurred in the broader set of our projects during the year 2023-2024. These meetings were not designed as an official interview setting but was set as an oral discussion to exchange information. Through these meetings we had more elaborated responses to conclude our findings, though in some cases the information provided through discussions was also not complete.

3.4.3 Data validation process

Once the initial data collection process was completed, we sent the files to the owners/representatives of each scheme to further verify and validate the answers we have identified and to also get approval for publication. Once the validations were received from each scheme owner, we started to identify the commonalities and differences, and get insights into best practices to draw conclusions on the critical success factors.

4 Status-quo: Results of the inventory analysis on LCA-based schemes

In this chapter, in response to the main research question on the status quo of LCA-based ecolabelling schemes, we will present the results of the assessment of the 16 ecolabel schemes referring to all the 40 assessment criteria as we presented them in Chapter 2. In some cases, we combine multiple criteria items that address similar issues into one sub-chapter to avoid giving repetitive examples or explanations. It is important to take into account that most ecolabel schemes are in development. Below we describe the situation as of spring 2024. Some schemes aim to address a broad range of impact categories but have only implemented one or two. While they may have concepts for operationalising other impact categories, these have not yet been put into practice, and plans often remain vague and uncertain regarding their feasibility.

Further on, some of the ecolabel schemes provide different solutions depending on the wishes of the client. It is for example possible just to get a climate score but it also possible to get an integrated scored covering several impact categories. Clients may use the label of the ecolabel scheme but are also free to develop their own label or other way of communication. Some clients may use the results only for scope 3 measurement and not communicate anything to consumers. All this complicates a direct comparison between ecolabels on all the relevant aspects.

4.1 What are the barriers to a harmonised LCA-based ecolabelling on food products?

Barriers around the LCA methodology

Creating a harmonised LCA-based eco-labelling system for food products faces several challenges. The LCA methodology has been in use for over three decades, but its lack of full standardisation has hindered the comparability of results across products. Addressing this issue, the European Commission has introduced a comprehensive LCA standard known as the Product Environmental Footprint (PEF), outlining the required methodologies and data for use. Additionally, specific methodologies tailored to product categories are further detailed in the Product Environmental Footprint Category Rules (PEFCRs), addressing category-specific considerations. The PEF encompasses 16 distinct environmental impact categories, such as greenhouse gas emissions and water use, from which a single weighted score can be derived through normalisation and weighting (Boone et al., 2023).

Currently PEF is the most comprehensive framework in product footprint methodology. However, the discussions around PEF easily get complex and thus can be confusing. Firstly, as mentioned in the most recent Green Claims Initiative, the missing issues and limitations in PEF, specifically related to agrifood sector should be completed and improved. Thus, uncertainty remains regarding whether the PEF methodology will be mandated as the sole framework for environmental product labelling across the European Union.

Despite the significant investment made by sectors in developing PEFCRs for selected food categories, limitations persist in the methodological approach across different product categories. One important factor is that each PEFCR establishes its own methodological standard, which means that comparison between product categories is no longer possible. PEFCRs are primarily intended to make comparisons within product categories only. Consequently, employing PEFCRs for assessments spanning multiple food categories poses challenges. Furthermore, conducting PEFCR studies is resource-intensive, requiring substantial LCA expertise. These factors have impeded the widespread application of PEFCRs due to the considerable costs involved. Additionally, PEFCRs solely address environmental performance and do not cover social externalities (such as animal welfare, human rights, living wage, and use of antibiotics etc.). Secondly, they may overlook certain negative or positive environmental externalities (impact on biodiversity), potentially leading to an under- or over-estimation of the performance of certain practices (Boone et al., 2023).

Barriers at operationalisation and harmonisation at international level

Inconsistent diverse standards and schemes: There are numerous ecolabelling schemes across Europe either developed by public or private institutions. Harmonising these standards both within and across borders requires agreement on common definitions, methodologies, and criteria for assessing environmental impact (Brimont and Saujot, 2021). The choices in methodology can also have consequences for the relative scores of products from certain countries. Governments would naturally want products from their own country to score as high as possible, which is also the case for private companies. Thus this can result in proliferation of methodologies applied differently depending on the interest of the parties.

Consumer Understanding: Eco-labelling must be meaningful and understandable to consumers. Harmonising labelling across regions requires careful consideration of cultural and linguistic differences to ensure that consumers can easily interpret and trust the labels (Teufer et al., 2023, Tiboni-Oschilewski et al., 2024)

Data access and information barrier: One barrier to enabling transitions to more environmentally sustainable food systems is the lack of detailed environmental impact information. While previous analyses have made progress in providing environmental impact information on foods, they focused primarily on single food commodities such as fruits, red meat, or nuts. This leaves a significant information gap, as most of the products available in retail stores contain multiple ingredients, making their environmental impacts not readily known. Two main reasons contribute to this. First, the exact quantities and supply chain details of each ingredient are often trade secrets and sensitive, not disclosed on ingredient lists. Second, the vast number of food products—often tens of thousands per retailer—makes comprehensive assessment a very challenging task (Clark et al., 2022).

Costs and Implementation: Collection of and generating data on product information can be a quite costly process, in particular if this process is done not on average product information but for product specific footprint assessments. Review and control process add an extra cost that can be high, depending on the control scheme framework. Cost during implementation has been identified especially evident as an important challenge. This is especially evident in challenges of implementing product environmental footprint (PEF) which is considered to be the most comprehensive framework on product footprint methodology.

Policy and Regulatory Differences: There can be major conflict of interests, and differences in regulatory frameworks, agenda, policies and political visions within and across countries. Aligning these differences requires a political will, a common political vision on a sustainable food system, and cooperation all the stakeholders in the value chain both at national and international levels (Brimont and Saujot, 2021).

Industry Resistance due to confidentiality of primary data, costs and barriers: In many cases industry do not want to share the primary data into their production inputs with everyone because it concerns competitively sensitive information. This is in particular the case for brands to share their data with retailers because they could use that information to improve their private label products (CAPS Research, 2021). This is in particular the case in high impact sectors (i.e., the meat industry).

Availability of primary data and data sharing: Besides the issue of confidentiality, the availability of primary data and the technical possibilities to share these data towards a similar goal require development. Integration of primary data from supply chains is crucial in making robust distinctions between similar products from different suppliers, and incentivising cooperations within supply chains to mitigate impact. However many suppliers do not yet have the data readily at hand, and/or the technical skills/ tools to share these data efficiently are still lacking.

Addressing these challenges requires collaboration among governments, industry stakeholders, consumer organisations, and environmental groups to develop common standards, build trust, and promote the adoption of eco-labelling as a tool for promoting sustainable food systems.

4.2 Generic information on the schemes

Several retailers and national governments already started piloting and implementing on small scale. Others retailers, food processing industry and catering services in Europe already implemented LCA-based ecolabelling over all products. The initial main motivation among many retailers and food industry is to report on their Scope 3 emissions along their supply chain to comply with SBTi, CDP or CSRD. In this regard, many private sector schemes have been offering solutions to the food industry and retailers on their product carbon footprint. Steadily this trend on product carbon footprint is evolving to include other environmental and social indicators on product level as the consumer awareness is increasing. While nearly all the private labelling schemes are officially in use either by retailers or food service industries, schemes initiated by public institutes are currently under development or in a testing phase (French, Dutch, Danish Climate label initiative and IGD (informing DEFRA, UK).

While most LCA-based ecolabelling schemes have been established relatively recently, starting from 2018, there are three pioneering private schemes that began earlier, dating back to 2008. HowGood was founded in 2007 as a food database before evolving into a labelling system. Eaternity started as an association in 2008 and transitioned into a company in 2014, and Beelong was launched in 2014. The French Initiative, ADEME has been working on environmental labelling since 2010.

The general finding illustrates that public institutions take a more cautious and phased approach to developing LCA-based ecolabelling. In contrast, private schemes respond to market trends and demands more swiftly, already offering ready-made solutions on LCA-based ecolabelling but often with less robust methodologies.

Table 4.1 gives a summary overview on the generic and governance information about the schemes.

Table 4.1 *Summary overview – Generic and governance information about the schemes.*

Criteria	**France inititave, ADEME (Ecobalyse)**	**Eco-score (Working with Yuka and Open foodfacts)**	**Planet-score**	**Inoqo**	**Beelong (Eco-score)**	**Eaternity**	**Foundation Earth (Ecoimpact)**	**IGD (Independent charity informing DEFRA)**	**Enviroscore**
Country of origin	France	France	France	Austria	Switzerland	Switzerland	UK and Spain.	UK	Spain and Belgium
The year of initiation	In 2020 official rollout (Development since 2010)	2021	2020	2020	2014	2008 Association (2014 Company)	2021	2021	2018
Country of application	In France (Developed and currently tested)	France, Belgium and Luxemburg.	Developed in France. Currently operational in 12 EU countries.	Europewide through brand customers. - Norway (Oda) - Switzerland (Migros) - NL (Albert Heijn, ImpactBuying) - Germany	Actively operational in Switzerland, currently being tested in Australia and Germany	Austria, Belgium, Czech, Germany, Liechtenstein, Netherlands, Switzerland, UK, USA, Brazil, Luxemburg	Currently working with companies around Europe,	In UK	In Europe
The regions where the scheme can be applied/scaled up? *(Governance)*	Currently applied only for French products, including imported products consumed in France. Scalable depending on: political choices and available data (Agribalyse data).	Currently applied in France, Belgium, and Luxemburg. Scalable to other EU and non-EU countries.	Yes, EU and worldwide	Yes, Worldwide	Applicable and adaptable worldwide.	Scalable worldwide. Yet most of database research was done for Switzerland, Germany and UK.	Scalable worldwide	UK based. Working on international harmonisation.	Europe
Current Status and Operationality of the ecolabel	Under development and consumer testing by (550) real products	Officially in use by 'Colruyt Group', using it in Belgium, France and Luxemburg. Carrefour has piloted also in France. Temporarily Piloted in Lidl stores in 6 countries.	Officially in use since 2022: 300 brands at work, 150 communicating by digital means.	Officially in use and operational by brands and retailers	Officially in use and operational by restaurants, retail (Coop) and brands.	Officially in use and operational by retailers and brands. Also catering organisations such as Sodexo and Compass	F2F beta methodology Officially in use and operational since March 2023	Under development with consumer testing started	Methodology is operational but not yet implemented. (Testing in EU since 2021)

Criteria	France inititave, ADEME (Ecobalyse)	Eco-score (Working with Yuka and Open foodfacts)	Planet-score	Inoqo	Beelong (Eco-score)	Eaternity	Foundation Earth (Ecoimpact)	IGD (Independent charity informing DEFRA)	Enviroscore
Stakeholders involved *(Governance)*	Public /Private Stakeholder input- decision making process under ADEME and ministry. + Independent scientific council.	Public Private industry partnerships. The methodology is being developed by a French independent consortium and other private parties.	Inputs and collective design and works with scientists and experts (agronomy, ecology, biodiversity experts, climate experts…) + consumer associations + NGOs (environment + animal welfare). See website for more info: www.planet-score.org	The Inoqo PIA Methodology was initially developed by Inoqo, a co-initiator of the European Sustainable Food Coalition (ESFC). EFSC coalition involves multiples stakeholders from retailers to NGO's.	Partnerships with LCA companies and individual experts, as well as with local universities	Private industry partnerships	FE has a holistic governance structure. Industry Advisory Group provides expert stakeholder input from industry on an advisory basis. Independent Scientific Committee has decision making power. on scientific matters. The FE Board of Directors holds authority over commercially sensitive matters	Decision making led by IGD and Steering Group formed of 15 organisations: leading UK retailers, brands, manufacturers, Department for Environment & Rural Affairs, WRAP Wider consultation: 100+ organisations from industry, government and compliance, academia, NGOs and charities, trade associations, other schemes & data providers	Research centres and Public and Private institutions
Custom made application	No	No	No, all products are assessed on the same basis and the same methodology.	Partly. LCA methodology and impact assessment is fixed to ensure standardisation. Only possible in labelling design.	No. Striving to have harmonised system.	Partly: Benchmark and Rating cannot be adjusted. The choice of labels / indicators can.	No	No. (One method for all)	No
Use of label and /or score as part of Scope 3 reporting and/or CSRD	No	No	The Climate value in Planet-score assessment is used by companies to monitor their progress relating to climate critical issues in the food sector. The Climate value in Planet-score assessment is broader than scope 3 (not only additional flows, but also climate value of permanent pastures for instance).	Yes, also used as part of Scope 3 reporting purposes of food retailers.	No	Yes. Offers Scope 3 reporting for food manufacturers, retailers and restaurants.	No	The methodology & data used is under development, but the intention is to allow a level of consistency between Scope 3 reporting and environmental labelling	No

