SPHERE: the packaging sustainability framework

Contents

We would like to express our sincere appreciation to those companies and organizations that contributed to the development of SPHERE.

Thank you to the Sustainable Plastics & Packaging Value Chains project members who supported the development of this work.

We collaborated with WBCSD to develop the SPHERE framework, which aligns with Aptar's vision and ambition to progress towards more sustainable packaging. The holistic approach proposed by the SPHERE framework enhances the decision-making process and supports development teams to better understand the environmental footprint of packaging solutions.

Christophe Marie
Global Product Sustainability Director, Aptar Group

At Circular Analytics we assess packaging every day. The art is to assess packaging in a comprehensive and holistic way and to balance all the different aspects of the sustainability of packaging. Only then can we optimize packaging so that the requirements of the consumer, the supply chain and the planet are in harmony.
We are proud to have been able to contribute to the development of SPHERE.

Ernst Krottendorfer
Managing Partner, Circular Analytics

Our clients call for a common view of what makes a packaging more sustainable. Similarly to what has been done through climate related initiatives I strongly believe that this new framework will bring clarity to decision makers with regards to packaging environmental impacts.

Olivier Jan
Sustainability Partner, Deloitte

Building a sustainable and circular future has always been at the core of my career. At Dow, I had the privilege to develop strategies to enhance key market drivers to solve circularity and keep plastics out of the environment. Fixing the issue of packaging waste is not always straightforward. This why I was pleased to be part of the SPHERE advisory group, working on a practical framework to support companies in making the most sustainable packaging choice for their needs. I believe that SPHERE can truly help businesses advance their sustainability strategies, paving the way to zero waste in the environment.

Jeff Wooster
Former Global Sustainability Director, Dow

We were thrilled to take part in the creation of the long-needed reconciliation of LCA [life-cycle analysis] metrics with end-of-life impacts and circularity. This has been a key need from the industry for meaningful decision-making and we hope it will be the giant step we aimed to create.

Julien Boucher, PhD
Founder and Director, Environmental Action

For more than 15 years, Quantis has led the development of key metrics to measure the impact of packaging, from LCA to plastic leakage to our biodiversity assessment. While each serves an important purpose in its own right to inform decision making, achieving true sustainability requires a holistic lens. The launch of the SPHERE framework marks a significant milestone for both Quantis and the packaging value chain as a whole, as it brings those individual measurements together into a single assessment that has the potential to scale the transformation of the industry to align with planetary boundaries.

Dimitri Caudrelier
CEO, Quantis

The SPHERE framework is a useful tool to help understand what sustainability means for packaging and make better informed choices when developing new packaging. The six principles defined in the framework will provide the Saint-Gobain innovation teams with useful and structured guidance.

Emmanuel Normant
Vice President for Sustainable Development, Saint-Gobain

Radical re-design of packaging is perhaps the biggest opportunity for companies to get a grip on the global challenge of packaging waste. It is also a crucial step before companies deploy the much-needed financing for regional collection and recycling of plastic waste. With the SPHERE framework, we hope to offer packaging designers a way to balance the trade-offs on waste, emissions, biodiversity and other environmental impacts.

Irene Hofmeijer
Head of Plastics and Circular Economy, South Pole

Sustainability has come of age at a time when collaboration between companies along the entire supply chain is needed more than ever. To address the significant challenges our planet is facing, we need to have a common goal and a common language. The SPHERE framework establishes the common ground so that we can act quicker and with more impact.

Michael Mapes
CEO, Trivium Packaging

Acronyms and abbreviations

IBC	Intermediate bulk container
CFF	Circular footprint formula
CGF	Consumer Goods Forum
CoC	Chemicals of concern
CTI	Circular Transition Indicators
EMF	Ellen MacArthur Foundation
EPR	Extended producer responsibility
FCOC	Food Chemicals of Concern
FU	Functional unit
GHG	Greenhouse gas
ISO	International Organization for Standardization
JRC	Joint Research Center
LANCA	Land-use indicator value calculation in life-cycle assessment
LCA	Life-cycle assessment
MCI	Material Circularity Indicator
MWI	Mismanaged Waste Index
PCR	Post-consumer resin or post-consumer recycled content
PEF	Product Environmental Footprint
SBT(s)	Science-based target(s)
SPHERE	Sustainability in Packaging Holistic Evaluation for Decision-Making
WBCSD	World Business Council for Sustainable Development

Foreword

The environmental impacts of packaging are increasingly evident, with headlines exposing the harm of single-use plastics on marine environments, land ecosystems and people.

