



Measuring Progress in Packaging Waste Prevention: Trends and Gaps in Communicated Indicators from National Policy and the Food Retail Sector

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Abstract

Effective packaging waste prevention requires appropriate indicators to monitor progress and design measures. This paper addresses the lack of research and standardization of packaging waste prevention indicators at the national and company levels. A two-part methodology is employed. First, a framework for inventorying indicators is established; then, the framework is applied to national waste prevention programs of European Environment Agency member and cooperating countries, as well as to published reports and communications of the German food retail sector. The analysis reveals that 23 out of 30 countries and 17 out of 32 companies use and communicate packaging waste prevention indicators. However, there are gaps in indicators addressing qualitative prevention as well as regulatory and economic instruments at the national level. At the company level, recycled content and the reduction of packaging are specifically addressed. The term “reduction” may involve various approaches, including replacing materials such as plastic with alternatives or simply reducing usage. Specific monitoring of secondary and transport packaging is lacking in both sectors. In terms of plastics, indicators lack consistency and clarity, potentially facilitating greenwashing at the corporate level. Monitoring and reporting practices vary, and few indicators have specific targets and monitoring schemes. Recommendations for improvement include establishing a common understanding of waste prevention, adopting a holistic approach to monitoring various packaging materials, enhancing indicator measurability, and harmonizing indicators through categorization and inventory frameworks. These improvements are crucial for effectively monitoring and addressing packaging waste prevention at both the national and industry levels.

Keywords Waste prevention · Packaging waste · Monitoring · Indicators

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Introduction

As a constantly and rapidly growing waste stream, packaging waste and its reduction have become major issues worldwide [1–3]. In the European Union (EU), the European Commission has taken steps to mandate more action toward the prevention of packaging waste and the promotion of a circular economy (CE) for packaging. In November 2022, the European Commission proposed a revision to the Packaging and Packaging Waste Directive (PPWR) as a part of the European Green Deal [4] that mandates that member states reduce packaging waste per capita. The proposal includes targets for minimum recycled content in packaging products and targets for reuse, refill, and overall packaging waste reduction [4]. By 2030, the target is a 5% reduction in packaging waste per capita compared with 2018, followed by a 10% reduction by 2035 and a 15% reduction by 2040 [5].

Generally, waste prevention as defined by the EU involves “measures taken before a substance, material or product has become waste, that reduce: (a) the quantity of waste, including through the reuse of products or the extension of the life span of products; (b) the adverse impacts of the generated waste on the environment and human health; or (c) the content of harmful substances in materials and products” [6]. The EU Waste Framework Directive (WFD) mandates that member states establish waste prevention programs (WPPs) with specific measures that are monitored via indicators and targets, particularly with respect to the quantity of generated waste. By December 2013, all EU states had to adopt a WPP. To meet its mandate of reviewing progress in WPPs, the European Environment Agency (EEA) regularly publishes country profiles in relation to waste prevention. These profiles include targets, indicators, monitoring systems, and evaluation approaches for WPPs [6].

Germany implemented a WPP in 2013 that was updated in 2021. However, a notable gap in this program is the absence of clear indicators and targets specifically focused on packaging waste prevention. Beverage containers are an exception. The updated WPP refers to the German Packaging Act, which sets a target of 70% reusable beverage containers. Other countries already use a larger set of indicators to monitor plastic or packaging waste prevention [7].

In addition to political attempts to prevent packaging waste, the packaging industry [8] and the retail sector [9, 10] have communicated efforts and achievements in packaging prevention strategies [11]. The EU Single-Use Plastics (SUP) Directive has attracted a large amount of media and public attention and has pushed the retail sector to act. Companies are increasingly committing to packaging waste reduction schemes on a voluntary basis, demonstrating that measurable targets can be set at the company level. Indicators used in this sector include metrics such as “share of unpackaged product” [12] or “saved packaging materials in tonnes per year” [13]. Since 2014, large companies (500+employees) in the EU must report on environmental issues in their annual statements [14]. The upcoming EU Corporate Sustainability Reporting Directive (CSRD) from 2024 will extend this requirement [15]. The CSRD and the linked European Sustainability Reporting Standards (ESRS) require companies to disclose their environmental, social, and governance practices. These standards establish the essential qualities of sustainability statements prepared according to ESRS, including relevance, faithful representation, comparability, verifiability, and understandability [16].

While circularity and CE indicators have been intensively studied [17–20], indicators that specifically monitor waste prevention have rarely been addressed. Possible reasons for

this include the complexity of measuring the effects of waste prevention efforts, the indirect and long-term effects, and the lack of standardized measurement methods [21, 22]. Wilts et al. [23] evaluated the WPPs of EU member states and other countries to develop indicators for Germany's waste prevention objectives, operational targets, and sub-targets, resulting in eight sets of indicators [22]. Nevertheless, packaging was not considered and remains a research gap, as this was not a focus of the first German WPP. With respect to indicators of WPPs, Wilts et al. [23] and Fottner et al. [7] evaluated previous national and regional WPPs in Europe. Their analysis identified specific indicators to monitor progress in reuse and plastic waste prevention. However, difficulties in monitoring progress persist due to a lack of clear and common targets for most product groups and data quality issues across countries [7, 23]. While plastic packaging has been partly addressed, no specific investigations of the entire packaging sector could be identified. Furthermore, previous studies are based on older WPPs.

Current indicators used in communication in the German food retail sector, especially with regard to packaging, have not yet been systematically assessed [24]. Evaluating these indicators can advance waste prevention policy, enhance transparency, and standardize measurement efforts for packaging waste prevention to address concerns in the Green Claims Directive [25] and the new CSRD [26] by requiring companies to provide reliable, comparable sustainability information for stakeholders.

Despite these efforts, the effective monitoring and standardization of indicators for packaging waste prevention remain inadequate. There is a lack of (standardized) indicators to monitor and assess packaging waste prevention efforts at the national level and at the company level, hindering the effective measurement of progress and strategy alignment.

Although indicators from the national WPPs and the retail sector share the goal of reducing packaging waste, they may differ in terms of their specific metrics, measurement methodologies, and scope. By examining relevant indicators from both sources, valuable insights can be gained with regard to (a) indicators used in other countries, (b) indicators of the food retail sector to be adapted and integrated into waste prevention policy, and (c) cross-sectoral approaches that are applicable in both sectors. This paper aims to address this lack of research and standardization of packaging waste prevention indicators to monitor progress or communicate achievements and to contribute to the further development, evaluation, and harmonization of indicators.

This evaluation and harmonization of indicators can improve the effectiveness and transparency of sustainable packaging waste reduction and prevention efforts. Hence, this study supports efforts toward responsible consumption and production (Sustainable Development Goal (SDG) 12). Moreover, (monitoring) progress in reducing packaging waste can lead to lower greenhouse gas emissions associated with production and waste management, thus contributing to climate action, as outlined in SDG 13 [27].

This study aims to investigate the following research questions: Which indicators are used in national WPPs as well as in published reports or communications of the German food retail sector to monitor packaging waste prevention? How is progress in packaging waste prevention measured? What are the shortcomings that prevent comprehensive monitoring of packaging waste prevention?

Methods

To answer these research questions, first, a framework was developed to inventory and categorize indicators of packaging waste prevention. This framework forms the basis for identifying indicators of packaging waste prevention, categorizing them according to their scope and characterizing the measurement approach. This framework is applied to two case studies: indicators from national WPPs of EEA member and cooperating countries (Chap. 2.3.1) and indicators from published reports and communications in the German food retail sector (Chap. 2.3.2). The methodology is detailed below.

Description of the Study Area

As the scope of this study, we chose a region with overarching waste and packaging waste framework legislation, such as EEA member countries. Following the subsidiary principle, these policies require implementation and action by member states. Further, this study presents a country-level case study of Germany and highlights the challenges and practicalities of national implementation and the gap between national ambitions and corporate adoption.

The EEA includes 32 member countries and 6 cooperating countries. The member countries include the 27 EU member states, Iceland, Liechtenstein, Norway, Switzerland, and Turkey. The cooperating countries are the six Western Balkan states: Albania, Bosnia and Herzegovina, North Macedonia, Montenegro, Serbia, and Kosovo [28]. Most EEA member countries are part of the EU and are characterized by shared policies on environmental regulations, trade agreements, and political cooperation. The European Commission, as the EU's executive body, proposes new laws and policies, monitors their implementation across MS, and manages the EU budget [29].

Germany ranks eighth in the EU for GDP per capita at €41,300, which is well above the EU average of €35,500 and accounts for 25.3% of the EU's total GDP [30]. In addition to Ireland, Germany generates the most packaging waste in the EU, totaling 236.7 kg/cap. The food retail sector is a significant contributor to this waste [31–33].

Establishing a Framework for Characterizing and Inventorying Packaging Waste Prevention Indicators

The framework for categorizing and inventorying waste prevention indicators consists of the following steps (Fig. 1):

- a) The identification of packaging waste prevention indicators (Sect. [Procedures to Identify Packaging Waste Prevention Indicators](#)).
- b) The categorization of indicators according to their scope to answer the question, “What do they measure?” (Sect. [Categorizing Indicators According to Their Scope](#)).
- c) The documentation of measurability criteria to answer the question, “How do they measure?” (Sect. [Categorizing Indicators According to Their Measurability](#)).