Criteria	Dayrize	Dutch ecolabelling initiative	HowGood	Mondra	CarbonCloud	M-check	Danish Climate Label Initiative
Country of origin	NL	NL	US	UK	Sweden	Switzerland	Denmark
The year of initiation	2020	2019	2007 (Food Database)	In 2020 Mondra was founded. The initiative 'BRC Mondra Coalition' was founded in 2022.	2019	2021	2022
Country of application	In US, NL	In NL	US, EU, UK and Latin America	in UK (planning/willing to scale into Europe)	Customers in Sweden, UK, USA, Spain, Slovenia, Singapore, Korea, Norway, New Zealand, Netherlands, Latvia, Italy, Israel, Ireland, Greece, Germany, Denmark, Canada and Australia	In Switzerland	Will be possible in Denmark. Yet it is not currently ready for testing.
The regions where the scheme can be applied/scaled up? *(Governance)*	Applicable worldwide.	NL. (Approach can be applied in EU or worldwide)	Scalable worldwide	Primarily UK based but they are already modelling using the same standard in Australia, New Zealand, a variety of European produced products and some in Asia.	Yes scalable worldwide.	Yes, scalable by the consultancy Migros works with.	Denmark
Current Status and Operationality of the ecolabel	Pilot testing & implementation at retailers.	Under development	Officially in use and operational by retailers, brands, food service industry, and suppliers.	In use and operational with most of UK Retailers that signed up in the coalition. Focus is on carbon currently.	Officially Operational for Product companies, such as Oatly and Tenzing, and retailers/ wholesalers, such as Menigo.	Officially in use and operational within Migros stores in Switzerland. Currently only online for all private label products. On pack they will have it on all the packaging by 2025.	Under development
Stakeholders involved *(Governance)*	Ethical Investor, Private Investments, Private industry partnerships	Public and private. Stakeholder input, decision making process	Private industry partnerships	Public and Private industry partnership and retailer coalition. Technical alignment committee includes DEFRA UK.	Private. Actors in the food and beverage industry who want to assess their products. For transparency we publish our methodology and our data on ClimateHub.	Private partnership with three LCA consultant companies 'Intep, Treeze and MyClimate (for verification of results) and University Research institute for Animal welfare.	Public /Private Stakeholder input, decision making process
Custom made application	Yes	No	Yes, but only on contract for specified products	No. Collectively as a Coalition amends can be made to the LCA Methodology. Individually this is not possible at this time, all modelling is completed to the same exact standard.	The system cannot be customised in order to keep the harmonisation.	n/a	No
Use of label/Score as part of the Scope 3 reporting and/or CSRD	Scope 3 reporting in general: Yes. CSRD: under development	No	Yes, possible	Yes, used as part of purpose for scope 3 reporting and CSRD initiative.	Yes, CSRD and SBTI compliant.	Yes, Scope 3, Category 1 is calculated on the M-Check values.	No

4.3 Governance of LCA-based ecolabelling schemes

It is important to analyse the governance of LCA-based ecolabelling as it can influence the transparency, harmonisation, flexibility and funding opportunities. Among the LCA-based ecolabelling schemes, we identified three types of schemes in terms of governance and ownership. We attained these insights both through analysis of transparency and disclosure tendencies in methodology among the ecolabelling schemes and supporting literatures by Garcia-Torea et al. (2017); Klintman (2016); and Minkov et al. (2020). Figure 4.1 in Section 4.4.4 also illustrates the proximity of each initiative to either public or private governance and ownership.

Private (for profit) Schemes:
These are developed and managed by private companies or industry groups. The methodologies and data sources used for labelling are not always disclosed openly, which can make it difficult for consumers and other stakeholders to assess their credibility and reliability. Private schemes often respond to the market and consumer needs rapidly and offer efficient and innovative solutions to product environmental impacts. These schemes tend to operate independently, with little effort to harmonise with other existing developments or standards. This can lead to a fragmented market with varying standards and criteria, making it challenging for consumers to compare products across different labels. While they can be innovative and quickly adaptable to market demands, their proprietary nature can limit broader acceptance and integration.

National (Public) Schemes:
These schemes are spearheaded by national governments or governmental agencies. National schemes are usually very transparent. They often follow rigorous, publicly disclosed methodologies and standards, which enhances their credibility and trust among consumers and stakeholders. Because they have the authority to make their methodology mandatory, they can prevent proliferation in their own country, but not internationally. The success and continuity of these schemes heavily rely on political support. Changes in government or political priorities can significantly impact their funding and implementation. High demand for national funding is a common trait. These schemes require substantial investment from the government, which can be a barrier and cause slow progress, especially in times of economic constraints or shifting political landscapes.

Non-profit Schemes:
These are driven by non-profit organisations, often with a mission to promote sustainability and environmental responsibility. Non-profit schemes tend to be very transparent. They usually publish their methodologies, data sources, and criteria openly, fostering trust and credibility. Execution and technical support often depend on third parties, such as academic institutions, research organisations, or technical consultants. This reliance can be both a strength and a weakness, as it brings in expertise but can also introduce dependencies. Securing funding is a significant challenge. Non-profits typically rely on grants, donations, and other forms of external funding, which can be unpredictable and limited. This financial instability can impact the sustainability and scalability of their schemes.

4.3.1 Stakeholders involved in the decision making process of the scheme

When it comes to decision making process, the analysis shows that public schemes are following a public private partnership approach, while most private schemes are involving mostly private actors and institutions in their decision making process. While most public schemes' main motive is to establish a harmonised methodology, private schemes are mainly responding to the demands of the market and consumers (i.e., CSRD, Scope 3 emissions, etc.) trying to identify a business model.

4.3.2 (Third party) Verification of the data

Third party verification of data used during LCA of a product is crucial to reach to credible, comparable and transparent results. For secondary data, public schemes that are based on PEF framework use already verified and peer reviewed secondary databases, while private schemes that rely on multiple data sources (including literature sources) state that their data is also usually verified by a third party but it is not always clear how exactly. There are two schemes that did not indicate any third party verification on their secondary data, but they did indicate third party verification on their LCA methodology and calculations.

For primary data, most schemes typically do not apply a third-party verification process. It is deemed to be impossible due to confidentiality and law of competition and most importantly due to associated costs involved. On the other hand, many schemes indicate that they have an internal validation and review process when it comes to primary data. Foundation Earth has some of the most specific requirements for primary data and a quality assessment template where the LCA provider that supports companies in scoring their products, collects and verifies the primary data in accordance with these rules (Foundation Earth Methodology, 2023).

The lack of proper (third party) assurance is something to be addressed in the future, as including company specific data will become more relevant and essential in making differentiation within the product categories. The fact CSRD requires limited assurance for Scope 3 reporting, and reasonable assurance from 2028 onwards, means that all companies that need to report for CSRD will have some assurance for at least GHG Scope 3 data. Accordingly, some EU member states might expand the scope and requirements of CSRD as they transpose it into local law. This development would contribute to the credibility of both the secondary and the primary data.

4.3.3 Can the scheme be applied and scaled up in other countries?

In terms of scalability for a wider implementation, all the private schemes and most public schemes are scalable worldwide, meaning the method and database are adaptable to be used in other countries with adjustments to country-specific datasets.

4.4 Methodological choices applied by LCA-based ecolabelling schemes

4.4.1 System Boundary

The system boundary defines which life cycle stages are analysed. It is important to define and apply a consistent system boundary to define the scope of the product footprint analysis, to focus on the most relevant processes and to enable comparability.

Some LCA methodologies such as PEF state that all life cycle stages from raw materials up until the end-of-life treatment of a product must be included. For other LCA methodologies such as ISO or GHG protocol, system boundaries of an LCA depend on the subject and the intended use of the study, thus it is more flexible in application. For use by consumers, the full life cycle is relevant but also most challenging.

8 out of 16 LCA-based ecolabelling schemes (which are to a greater or lesser extent PEF based) apply a ‘Cradle to grave’ system boundary, the rest of the schemes (which are either ISO or GHG protocol based) predominantly apply ‘Cradle to fork’ or ‘Cradle to retail’. Only one scheme (HowGood) offers the option explicitly to apply a different system boundary according to the client’s demands and needs but others offer this service next to their standard methodology for special purposes (such as Scope 3 GHG). See Table 4.2 for more details.

4.4.2 Functional unit

The Functional Unit (FU) is defined by specifying the function provided by the product, including the quantity, quality, and duration of this function. The discussion around the functional unit in LCA-based ecolabelling centres on its critical role in ensuring consistency and comparability of results. All input and output flows in the analysis are linked to the specified FU. However, some products or product groups can serve multiple functions, making it challenging to define a single FU. Food intake functions range from supplying basic energy/nutrients to fulfilling social or cultural roles. Due to overconsumption, food intake extends beyond meeting nutritional requirements. This broad range of functions complicates the definition of a single FU. (Foundation Earth Methodology, 2023).

This broad range of considerations is also visible in the different adoptions of FU by different schemes.

The analysis shows that PEF based schemes (PEF recommends applying a declared unit, such as mass or volume) are applying commonly the functional unit of '1 kg of consumed food product', but the French government also considers to have a functional unit by 'selling unit'. In most cases this excludes the inedible parts of the product and the weight that is lost when preparing (such as water lost during cooking).

ISO and GHG protocol based schemes commonly use the functional unit '1kg of food products sold in the shops'. There are, on the other hand, schemes that use other types of FUs, either related to 'Daily calorie intake in kcal' (Beelong), or Daily food unit (Eaternity), according to the 'production system scale' (Planet-score) or according to the planetary boundaries such as 'Daily planetary limits' (IGD).

Eaternity uses the 'Daily food unit' as the functional unit. 'Daily food unit' is a standardised measure to assess the environmental impact of food items based on their contribution to a balanced diet over a single day. It reflects the amount of a specific food required to fulfill a percentage of an average daily nutritional need, based on dietary guidelines. This method allows the rating system to be applied to different food portions, such as buffets, side dishes, and snacks, making it suitable for diverse businesses and enabling a more accurate comparison across restaurants. Previously, Eaternity normalised ratings either by weight or caloric content, but this led to biased results: water-rich foods appeared more favourable when measured by weight, while high-fat foods scored better based on caloric content. In this regard, Eaternity acknowledges the need to balance these factors to better reflect the nutritional and environmental value of food items.

In the case of Beelong, instead of 1 kg of product, they weigh the ingredients depending on their contribution to the total daily average kcal intake. This functional unit focuses on the energy provided by food, aligning with how food contributes to daily nutritional needs. It emphasises the efficiency of foods in providing energy relative to their carbon footprint. In this case, however, there may be a risk that high-calorie foods may have a lower carbon footprint per calorie, even if they have a higher footprint per kilogram. Most people eat already too many of some (less healthy) nutrients so ideally you would not optimise per calory but only per (healthy) nutrients that the average consumer is lacking. It is hard to define such a unit, however.

Planet-score on the other hand uses 'Production system scale' in addition to the functional unit of mass. In the end the environmental impact is expressed per kg of mass but through a bonus/malus system that takes the full production system into account, they can reward extensive systems that can deliver positive regional externalities. They reason this in particular in calculation of the biodiversity impact category. Planet-score contends that biodiversity should be assessed based on surface area rather than mass, as it cannot conceptually or practically be related to kilograms. Only using a mass-based unit could lead to unintended negative consequences, such as justifying an accounting improvement in biodiversity by increasing the use of pesticides, resulting in a proportionately higher increase in yield. More broadly, they argue that the implications of choosing an exclusive mass-based functional unit to reflect the environmental value of agri-food production should be approached with great caution.