WBCSD's vision for Products & Materials is that by 2050 resource use is optimized to meet society's needs while allowing the systems that provide resources to regenerate. WBCSD's Products and Materials work builds upon existing initiatives to provide a platform for the world's biggest and boldest companies to drive circular solutions that align global resource consumption with the climate, nature and societal challenges that we face.

As more and more companies look for ways to tackle their packaging footprint and pressure from consumers is growing, how can we make sure that we capture and analyze the full impact of packaging on the environment?

This was the question posed by the World Business Council for Sustainable Development (WBCSD) Sustainable Plastics & Packaging Value Chains workstream on circular sustainability assessment for packaging. To answer the question, workstream participants created the **S**ustainability in **P**ackaging **H**olistic **E**valuation for **R**ecision-Making (**SPHERE**) framework.

Conceptualized as a framework to support decision-making for packaging strategies spanning company departments, SPHERE strikes a balance between complexity and simplicity.

The framework collects all the aspects required to evaluate packaging from an environmental sustainability perspective and distills an approach that facilitates a holistic assessment. In its current version, the framework does not consider the economic and social aspects of sustainability.

Life-cycle assessment (LCA) tools are often the sole basis for evaluating the environmental sustainability of packaging materials. Similarly, other tools and methodologies might integrate additional considerations but fail to collectively evaluate all aspects of environmental sustainability. For example, circularity – as measured by WBCSD's Circular Transition Indicators (CTI) – integrates further considerations than those covered by a waste management LCA but currently does not cover sustainability aspects of packaging such as its impact on biodiversity.

Ultimately, many approaches exist to assess the environmental impact of packaging, each with its limitations and often unarticulated among one another.

With high public environmental awareness increasing the scrutiny of sustainability claims, it is necessary to have robust tools and methodologies to make packaging decisions.

The SPHERE framework is a unique approach for decision-making for sustainability in packaging. By nesting all aspects of environmental packaging sustainability under a common framework, it allows you to decide what packaging to opt for based on the assessment of trade-offs of a packaging or delivery system. Ultimately, the framework consolidates all the relevant and available information in one place, informing priorities for action and allowing for monitoring of performance and progress over time.

Erwan Harscoet
Sustainability Director, Deloitte

Jenny Wassenaar
Chief Sustainability Officer, Trivium Packaging

Executive summary

The SPHERE framework supports decision-makers in navigating all aspects of the environmental impact of packaging design, aiming for a net-zero and nature positive future.

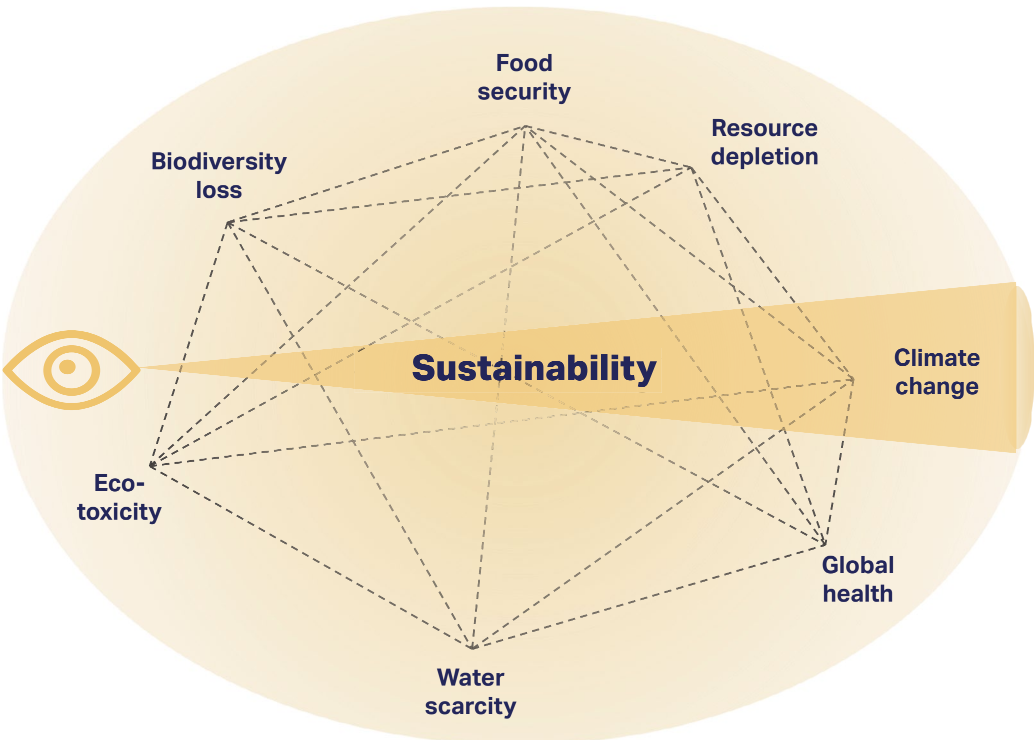
Environmental sustainability is traditionally looked at through the lens of climate action, driving a siloed approach. As shown in Figure 1, however, sustainability is multidimensional and requires looking at the systems in their full complexity. This framework aims to support decision-makers in breaking out of this tunnel vision to look at the environmental impacts of packaging from a holistic perspective.