The categorization of indicators within this framework involved the development of codes and code lists for categories and subcategories to describe the scope and measurability of identified indicators. Codes and code lists can ensure consistency in how indicators are

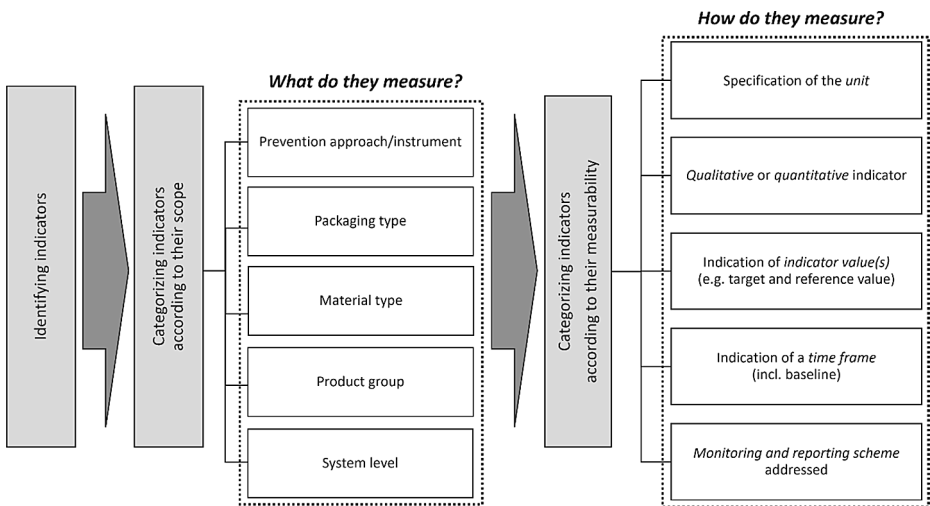


Fig. 1 Framework and data model for categorizing and inventorying packaging waste prevention indicators

categorized and labeled across different datasets, projects, or organizations. They allow the characterization and description of datasets. This standardization simplifies data integration, comparison, and sharing. Consequently, in the process of code development to characterize indicators in more detail, we sought to incorporate definitions and classifications endorsed by official regulations, standards and authorities or established in the academic literature. The framework and code development are further described in the following sections. Code lists and descriptions of each code can be found in the supplemental information (SI).

Procedure to Identify Packaging Waste Prevention Indicators

Indicators were selected based on whether they were used or communicated to (a) measure achievements or goals (for example, targets), (b) reflect changes connected to an intervention or (c) assess performance (for example, monitoring). The identification of indicators further relied on specific criteria, including whether they were defined as indicators in the text (for example, as “proposed indicators”), referred to a quantitative target, or contained a unit indication.

This study focused only on “packaging-related” indicators. Indicators without clear specifications of packaging products, packaging waste or packaging materials were not considered.

Packaging-related was defined as follows:

- Indicators that refer directly to packaging, for example, “number of plastic carrier bags put on the market”.
- Indicators that refer to typical packaging or packaging materials and include other waste streams, for example, the “quantity of packaging and paper waste collected separately per capita per year”.
- Indicators specifically referring to single-use plastics (SUP).

- d) *Specifically, for the retail sector*, the analysis also considered indicators related only to “plastic” or “paper” (for example, “saved virgin plastic in tonnes per year”, “saved cartonnages in tonnes”) because it was assumed that in food retail, these waste fractions typically consist of packaging.

In this study, we adopt the EU’s definition of waste prevention, as mentioned in the introduction. The study focuses on indicators that directly relate to prevention approaches and instruments (for example, reuse of “the amount of reusable packaging”) and those that gauge the effectiveness of packaging waste reduction (for example, the “quantity of packaging waste”) (Sect. 2.1.2.). Indicators that provide information on packaging (waste) amounts without specifying related prevention approaches are included in this study since they provide a baseline to assess progress in waste reduction efforts (for example, the total amount of packaging waste generated within a specific area or time frame). The use of recyclates (recycled content) is considered in this study since this measure can lead to reduced demand for virgin materials. The recyclability of packaging is also considered. While recyclability may not directly prevent waste at disposal, it is an essential strategy that operates at the product level and can lead to reduced resource consumption. In some WPPs, increasing recyclability is listed as a possible measure (for example, Austria). Indicators that address the substitution of plastic with biobased plastic are not considered waste prevention since sources indicate that they are associated with significant negative environmental impacts and the benefits have not been conclusively proven [34].

Categorizing Indicators According to their Scope

According to the framework, all packaging waste prevention indicators were assigned to the specific prevention approach they addressed in the corresponding text from which they were extracted. Whenever applicable, indicators were categorized into subcategories to provide a more detailed description of the prevention approach (or instrument at the national level). The (sub)categories describing existing prevention approaches were based on the WFD [6], van Sluisveld et al. [8] and Wilts et al. [23]. When these definitions were not sufficient for this analysis, (sub)categories were adapted and complemented after the review of existing indicators. The categories describing the prevention approach addressed by indicators include the following:

- Avoidance (including subcategories such as (nonlegal) bans or elimination of packaging).
- Reuse.
- Reduction of packaging amounts and used materials (including subcategories such as lightweight packaging, removal of packaging components or bulk packaging).
- Qualitative prevention.
- Use of (post-consumer) recyclates or (post-consumer) recycled content.
- Recyclability.
- Prevention instruments at the national level (including subcategories such as regulatory instruments or voluntary commitments).
- Indirect (including subcategories such as material input or packaging (waste) amounts).
- Other (where other approaches or more than one approach is addressed).

As one part of describing the scope of indicators, categories were used to identify the packaging types covered by these indicators. In Germany, packaging is categorized and regulated under the Packaging Act. The act defines various types of packaging that are used as the bases for categorization: (a) product and sales packaging, (b) service packaging, (c) shipment, secondary and transport packaging, and (d) other [35]. Subcategories are employed to provide more specific descriptions of the packaging types, such as carrier bags or to-go packaging for service packaging. The German categorization was chosen because it is more current and detailed than the current Packaging Directive.

Indicators were further categorized based on the specific materials they address, following the German Packaging Act's Annex 5 for packaging labeling. These categories include glass, liquid board, plastic, paper, metal, textile, wood, composite, and other/unspecified materials. If applicable, subcategories were used to provide more detailed material specifications for the plastics HDPE, PP, PS, PVC, LDPE, or PET and for metals, aluminum, or iron.

Product group categories (for example, agricultural products, beverages, and cleaning and washing products) were designed according to the Catalog for Packaging of Mandatory System Participation [36]. The catalog lists packaging that must be part of a recycling system in Germany under the Packaging Act and helps manufacturers and primary distributors classify products accurately. The categories and codes for inventory can be found in the SI.

The system level addressed by indicators was divided into two categories: (a) regional (macro) and (b) interorganizational/organization (meso), including the product level (micro) [19, 37]. Evaluating and gauging performance at the product level can typically involve the organizational level as well, including various elements within the value chain or network. Therefore, the product and organizational levels for the case of packaging were considered together as one category.

Categorizing Indicators According to their Measurability

The SMART criteria (Specific, Measurable, Achievable, Relevant, Timely/Targeted), initially introduced as a management tool for setting goals and objectives, have gained widespread acceptance in the fields of monitoring and evaluation [38]. As described here, measurability refers to the indicator's ability to be quantified, analyzed, and monitored. If an indicator cannot be adequately measured and monitored, assessing progress becomes difficult and determining the achievement of desired outcomes becomes uncertain. To address the question of how indicators are measured, various categories are considered to characterize the measurability of each identified indicator:

- a) Specification of the *unit* for the indicator.
- b) *Quantitative* or *qualitative* indicators.
- c) Indication of *indicator value(s)*, meaning a specific data point(s) or a measurement that quantifies the current state, progress, or target of the indicator (for example, status quo, achievement, mid-term and/or future target) as well as reference values for the correct interpretation.
- d) Indication of a *time frame* to describe the present termination of an indicator value (for example, indication of year/date and whether a baseline is specified).

To describe whether a *monitoring and reporting scheme* is addressed for the respective indicator, further categories were developed (for example, “monitoringAddressed_”) (SI). Specific codes, such as “standard_GRI,” were created to represent the sustainability reporting standards referenced in the document from which the indicator was extracted (SI).

Applying the Framework for Categorizing and Inventorying Packaging Waste Prevention Indicators

The developed framework was applied to two case studies: a) national WPPs from EEA members and cooperating countries and b) German food retailers. Factsheets from national WPPs and reports from the German food retail sector were reviewed for packaging waste prevention indicators. The process is described in more detail in the following sections.

Case Study: National Waste Prevention Program Fact Sheets

To identify indicators from national WPPs from EEA member and cooperating countries, the country fact sheets, published by the EEA in the context of reviewing national and regional WPPs (Table 1), were reviewed. All WPP factsheets from 2016 to 2021 available from 2019 until February 2023 were considered. The list of all considered WPP factsheets can be found in Annex Table A. All indicators and indicator values (for example, targets) addressing the prevention of packaging waste identified in the selected documents were compiled and categorized in the framework (Sect. 2.1). During the review, the “quantitative targets” and “indicators” sections of the fact sheets were screened for indicators.