Table 4.2 *Overview of basic LCA methodological choices applied by each scheme.*

Scheme	LCA methodology	System boundary	Functional Unit	Comparability both within and between product categories.
France initiative, ADEME (Ecobalyse)	PEF-based with adaptations	Cradle to grave, except food losses at consumer home	Under development - probably the environmental score will be expressed per portion sold AND per 100 g	Yes
Eco-score (Working with Yuka and Open foodfacts)	PEF-based with adaptations	Cradle to grave, except food losses at consumer home	1 kg of consumed product	Yes
Planet-score	PEF-based database, Agribalyse is used (yet very strong adaptations made in final score)	Cradle to grave, except food losses at consumer home	1 kg of food product taken differences in production systems into account.	Yes
Inoqo	ISO standards (PEF elements are integrated where possible)	Cradle to grave (Currently excluding user stage)	1 kg of food product sold in the shops.	Yes
Beelong (Eco-score)	PEF-based with strong adaptations	Cradle to retail	1kcal (The ingredients weighted depending on their contribution to the total kcal, and the exact recipe (ingredient list + ingredient %) of the final product	Yes
Eaternity	ISO standards	Cradle to retail	Daily Food unit	Yes
Foundation Earth (Ecoimpact)	PEF-based (deviations made only to enable comparisons across product categories)	Cradle to grave	1 kg of consumed product	Yes
IGD (Independent charity informing DEFRA)	ISO standards (PEF used for weighting)	Cradle to fork (with cradle to grave included for packaging)	Daily Planetary Limit in 100 gr of product (under review)	Yes
Enviroscore	PEF-based (Closest to be PEF compliant compared to others though adaptations made on normalisation and toxicity indicators)	Cradle to grave	1 kg of consumed product.	Yes
Dayrize	ISO and GHG compliant	Cradle to factory gate. Retail, use phase and end-of-life (e.g., recycling) are not included in LCA-based indicators, EOL is reflected in Circularity theme.	Either/or: 1 kg of product in the shops or 1 retail unit	Yes, but limited
Dutch ecolabelling initiative	PEF-based	Cradle to grave	1 kg of consumed product	Yes
HowGood	ISO and GHG Protocol compliant.	Cradle to grave (depending on client request)	1 kg of food product in the shops.	Yes
Mondra	ISO standard based	Currently modelling is limited to cradle-to-factory-gate, with option to enable cradle-to-retail. Cradle-to-grave is in development, due year end '24.	1 kg of the unprocessed produce at farm-gate 1 kg live weight for meat and fish at farm-gate 1 kg of food product - in the shops (if the system boundary is cradle to retail)	Yes
CarbonCloud	ISO and GHG protocol	Farm to store shelf (no user phase and waste treatment)	1 kg of product on store shelf for consumer products.	Yes
M-check	ISO standard based	Cradle to packaging	1 kg of food product in the shops.	Yes
Danish Climate Label initiative	PEF-based with adaptations (only climate indicator)	Cradle to retail	1 kg of food product sold in Denmark market	Yes

As the Table 4.2 above also shows, comparability both within and between the product categories is possible with all the LCA-based ecolabelling schemes. The Danish government is the only one that considers two labels: one fully based on product category averages, allowing for comparisons between categories, and another where producers provide detailed primary data, enabling comparisons within a category.

4.4.3 LCA methodologies used

Life Cycle Assessment (LCA) of a product adheres to several standards to ensure consistency, reliability, and accuracy in evaluating the environmental impacts. Pre-dominantly, the primary standards applied in LCA are: ISO 14040-44, GHG protocol, PAS 2050 and Product Environmental Footprint (PEF) and/or Product Environmental Footprint Category Rules (PEFCR's).

Among the schemes assessed, while most government (Public) schemes are heavily influenced by PEF, private ones are mostly based on ISO and/or GHG protocol standards. There are also non-profit and charity-based organisations that use some of the elements from PEF, but not on a large scale (such as IGD, Eco-score and Planet-score). Based on this analysis, we drafted Figure 4.1 to visualise the different LCA standards applied and adopted by both public and private schemes. In some cases, it was challenging to categorise a few schemes on their LCA methodology, in particular the approach of Planet-Score uses. Their LCA methodology is not entirely clear on whether it is a PEF-based or ISO-based approach. The scheme uses a PEF-based database Agribalyse, yet applies strong adaptations and adjustments towards final score and labelling.

4.4.4 Role and application of PEF among schemes

Different standards are applied in the product LCA method, varying in their for the LCI process, system boundary, allocation, and impact assessment methods. PEF provides the most complete methodological guidelines to conduct an LCA (European Commission, 2021).

The PEF initiative, established by the European Commission, aims to standardise the assessment of environmental impacts of products throughout their life cycle using the principles of LCA (LCA).

In the Table 4.2 above we present how each scheme applies PEF or not. We see that each scheme differs in the way it applies the PEF principles.

We employ 'PEF-based' categorisation in the following way: schemes that primarily follow the main guidelines of PEF but adapt certain requirements to address its limitations (such as human toxicity indicators and weighting) and to meet specific consumer and market demands. Conversely, some private schemes incorporate only select elements from PEF, such as weighting.

Adoption of PEF varies across public and private schemes. Public ecolabelling schemes are mainly PEF based with some adaptations. However, some schemes, such as Enviroscore, are closer to being PEF compliant compared to other public schemes. We see that non-profit or charity-based private organisations do get inspiration and use some of the elements from PEF framework. Out of 16 schemes, 9 are PEF based with adaptations.

Most (profit based) schemes follow the ISO or GHG protocol in their LCA methodology. Given the current limitations of PEF, as well as the focus and pressure on companies and retailers for CSRD and SBTI Scope 3 GHG reporting, private schemes currently largely shy away from fully adopting PEF. Due to CSRD and SBTi obligations, many retailers also do not have the ambition to communicate the sustainability of their products separately. However, it is also noted by many private LCA-based schemes that in case PEF becomes mandatory method within Europe, they have the capacity to adopt it swiftly. It is questionable, however, if this change in methodology could be made as easy as they suggest.

Figure 4.1 illustrates the positioning and proximity of each scheme in terms of its governance structure (public vs. private (including profit and non-profit) and to either the PEF-based or ISO and GHG Protocol methodologies.

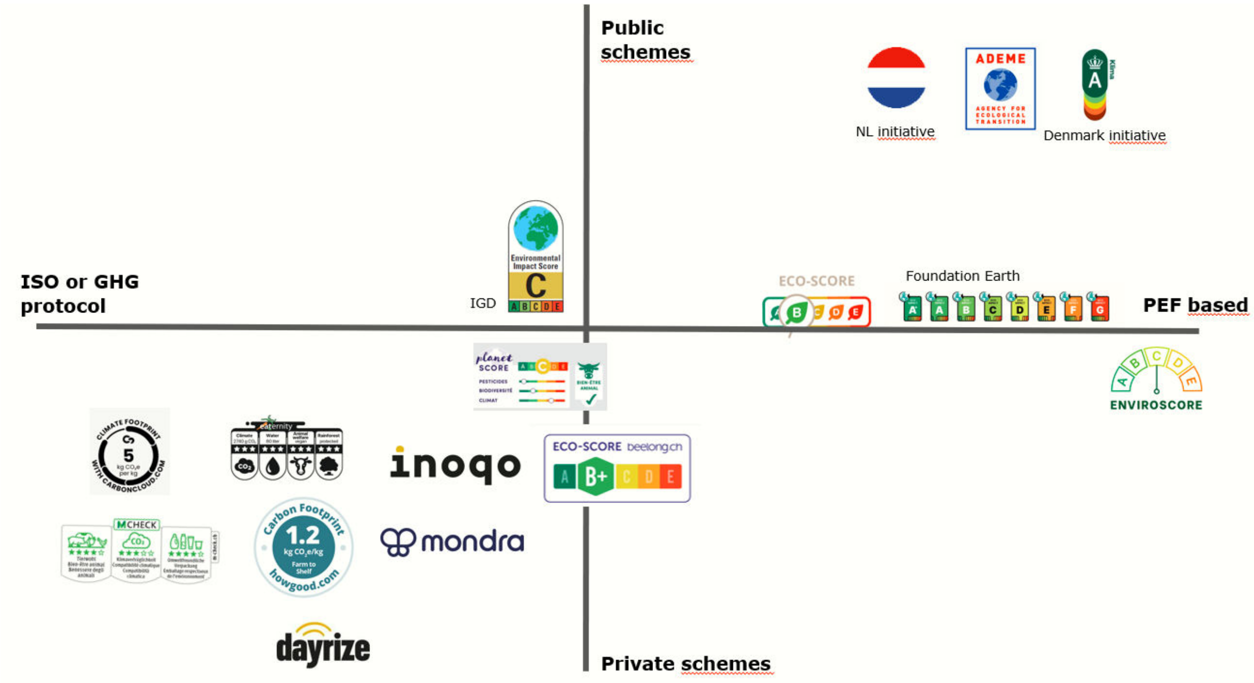

Figure 4.1 *Positioning of each scheme in terms of governance/ownership and use of LCA methodology.*

4.4.5 Impact assessment methods

The public schemes that are PEF-based or PEF compliant dominantly consider all the 16 PEF indicators and apply the impact assessment method required and recommended by PEF (LCIA EF method). However, several of them make adaptations on weighting or normalisation factors (such as French, Eco-score and Enviroscore).

The Climate/Carbon impact category is one of the most commonly assessed areas in both public and private schemes. Most schemes rely on the IPCC 2013 or 2019 guidelines for calculating the carbon footprint. For other impact categories, private schemes utilize a variety of impact assessment methods, reflecting a less harmonized approach compared to that of public schemes.

A particular critical discussion point on the impact assessment is the impact of pesticide use. Pesticide use poses a major environmental challenge in agricultural products and food Life Cycle Assessment (LCA) studies. It is a key driver of eco and human toxicity impacts, with both organic and inorganic (including metal) pesticides contributing to the problem. Current LCA methods and Life Cycle Inventory (LCI) databases, such as the Environmental Footprint (EF) method, often lack accuracy and consistency in pesticide modelling, leading to debated toxicity impact assessments. Accurate consideration of pesticides in LCA methods, such as PEF, is therefore critical (Fantke, 2019).

In this aspect (as will be discussed in the chapter on impact categories), some schemes are adjusting or developing new ways of assessing the impact of pesticide use related to toxicity indicators.

4.4.6 The role of data and databases

Data and databases play a crucial role in achieving credible Life Cycle Assessments (LCA) for agri-food products. They should be able to provide an accurate baseline, contextual information (regional practices, climatic conditions,.etc), ensuring consistency and comparability with standard modelling and methodology.

Most schemes use a combination of primary and secondary data. Public schemes that follow PEF principles adhere to PEF guidelines in selecting recommended databases as secondary data sources.

The French government has started the development of LCA-based ecolabels by developing the Agribalyse database. They asked several parties to conduct ecolabel experiments that, for example, resulted in Planet-score and Eco-score. After that, many more schemes and other approaches were introduced to the LCA-based ecolabelling. The first ecolabels that were initiated by public institutions are mainly based on EU PEF and French Agribalyse databases. New private ecolabels develop their own methodologies and private databases although several of them use elements of Agribalyse and the default approach for the final life cycle stages (e.g. retail, distribution, end-of-life as described in the PEF guidance. Private ecolabelling schemes rarely rely heavily on PEF, attributing this to the lack of client demand for PEF-based methodologies. This is because PEF is not the mandatory framework within Europe for scope 3 GHG (CSRD) reporting, which is where most client focus currently lies. CSRD does not demand a PEF-based methodology (although it is allowed) and follows the GHG protocol that can also be used for SBTI reporting. The GHG protocol is far less strict than PEF, and thus easier to apply. Some of the most commonly used databases include Ecoinvent, Agri-Footprint, World Food LCA database and HESTIA.