In a context where a multitude of discrete methodologies exist to measure the environmental impacts of packaging at different life-cycle stages – production, use and end of life – decision-makers often must make trade-offs. For example, replacing packaging materials like glass or metal with plastic can lead to a lower initial carbon footprint; but the switch to single-use plastic can be a key contributor to the plastic packaging pollution crisis in countries lacking integrated solid waste management systems for plastic.

By developing SPHERE, WBCSD has created a material-agnostic framework that provides an overview of these impacts and trade-offs. Packaging designers, product portfolio managers and sustainability managers, among others, can use the framework to guide sustainability packaging design according to their own specific context.

The framework centers on the environmental impacts of packaging and delivery systems. It is designed to be future-proof and can easily be adjusted as new methodologies emerge. The design also allows for the addition of the social and economic dimensions of sustainability.

Figure 1: Sustainability tunnel vision



Source: Adapted from Jan Konietzko's "carbon tunnel vision".

As with all anthropogenic activity, packaging will always have an environmental impact. For the purpose of the framework, SPHERE provides a holistic definition of packaging sustainability, one that must account for the environmental impacts generated at all stages of the product life cycle – from production to use to end of life.

SPHERE defines sustainability in packaging as **maximum circularity and minimum environmental footprint, while avoiding the presence of harmful substances**.

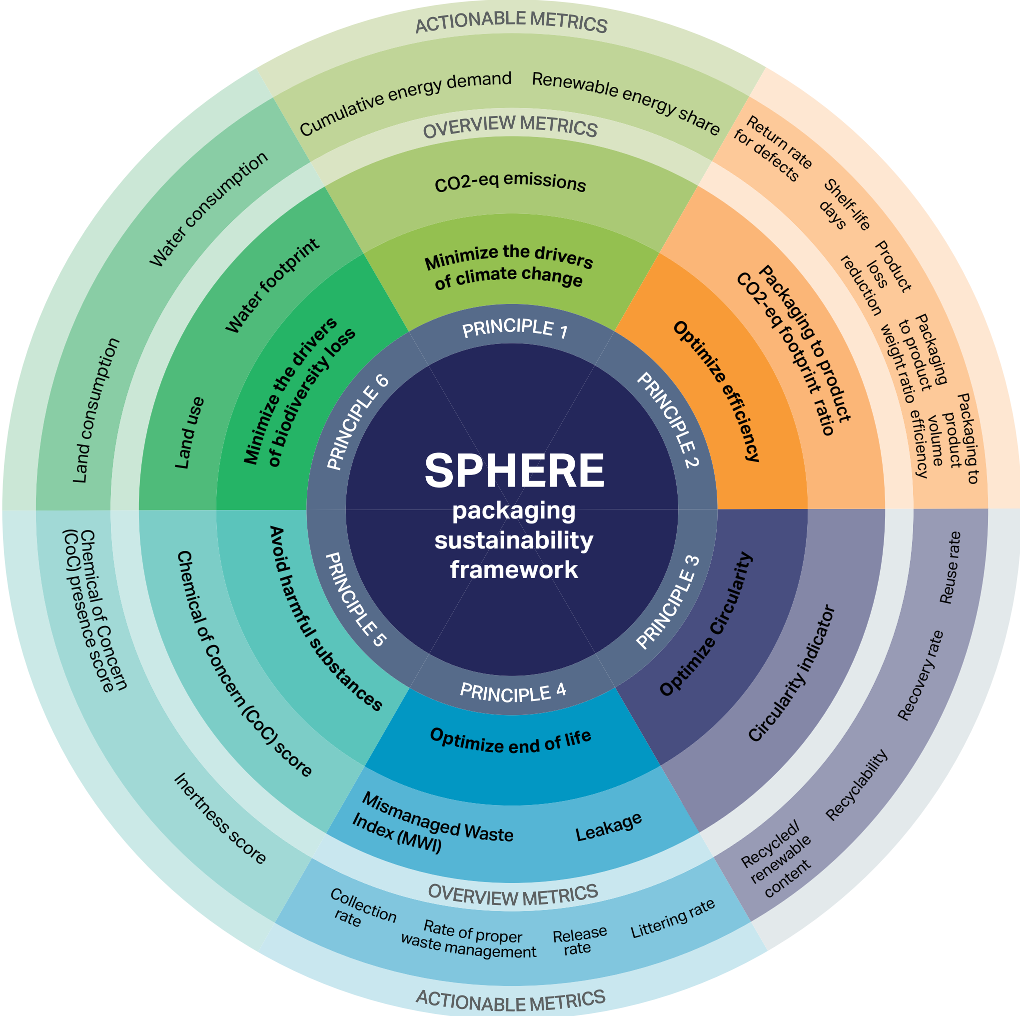
Six guiding principles support this definition:

1. **Minimize the drivers of climate change** relates to the importance of minimizing the climate impacts of packaging;
2. **Optimize efficiency** considers product protection (meaning avoiding product damage, losses and waste);
3. **Optimize circularity** addresses the need to promote the use of recycled content and renewable content;
4. **Optimize end of life** designs for recyclability, taking into consideration effective end-of-life management schemes;
5. **Avoid harmful substances** limits present and future human health impacts due to leakage, ingestion and bioaccumulation;
6. **Minimize the drivers of biodiversity loss** currently accounts for water and land use; in the future, it can address measurements related to biodiversity impacts due to leakage.

The framework uses existing metrics and methodologies applicable to each guiding principle as its foundation (see Figure 2). Although metrics and methodologies exist for most principles, some principles are missing methodologies. The structure of the framework allows for the integration of future methodologies where needed, making it dynamic and capable of evolving over time.

The long-term vision for the framework is to help inform those people spanning company departments who are responsible for packaging decision-making of the holistic impact of the packaging products they intend to put on the market and to help them design long-term strategies to mitigate the environmental impact of their packaging choices. The framework adds value to existing tools and methodologies because it has a unique way of combining relevant metrics. The use of thresholds for each metric allows for the benchmarking of the assessment against a boundary condition. The objective is to employ the framework iteratively to set and update packaging sustainability goals.

Figure 2: The SPHERE framework



Created to support decision-making, different teams can apply the framework to aid the selection and design of specific product packaging and to improve packaging decisions at a portfolio level. While a packaging design team might be looking to evaluate packaging at a product level to facilitate eco-design, a strategy team can take a portfolio approach. The framework's use at a portfolio level enables corporate assessments that can guide key strategic decisions locally. The framework offers a variety of threshold levels that allow you to look at absolute numbers and perform some comparison and benchmarking. The purpose of SPHERE is to be used internally, informing decision-making within your company.

In part 1 of this report we elaborate on the context and intended use of the framework. Applying the framework consists of four steps: 1) understanding the approach; 2) scoping the assessment with a packaging taxonomy; 3) selecting methodologies; and 4) setting thresholds.

Part 2 provides an explanation of each step of the process.

Part 3 presents the pilot studies. To bring the framework to life, we conducted four pilots to test the framework and highlight how you can evaluate packaging solutions for a variety of cases using the SPHERE framework.

Part 4 provides further guidance on how to apply the principles. The framework outlines methodological suggestions and good practices for assessing each principle with the metrics currently available.

Finally, part 5 calls on business to take action to shift the needle of the packaging narrative towards positive environmental impact.

PART 1
SPHERE: A meta-framework for sustainability in packaging

1 Context

> **Packaging can be theater, it can create a story.**
>
> – Steve Jobs

The mental imagery that consumers summon up of single-use packaging worldwide today is a story that typically ends with floating ocean plastics. Yet, the story of packaging can also be one of achieving sustainability targets, responding to consumer scrutiny, and developing robust policies, all while serving its primary purpose: safely delivering products to consumers all over the world. For the packaging story to shift to one of lower impact and positive imagery, the industry must evaluate its packaging choices more carefully moving forward.

Though tools, metrics and methodologies already exist to guide companies in choosing packaging sustainability options, they often fail to address the impacts of packaging holistically. Packaging touches on a multitude of systems and, consequently, trade-offs – from raw material impact to production emissions, food waste prevention, end-of-life management options, and material toxicity. Therefore, choosing appropriate packaging requires prioritizing and addressing multiple considerations.