Table 1 Countries and regions for which WPP country fact sheets were covered

EEA member and cooperating countries/regions from 2019 to 2023 with WPP fact sheets		
Albania	Germany	North Macedonia
Austria	Greece	Netherlands
Belgium (Brussels, Flanders, Wallonia)	Hungary	Norway
Bosnia and Herzegovina	Iceland	Poland
Bulgaria	Ireland	Portugal
Croatia	Kosovo	Romania
Cyprus	Italy	Serbia
Czechia	Latvia	Slovakia
Denmark	Lithuania	Slovenia
Estonia	Luxembourg	Spain
Finland	Malta	Sweden
France	Montenegro	United Kingdom (England, Northern Ireland, Scotland, Wales)

Case Study: Waste Prevention Communication by the German Food Retail Sector

To identify communicated indicators in the field of packaging waste prevention by the German food retail sector, a review was conducted of publicly available documents and reports from the ten retailers with the highest net sales in Germany, including their subsidiaries. Two organic supermarket companies with the highest sales in Germany were also considered. Therefore, a total of 32 companies and subsidiaries were covered. The selection of companies included in the review without their subsidiaries is outlined in Table 2.

The companies' websites were screened for specific documents that were likely to contain information related to packaging waste prevention. The following types of documents were included in the search:

- Corporate responsibility (CR) programs, policies and reports.
- Sustainability, progress, and general company reports.
- Corporate guidelines for packaging and purchasing.
- Documents with information targeted toward policymakers and customers.

The literature was collected for the publishing period from 2019 until February 2023. A total of 34 relevant documents were identified and analyzed (Appendix A, Table B). In each case, the most recent document available was chosen. After these documents were selected, each was reviewed to find indicators and their indicator values for packaging waste prevention. In the inventory of indicators from the food retail sector, only indicators that meet the definition of indicators given in Chap. 2.2 were considered. If identical indicators with the same scope, target, termination criteria, and monitoring/reporting scheme were identified, they were reported only once for each company. All relevant information on the indicators was compiled and categorized using the framework developed for this study.

Table 2 German food retail companies included in the review and 2021 net sales

Rank	Company	Net sales (in billions of euros)
1	Edeka-Gruppe	57.70
2	Schwarz-Gruppe	40.05
3	Rewe-Gruppe	34.16
4	Aldi-Gruppe	29.10
5	dm Drogeriemarkt	7.76
6	Rossmann	6.80
7	Real	4.48
8	Norma	3.61
9	Müller	2.91
10	Globus	2.90
...
19	Alnatura	0.63
20	Denree Denns/Biomarkt	0.63

Source Authors' compilation based on [39]

Results

Case Study: National Waste Prevention Program Fact Sheets of EEA Member and Cooperating Countries

Number of Identified Indicators from National Waste Prevention Program Factsheets

The analysis revealed that 23 out of 30 countries use packaging waste prevention indicators according to their WPP factsheets. Germany, for instance, communicates two indicators¹. In total, there are 123 different indicators related to packaging waste prevention, with only one indicator, “share of reusable packaging”, mentioned twice across the 36 national fact sheets. Among these indicators, 84 directly refer to packaging (68%), and 31 (25%) include packaging within their scope along with other product or waste streams, for example, the “quantity of packaging and paper waste collected separately per capita per year” (Austria). Additionally, eight indicators (7%) are only material related specifically to packaging, for example, the “amount of certain types of single-use plastic products in tonnes” (Denmark). The number of packaging waste prevention indicators reported by different countries varies between $n=36$ (Greece) and no indicators (Albania, Cyprus, Czechia, Finland, Hungary, Ireland, Kosovo, Latvia, Malta, Norway, Portugal, Romania). The list of all identified indicators per country can be found in the SI.

Scope of Communicated Indicators from National Waste Prevention Program Factsheets

The national WPP factsheets show a predominant focus on monitoring packaging amounts ($n=26$, 21%) and packaging waste amounts ($n=14$, 11%), particularly plastics, without a specific prevention approach addressed (Fig. 2). Reuse ($n=23$, 19%) is a significant approach, followed by informative ($n=14$, 11%) and research-oriented packaging waste prevention indicators ($n=8$, 7%) and addressing voluntary agreements ($n=12$, 10%) in the context of packaging waste prevention. However, there is a notable gap in indicators related to qualitative prevention, regulatory instruments, and economic instrument-oriented indicators. Where a material specification is made, the trend suggests a specific emphasis on monitoring the prevention of plastic packaging, whereas indicators related to paper/cardboard, glass and metals are limited or not present.

Most identified indicators are designed to monitor the prevention of packaging waste in a broad sense without targeting specific packaging types ($n=71$, 58%) (Fig. 3). Carrier bags receive notable attention with 18 indicators with a focus on communication efforts and achievements in the reduction of plastic carrier bag consumption. These are followed by indicators targeting product and sales packaging with 17 indicators (14%) without further specification. The “other” category (for example, specifications such as “nonfood packaging”) includes 14 indicators (11%) covering various packaging types. Takeout, to-go or take-away packaging is less frequently addressed, with indicators in only three countries. No specific indicators related to shipment or secondary/transport packaging are mentioned, indicating a potential gap in waste prevention monitoring.

¹ Factsheet 2019: “quota of reusable packaging for the various types of packaging, taking into account the respective total quantity for packaging”; factsheet 2021: “share of reusable beverage containers”.

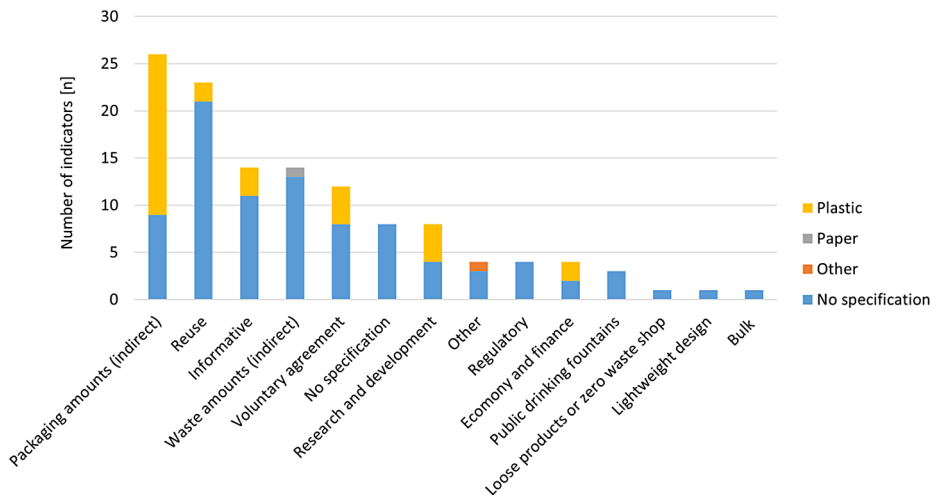


Fig. 2 Prevention approaches and material types addressed by packaging waste prevention indicators [n] from 36 reviewed national WPP factsheets from EEA member countries and cooperating countries (between 2019 and 2023) published by the EEA. $n_{total}=123$

Fig. 3 Packaging types addressed by indicators [n] in 36 reviewed national WPP factsheets from EEA member and cooperating countries (between 2019 and 2023) published by the EEA. $n_{total}=123$

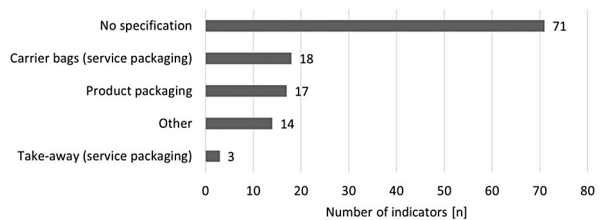


Table 3 Product groups addressed by indicators [n] in 36 reviewed national WPP factsheets from EEA member and cooperating countries (between 2019 and 2023) published by the EEA. $n_{total}=123$

Product group	Number of indicators [n]
No specification	104
Beverages	15
Other products	4
Total	123

A significant number of the indicators do not specify a particular product or packaging type ($n = 104$, 85%) (Table 3). These indicators may be applied broadly across various products and packaging materials. Beverages have 15 indicators (12%), suggesting a specific focus on waste prevention indicators for various types of beverages (for example, “quantity of plastic water bottles consumed” (Greece) and “rate of increase in the amount of primary packaging for soft drinks, mineral water and beer, compared with 2017” (Romania)). Four indicators address other products, for example, “cups for beverages, food containers according to Part A of the Annex to the SUP Directive”.