Most schemes are scalable worldwide using country-specific datasets for yields, electricity mix etc. In some cases averages are used for large parts of the world (e.g. rest of EU, rest of the world, in addition to some data for specific countries). Most private schemes develop their own ingredient-level databases, whereas public schemes depend on existing PEF-aligned databases (such as Agribalyse) to build average country datasets at product level.

The integration of primary data varies, ranging from only easily available variables that are already available at retail level to performing nearly a full LCA (see Section 4.4.7).

4.4.7 Primary data integration

Primary data integration within the LCA model is important to make product differentiation within product categories possible.

Currently, some tools require a minimum number of primary data so that average score of the database can be adapted to a specific product. Most tools also aim to include more detailed primary data (e.g., on cultivation and animal husbandry) if available, but this is not a requirement and is in most cases not yet possible or not on a large scale. Some tools also have procedures to estimate primary data. The quantity of ingredients is estimated, for example, based on nutritional information, quantities used in similar products and the order in which ingredients are listed on the label. Country of production is estimated based on average production in that country and average imports and exports to that particular country (or region). In these cases estimates of environmental impact can be made with no other information than just a product name and the on-pack information. There are many different types of primary data with different administrative burdens when it comes to gathering the data. It is important to identify which primary data can be integrated in which life cycle stage in order to substantiate the impact assessment results and differentiation within the product categories.

Ultimately, there are two levels at which primary data can affect the calculation:
1. Primary data which change the way the LCA is done, leading to a new outcome of the LCA, and
2. Primary data which are used to change the outcome of the LCA via bonus/malus or complementary points.

With respect to the first type of primary data integration, 12 out of 16 LCA-based Ecolabelling schemes have the feature to integrate primary data within the LCA model. Among PEF-compliant schemes, Foundation Earth for example have categorised which data should be primary and secondary according to the PEF framework, and the circle of influence of the company doing the assessment. Foundation Earth and Enviroscore are most demanding on the primary data that must be available. Their methodology is quite close to performing a full PEF-compliant LCA. It leads to a very precise score but is also demanding for companies and therefore far more difficult to apply for a retailer on a large scale.

The methodology of the Danish government's initiative on climate labels, for example, requires the use of EF-compliant datasets, incorporating crop type-specific and country/region/climate-specific foreground data.

This includes yield, water, land use, and land use change and pesticide amount (per active ingredient), and per hectare per year. For other PEF-based schemes and other private schemes that follow the ISO or GHG protocol, the most commonly used primary data at processing level are: ingredient list and amount, packaging material and amount, and country of origin of the ingredients. These primary data are in most cases already available for all private label products in the databases of retailers. If not, they can either be provided by the producer or obtained from the packaging info on the product.

With respect to the second type primary data integration, six out of sixteen schemes use a bonus-malus or complementary approach. They integrate specific primary data from the producer/supplier to change the outcome of the LCA score through bonus or malus (+-) points or through complementary points (+). The most commonly used additional indicators as primary data are: production types and farming practices (organic vs conventional), certifications (organic, fair trade, animal welfare friendly), seasonality, packaging type, fishing method, and circularity. For example, HowGood, and Eco-score where available, use product certifications as additional data for bonus malus approach.

Smart ways of including primary and secondary data

As described before, some schemes use product data that are already available with nearly all retailers such as ingredients, packaging material and country of production to make an estimate of the environmental impact. Others such as the French government use GIS databases that indicate the average number of hedges and other landscape elements, average plot size and diversity in crops per agricultural product, both for conventional and organic. Just based on the 'primary' information which agricultural ingredient is used in the product and the fact if a product is organic or not, a biodiversity score can be calculated. Several schemes are investigating the possibility of growing availability of GIS (satellite) data and the (estimated) origin of ingredients to make better estimates of deforestation, water scarcity, biodiversity, soil quality etc.

Mondra investigates opportunities to cooperate with companies that assemble farm level data for hundreds of thousands of farms all over the world. If the country (or even region) of agricultural production is known or can be estimated in a reliable way, the use of this primary farm data can lead to more reliable results.

Some schemes have developed innovative methods to incentivise companies to provide more specific data. For instance, Inoqo assigns a 'lower than average' score to products that lacks transparency or fail to report necessary information. This approach indeed incentivises the use of more primary data; however, its divergence from PEF methodology introduces complexities. Custom calibrations may require extensive data, and if secondary data are penalised too heavily compared to primary data, ecolabel scores might reflect 'data quality' rather than the true environmental impact of products. This could also create biases, favouring larger companies with advanced data management capabilities over smaller stakeholders. Further testing is essential to address these issues effectively.

There are also opportunities where we see that primary data can be taken from existing data exchange platforms such as GS1. GS1 is a global, non-profit organisation that develops and maintains standards for supply chain communication. Such platforms are essential for ensuring that products can be accurately identified, tracked, and managed as they move through supply chains. Thus, GS1can be a powerful platform for sharing primary data on the agrifood value chain. For instance, GS1 Benelux included the necessary primary variables for Ecoscore into their scheme at the request of Colruyt.

4.4.8 Product or ingredient level database

Ecolabels that use food product databases, use secondary LCA scores for the entire life cycle of food products as sold to consumers. Ecoscore, for example, uses the Agribalyse database that includes scores for 3,000 food products. A product gets the score of the typical generic product that is most close to their product in the database and is then corrected via bonus-malus, based on primary information around packaging and traditional labels. Differences in the (amount of) ingredients with this typical product are not taken into account. For single ingredient products this does not make a difference but for product categories with many ingredients such as ready-made meals this can make a big difference. In addition to the ingredients, other instances where differences can be seen between products of the same product category are not considered (e.g. packaging materials, farm parameters etc.).

Ecolabels that use ingredient databases start with the amounts of raw or minimally processed ingredients. If the real amounts of ingredients are available, they can take that into account and make a more precise calculation than the ecolabels using a food product database. If the amounts are not available, however, they need to make an estimate of these amounts (see Section 3.3.7). In addition to the amount of ingredients, they can take other primary information into account, such as the country of production of the ingredients, using country-specific secondary LCA data on farm/ingredient level. For country of processing and country of sales they can take account of differences in energy grid in these countries and based on all these locations, they can make a better estimate of transport distances and modules. As most retailers have databases with ingredient amounts and country of production, processing and sales readily available for at least all their private label products, this is an easy way to make calculations more precise, differentiating between products within a specific product category. It also means that assumptions need to be made about the (impact of) needed processing steps, the amount of ingredients that are needed in these processes to end up with a certain amount in the final product (taken into account change in water % etc.) and composed ingredients need to be split up in sub-ingredients. The variety of ingredients and country of production is enormous. This means that in many cases no specific data for an ingredient is available in the database and assumptions need to be made about an ingredient that might have similar impacts. In this way the full supply chains is modelled as a detailed digital twin.

For ingredient databases, for farm level all information about yields, use of fertilisers and pesticides and energy use are in the model and can be updated, for instance based on yearly updates of statistics such as FAO trade data and FAO crop data and FertiStata. If the model is set up in a smart way, all elements in the model can be replaced by primary data to make the calculation even more precise. Although this is the long-term vision of many of the ecolabels, most of them have not implemented this in such a way that primary data of large amounts of products can be as easily integrated in the models as ingredient information and country of production. Some tools such as Carbon Cloud already have the opportunity for suppliers to also adapt these types of variables manually on their platform.

The French government has developed a food product database. They have also built a tool, Ecobalyse, that can take account of differences in ingredients, transport, how the food is prepared and stored, etc. Ecobalyse uses the ingredients and other processes available in Agribalyse. It does however not have a global coverage of production countries but only includes the major import countries for France that were used to calculate the country average in the Agribalyse database. All private schemes that are for profit (7 out of 16 schemes) are offering ingredient level databases. The rest of the schemes are either only offering a methodology without a secondary database or have not (yet) built their own database (Foundation Earth, Danish climate label initiative, and Enviroscore).

4.4.9 Granularity of the databases and Regional coverage of the database

With this criteria item, we aimed to find out the size of the databases offered by the schemes in terms of number of products and ingredient datasets for which country or countries. The more granular a database is, the more differentiation can be made both within and between the product categories. The national schemes currently offer databases that represent only the national average datasets, differentiating only in production data for the most important import countries used to calculate the country average.

Many private schemes, on the other hand, already offer ingredient level databases with worldwide coverage. Inoqo, Carbon Cloud and Mondra (Scalable worldwide) offer ingredient level datasets. Inoqo indicates that their database encompasses data for over 160 primary crops found in around 200 territories, resulting in over 9,000 country-specific values for agricultural products alone. We did not get a good indication however how many countries really have a separate value in these databases. For crops, several ecolabels use yields of FAO that are available for nearly 160 crops and 200 countries and regularly updated. It is possible however that for other (animal based or rare) ingredients and variables the same value is used for many countries (a rest of the world score).

4.4.10 Impact categories and inclusion of non-LCA and non-environmental indicators

The ecolabels evaluated differ in the indicators used in their impact assessments, which can influence the final scores and potentially impact consumer purchasing decisions based on the weight given to specific indicators.

- All labels incorporate climate impact on their label. After climate most commonly used impact categories are water and land use.
- PEF based schemes are including either all or selected/adjusted list of PEF indicators and they are consistent in using the recommended EF impact assessment methods.
- ISO based schemes vary in the selection of impact categories and impact assessment methods.

Often, LCA-based environmental categories are considered as not sufficient to evaluate and score the products for their sustainability (See Section 1.4.1 on Green Claims initiative reference). Thus, many schemes include adaptations and/or (social and environmental) additions to provide a more comprehensive assessment for sustainability and to respond to consumer appreciation and demands (Teufer et al., 2023). This viewpoint finds support in Howard's (2006) study, which revealed that many individuals struggle to pinpoint the most crucial attributes associated with food production (such as environmental impact, animal welfare, local sourcing, fair compensation for farmers, etc.) and express a preference for food that satisfies all these criteria (Teufer et al., 2023).

The Life Cycle Assessment (LCA) methodological framework has limitations, particularly in its ability to account for certain impacts related to for example biodiversity. While major causes of biodiversity loss, such as climate and land use (changes), are addressed in LCA, other factors such as agricultural management practices delivering ecosystem services are inadequately considered. Failure to account for these 'local' factors can affect environmental impact calculations, potentially penalising certain production systems. Thus, it is found necessary by some of the ecolabelling schemes to adjust or supplement the current LCA framework to better incorporate these factors.

PEF-based private (NGO or charity) tend not to consider all the 16 impact categories but they select only the most relevant impact categories and apply their own developed weighting and normalisation factors to come to a final or aggregated score. In this aspect, IGD, for example, uses planetary boundaries to determine the impact categories. IGD identifies which impact categories directly relate to the various planetary boundaries, such as climate change, biodiversity loss, land-use change, and freshwater use. Categories that align closely with planetary boundaries that are currently most at risk would be included as an impact category.

Among public schemes that are PEF based and consider all 16 PEF indicators, one of the commonly applied adaptations is done in particular on the toxicity indicators related to use of pesticides. In relation to this, some schemes either adapt or completely remove the human toxicity indicators among the 16 PEF schemes (French Government Initiative, Enviroscore and Planet-score). These schemes either dismissed and/or adapted the weightings of the impact categories related to toxicity (human toxicity cancer and non-cancer effects, and ecotoxicity) due to the lack of robustness of the methodologies to calculate those impacts.

In the newly initiated private ecolabels we see that there is more tendency of including one or more social indicators either aggregated in the final score or presented as a separate score. While the most labels primarily emphasise ecological concerns, there is a trend towards the inclusion of an increasing number of social indicators in various schemes (pre-dominantly in private schemes). However, in many cases it is more of an ambition but has not yet been fully operationalised.