Focusing on one characteristic to decide what packaging or delivery system to use inevitably leads to trade-offs. For example, choosing a material with high recyclability can result in increasing the packaging cradle-to-grave carbon footprint (such as when substituting plastic packaging with glass packaging) or in increasing losses and waste (for example, when unwrapping perishable foods). When used in isolation, existing metrics and methodologies only partially address the complexity of sustainability issues linked to packaging choices.

To achieve its mission of facilitating the transition to circularity for industry, our Sustainable Plastics & Packaging Value Chains project aims to make all packaging circular and sustainable by 2050. For this transition to happen, industry needs a framework that can facilitate decision-making on delivery system development, packaging design, material sourcing, and waste mitigation.

The SPHERE framework presents a global common framework to evaluate packaging and delivery systems. Going beyond circularity and aiming to address packaging sustainability holistically, the framework is a guide for internal decision-making.

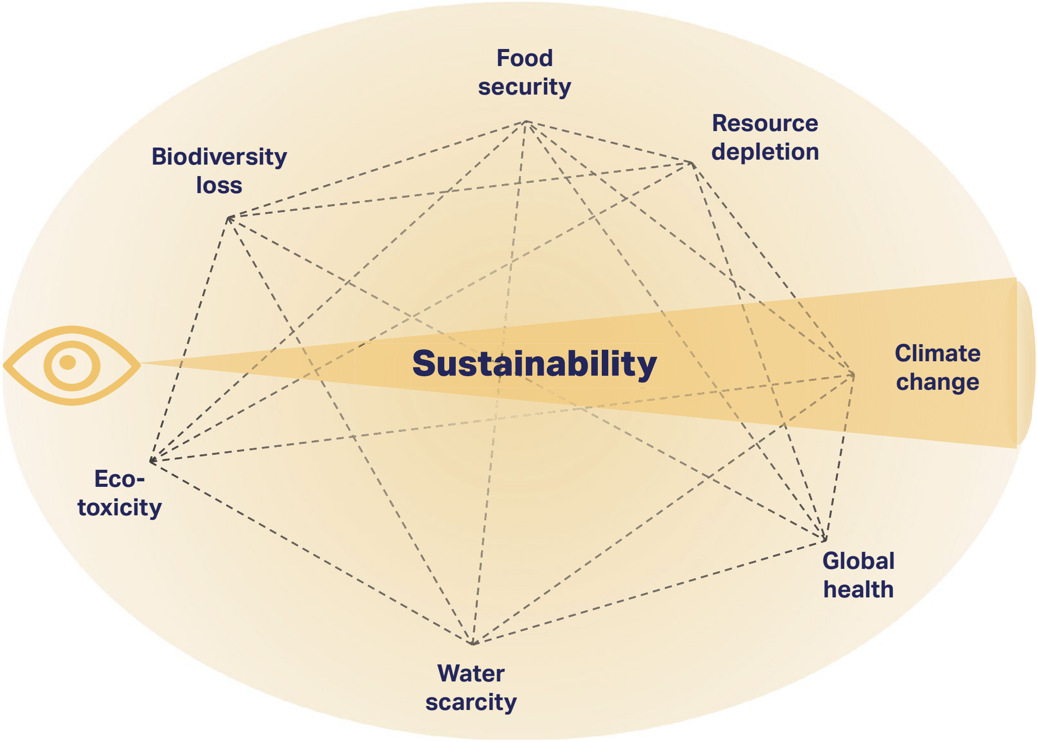
Rather than reinventing the wheel, the framework builds on existing metrics and methodologies to establish a meta-framework. Current methodologies do not connect to one another and can generate conflicting results, creating a challenge for packaging developers.

By nesting existing quality methodologies and future ones in a single framework, developers and strategists can use the framework's guiding principles to support packaging sustainability decision-making.

As shown in Figure 3, sustainability is multidimensional and requires looking at the system in its full complexity. For companies to fulfill their sustainability claims and pledges, choices must look at the system as a whole. This framework aims to support decision-makers in breaking out of sustainability climate change tunnel vision to look at the environmental impacts of packaging and delivery systems in their full complexity.

Serving as a guide that considers all aspects of environmental sustainability, the framework aids in setting and updating packaging sustainability goals. Choices made using the framework will help reduce environmental pollution, greenhouse gas emissions, and nature loss associated with packaging production and use. By identifying areas of improvement at either the product or portfolio level, the framework will allow you to address issues through improved design.

Figure 3: Sustainability tunnel vision



Source: Adapted from Jan Konietzko's "carbon tunnel vision".

② Defining packaging sustainability

The main tenet of sustainability is using the resources needed to support humanity today without depleting the Earth's biosphere for future generations. Applied to packaging, sustainability can take on myriad meanings, from low-carbon footprint to ease of recyclability, to the protection of the very product it packages. Moreover, there is no universal definition for packaging sustainability.