The Measurability of Communicated Indicators from National Waste Prevention Program Factsheets

Among the indicators collected from WPP factsheets, 107 are quantitative (87%), and 16 take a qualitative approach (13%). Many quantitative indicators lack specificity; 37 of them do not specify a measurement unit (30%). The range of quantitative units in the remaining indicators underscores the complexity of evaluating and monitoring the effectiveness of preventing packaging waste:

- Count-based units, using “n” (count) ($n=53$).
- Share/ratio/rate-based units (%) ($n=21$).
- Time-related units, indicating an annual evaluation approach ($n=12$).
- Mass-based units such as kilograms ($n=9$).
- Units assessing waste generation on a per capita or individual basis (for example, “kg/cap*year”) ($n=9$).
- Monetary units, such as “leva” (currency) ($n=1$).

Among the 123 indicators, only 15% ($n=19$) have established targets, of which 14 (11%) indicators have a further time frame indication (Table 4). The present targets are related to packaging amounts or waste amounts, followed by those that address reuse as a prevention approach. Four indicators focus on single-use carrier bags.

The monitoring and reporting approaches addressed in WPP factsheets vary. Of 123 indicators, 67 (54%) are featured factsheets emphasizing program-wide (report-related) monitoring and reporting without specifying reporting a monitoring scheme (for example, data requirements and calculations) on individual indicators (Fig. 4). It remains unclear whether monitoring and reporting include a scheme for those indicators. Additionally, 23 (19%) indicators are present in factsheets addressing program-wide monitoring without clear reporting period details. Notably, 19 (2+10+7) (15%) indicators from eight countries are specified with monitoring and/or reporting addressed at the indicator level:

- Italy entrusted the Ministry of the Environment with monitoring through a ‘technical round table.’.
- The Polish WPP factsheet from 2016 mentioned a chapter on monitoring with specified quantitative indicators.
- In Spain, information from various governmental bodies is used for monitoring.

No common monitoring and reporting scheme for indicators across countries could be identified in the respective national WPP factsheets.

Case Study: Waste Prevention Communication by the German Food Retail Sector

Number of Identified Indicators from the German Food Retail Sector

In the German food retail sector, 17 out of 32 companies (32 in total, including both parent companies and subsidiaries) have adopted packaging waste prevention indicators according to the reports evaluated. These indicators were found in 28 different documents out of

Table 4 Packaging prevention indicators with quantitative target and time frame specifications identified in 36 reviewed national WPP factsheets from EEA member countries and cooperating countries (between 2019 and 2023) published by the EEA

Country	Indicator and unit	Target and time frame addressed
Austria	(Reduced) number of plastic carrier bags put on the market [n/cap*year]	Reduced by 50% by 2019 (reference year 2014); this means a reduction of about 25 plastic bags per person per year until 2019
Belgium (Wallonia)	(Reduced) quantity of household packaging [kg/cap*year]	Reduced by 7.3 kg per capita by 2025 in comparison with 2013
Belgium (Brussels)	Amount of retail stores transitioned to bulk shops [n]	100 retail stores in Brussels have transitioned to bulk shops; to be achieved by 2023
Belgium (Brussels)	Amount of restaurants that have developed new alternatives regarding beverage packaging, disposable tableware and reusable food packaging [n]	100 restaurants in Brussels have developed new alternatives; to be achieved by 2023
Estonia	Growth rate of packaging waste generation as a percentage of gross domestic product (GDP) growth during a period [%]	The generation of municipal waste should grow by no more than 1.5% per annum; during the same period, the growth rate of packaging waste generation should be less than two thirds that of gross domestic product (GDP)
France	Share of reused packaging placed on the market [%]	5% in 2023 and 10% in 2027
Greece	(Reduced) consumption of single-use plastic (SUP) products [no specification]	30% by 2024 and 60% by 2026, compared with 2022
Iceland	Number of plastic bags [n/inhabitant per year]	Should not exceed 40 bags/inhabitant per year by 2025
Iceland	Number of returnable beverage packaging per capita [n/inhabitant per year]	Should not exceed 400 per year by 2027
Romania	Increase in the amount of packaging waste compared with 2017 in comparison to GDP growth) [no specification]	The increase in the quantity of packaging waste in 2025 in comparison with 2017 should be at least 10% lower than the GDP growth during this period
Slovenia	Amount of lightweight plastic carrier bags (in households) [n/household*year]	The annual level of consumption does not exceed 90 lightweight plastic carrier bags per person by 31 December 2019 or 40 lightweight plastic carrier bags per person by 31 December 2025
Sweden	Use of single-use plastic bags per person per year [n/person*year]	The use of single-use plastic bags should not exceed 90 bags per person per year by 31 December 2019 and 40 bags per person per year by 31 December 2025
Sweden	Proportion of reusable packaging placed on the market [%]	Increase by at least 20% from 2022 to 2026 and at least 30% from 2022 to 2030
UK	(Reduced) amount of traditional grocery ingredient, product and packaging waste in grocery supply chains [%]	Reduce by 3% by 2015 from a 2012 baseline

34 documents analyzed (Appendix, Table B). A total of 229 indicators were identified, 47 (21%) of which were duplicates due to identical formulations. Examples of duplicates can be found in Table 5. However, these duplicate indicators were applied to different product or material groups or types of packaging or used by different companies in the documents; therefore, they are considered separate indicators in the following sections. The number of identified indicators per company can be found in Appendix Table C.

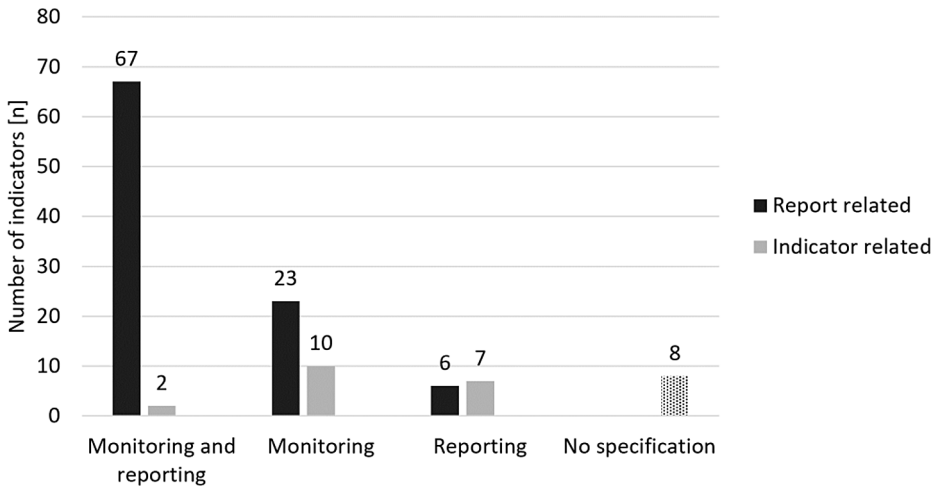


Fig. 4 Number of packaging waste prevention indicators [n] in WPP factsheets from EEA member and cooperating countries (between 2019 and 2023) published by the EEA classified according to addressed monitoring and reporting schemes: **a**) indicators from factsheets that mention monitoring and/or reporting for the entire program (report related), **b**) indicators from factsheets that provide specific details about monitoring and reporting for the individual indicator (indicator related). $n_{\text{total}}=123$

The data indicate that there is a substantial focus on waste prevention indicators that directly address packaging, with 205 (90%) of 229 indicators. A few indicators address other products or waste streams together with packaging (packaging included) ($n=17$, 7%). Material-related waste prevention indicators that include packaging (for example, SUP) receive less attention ($n=7$, 3%). The list of all identified indicators can be found in the SI.

Scope of Communicated Indicators from the German Food Retail Sector

The analysis of the German retail sector reveals a diverse range of packaging waste prevention indicators, with a focus on recycled content ($n=75$, 33%) (Fig. 5). Plastic, particularly PET, is the most frequently addressed material group in all indicators ($n=116$, 51%). This is followed by reduction approaches that emphasize strategies such as general reduction without specification, and reduction through packaging optimization as lightweight designs, removal of components, smart packaging solutions, and refill options. “Reduction” without specifying the approach is the second most frequently addressed approach ($n=36$, 16%) by indicators but seems to have different definitions depending on the company.

Indicators addressing reuse ($n=20$, 9%) also represent monitoring or communication efforts in the use of reusable packaging. Several indicators measure packaging amounts ($n=14$, 6%), material inputs ($n=7$, 3%), and packaging waste amounts ($n=6$, 3%) without specifying the prevention approach. Plastic materials are extensively monitored, whereas other materials, such as paper, cardboard, aluminum, and glass, receive less attention. However, indicators related to recycled content and the qualitative prevention of aluminum and paper are addressed in certain instances. Some approaches, such as avoidance (for example, elimination of packaging, loose products or zero waste stations), have fewer indicators.