Many schemes in our analysis have also included one or more environmental indicators which are not thoroughly covered in LCA, as a supplementary indicator. These additional indicators are in many cases included using a bonus-malus approach or as complementary (plus points), as in Eco-score and the French initiative case. These additional indicators are usually related to non-LCA and social indicators. Analysis of the ecolabelling schemes shows that 80% of the them are including one or more non-LCA environmental indicators on top of the defined LCA-based environmental indicators. The most commonly included non-LCA-based environmental indicators are the biodiversity (rainforest), antibiotics, soil health, circularity, and seasonality. The most commonly used social indicators are animal welfare, social welfare, nutrition, human health, antibiotics and use of GMOs. Antibiotics are considered an environmental issues/indicator by some schemes, rather than a social indicator. We see that some schemes (i.e Eco-score, Planet-score) use the existing traditional labels and certifications (i.e fairtrade, sustainable fisheries, animal welfare) on products to include in their bonus-malus or complementary measures.

It should be noted that environmental impact assessments involve numerous decisions, such as determining which environmental impacts and life cycle stages are within scope, how to allocate impacts across multiple outputs (e.g., oilseeds yielding both protein meal and vegetable oil), and selecting approximations for hard-to-measure impacts. A key challenge is that methodologies and datasets are unevenly developed across different environmental factors. For example, some methodologies, such as the EU's Product Environmental Footprint (PEF), have been criticised for insufficiently capturing critical impacts such as soil carbon and on-farm biodiversity (Deconinck et al., 2023). However, when addressing these inefficiencies, it's essential to ensure that new risks/double counts are not unintentionally introduced.

Risk of double counting

It should also be taken into account that there is a risk of double counting when these additional environmental indicators are added on top of the LCA impact categories. For example, seasonality is already indirectly reflected in the LCA of agrifood products, as the cultivation method includes the water, energy and resource use differences during different seasons (although seasonality would be better reflected by having different scores per season instead of an average of the seasons). Another important point is that biodiversity is defined differently in LCA than in some other biodiversity assessment models. In LCA, biodiversity is assessed through a combination of impact categories that indirectly relate to biodiversity, such as land use, water use, and ecotoxicity. Land use is one of the primary ways biodiversity is impacted in LCA through which 'Potentially Disappeared Fraction' is calculated which estimates the fraction of species potentially lost due to a specific land use activity. Models such as USEtox (one of the PEF recommended impact assessment methods) are used to calculate the potential impacts of chemical emissions on aquatic and terrestrial ecosystems, which indirectly influence biodiversity. This also has some relevance and reflection on the soil health indicator. Also, methods such as AWARE (Available WAter Remaining, also one of PEF's recommended impact assessment methods) consider the relative scarcity of water in different regions and its potential impact on ecosystems. Thus, addition of environmental indicators on top of the existing LCA calculations should be taken with great caution to prevent double counting.

Table 4.3 *LCA, non-LCA and non-environmental (impact) categories applied by each scheme (some categories might still be in development).*

	Climate	Water	Land Use	Eutrophication	Additional environmental and non-LCA indicators	Social Indicators
French national initiative	16 PEF indicators (Adaptations made on toxicity indicators)				4 indicators incorporated for local biodiversity / ecosystem services and territorial resilience. Antibiotics is on the agenda	
Danish Climate label initiative	Climate only				No	No
Dutch national initiative	16 PEF indicators				Under development	Under development
Eco-score a) (Will be renamed)	16 PEF Indicators				Biodiversity, endangered species., packaging, transport, certifications	A number of labels used in the on top calculations include social parameters (such as fairtrade and the EU Euroleaf label)
Foundation Earth	16 PEF Indicators				No	No
Planet-score	12 LCA indicators (3 toxicity related indicators and water use removed)				13 non LCA indicators including, biodiversity, antibiotics, GMO, local products.	Animal welfare.
Enviroscore	13 out of 16 PEF indicators are considered (Removing toxicity indicators)				No	No
IGD (Informing DEFRA)	Yes	Yes	Yes	Yes	No	No
INOQO	Yes	No	No	No	Biodiversity, seasonality, locality, packaging.	Social welfare, animal welfare, nutrition.
Eco-Score Beelong	Yes	Yes	Yes	Ye	Biodiversity	Animal welfare.
Eaternity	Yes	Yes	No	No	Rainforest (Deforestation)	Animal welfare, Regionality (Regionality Rating and Label in progress), Health
Dayrize	Yes	Yes	Yes (via Biodiversity)	No	Circularity	Livelihoods and well-being. Under development: halth.
HowGood	Yes	Yes	Yes	No	Soil health, Biodiversity	Animal welfare, labour rights
Mondra	Yes	Yes	Yes	Yes	Biodiversity	None
Carbon Cloud	Yes	Yes a)	Yes a)	No	No	No
M-Check	Yes	No	No	No	Packaging, Sustainable fisheries, recyclability, circularity.	Animal welfare

a) CarbonCloud water and land use reported separately and still in development.

4.4.11 Data quality checks

Data quality assesses the condition of a specific data point based on parameters such as representativeness, completeness, consistency and reliability. It plays a crucial role as a complementary evaluation of the applicability of LCA. Importantly, data quality should evaluate both the data source whether primary or secondary, the background data used in LCA models and the quality of the modelling (incl. assumptions/ proxies). Data quality ratings can also be utilised in a scoring or grading system, for instance, to evaluate the quality of additional data used for assigning bonus or malus points (Foundation Earth Methodology Paper, 2023).

For an LCA study to be compliant with the ISO 14040 and 14044 standards, it needs to include the data quality requirements and a data quality analysis. This can be done either by a PEF based DQR or own developed DQR system.

The PEF DQR method (currently under review and likely to be adapted) enables the calculation of precise and accurate data quality ratings. However, it is time-consuming, complex to implement, and challenging to interpret the results. Furthermore, not all background databases include EF-DQR scores.

In our analysis we see that the schemes that apply the PEF principles (although not PEF compliant) are mostly applying a ‘PEF-based’ DQR. The other schemes that apply ISO or GHG protocol standards usually develop their own DQR system.

Apart from a Data Quality Rating system, many private schemes have built internal data quality checks and validation checks where they make sure the product matches, quantities, translations, names and deviations are evaluated (automatically).

4.5 Labelling system: From LCA impact to an Ecolabel

As a the final and one of the most crucial steps in communicating the environmental impact of a product to consumers, the scoring system and design of the label play a crucial role. Ideally, a label format must align with the objectives of the Ecolabel. First, it could inform consumers about the environmental impact of the product, aiding them in making informed decisions. Second, it could direct consumers towards products with lower impacts within the same food category. Third, it could help reduce consumption quantities and food waste by making consumers aware of the absolute impact of food (Hélias et al., 2022).

4.5.1 Scoring system

In LCA-based ecolabelling for food products, various scoring methods can be used to evaluate and communicate environmental performance. Below are the common types of scoring methods used by the schemes.

A Single (intensity) score
Scores are assigned based on the absolute environmental impacts of the product, such as total greenhouse gas emissions or water usage. A product might receive a score based on its total carbon footprint in kilograms of CO_2 equivalent per unit of a specific metric such as weight, or volume.

Aggregated Score
An aggregated score is created by combining various environmental indicators into a single score, often using normalisation and weighting techniques. This aggregated score can be an absolute score or a relative score.

Normalisation is done to be able to express the different impacts into the same unit. This can be done by comparing the product’s impact to benchmarks or averages to provide context. The greenhouse gas emissions and water use of a product could for example both be expressed as a percentage of the total greenhouse gas emissions and water use of an average European citizen per year. Weighting is done by assigning importance to different environmental impact categories based on their significance. In some cases weighting is also applied within a category to get a final score per category. We will not go into these details. Finally, aggregation is done by combining the normalised and weighted impacts to create an overall score that represents the product’s environmental performance.

Most of the schemes (10 out of 16) apply an aggregated single score (combining the impact of all the indicators assessed) after applying normalisation and weighting factors. The rest apply a single score per impact category.

It should be noted that combining different impact indicators into a summary indicator raises also important questions around relative weights assigned. In this aspect, while PEF-based schemes predominantly use consistent weighting factors for all 16 impact categories (with a few exceptions), ISO based schemes use various weighting methods in the aggregation of scores for each indicator. Table 4.4 illustrates the scoring system applied by each LCA-based scheme.

Table 4.4 *Label Scoring system applied by each scheme.*

Schemes	Scoring methodology	Weighting and normalisation method	Additional steps
French national initiative	Aggregated single score	PEF weighting and normalisation with adaptations (Human tox totally removed in last proposal (weighting = 0%)	Yes, with (positive) complements on Ecosystem Services.
Danish Climate label initiative	Single score for climate	No weighting	None
Dutch national initiative	Aggregated single score	PEF weighting and normalisation (Under development)	Under development
Eco-score a) (Will be rebranded officially)	Aggregated single score	PEF weighting and normalisation. Then products are scored from 0-100	Yes, bonus malus
Foundation Earth	Aggregated single score	PEF weighting and normalisation.	None
Planet-score	Single score per impact category along with an aggregated score.	Own customed normalisation and weighting (i.e., climate weighs much less and crop protection products weighs much more heavily as opposed to PEF)	Yes, bonus malus and corrections to LCA indicators.
Enviroscore	Aggregated single score	PEF weighting and adapted the PEF normalisation factors to better fit food.	None
IGD (Informing DEFRA, UK)	Aggregated single score	Based on PEF weighting	Absolute scoring approach based on planetary boundaries per indicator. Later for aggregated score they use the PEF weighting that is normalised.
INOQO	Single score per impact category. Only 3 most important categories are shown on label	No Weighting	None
Beelong-Eco-score	Aggregated single score	PEF weighting with adaptations.	Yes, bonus malus
Eaternity	Single score per impact category.	Creating a food-unit to normalise all food items for the rating. No weighting.	They first calculate a benchmark level, for example, for CO_2/DFU (and other indicators) to set a standard for comparison. Then, they compare each food item against this benchmark to determine its star rating. (Within 3 star rating).
Dayrize	Aggregated single score	Own custom normalisation and weighting, different for each impact category and equal weighting per impact category to calculate single score	Other non-LCA methods
HowGood	Aggregated impact score	Equal weighting of all indicators. All impact categories have 1 indicator except climate which has two so gets double weighting.	Yes, bonus malus
Mondra	Single intensity score per impact category	No weighting.	None
Carbon Cloud	Single absolute score per impact category	N/A	None
M-check	Single star rating per impact category	No weighting. Normalisation is done for star rating, by defining a range based on the amount of CO2 emitted from 1 (worst) to 5 (best) across entire product range	None

a) The Ecoscore may officially be rebranded as a label in the near future.

4.5.2 Label design

Seven out of sixteen schemes use a coloured letter grade label design (i.e., 5 letter RAG (traffic light colours) scale, from A to E). Others apply either a star rating (M-Check) or colour coding (next to its score) per impact category (Inoqo, HowGood). This is done, for instance, by defining a range based on the amount of CO_2 eq. emitted from 1 (worst) to 5 (best) across the entire product range.

Two schemes currently focus on Scope 3 reporting instead of consumer communication (Carbon Cloud and Mondra) and provide the retailers only with a single score (i.e., carbon intensity score, kg CO_2 eq/kg of product) but no label associated with that score. Inoqo offers a comprehensive labelling format which incorporates a combination of descriptive elements including numerical values, letter grading and color coding. Inoqo is the only one that intends to only show the scores of the 3 most important impact categories per product. So, depending on the product category, the scores of different impact categories will be shown. Label design of public (national) schemes are currently under development. The French government probably will use a combination of an absolute score and relative one (e.g. by color grading).

4.5.3 Presentation of additional indicators.

The schemes that use additional non-LCA and social indicators include them within their aggregated single score (French initiative, Eco-score, Beelong, IGD) or separately include them next to the aggregated score (HowGood, Planet-score) or use a separate label per indicator (Inoqo, Eaternity, M-check).

Around labelling methods, some labelling schemes are adopting interesting practices, such as referencing existing traditional labels and certifications (e.g., Fairtrade, sustainable fisheries, animal welfare) on products as part of their bonus-malus systems such as (HowGood, Inoqo and Eco-score). And as discussed in Chapter 3.3.8 some schemes are assigning a 'lower than average' score to products that lack transparency or fail to report necessary information.

The critical role of label design as a success factor is also discussed more in Chapter 4 of this report.