Biasing the definition of packaging sustainability toward only one aspect of sustainability can lead to detrimental consequences for all other aspects. For example, it could mean the packaging option with the smallest carbon footprint based on a life-cycle assessment (LCA). Such an evaluation might lead to replacing reusable glass bottles with disposable plastic bottles in a country with limited waste management infrastructure that cannot treat the latter appropriately. The definition of sustainability as carbon impact measured by a cradle-to-grave LCA does not account for the environmental impact of physical pollution such as plastic leakage into the environment. Furthermore, it does not account for the societal impact of flooding a market with a waste material it cannot treat, meaning it does not account for material circularity in the local context.

Defining packaging sustainability is a feat. As with all anthropogenic activity, packaging will always have an environmental impact. While we do not claim to have created a final definition for it, we have attempted to find a definition that captures the guiding principles of the framework – what sustainability in packaging means to us.

To achieve greater sustainability in packaging, it must account for the environmental impact generated at all stages of the product life cycle – from production, to use, to end-of-life. To this end, we developed the framework based on our holistic definition of packaging sustainability:

Packaging sustainability is maximum circularity and minimum environmental footprint, while avoiding the presence of harmful substances.

Six guiding principles support this definition:

1. **Minimize the drivers of climate change** relates to the importance of minimizing the climate impacts of packaging;
2. **Optimize efficiency** considers product protection (meaning avoiding product damage, losses and waste);
3. **Optimize circularity** addresses the need to promote the use of recycled content and renewable content;
4. **Optimize end of life** designs for recyclability, taking into consideration effective end-of-life management schemes;
5. **Avoid harmful substances** limits present and future human health impacts due to leakage, ingestion and bioaccumulation;
6. **Minimize the drivers of biodiversity loss** currently accounts for water and land use; in the future, it can address measurements related to biodiversity impacts due to leakage.

The guiding principles are at the center of the framework. To draft the guiding principles, we developed a long list of packaging sustainability attributes. We reviewed existing metrics and methodologies to assess how they serve to evaluate each of the guiding principles. See Annex 2 for the process used to define the guiding principles.

While we developed most of the guiding principles based on existing metrics and methodologies, some are missing methodologies. For example, there is currently no methodology to assess the impact of macro- and microplastic waste on biodiversity.

The structure of the framework allows for the integration of future methodologies where needed, making it dynamic and capable of evolving over time.

Table 1: Principles

Principle 1	**Minimize the drivers of climate change**	Minimize climate change impact over the packaging life cycle
Principle 2	**Optimize efficiency**	Optimize packaging efficiency while ensuring content integrity
Principle 3	**Optimize circularity**	Maximize circularity (including considering recycled content, renewable content, reuse, repair, recycling rate, etc.)
Principle 4	**Optimize end of life**	Ensure optimized end-of-life footprint (including proper waste management solution in place and at scale in each market, plastic leakage, littering rate, etc.)
Principle 5	**Avoid harmful substances**	Avoid the presence of harmful substances
Principle 6	**Minimize the drivers of biodiversity loss**	Minimize other drivers of biodiversity loss (in terms of land use, water footprint)

3 Framework objective

Serving as a guide for decision-making, the long-term vision for the framework is for it to provide information on the holistic impact of the packaging products you intend to put on the market. By better understanding the environmental footprint of packaging products, you can design long-term strategies to mitigate negative impacts. The framework has a unique way of combining relevant metrics and the use of thresholds enables you to benchmark their assessment against a boundary condition.

Growing focus on the sustainability of packaging has led to a proliferation of metrics, data sources, guidelines and frameworks for environmental impact accounting (see Annex 3). As shown in Annex 2, there are numerous gaps in existing metrics.

Production phase metrics rarely combine environmental and recycling metrics, while use-phase metrics fail to provide actionable changes. End-of-life metrics rely on limited data sources.

The framework addresses existing research gaps and brings together multiple dimensions, such as LCA and circularity metrics combined with considerations related to food contact, product protection, minimizing waste mismanagement, and ecosystem impacts.

Furthermore, the framework enables the creation of thresholds for comparison. This is crucial as decision-makers need points of comparison to determine the sustainability of their packaging designs. Part 2 section 4 explains how you can set thresholds by product category in each market.

This exercise allows you to set baselines against which you can compare packaging options. Establishing thresholds facilitates goal setting by industry stakeholders as it shows them what is already feasible and enables them to measure progress achieved through new designs.