Table 5 Examples of packaging waste prevention indicators identified multiple times (duplicates with the exact same formulation) based on a review of 34 published documents (for example, sustainability reports) identified, communicating waste prevention efforts by the German food retail sector. $n_{\text{total}}=229$

Focus	Indicators
Avoidance	• Share of unpackaged fruit and vegetables ($n=3$)
Reuse	• Share of fruits and vegetables delivered in reusable boxes ($n=2$)
Recyclability	• Recyclability in % ($n=2$)
Recycled content	• Average recycled content in own-brand packaging in % ($n=2$) • Average recycled content in own-brand plastic packaging in % ($n=2$) • Recycled content (post-consumer) in % ($n=2$) • Recycled content in % ($n=4$) • Recycled content in own-brand PET bottles in % ($n=2$)
(Packaging) material	• Reduction of plastic in % ($n=2$) • Saved plastic in kg per year ($n=6$) • Saved plastic in tonnes ($n=8$) • Saved plastic in tonnes per year ($n=6$) • Saved virgin plastic in tonnes per year ($n=3$) • Saved cartonnage in tonnes ($n=2$) • Saved packaging material compared to the base year in tonnes ($n=3$) • Saved packaging material in tonnes ($n=2$)
Carrier bags	• Reduced consumption of disposable carrier bags (plastic and paper) in % ($n=2$)
LCA-based	• Saved CO ₂ -emissions in tonnes ($n=4$) • Saved CO ₂ -emissions in tonnes per year ($n=2$)

There is extensive monitoring or communication of prevention efforts regarding packaging used for product sales, especially under own brands, as shown by 96 indicators (42%) (Fig. 6). Product sales packaging without the specification of “own brand” follows with 52 indicators (23%). Carrier bags constitute the third-highest category, with 30 indicators (13%). Nineteen indicators lack specificity in the packaging type (“no specification”). In contrast to the WPP factsheets, transport and shipping packaging are addressed by indicators even though they have a small focus. Takeout or to-go food packaging has only one indicator, showing a lower focus on monitoring in this context.

Indicators used without specification of the addressed product groups stand out with 110 indicators (48%) Table 6. Agricultural products take the second position with 30 indicators (13%) related to farming products, especially fruits and vegetables. Agricultural products often feature in indicators related to prevention approaches such as packaging elimination, loose products, and reuse (for example, reusable nets). Other products (for example, specifications such as “packaging in the self-service goods sector” and “reusable coffee cups and reusable fruit and vegetable bags”), represented by 23 indicators (10%), cover categories such as self-service goods, batteries, and paint. This is followed by cleaning and washing products, which are covered by 21 indicators (9%), mainly addressing the approach of recycled content in packaging. Beverages ($n=19$, 8%) and personal care products ($n=11$, 5%) are also addressed by several indicators.

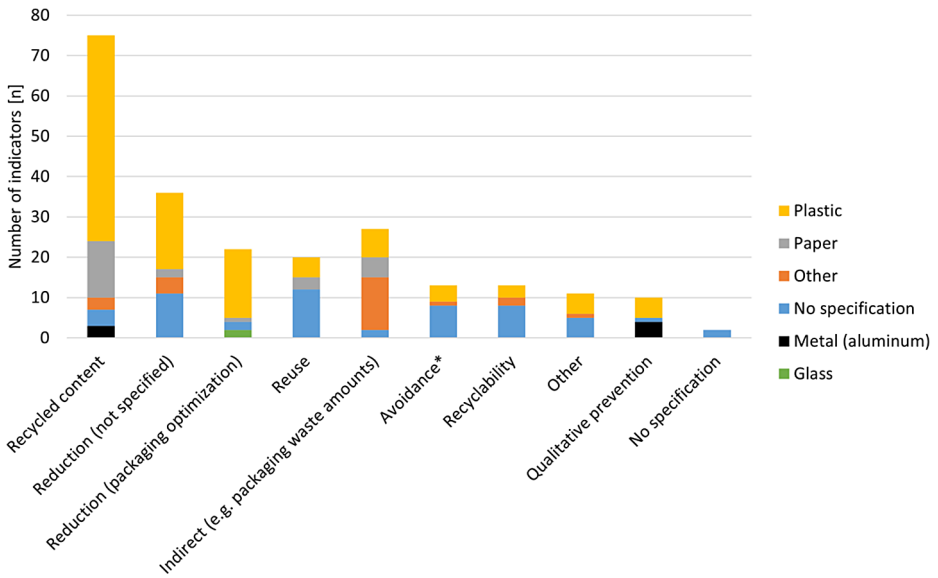


Fig. 5 Prevention approaches and material types addressed by packaging waste prevention indicators [n] based on a review of 34 published documents (for example, sustainability reports) identified, communicating waste prevention efforts by the German food retail sector. Indicators such as “packaging (waste) amounts and “material input” are defined as “indirect” since they provide a baseline to assess progress in waste reduction efforts. $n_{total}=229$; *avoidance=through ban, elimination of packaging, loose products and/or zero waste stations/shops

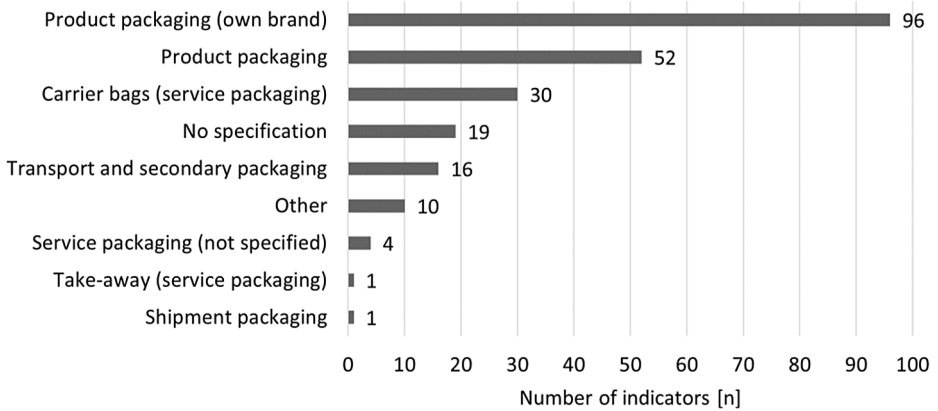


Fig. 6 Packaging types addressed by packaging waste prevention indicators [n] based on a review of 34 published documents (for example, sustainability reports) identified, communicating waste prevention efforts by the German food retail sector. $n_{total}=229$

Table 6 Product groups addressed by packaging waste prevention indicators [n] based on a review of 34 published documents (for example, sustainability reports) identified, communicating waste prevention efforts by the German food retail sector. $n_{\text{total}}=229$

Product group	Number of indicators [n]
No specification	110
Agricultural products	30
Other products	23
Cleaning and washing	21
Beverages	19
Personal care products	11
Other dairy	4
Baked goods	2
Frozen food	2
Meat, sausage, and fish	2
Household and furniture	2
Dry products	1
Other food	1
Gastro and to-go	1
total	229

Source Authors' compilation

The Measurability of Communicated Indicators from the German Food Retail Sector

In total, only two indicators lack specification of a measurement unit. As in the WPP fact-sheets, various units are employed for assessment. The most common in retail are percentages (%), which appear in 115 indicators (50%). Mass-based units, including kilograms (kg), kilograms per year (kg/year), and tonnes, are also significant (74 indicators, 32%).

- Count-based units represented by “n” ($n=36$).
- Units related to annual measurements (time-related), such as kg/year and tonnes/year, ($n=28$)
- Units tailored to sales areas, such as n/m^2 of sales area and kg/m^2 of sales area ($n=7$).
- Store and market-specific units, such as “kg/day* store” and “kg/workday*market ($n=2$).
- Environmental impact units, such as “tonnes CO₂eq” (tonnes of CO₂ equivalent) ($n=1$).

Among the 229 indicators, 31% ($n=72$) are associated with a quantified future target (Fig. 7). This percentage decreases to 30% ($n=71$) when the target is communicated with a specified time frame. Among the 72 indicators with a quantified target, 25 (11% of 229) also communicate achievements or progress toward the target. Examples of indicators with quantified targets and time frames can be found in Table 7. Only indicators with quantified targets from 2024 onward are considered in the table.

Most indicators identified by the review of 34 documents communicating waste prevention in German food retail are used to communicate the status quo or achieved success. 48% ($n=109$) of all indicators are employed to communicate success in reducing packaging (material) (Fig. 8). Notably, in 52 cases of communicated success, a reference value and an indication of a baseline are lacking. A reference value for the correct interpretation of the indicator value is missing when, for example,

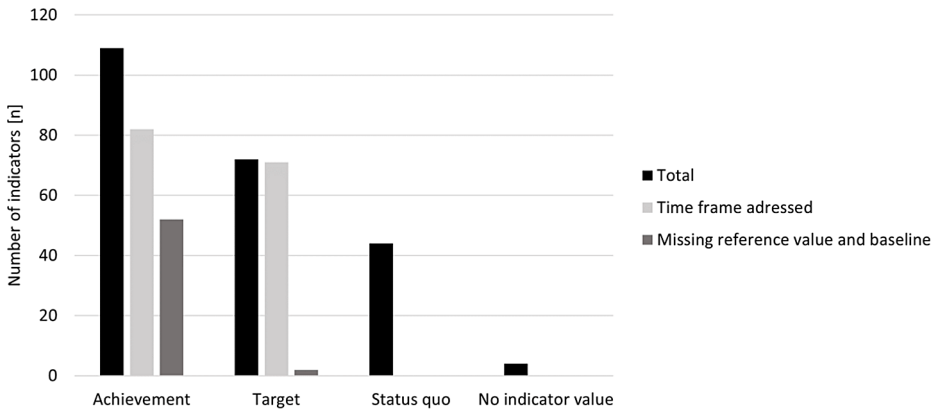


Fig. 7 Number of indicators communicated with their respective indicator values (achievement, target, status quo) based on a review of 34 published documents (for example, sustainability reports) identified, communicating waste prevention efforts by the German food retail sector. The Figure includes if time references are addressed or reference values/calculation basis for correct interpretation is missing. $n_{\text{total}}=229$