To note, a more detailed analysis is conducted on labelling systems, logo design and methodology by another work package team within the Eco Food Choice project. It is for this reason that we did not focus on a detailed evaluation of the labelling systems used in LCA-based ecolabelling schemes. Instead, we provided a general overview of the labelling designs and systems implemented by these schemes.

4.6 Software tools and platforms

While most of the private schemes establish their own software tools with their own developed databases, public schemes rely on existing LCA software tools, developed their own tool (French government initiative) or still have to decide.

Among private schemes we see there is increasingly more attention to make the software tools and platform more engaging for the users: producers and retailers (Mondra, Carbon Cloud, HowGood, Inoqo). They increasingly make use of AI in product matching, completing missing recipe data etc. In order to stimulate more sustainable production and exchange of data, some schemes are offering to make some of the data open where suppliers and retailers can see the performance of other products (Carbon Cloud). They also build in the opportunity to integrate additional primary data when available from the producers although in most cases this is only possible for individual producers and not on large scale. This way producers and suppliers are encouraged to provide more data, to produce and supply more sustainable products.

4.7 Summary results - Overview of key best practices and ideas

The analysis of the LCA-based labelling schemes have shown that while they share various commonalities, there also have large differences in aspects such as methodology, governance and labelling systems. In particular, we see that with PEF-based (mostly public) schemes, although slightly varying in some aspects, they share a more commonly applied, transparent approach and harmonised between another when it comes to selection of impact categories, functional unit, system boundaries, verification of data, data quality, use of databases and impact assessment methods.

On the other hand, private schemes that follow ISO or GHG protocol standards apply various approaches and methods in these same criteria aspects, with much less harmonised between another. However, they also offer agile and fast application systems. The urgent reason for many retailers to start working with private schemes is to comply with CSRD/SBTi focusing on scope 3 GHG reporting. CSRD and SBTI allow to report following less stringent guidelines than PEF, such as GHG protocol, resulting in the fact that following PEF is more burdensome than needed for the purpose. Some of the most advanced private schemes have globally applicable LCA databases (with primary production, consumption and processing stages) using detailed supply chain models that can be easily updated using statistics that become available on a periodic base. They can already make reasonable reliable estimates of GHG Scope 3 impacts using data from existing retail databases (e.g. GS1) and have developed procedures to fill the gaps for missing data. Over time, these private schemes intend to provide producers the possibility to provide more primary data. Although in some cases their solution and methodology can be imprecise, they are improving fast and increasingly using AI to automate and increase precision.

Below is a summary table illustrating the key common themes, approaches and different application per type of LCA methodology applied by the schemes.

Table 4.5 *Summary of common and other approaches applied by PEF based and ISO/GHG based schemes.*

LCA aspect	LCA methodologies	Common methodologies	Other (interesting) approaches
System boundaries	PEF based (with adaptations)	Cradle to grave	Farm to store (no user phase and waste treatment) (Dayrize and Carbon Cloud) Some schemes also adjust the system boundary according to the clients needs.
	ISO based or GHG protocol	Cradle to retail (some of them only until packaging stage before retail)	
Functional unit	PEF based (with adaptations)	1 kg of consumed food product	Daily Planetary Limit in 100 gr of product (IGD) Daily food unit (Eaternity: i.e 685 g CO_2/DFU) Per 1kcal (Beelong) Production system scale (Planet-score)
	ISO based or GHG protocol	1kg of food product in the retail shops	
Company specific data	PEF based (with adaptations)	Various integrations of primary data either through complementary (French initiative) or bonus malus approach on top of the LCA score from the supplier.	Most primary data is from databases that retailers own (ingredients, country of origin, packaging). Otherwise it is estimated or producers/suppliers provide the information.
	ISO based or GHG protocol	Primary data is often integrated within the LCA model (not on top of LCA score).	
Set of environmental indicators	PEF based (with adaptations)	16 PEF indicators + additional social/environmental indicators	14 PEF indicators, Excluding/adapting toxicity indicators (Enviroscore, French initiative and Planet-score). Animal welfare and biodiversity most commonly used'additional' indicators.
	ISO based or GHG protocol	Ranging from climate only to 5-8 indicators. (i.e carbon, water, biodiversity, animal welfare, land use, circularity, social welfare)	
Type of databases used	PEF based (with adaptations)	Product level databases[1]	
	ISO based or GHG protocol	Ingredient level databases	
Verification	PEF based (with adaptations)	Verified secondary databases used.	For primary data commonly no third party verification process is applied by most schemes. This is something to be addressed in the future, as it will become more relevant. Foundation Earth: Provides/updates certification periodically on brands using their label. Private schemes are working on making their platforms more accessible to external verifiers.
	ISO based or GHG protocol	Secondary data is verified, usually by a third party.	
Data quality	PEF based (with adaptations)	PEF based DQR. (e.g how Agribalyse methodology adopted PEF DQR).	Simplified PEF based DQR developed (by Foundation Earth, likely to be adapted under current methodology review) Regular updates on built databases and methodology.
	ISO based or GHG protocol	Internally developed automatic and manual data quality checks. (On product match, tracking deviations, and translations)	

Overall, one of the key points in LCA-based ecolabelling is the use of secondary and primary (product-specific) data.

Most ecolabelling schemes assessing environmental impact typically use a combination of primary and secondary data. While primary data increases accuracy and is crucial for product differentiation and comparability, it can pose barriers to widespread adoption due to higher time and cost requirements.

In addition to the primary data that are already available in databases of retailers, some schemes also try to integrate primary data that are available in other databases. Some schemes experiment with using databases with data of tens of thousands of farms to calculate more precise regional averages. Or, when the farms can be identified that delivered to the suppliers of the retailer, the data from these databases can even

[1] Although French database Agribalyse includes both levels (product and ingredient) and the French initiative uses the ingredient level in the modelling through Ecobalyse, Agribalyse does not have the scope of a globally applicable ingredient database (yet).

be used as primary data. Other investigate satellite imagery to assemble primary data around deforestation, water scarcity, yields etc.

It is also critical to incentivise the producers to provide more primary data and improve their production practices. There are interesting practices such as scoring a product ‘worse than average’ if company are not willing to provide data. Some of the private schemes have plans to integrate modules allowing to advise on improvement opportunities and simulation opportunities to support producers to make improvements in their production practices.

The ideal scenario is for these diverse applications and innovative best practices to converge into a harmonised framework that ensures accuracy, credibility, and comparability in LCA-based ecolabelling. In connection to this, we will elaborate more on the needs and key success factors for a harmonised framework in the next chapter.

5 Critical success factors and measures towards harmonised eco-labelling schemes

One of the objectives and sub-questions of this study was to identify the critical success factors and measures towards harmonised eco-labelling schemes. Stemming from the insights and applications we have gathered on LCA-based ecolabelling schemes, literature and conversations held with the LCA-based initiative owners, we have listed several factors to be addressed that can, in turn, aid the implementation and adoption of a harmonised eco-labelling schemes at European level. It should be noted that this chapter is not meant to find direct solutions to the issues, but rather to address and emphasise the key factors that would aid to explore the ultimate solutions to the barriers faced. We have categorised these factors into two groups: methodological factors and organisational factors. These factors are also very much connected to the barriers and challenges we have addressed in Chapter 4.1.

5.1 Methodological factors

5.1.1 Operationality - Right balance between administrative burden and quality of measurement

Conducting LCA-based labelling can be quite challenging. This is primarily due to the complexity of implementing the LCA-method, which is data-intensive, requires a lot of expertise and is therefore potentially costly, particularly for small and medium-sized enterprises. In this regard public/national schemes are creating average representative product databases at country level. For instance, in France, the public life cycle inventory database AGRIBALYSE (2020) describes 2,500 generic food products to represent the variety available on the market. Such a database can be a powerful way to reduce administrative burden of implementing environmental labelling. For each of these representative products, an average environmental impact value is provided, offering a general 'generic' value. While these generic data can help reduce the cost of environmental labelling, impact estimates might be less accurate because the representative products in AGRIBALYSE may differ to varying extents from the product being assessed. For a more accurate differentiation within food categories, more detailed data are required (Hélias et al., 2022).

We see diverse levels of data and calculation requirements in the LCA-based ecolabelling schemes. Most schemes use average/representative product or ingredient information, and require either very limited primary data that is already available for most private label products in retail databases (or can even deal with only the information that is on the packaging label of a product) or demand some basic primary information from suppliers. In all these cases, however, the resulting score will be an estimate and most likely not in full compliance with current PEF guidelines regarding the use of primary data.[2] In most cases it will be good enough to support consumers to select between product categories. Other schemes such as Enviroscore and Foundation Earth stay much closer to PEF regarding the primary data requirements which leads to a far more precise estimate of the impact. But this also means that all suppliers need to perform a full LCA which makes the approach quite costly to scale for all products of a supermarket and suppliers might either not have the expertise or might not be willing to supply the data.

For operationality, it is essential to maintain the system's efficiency, scalability, adoption and credibility. This is especially important if the system is to be adopted at European scale where thousands of products with multiple ingredients are to be scored.

[2] Requirements for use of primary data are defined on product category level (in PEFCRs), and these are not yet available for all product categories. This means it is impossible to make a full comparison for all products between the schemes and the PEF guidelines.

A more step-by-step approach can be followed, similar to the national databases, with more primary data integrated over time. This is of course to be achieved with a balance on the quantity and the accuracy of the product information.

5.1.2 Sufficient level of primary data to make differentiations within products to incentivise producers to improve

Building on the first point above, in order to make fair comparisons both among and within product categories, it is essential to establish a sufficient level of primary data requirements. This will enable differentiation, incentivise producers to improve, and guide consumers in making better-informed dietary choices. Currently, many schemes rely for a large part on average product information, as the accessibility to primary data can be quite challenging due to costs, and confidentiality issues involved. In this regard, there are schemes such as Mondra that are working on platforms where farm level data can be shared more effectively among producers and suppliers. It also ingests primary data from known farmers across the supplier base and triangulates with data collected annually from statistically representative farms across the globe (Mondra website, 2022). However, it is yet to be seen whether these kind of platforms can provide an open access or be cost effective for interested parties at a large scale application in the future.

5.1.3 Data quality indicator

As indicated in Section 3.4.12, data quality assesses the condition of a specific data point based on parameters such as accuracy, completeness, consistency, and reliability. It plays a crucial role as a complementary evaluation and interpretation of the of LCA’s (Life Cycle Assessment) environmental results, especially in comparison between products with different use of primary data. Implementing a data quality indicator will help maintain the integrity and reliability of the information.

Currently, we see that most schemes do not have a data quality indicator, and the ones that do, apply their own developed data quality rating systems differing in level of complexity and ease of application. The most precise and accurate method is the PEF DQR method. However, it is very time-consuming and complex to implement, and is also under review due to its complexity. There should be a simplified method, without undermining the accuracy and reliability, in order to make it more applicable at large scale.

5.1.4 Prevent trade-offs between impact categories

LCA is viewed as the most appropriate and legitimate methodological framework for a multi-criteria environmental assessment. Many users currently focus on climate as this is the most urgent impact category they are expected to report on. Others focus on a selection from 16 PEF impact categories or all the 16 PEF impact categories (most public initiatives). In all these cases companies might improve their performance on only a few themes, at the risk of a lower score on other themes that are not taken into account. Although there is in general a quite strong correlation between for example climate on the one hand and some other environmental impact categories on the other hand, this is not always the case.

Even if all 16 PEF impact categories are applied, there is the reality that that not all environmental and health issues are covered (Hélias et al., 2022). Thus, as indicated in Section 4.4 many schemes include additional non-LCA environmental indicators as complementary or bonus malus to the final LCA score. Adding a non-LCA indicator has, however, also some strong drawbacks as it results in an inconsistent methodology, that is less objective and there is a risk of double-counting as discussed in Section 4.4.10.