Sustainability research is constantly evolving. Organizations regularly update methodologies and tools and publish new ones. Designed to be future-proof, the framework is evolving and anticipates the inclusion of future methodologies based on scientific progress.

4 Intended use and impact

The framework tackles the current limits of tools and methodologies, providing comprehensive data to support companies in achieving their sustainability goals and reducing the environmental impact of packaging. The objective is for you to employ the framework iteratively to set and update packaging sustainability goals. We developed the framework to support decision-making on the selection and design of product packaging and to improve packaging decisions at a portfolio level.

The scope of analysis of the framework is by default cradle-to-grave, encompassing packaging production, use and end of life. The framework can also be cradle-to-cradle if packaging recovery cycles are included. As a practical guide, it offers flexibility in use and provides clear examples for application. While it focuses on actions within the decision-making space of packaging producers and customers, it can also inform actions outside the direct control of the value chain that advocacy can influence, for example involvement in developing extended producer responsibility associations to strengthen appropriate management of waste materials.

We encourage you to look at the environmental impacts of packaging holistically, including waste impacts and greenhouse gas emissions. We aim for a wide range of teams within an organization – from industrial design and sourcing teams responsible for packaging procurement, to strategy teams designing long-term sustainability targets and strategies – to use this framework. Ultimately, it should serve as a common guide and language that an organization can apply universally internally and with its associated stakeholders across the value chain, for example suppliers.

The team's profile will also determine the use case. While a packaging design team might be looking to evaluate packaging at a product level to facilitate eco-design, a strategy team can take a portfolio approach. The use at a portfolio level allows for a corporate assessment to guide key strategic decisions at the local scale.

For example, it could help stakeholders understand that making changes to the packaging of a product that scores relatively high on sustainability but accounts for 50% of sales in a country might have a much larger impact than making changes to the packaging of a low-scoring product that only accounts for 1% of sales in that country. Hence, the portfolio approach can serve to ensure the alignment of the packaging strategy with a company's sustainability strategy goals and pledges. As the scope is holistic, it can support the integration of different company environmental strategies.

Although the framework offers a variety of threshold levels that enable you to look at both absolute numbers and comparison and benchmarking, our aim for it is to support internal decision-making and guide companies in their packaging sustainability strategies.

5 Definitions

Table 2: Definitions for the key concepts used throughout the framework

Key concept	Definition	Example
Principles	A sub-component of the "packaging sustainability concept" that you can quantitatively measure using one or several metrics	How does the packaging include recycled content? How does the packaging include recycling after disposal?
Metric	A measure of quantitative assessment commonly used for assessing, comparing and tracking the performance of one or multiple products	% of recycled content
Methodology	A structured guideline underlying the design and evaluation of a metric	Circular Transition Indicators, WBCSD; An approach to measuring circularity, the Ellen MacArthur Foundation (EMF)
Indicator	A specific output resulting from the evaluation of a metric based on a specific methodology	WBCSD Circular Transition Indicators (CTI) methodology; % circularity
Tool	Facilitates the calculation of one or several metrics using a specific methodology, yielding one or several indicators	Circular Transition Indicators (CTI) tool
Dataset	A collection of related data	Joint Research Center (JRC) annex C, Product Environmental Footprint (PEF) default values for circular footprint formula (CFF) parameters
Framework	Sets out procedures and goals to support the selection of the appropriate metrics, methodologies and data sources needed to evaluate a product design over its full life cycle	Circular Transition Indicators (CTI) 2.0, WBCSD; Circular Indicators Project, EMF
Criteria	Rules or principles for evaluating the relevance of certain metrics found in the literature (as well as their associated methodologies) to the framework	Does it cover the packaging and the product? Is it possible to define a sustainability performance threshold for this metric?
Portfolio analysis	Screening of and identifying hotspots in a packaging portfolio from a company-level perspective (covering all functionalities, all geographies – plastic packaging as example)	Case study 2: comparing different packaging formats for beverage containers in different markets
Eco-design analysis	Benchmarking of different options for a single product category with the same functionality	Case study 1: comparing three packaging solutions for an electronic device

6 Scope of the framework

The framework defines packaging sustainability as maximum circularity and minimum environmental footprint, while avoiding the presence of harmful substances. The six associated guiding principles provide the scope of the framework. When analyzing product packaging or a packaging portfolio, the framework applies to primary, secondary and tertiary packaging and to associated delivery systems. By aligning with the definition, actors across the packaging value chain demonstrate that they recognize the array of environmental considerations to reconcile and evaluate simultaneously to design packaging that is more sustainable.