Table 7 Indicators with quantitative target and time frame specifications (between 2024 and 2030) addressed in German food retail based on a review of 34 published documents (for example, sustainability reports) identified, communicating waste prevention efforts. $n_{\text{total}}=229$

Indicator	Target	Time frame
Share of unpackaged fruit and vegetables	40-90%	Until 2025
Share of own-brand packaging to be recyclable, compostable or reusable	100%	Until 2025
Share of fruit and vegetables in reusable transport packaging instead of cardboard packaging	75%	Until 2024
Share of environmentally friendly own-brand packaging	100%	Until 2030
Reduction of absolute greenhouse gas emissions in the supply chains of own-brand articles in %	15%	Until 2030 (Baseline 2019)
Recycled content in own-brand plastic packaging in %/ average recycled content in own-brand plastic packaging in %	25-30%	Until 2025
Recycled content in own-brand paper and PET packaging in %	50%	Until 2025
Number of own-brand products and articles whose packaging material has been assessed for recyclability and modified where necessary	150	Until 2025
Share of own-brand plastic packaging maximum recyclable	100%	Until 2025
Share of own-brand packaging that can be recycled into high-grade recyclate	70%	Until 2025

- How much (material) savings are indicated, but there is no indication of how the savings have been calculated (for example, assumptions) or how much the initial amount was (baseline value).
- A reduction of, for example, x% is targeted, but it is unclear what it refers to (no reference value).
- The indicator shows a comparison with a specific year (for example, the baseline), but no further information from the year is given (for example, the amount it refers to).

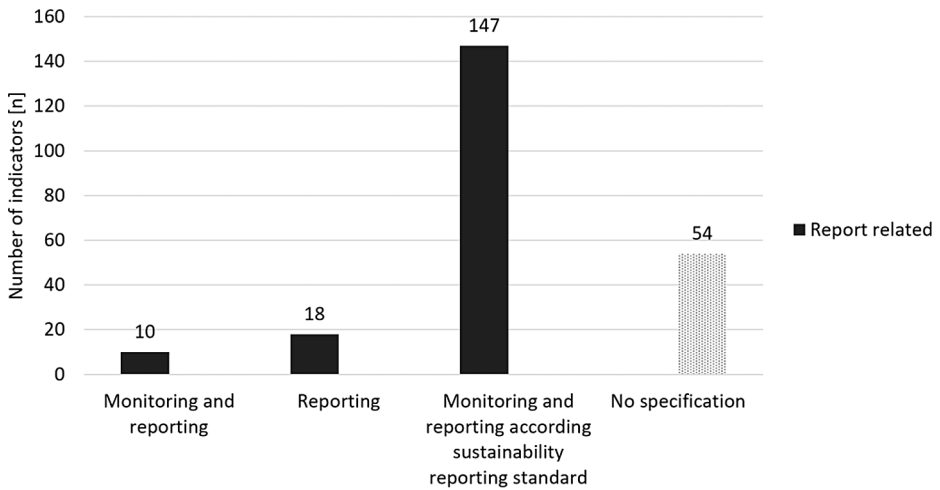


Fig. 8 Number of indicators [n] from documents that mention monitoring and/or reporting for the entire report/document (report related), based on a review of 34 published documents (for example, sustainability reports) identified, communicating waste prevention efforts by the German food retail sector. $n_{\text{total}}=229$

Examples of such indicators include the following:

- Reduction of cardboard packaging by x% in many cereals.
- x million tonnes of plastic saved by not using foil for cucumbers.
- x saved amount of knotted bags per year.

In these cases, no information about the reference/basis for calculation is provided.

Monitoring and reporting practices in reports of the food retail sector in Germany lack clear (monitoring) schemes for indicators. Notably, monitoring and reporting are addressed at the report level but not specifically at the indicator level, particularly for sustainability reports. However, 147 indicators (64%) from 11 different companies align with the sustainability reporting standard Global Reporting Initiative (GRI). No reference to other sustainability reporting standards is made, reflecting a common industry practice in Germany. Additionally, 54 indicators (24%) are identified in documents that do not specify any particular reporting or monitoring schemes or standards. In total, 13 companies address monitoring and/or reporting in their reports.

Discussion

Variations in the Amount of Used Packaging Waste Prevention Indicators

Packaging waste prevention is a global concern. Various countries have proposed indicators to monitor and address this issue, as shown in this study, but there are notable differences in their amount and design. For example, Greece, Bulgaria, and Belgium stand out for their significant contributions to the amount of packaging waste prevention indicators. Greece has proposed numerous indicators, including qualitative indicators, as Greece diligently

monitors achievements by indicators per proposed waste prevention action. Belgium's substantial contribution may be attributed to its regional waste management plans with separate proposed indicators (Brussel, Flanders, Wallonia) and EU presence (for example, home to the European Parliament). Despite having the smallest packaging waste generation per inhabitant together with Croatia [40], Bulgaria has a high number of indicators. This is primarily due to the inclusion of variable indicators, which are applicable to several waste streams according to the WPP factsheets.

Differences in the existing indicators and those identified in the factsheets also stem from variations in governance. Some countries have adopted voluntary agreements with industry for specific waste streams that are not included in formal WPPs. For example, Switzerland has a voluntary agreement for reducing single-use plastic bags with specific indicators to monitor it [41]. In the UK, there is also a national voluntary agreement (the Plastics Pact) between the government, businesses, and NGOs. The signatories represent 85% of the plastic packaging on the market [42]. France relies on laws such as the 2020 Anti-Waste Law, which bans plastic packaging on certain products, including reduction targets for plastic bottles on the market [43]. Some national WPP factsheets reference some laws and agreements but not all, suggesting that these programs might provide only an incomplete picture relative to the overall waste prevention policies of countries.

The term “indicator” has various interpretations that are also apparent in national approaches for proposed indicators. For example, in Greece, distinguishing between qualitative indicators and concrete measures, as in the case of the indicator “implementation of the relevant action regarding the promotion of labeling for environmentally friendly packaging,” is not clear.

In the German food retail sector, communication efforts and the monitoring of packaging waste are well established. However, there are inconsistencies in the number, design, and use of indicators. Companies predominantly use indicators to showcase achievements rather than monitor progress (Fig. 8), which can impact the design and number of indicators used. The issue of minimizing packaging and its importance is not consistently prioritized across the food sector, as indicated by Phelan et al. (2022). According to Phelan et al. (2022), the shift to sustainable packaging in the food and beverage industry is slow and inconsistent [44].

Recommendations for Further Development of Indicators and Enhancing Harmonization in Waste Prevention Policies

A Common Definition and Understanding of Waste Prevention

The analysis reveals that the perceptions and definitions of packaging waste prevention vary significantly at both the national and company levels. At the national level, while recyclability and recycled content are mentioned in WPPs, concrete indicators and goals are not consistently proposed. It is questionable whether recycled content and recyclability can be assigned to waste prevention. Notably, a previous critical examination of WPPs indicated that approximately 51% of these plans do not precisely align with the EU's waste prevention definition [21]. These plans often emphasize recycling and recyclability, underscoring the need for a more uniform interpretation and application of waste prevention concepts. To integrate recyclability and recycled content into waste prevention efforts and align with the

definition, clear criteria are essential for their assessment as well as for the quality of recycling. We must define and differentiate recycling based on its quality, which is intricately linked with both its value and output [45].

This disparity is also evident in waste prevention communication in the German food retail sector. The use of recycled materials holds a prominent place in retail waste prevention indicators and is therefore assumed in their strategies. This is affirmed by Phelan et al. (2022), who conducted a systematic review of 68 corporate sustainability reports in the food and beverage sector and highlighted efforts to address plastic pollution [44]. In contrast with Phelan et al. (2022), the reduction and reuse of packaging play a significant role in communicating successes and monitoring progress. However, terms such as prevention and reduction are not unequivocal. The term “reduction” may involve various approaches, including replacing materials such as plastic with alternatives or simply reducing usage. Nonetheless, the precise interpretation of the term “waste reduction” remains open to discussion in certain instances, which can lead to distorted statements and greenwashing. Therefore, waste prevention definitions and terminology at both the national and corporate levels should be clarified to enhance verifiability and ensure a focused interpretation of prevention measures. In this context, prevention strategies should consistently contribute to actual environmental benefits and not lead to displacement effects.

A More Holistic View of Monitoring Packaging Waste Prevention

The identified indicators at both the national and retail levels primarily target the prevention of packaging in general, which can encompass various packaging types and product groups. However, the responsibility of different stakeholders for specific packaging types may not be adequately addressed by these generalizations. Therefore, more specific indicators (for example, packaging type as transport packaging or product group specific) can complement these more general indicators.