5.1.5 Being able to start with a reasonable reliable score for all food that incentivises companies to provide better information

Currently retailers do not invest a lot in assembling impacts of food products because many suppliers are not able or not willing to share harmonised data that they can act on. Many producers do not invest a lot because data is not used by their clients anyway. LCA-based ecolabelling has the potential to break this stalemate by being able to make a reasonable estimate based on information that is already available at retail level or can easily be provided by all suppliers. Thus, the advantage of LCA-based labelling to incentivise producers should be utilised more. This approach would encourage producers to enhance the accuracy and thoroughness of the data they provide, better reflecting their products and the improvements they have made. This will improve the usefulness of the data for retailers and the chance that they will take it into account in their decision making and communication to the consumers.

5.2 Organisational factors

5.2.1 Transparency and accessibility

LCA is a complex methodology and conducting an LCA requires a lot of expertise, especially when it comes to agricultural and food products. The use of variables available at retail level to make an estimate of the impact of a product has the risk that the way scores are calculated is a black box for many producers.

Therefore, transparency is key when it comes to the methodology and secondary databases, and they should be shared among the key stakeholders in the value chain. Transparency about the methodology and data builds trust and reliability among the stakeholders, supports the harmonisation process facilitates continuous improvement over time. We see that national/public schemes are very transparent both in sharing methodology and data, while private -for profit- schemes are more conservative in this regard due to competitive nature of their business. It should be noted that some of the 'non-profit' but private schemes were also not entirely transparent in sharing their methodology. Since some methodological choices can make big differences in results, (such as weighting, allocation, default values.etc), full transparency on the method is an absolute need.

In addition to transparency, accessibility is important. Methodologies should not be just available for experts but the most important elements should also be made available in such a way that it is also possible for non-experts to understand. Because LCA is so complex there is a risk that only a small number of LCA experts can understand the methodologies while it is important that a much broader community of stakeholders can provide feedback. User friendliness and 'open access' tools such as Ecobalyse can be a solution in that sense.

As all supply chain partners are expected to report, it is important that less influential groups (e.g., farmers) are not only forced to deliver data but that they keep ownership of the data and can decide to grant access to it to particular users for specific purposes. They should also be guaranteed that the data is not used against their interests and that they are compensated for additional costs. Introduction of ecolabelling should also not lead to trade barriers for developing countries, as it could be more challenging for companies from these countries to assemble the necessary data.

5.2.2 Assurance and audits of data used

We have seen that nearly all schemes are using externally validated secondary databases and that their methodology is sometimes also verified by a third party. In addition to the externally validated databases, some schemes also rely on existing literature studies, other data sources – which are always not externally validated – to build on their own developed databases. As these database are huge, combining many different data sources, they have a very strong influence on the results and in the case of private schemes are not publicly accessible, a thorough and standardised review of these databases would be essential.

When it comes to the primary data, currently there is no solid mechanism among the schemes to get third party assurance. Many schemes though have their own internal validation and review systems in place for primary data but this is mainly targeted to check outliers. This lack of proper (third party) assurance needs to be addressed in the future, as including company specific data will become more relevant and is essential for differentiating between food products within the same product category. Conducting systematic ex-ante reviews of primary data can be costly and is widely viewed by stakeholders as unsuitable for scaling up ecolabelling efforts. Flexible, ex-post review systems might offer a more feasible solution, balancing reliability with cost efficiency, though they have yet to undergo practical testing.

Assurance and audits are essential to maintain credibility and accuracy of the results, in particular when more primary data are integrated in the LCA assessment. As indicated in Section 3.2.2, CSRD expects a minimum level of assurance for the reported information and the demands for the quality of this assurance will grow over time. As many retailers use the schemes for CSRD reporting this could contribute in enhancing the transparency and credibility of both secondary and primary data.

5.2.3 Prevention of proliferation and alignment with political dynamics

As many different ecolabels become implemented, there is a risk of proliferation of many systems next to each other which will confuse consumers and will lead to much higher administrative burden for producers as they will have to deliver different data to different clients. At a later stage, the incentive to improve will be much lower as it is likely that producers will receive different types of requests from their clients to support mitigation of impact. European harmonisation is needed. For private schemes this can be challenging because they have an interest in being different from their competitors.

For both public and private schemes, differences in regulatory frameworks, policies, and political visions at national level can create obstacles to harmonisation. On the one hand, it is crucial that the development and implementation of ecolabelling schemes align with the national policies and vision surrounding the transition to a sustainable food system. On the other hand, it should not lead to many different national ecolabel methodologies which makes it difficult for companies acting on many markets. Achieving alignment requires transparency, political will for a sustainable food system, and cooperation among governments and key actors in the agrifood value chain. However, harmonising these efforts is challenging, given the diverse interests involved. Methodological choices will have an effect on the scores of products that play an important role in international trade. There may be a strategic interest in selecting methodologies that result in higher scores for key export products, thereby making these products appear more environmentally friendly or competitive in international markets. Thus, a harmonised approach should consider this risk. This approach, however, must be balanced against international trade regulations. For instance, the World Trade Organisation (WTO) emphasises that ecolabelling standards should not create unnecessary barriers to trade, ensuring that they are fair, transparent, and non-discriminatory (Du, 2021).

5.2.4 Engagement of broad range of stakeholders

Involving a wide range of stakeholders—such as producers, NGOs, retailers, policymakers, and consumers—is essential for a harmonised approach and to avoid conflicts in adopting the method. National public schemes are typically transparent and methodologically robust, though they may lack speed in implementing and scaling up their ecolabelling schemes. Conversely, private schemes, while often less transparent and methodologically rigorous, excel in swift and innovative implementation, particularly in data integration and relationships with retailers, suppliers, and producers. Combining the strengths of these two parties, along with the contributions of key actors, could aid the development of a harmonised ecolabelling methodology.

5.2.5 Consumer awareness-education and support measures

Communication about the sustainability impact of food products is currently mainly done via traditional sustainability labels and logos at product level. Many consumers find these labels and logos difficult to understand and do not always feel all relevant issues are addressed. As a result, labels and logos in their current form have limited impact on changing consumer behaviour (Dwyer and Onwezen, 2024). Raising consumer awareness and educating them on label information and design enhances the effectiveness of the ecolabels. If consumers are not well aware or informed on the labels they see, the objectives of the labelling will not be achieved in changing consumer behaviour towards a more sustainable diet. The fact that one ecolabel will be used for all products, not only highlighting ones that do well but also the ones that do less well, will increase the effectiveness of labels. But as Colruyt experienced with their introduction of the Ecoscore, this also requires the use of communication campaigns to educate consumers. Colruyt also introduced additional measures such as the opportunity to earn green points when consumers buy more sustainable products. Apps based on loyalty cards of retailers that stimulate social gaming (e.g. comparing your improvements with your friends and neighbours) can also increase the effect. Therefore, awareness raising and stimulating campaigns would aid the consumers to understand the labels more and make better informed decisions.

5.2.6 Broader use of harmonised data than just for a consumer label

To more effectively promote data harmonisation, its use by other institutional mechanisms can be encouraged. Harmonised data at the product level can be utilised by financial institutions, food processing companies and governments to incentivise more sustainable production. Financial institutions can provide interest discounts to companies producing sustainable products because they have less sustainability related risks. Food processing companies can incentivise farmers to implement mitigating farm management practices. For example: the Dutch dairy cooperative Royal Friesland Campina (RFC) pays a milk price to its farmers that is dependent on a very wide range of impact indicators. RFC is in the lucky position that for all dairy farmers in the Netherlands a broad set of impact indicators is available because of Dutch regulation and a high form of digitalisation in their supply chains. In addition, they sell to big brands that are willing to pay a higher price for more sustainable milk. Ecolabelling might make these kind of financial incentives possible for a much broader range of farmers all over Europe and beyond.

6 Creating a vision for the future of ecolabelling in the EU

In this chapter we answer the research question of what a potential vision for a harmonised EU ecolabelling could look like. Based on the learnings from this study, we see that the space of ecolabelling is dynamic and changes are happening quickly. Each individual ecolabelling initiative is learning and adjusting while operationalising at the same time. This comes at a cost, as the individual developments lack alignment. In the near future, it will be crucial to align and find a common approach to ecolabelling in EU, arriving at a harmonised approach with the right governance in place to secure trustworthiness, transparency, consistency and future developments and updates.

From this study we have learnt that there are a couple of elements of ecolabelling which are best harmonised between all ecolabelling schemes. We have identified six elements specifically, which we think should be governed and made available to all stakeholders to harmonise ecolabelling in EU in the future.
These six elements are:

1. The LCA method
   This should include all the elements of LCA on which value choices can be made (e.g. allocation, system boundaries, emission models, LCIA method etc.), ensuring that the outcomes are comparable.
2. The primary data points
   Since ecolabelling can only become successful when a certain level of primary data is used, it is essential to define the minimum primary data that must be collected. The requirements for use of primary data might require differentiation between product categories, as hot spots can vary significantly between product categories. Ideally, primary data would be gathered for the most relevant data points.
3. The secondary database
   LCAs are a combination of secondary and primary data (company-specific data). The use of one specific background database for secondary data is crucial for ensuring that outcomes are comparable. Secondary data are needed on for instance production of energy, emissions of transport and production of materials, but specifically for food products secondary data on production of ingredients (cultivation and processing) are very important. The secondary database needs to grow continuously to cover all origins of raw materials and food ingredients. Secondary databases need to be transparent and disaggregated, allowing users to assess how well they align with their specific situation (especially in hotspot areas), and determine whether replacing the values with primary data might be worthwhile.
4. The ecolabelling method
   This method is about translating LCA outcomes into something that can be communicated to consumers. It can also include adjustments to account for additional non-LCA indicators (e.g. biodiversity, marine resource depletion, plastic pollution).
   relevant data points.
5. Verification of compliance
   Verification is important for the trustworthiness of ecolabelling. It should be verified whether ecolabelling schemes comply with the LCA method, the ecolabelling method and use of the appropriate secondary and primary data. The verification procedure should be defined and in place to be applied during the operationalisation of an ecolabel.
6. Design of the label itself
   For the recognisability and trustworthiness of the ecolabel, it is important that the design of the label is equal all over the EU, and is fit for purpose: changing consumer behaviour towards more sustainable purchasing decisions and incentivising companies to mitigate impact.

A robust governance structure seems crucial in the near future. We have envisioned a potential governance structure which could be established for the cause (Figure 6.1). The governance structure includes the six elements mentioned before. It involves all the necessary stakeholders, as ecolabelling is complex and each stakeholder plays a crucial role in successful ecolabelling in EU. This vision could be used in developing a governance structure in co-creation with all relevant stakeholders (at the risk of losing speed of development).

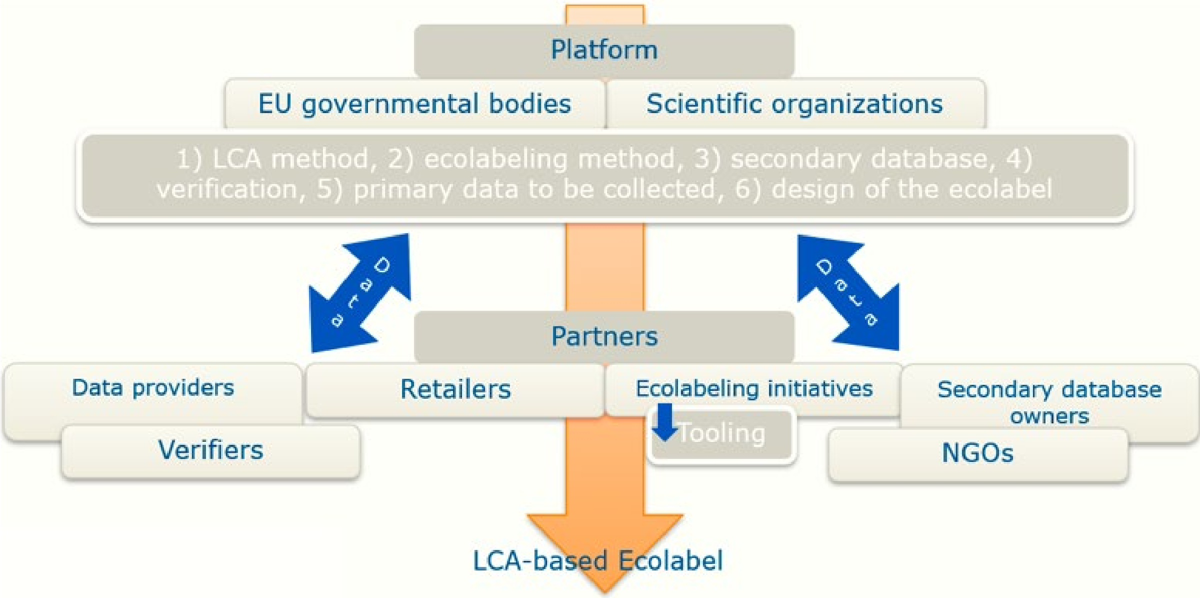

Figure 6.1 *Vision of a potential governance structure for harmonised ecolabelling in EU.*

The governance structure could comprise a platform and its partners. The platform would primarily consist of EU governmental bodies and scientific organisations responsible for overseeing the maintenance, updates, and publication of the six essential elements for harmonised ecolabelling. The partners represent all stakeholders, each with their own specific roles, such as:

- *Ecolabelling schemes* work with clients to operationalise ecolabelling, using their own tooling to achieve this.
- *Retailers* provide information to the platform on data availability and learnings from consumer behaviour
- *Data providers* provide data either to further develop the background database or to meet the primary data requirements.
- *Secondary database owners* support the development of the secondary database.
- *Verifiers* assess whether ecolabelling schemes comply with the LCA method, ecolabelling method and data requirements.
- NGOs provide their critical view, raise awareness, and act as advocates for social change.

This list of stakeholders is provided as an example and is likely not exhaustive.

The draft vision in this chapter encompasses that some of the elements which are currently managed by individual (private) ecolabelling schemes are taken up by the platform. This raises the question what the commercial opportunities are for the private market. By providing the elements required for ecolabelling and leaving the operationalisation to ecolabelling schemes, we think that there is room for commercial opportunities for the private market. For instance:

- The collection of primary data at scale is a craft in itself and linking to data management systems could make private schemes stand out.
- The development of the tooling which operationalises ecolabelling can provide commercial advantages (e.g. feedback loops, identification of mitigation actions, speed of assessment) to private schemes.
- Providing solutions for more sustainable purchasing, such as nudging and social gaming, can be provided by private market.
- Verification activities can be operationalised by the private market.

The Eco Food Choice project seeks to establish a harmonised approach to ecolabelling within the EU. Several of the six elements are being further developed as part of this initiative. Collaborating with experts and stakeholders involved in the project, we aim to advance our vision for the future of ecolabelling in the EU, ultimately delivering the outputs of Eco Food Choice to the governance structure and ensuring the continuity of these developments.

7 Discussion and Conclusion

There is an urgent need for a harmonised and reliable LCA-based ecolabelling methodology in Europe. Such a framework is essential to address environmental targets and challenges (i.e., around climate, and biodiversity), the increasing pressures industries face to meet rising consumer demand for more sustainable products, and stricter regulations on environmental reporting.

Addressing the challenges and acting on opportunities requires collaboration among public and private sector, governments, industry stakeholders, consumer organisations, and environmental groups. Joint efforts are necessary to establish common and operational standards, build trust, and promote the widespread adoption of LCA-based ecolabelling as a tool for sustainability.

7.1 Limitations of the study

It should be noted that comparing and assessing existing LCA-based ecolabelling schemes presented several challenges and limitations. Many schemes have commercial interests, making it sensitive to disclose certain details about their methodologies, which can hinder a full understanding of their systems. Additionally, due to the evolving nature of regulations and developments in environmental labelling, these schemes are continuously updated, meaning that their methodologies, datasets, and label designs can quickly become outdated. Therefore, while the key conclusions of this overview remain valid, the results should be revisited in due time and interpreted with caution.

7.2 Conclusions

What is the state the art on LCA-based ecolabelling schemes for food products across Europe?
While current LCA-based ecolabelling schemes are promising and innovative in their calculation and reporting of environmental footprints, there is a clear need to improve and harmonise the methodologies and data sources used. The analysis of LCA-based labelling schemes reveals both commonalities and significant differences, particularly in methodology, governance, and labelling systems. PEF-based (mainly public) schemes are more harmonised, with transparent and consistent approaches to impact categories, functional units, system boundaries, data verification, quality, and impact assessment methods. In contrast, private schemes following ISO or GHG protocol standards show greater variability in these aspects however offer more agile, and faster application systems which could offer great insights for an operational harmonised system. Retailers often prefer private schemes to meet CSRD/SBTi requirements for scope 3 GHG reporting, as these standards are less stringent than PEF, making PEF more burdensome than necessary for this purpose.

What are the current barriers towards harmonisation among these LCA-based ecolabelling schemes?
Harmonising LCA-based eco-labelling for food products in Europe faces challenges such as inconsistent methodologies, limited comparability across categories, and a focus on environmental rather than social impacts. The European Commission’s Product Environmental Footprint (PEF) and Category Rules (PEFCRs) address some issues but are still limited in scope. Operationalising eco-labelling is hindered by varying national standards, high data collection costs, and industry reluctance to share sensitive information. Additionally, differing regulations and the need for consumer-friendly labels add complexity. Overcoming these challenges requires cooperation among governments, industry, and stakeholders.

What are the key factors for success and the challenges associated with recently launched LCA-based ecolabelling schemes for food products in the EU?
LCA-based ecolabelling faces operational and organisational challenges. Balancing administrative burden with accurate measurements is key, with databases such as AGRIBALYSE helping reduce costs but potentially lowering accuracy. A sufficient level of primary data is necessary to make meaningful product comparisons, though accessibility and confidentiality issues persist. Data quality indicators are essential for maintaining reliability, but current systems lack standardised assurance mechanisms, especially for primary data. Preventing trade-offs between environmental impact categories and aligning with national policies are critical for harmonisation. Broad stakeholder engagement, transparency, and consumer education will be crucial for the success of ecolabelling schemes. Additionally, using harmonised data for more than just labels—such as for financial incentives—could further incentivise sustainability across the food value chain.

How could a potential harmonised EU LCA-based ecolabeling scheme look like?
The study outlines six key elements for harmonising EU ecolabelling: 1) standardising LCA methods, 2) defining primary data requirements, 3) creating a consistent secondary database, 4) translating LCA results into consumer-friendly labels, 5) implementing verification processes, and 6) ensuring uniform label design. A proposed governance structure involving EU bodies and stakeholders such as private LCA-based ecolabelling schemes, retailers, and NGOs would oversee these elements. This platform could also offer commercial opportunities for private market players in data collection, operationalisation, and verification.

Overall all these elements discussed could aid the Eco Food Choice project to establish a unified ecolabelling system for sustainable food in the EU.

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Appendix 1 Reference documents and sources used to retrieve information on LCA-based ecolabelling schemes.

Ecolabel scheme	Document /Source title	Source/Document type	Link to source
French Initiative	Implementing environmental labelling of food products in France	Methodology paper	Implementing environmental labelling of food products in France (ademe.fr)
French Initiative	Overall discussion on methodology and deviations from PEF.	Oral discussion/information	
French Initiative	Food Environmental Display-French ADEME initiative	Webinar	Présentation Webinar of ECO FOOD CHOICE Life project - video Dailymotion
French Initiative	General info on the methodology, governance and labelling system.	Webpage	Food and environnement | Affichage environnemental - Ecolabelling (ademe.fr)
Eco-score	Open access to calculation app.	Webpage	https://docs.score-environnemental.be/v/eng/implementation/outil-de-calcul and collectandgo.be/colruyt/fr
Eco-score	How do we calculate Eco-score	Webpage	How do we calculate the Eco-score? | Colruyt Group
Eco-score (via Colruyt)	Overall discussion on the methodology, governance and label system.	Oral discussion/information	
Planet-score		Webpage	Planet-score | Take care of the planet while shopping
Planet-score		Methodology paper	Confidential
Planet-score	Overall discussion on the methodology, governance and label system.	Oral discussion/information	
Inoqo	General info on the methodology, governance and labelling system.	Webpage	Home (inoqo.com)
Inoqo	Overall discussion on the methodology, governance and label system.	Oral discussion/information	
Beelong	Overall discussion on the methodology, governance and label system.	Oral discussion/information with Coop Switzerland	Introduced by Coop Switzerland
Beelong	General info on the methodology, governance and labelling system.	Webpage	ECO-SCORE® by Beelong – Beelong
Eaternity	Bechmark calculation.	Methodology paper	https://eaternity.notion.site/Benchmark-Calculation-EN-DE-04e7e19eaab64c7b9918e21f71ab450f
Eaternity	Eaternity database references	Methodology paper	2022-03-21-EDB-References-public (eaternity.org)
Eaternity	Open source free app	Webpage	http://app.eaternity.ch
Eaternity	General info on methodology, governance and labelling info.	Webpage	Eaternity ♥ App'etite for Change.
Foundation Earth	General information on the initiative	Webpage	Foundation Earth - Environmental scoring of food & drink products (foundation-earth.org)
Foundation Earth	Overall discussion on the methodology, governance and label system.	Oral discussion/information	
Foundation Earth	LCA methodology for Environmental Labelling.	Methodology paper	Foundation-Earth-LCA-Methodology-Beta-Version-1.0.pdf
IGD	Environmental Labelling, March 2024 Virtual update	Presentation	Environmental labelling: March 2024 virtual update (igd.com)
IGD	General info on the methodology, governance and labelling system	Oral discussion/information	
Enviroscore		Webpage	Home - Enviroscore (azti.es)

Ecolabel scheme	Document /Source title	Source/Document type	Link to source
Enviroscore	Enviroscore: normalisation, weighting, and categorisation algorithm to evaluate the relative environmental impact of food and drink products.	Methodology paper	Enviroscore: normalisation, weighting, and categorisation algorithm to evaluate the relative environmental impact of food and drink products | npj Science of Food (nature.com)
Enviroscore	General info on the methodology, governance and labelling system	Webpage	Home - Enviroscore (azti.es)
Dayrize	General info on the methodology, governance and labelling system	Webpage	Dayrize - Sustainability Intelligence
Dayrize	Dayrize methodology overview	Method presentation-Oral assessment	Confidential
Dayrize	Overall discussion on the methodology, governance and label system.	Oral discussion/information	
Dutch ecolabelling initiative	Proposal for PEF wise method on environmental footprin of products in NL.	Presentation-Methodology paper from NL Subwerk group	
HowGood	General info on the methodology, governance and labelling system	Webpage	Research and Methodology (HowGood.com)
HowGood	HowGood’s methodology measuring sustainability	Methodology Paper	HowGood’s Methodology for Measuring Sustainability | Latis Help Center
HowGood	Product carbon footprint methodology	Methodology Paper	HowGood Product Carbon Footprint Methodology | Latis Help Center
HowGood	General info on the methodology, governance and labelling system	Webpage	Sustainability Intelligence for Food Companies (howgood.com)
HowGood	Overall discussion on the methodology, governance and label system.	Oral discussion/information	
Mondra	General info on the methodology, governance and labelling system	Webpage	Mondra
Mondra	Farm data done better	Presentation	Confidential
Mondra	Overall discussion on the methodology, governance and label system.	Oral discussion/information	
CarbonCloud	Extended Methodology-Carbon Cloud	Webpage	Extended Methodology - CarbonCloud
CarbonCloud	Open calculator tool/app	Webpage	‘‘ | CarbonCloud
M-check	General info on the methodology, governance and labelling system	Webpage	M-Check: Sustainable shopping made easy • Migros
Denmark Government (Danish Climate label initiative)	Guidelines for calculating the carbon footprint of food products available on the Denmark market	Methodology paper	Guidelines for calculating the carbon footprint of food products available on the Denmark market (au.dk)
Denmark Government (Danish Climate label initiative)	Climate-friendly food and consumer behaviour	Position paper	climate-friendly_food_and_consumer_behaviour_1.pdf (klimaraadet.dk)

It should be noted that all the data we have presented in the tables in the report are validated separately by the owners of the LCA-based ecolabelling schemes.

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