Plastic is frequently considered in the identified indicator sets. In the literature, plastic, especially mixed plastics, is associated with challenges in recycling and has negative environmental impacts on water bodies [46, 47]. It is crucial not only to consider individual packaging types, materials, or products but also to avoid overlooking potential environmental drawbacks and displacement effects, such as material substitution (for example, from plastic to paper). Some life cycle assessment studies have revealed that paper may not necessarily be an environmentally friendly solution [48, 49].

The emphasis on indicators related to service packaging, such as carrier bags, can be attributed to directives such as the Plastic Bags Directive, national implementations of charges and prohibitions, and voluntary commitments in Germany [50]. The current focus on product packaging at the national level, particularly in the food sector, may be influenced by established monitoring structures in the beverage sector with an emphasis on reuse. At the retail level, product packaging is the most visible packaging type for the public, whereas secondary and tertiary packaging, which are disposed of mainly as commercial waste, are less obvious to end consumers [9].

While companies in the retail sector have insights into their own supply chains and production processes, limitations in indicators of “own brands” hinder quantity estimation and comparison to the overall packaging volume. Additionally, it is crucial to consider shipping, transport, and secondary packaging in monitoring, which contribute significantly to

total packaging waste. In Germany, private end consumers contributed only 8.73 million tonnes out of the total 18.78 million tonnes of packaging waste in 2020 [51]. Glass and (ferrous) metals lack specific indicators, possibly because of established recycling technologies; therefore, they should also be considered in future indicators. The implementation of the PPWR may broaden the focus of indicators to include other product packaging and materials.

A single indicator may not adequately capture the diverse array of packaging waste streams and prevention strategies, emphasizing the need for a comprehensive set of indicators tailored to specific contexts. A variety of indicators—as seen in this study—not only acknowledges this complexity but also offers a more robust framework for effectively assessing and managing packaging waste prevention. Therefore, the criteria for a good and verifiable indicator should be met in each case.

Improving the Measurability of Packaging Waste Prevention Indicators

Within WPP factsheets, several challenges hinder the measurability of packaging waste prevention efforts. One prominent issue is the absence of communicated and standardized clear measurement units coupled with vaguely formulated indicators that allow for excessive interpretation. Moreover, the lack of a clear indicator-specific monitoring and reporting scheme further complicates the assessment of progress.

This lack of standardization also makes cross-country comparisons challenging due to the disparate reporting practices and metrics utilized in packaging waste prevention. The inconsistency in indicators across different packaging areas and approaches to waste prevention (for example, zero waste/bulk shops, promotion of public drinking fountains, informative instruments) exacerbates this problem.

The EEA published guidance for evaluating WPPs in 2021 [52] to address these issues. Actions were proposed for setting or revising indicators and targets and ensuring their measurability:

- Ensure indicators are easy to understand and track progress toward defined targets.
- Ensure the alignment of indicators/targets with available data.
- Evaluate whether indicators/targets align with key legislation, such as the circular economy action plan and WFD.
- Solicit feedback from stakeholders, including national statistical agencies and environmental ministries, on indicators and targets.

The source also provides insight into how monitoring and reporting related to indicators/targets can be enhanced. The proposed actions are aimed at assessing and comparing the data necessary for monitoring indicators with what is currently accessible and ensuring that the data meet the required quality standards and originate from reliable sources [52].

This inconsistency also extends to the retail sector in Germany, making it difficult to evaluate the efficacy of measures implemented at the company level. An explanation for the differing levels of detail regarding indicators with specific targets in the retail sector could lie in the varied nature of different documents (for example, information for customers compared with official sustainability reports). Metrics, calculation methods, and monitoring mechanisms are listed in varying levels of detail or sometimes not mentioned at all. Never-

theless, the question should be raised as to whether a high level of specificity and detail in reporting/monitoring is required in documents used for customer information or advertising purposes, especially when communicating environmental benefits and successes, to avoid greenwashing. In cases where the basis for assessment is absent (for example, reference values), there is a heightened risk of greenwashing.

Harmonization of Indicators through Categorization and Inventory

The suggested inventory framework serves as a foundational tool that includes definitions and categorizations to identify and systematically document indicators for monitoring packaging waste prevention. This framework facilitates the collection, overview, and categorization of indicators and enables quick identification of weaknesses and gaps in commonly used indicators. This could support the development of national waste prevention strategies by inventorying indicators with goals, monitoring, and reporting schemes. Researchers such as Landrum and Ohsowski (2018), Lock and Seele (2016), and Roca and Searcy (2012) have observed disparities in corporate sustainability reporting, underscoring the need for clearer, standardized approaches [44, 53–55].

However, there are ongoing challenges. In the categorization of indicators, there are also some challenges and limitations to highlight. The official definition of waste prevention as outlined in the WFD leaves room for interpretation. Efforts have been made to develop a coding system for categorizing waste prevention strategies. However, it remains challenging to precisely categorize actions as “prevention,” “reduction,” or “reuse” because these approaches often overlap and complement each other. For example, promoting the use of public drinking fountains not only helps to avoid single-use plastic bottles but also encourages reuse by refilling personal bottles. Similarly, zero waste shops may not focus exclusively on waste prevention; they may also contribute to waste reduction through bulk sales or reusable packaging. These complexities underscore the ongoing issues and challenges in defining waste prevention, as discussed further in Sect. 4.3.1.

Continuous updates based on evolving documents or regulations are imperative to ensure the relevance and efficacy of the framework. Recommendations for national uniformity include the implementation of the EEA guideline for monitoring and reporting WPPs to establish a common framework and enhance consistency across different initiatives. Further development of standardization by utilizing an international inventory and a framework for identifying gaps and trends could also enable commonly used indicators, if present.

To enhance retail sustainability reporting, harmonizing reporting and communication practices is crucial. This means establishing a unified approach or standard for reporting and monitoring waste prevention indicators nationwide at the company level. Harmonization within retail sustainability reporting standards, such as defining and measuring packaging waste prevention, recyclability, recycled content, and specific key performance indicators (KPIs), could foster transparent calculations and enable cross-company comparisons.

Challenges addressed by directives such as the PPWR, the Green Claims Directive and the new CSRD also present opportunities. Incorporating future guidelines from these directives could help to create clearer monitoring and reporting frameworks and mitigate the risk of greenwashing.

Limitations

With the rapid changes in EU-level packaging regulations, such as the upcoming PPWR in line with the European Green Deal and the latest circular economy action plan, there are also ongoing developments at the national level. It is likely that various indicators in additional (upcoming) legal documents will play a crucial role in evaluating efforts related to the prevention and monitoring of packaging waste. Importantly, these specific indicators were not examined as part of this study. Furthermore, WPPs are regularly updated and revised, and new factsheets are published. This study covers factsheets only up to February 2023 and excludes any subsequently released material. The use of WPP factsheets rather than original WPPs in local languages was necessitated by language barriers. Because the factsheets underwent a review and translation process, there is a possibility that relevant information might have been lost, potentially leading to discrepancies between the content of the factsheets and the actual WPPs in the respective countries. In addition, there are no consistent requirements for the frequency with which the programs must be updated, which leads to very different program statuses.

There are further limitations of the available sources at the retail level due to the reliance on publicly accessible information. Furthermore, the absence of internal KPIs of companies may result in an incomplete understanding of waste prevention efforts and the use of indicators for monitoring at the company level.

Conclusion

The study shed light on the current state of communicating successes and monitoring packaging prevention efforts through indicators in two case studies. Through the analysis of WPPs and the German food retail sector, valuable insights have been gained into ongoing efforts to address and monitor packaging waste (prevention). By identifying and categorizing indicators using a developed inventory framework, this study offers an overview that can guide the revision, expansion, and future integration of indicators in this field.

The analysis revealed significant disparities in the quantity, scope, and measurability of packaging prevention indicators both across countries and within a specific industry sector. This study emphasizes the urgent need for a standardized approach to designing, monitoring, and reporting packaging waste prevention indicators.

While many countries prioritize monitoring the quantity of packaging waste, particularly plastics, there are noticeable gaps in indicators related to qualitative prevention measures, regulatory instruments, and economic strategies. Additionally, indicators of shipment or secondary/transport packaging receive insufficient attention, indicating a potential gap in waste prevention monitoring. The focus on materials such as plastics or packaging types such as single-use plastic bags does not allow for comprehensive monitoring of prevention efforts. Consequently, associated target values may fail to provide sufficient incentives, especially when other relevant material streams such as transport and secondary packaging are excluded.

Similarly, within the German food retail sector, a diverse range of communicated packaging waste prevention indicators exist with a predominant focus on recycled content and general reduction strategies for plastics. However, critical areas such as indicators for materials

beyond plastics are often neglected. Moreover, the term “reduction” in packaging waste prevention indicators can encompass diverse approaches, such as substituting materials or simply using less. Its precise interpretation is often ambiguous, leading to the potential for distorted statements and greenwashing.

Both sectors exhibit diverse practices in monitoring and reporting these indicators. Only 15% of the identified indicators from the WPPs have set specific targets with varied time frames. Monitoring and reporting approaches vary across countries, with some emphasizing program-wide monitoring without specific reporting schemes for individual indicators. Furthermore, there is a lack of common monitoring and reporting schemes across countries. In German food retail, 31% of indicators have future targets, whereas 48% focus on packaging (material) reduction successes. These indicators often lack clear reference value or transparent communication of the calculation/baseline, which could facilitate greenwashing. Although monitoring and reporting practices often align with sustainability standards, there is a lack of clear schemes for packaging at the indicator level. Future legal frameworks may require revisions to these standards, offering a chance for transparent communication and improved monitoring of packaging reduction efforts.

Recommendations for improvement include establishing a common understanding of waste prevention, adopting a holistic approach to monitoring that includes various types of packaging and material to avoid displacement effects, enhancing the measurability of indicators and harmonizing indicators through categorization and inventory frameworks (national or EU-wide). Challenges present opportunities for growth, particularly through directives such as the PPWR and the CSRD, as well as through the regular updating of national WPPs. Ultimately, concerted efforts to address these challenges will be crucial in advancing toward more effective prevention of packaging waste.

More extensive research beyond the scope of this study is necessary. Future research should cover investigations of coherent procedures to generate complete, sufficient, and high-quality data for indicators, their target development and their monitoring. In particular, methodologies for monitoring actual changes in environmental states and impacts as well as socioeconomic impacts throughout the entire life cycle of packaging should be examined.

Appendix

Table A Countries/regions and the respective WPP factsheets covered in the case study: EU Waste Prevention Program fact sheets

EEA States	Date of factsheets included in this study	Duration of the program (from the newer factsheet)
Albania	2021, September 2018	2020–2035
Austria	2021, July 2019	2017–2022
Belgium	October 2019	Brussels: 2018–2023 Flanders: 2016–2022 Wallonia: 2018, revised if necessary after 6 years
Bosnia and Herzegovina	2021, November 2018	2017–2026
Bulgaria	2021, October 2016	2021–2028
Croatia	2021, July 2019	2017–2022
Cyprus	2021, October 2019	2015–2021

Table A Countries/regions and the respective WPP factsheets covered in the case study: EU Waste Prevention Program fact sheets

EEA States	Date of factsheets included in this study	Duration of the program (from the newer factsheet)
Czechia	2021, July 2019	2014-onward
Denmark	2021, October 2016	2021–2032
Estonia	2021, October 2017	2014–2022
Finland	2021, July 2019	2017–2023
France	2021, October 2016	2021–2027
Germany	2021, July 2019	2021–2027
Greece	2021, October 2016	2021–2030
Hungary	2021, October 2016	2021–2027
Iceland	2021, October 2016	2016–2027
Ireland	2021, October 2016	2004 (biennially revised)
Kosovo	2021	2020–2029 (strategy plan) 2020–2022 (action plan)
Italy	2021, October 2016	2013–2020
Latvia	2021, October 2016	2021–2028
Lithuania	2021, October 2016	Until 2022
Luxembourg	2021, October 2019	2016–2022
Malta	2021, July 2019	2021–2030
Montenegro	2021, November 2017	2022-unknown
North Macedonia	2021, November 2017	2020-onward
Norway	2021, October 2016	Adopted in 2013; of indefinite duration
Poland	2021, October 2016	No information
Portugal	2021, October 2016	2016–2025
Romania	2021, July 2019	2014–2020
Serbia	2021, November 2017	2020–2025
Slovakia	2021, July 2019	2019–2025
Slovenia	2021, July 2019	2016-present
Spain	2021, October 2016	2014–2020
Sweden	2021, July 2019	2018–2023
The Netherlands	2021, October 2016	2020-onward
United Kingdom	July 2019	England: No final duration envisaged Northern Ireland: 2014–2019 Scotland: launched in 2016

Table B List of reports and documents reviewed from German food retail outlets in alphabetical order in the case study: Waste prevention communication by the German food retail sector

Company	Title of document	Type of document	Year of document
Aldi Group	Aldi's International Recyclability Guideline. A Global Recommendation for Circular Packaging Design	guide_Packaging	2022
Aldi Nord	ALDI Nord. Sustainability Report 2021	report_Sustainability	2022
Aldi Sued	Einfach verantwortlich	information	2020
Aldi Sued	Aldi South Group: Roadmap to Vision 2030	catalogue_Measures	2022

Table B List of reports and documents reviewed from German food retail outlets in alphabetical order in the case study: Waste prevention communication by the German food retail sector

Company	Title of document	Type of document	Year of document
Aldi Sued	Bewusst einkaufen? Bei uns ganz einfach!	information	2022
Aldi Sued	Fortschrittsbericht zur Nachhaltigkeit 2022	report_Progress	2022
Aldi Sued	Heute für morgen	information	2022
Aldi Sued	Report on Corporate Responsibility. Performance 2020	report_CR	2021
Alnatura	Unser Beitrag für Mensch und Erde. Nachhaltigkeitsbericht 2021/22	report_Sustainability	2022
Budni	budni & WWF. Strategische Partnerschaft für Nachhaltigkeit. Baseline-Bericht 2021	report_Company	2022
dm	Bericht zur Zukunftsfähigkeit. Nachhaltigkeitsbericht Geschäftsjahr 2021/22	report_Sustainability	2022
Edeka Group	Breaking new ground. Company Report 2021 Edeka Group	report_Company	2022
Edeka Group	Edeka and the WWF strategic partnership. 2021 Progress Report	report_Progress	2022
Edeka Group	Verpackungsdreiklang im Supermarkt. Vermeidung, Reduzierung und Recycling. Informationen für politische Entscheider	information	2020
Edeka Minden-Hannover	Auf ZukunftsWegen. Maßnahmen für mehr Nachhaltigkeit im Markt	catalogue_Measures	2021
Edeka Minden-Hannover	Zukunft. Besser. Machen. Unternehmensbericht 2021	report_Company	2022
Edeka Nord	DNK-Erklärung 2021	report_Sustainability	2022
Edeka Nord	Verantwortung liefern - Verantwortung leben. Geschäftsbericht 2021	report_Company	2022
Edeka Nordbayern-Sachsen-Thüringen	Wie lieben Lebensmittel. Jahresbericht 2021	report_Company	2022
Edeka Südwest	Heimat bewahren. Fortschrittsbericht 2021 zur Nachhaltigkeit	report_Progress	2022
Edeka Südwest	Heimat leben. Nachhaltigkeitsbericht 2020	report_Sustainability	2021
Edeka Südwest	Was uns verbindet. Jahresbericht 2021 EDEKA Südwest	report_Company	2022
Globus	Geschäftsbericht 2018–2019. Mein Globus	report_Company	2020
Kaufland	Machen macht den Unterschied. Nachhaltigkeit bei Kaufland	policy_IdCSR	2021

Table B List of reports and documents reviewed from German food retail outlets in alphabetical order in the case study: Waste prevention communication by the German food retail sector

Company	Title of document	Type of document	Year of document
Lidl	Werte weiterdenken. Gemeinsam handeln. Nachhaltigkeitsbericht Geschäftsjahre 2020–2021	report_Sustainability	2022
Netto	Netto & WWF - Strategische Partnerschaft. Fortschrittsbericht 2021	report_Progress	2022
Netto	Verantwortung für unser Handeln. Nachhaltigkeitsbericht 2019–2020	report_Sustainability	2021
Norma	Nachhaltigkeitsbericht 2021. Norma Lebensmittelfilialbetrieb Stiftung & Co. KG	report_Sustainability	2022
Real	Handeln aus Verantwortung. Die CSR-Policy von Real	policy_IdCSR	2019
Rewe	Leitlinie für Kreislaufwirtschaft	guide_CE	2021
Rewe	Rewe Group - Nachhaltigkeitsbericht 2021 nach GRI-Standards	report_Sustainability	2022
Rewe	Leitlinie für umweltfreundlichere Verpackungen	guide_Packaging	2020
Rossmann	Nachhaltiges Wirtschaften Rossmann [Nachhaltigkeitsbericht 2022]	report_Sustainability	2022
Schwarz Group	Talking plainly. Acting sustainably. Making progress. Communication on Progress on the Sustainability Activities of the Schwarz Group in the 2020 Fiscal Year	report_Progress	2021

Table C Number of identified packaging prevention indicators per company in German food retail based on a review of 34 published documents (for example, sustainability reports) identified, communicating waste prevention efforts by the German food retail sector. $n_{\text{total}}=229$

Company	Number of identified indicators [<i>n</i>]
AldiNord	16
AldiSued	26
Alnatura	14
Dm	17
EdekaBudni	9
EdekaGroup	32
EdekaNetto	24
EdekaRegioMindenHannover	8
EdekaRegioNord	5
EdekaRegioSüdwest	7
Globus	1
Norma	11
ReweGroup	21
Rossmann	12

Table C Number of identified packaging prevention indicators per company in German food retail based on a review of 34 published documents (for example, sustainability reports) identified, communicating waste prevention efforts by the German food retail sector. $n_{\text{total}}=229$

Company	Number of identified indicators [n]
SchwarzGroup	5
SchwarzKaufland	2
SchwarzLidl	19
Total	229

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Data availability The data generated and analyzed during this study are included in this published article and its supplementary information file.

Declarations

Conflict of Interest The authors declare no conflict of interest.

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