Alignment with the definition and approach is the first step in using the framework.

Similarly, the definition and guiding principles were integral in designing the framework. Note that although the framework integrates multiple existing methodologies, it is not an exhaustive analysis. The selected metrics and methodologies do not limit the framework to a single material type (for example, plastics) and are flexible enough for use across a range of material types (such as plastics, glass, metal, etc.). The use of a broad scope increases the number of packaging options that a user can compare. Additionally, the framework enables the analysis of packaging for both food and non-food applications.

The framework encompasses all aspects of environmental sustainability, one of the three pillars of sustainability. The dynamic design of the framework allows for future iterations to integrate metrics on the social and economic pillars of sustainability as the science evolves.

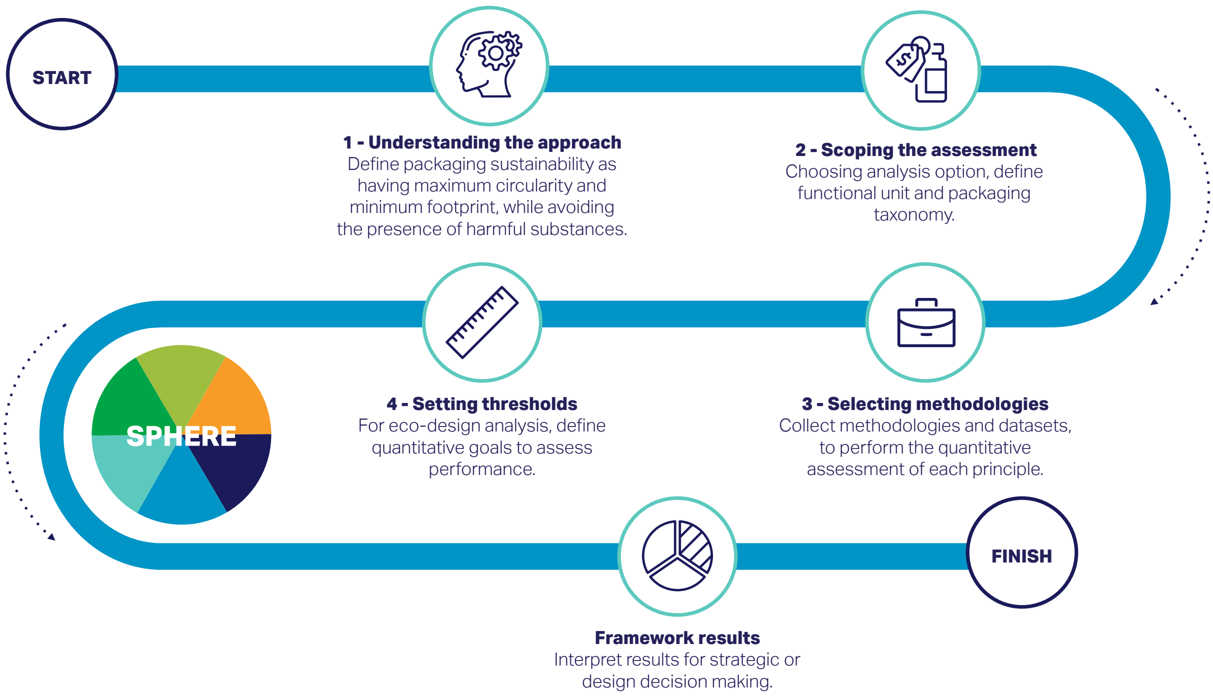
PART 2
How to use the SPHERE framework

The framework has four steps:

1. Understanding the approach;
2. Scoping the assessment with a packaging taxonomy;
3. Selecting methodologies; and
4. Setting thresholds (for eco-design analysis).

The following sections summarize the approach used for each of the steps.

Figure 4: The SPHERE framework: a 4-steps process



⑦ Understanding the approach

Considering the vast landscape of methodologies, guidelines and databases that exist to account for the environmental impact packaging, the first step in using the framework is to align with the definition of packaging sustainability as having maximum circularity and minimum environmental footprint, while avoiding the presence of harmful substances.

By adopting this definition, you reconcile different environmental considerations and can work from the same starting point. The six guiding principles that capture environmental impacts across the packaging product life cycle support the definition.

In step 4, which involves setting thresholds to facilitate quantitative assessment and performance tracking for eco-design analysis, you select a metric for each principle.

8 Scoping the assessment with a packaging taxonomy

To begin to use the framework, you must decide if you will take on an eco-design analysis or portfolio analysis. Eco-design analysis enable the comparison of packaging options for a single product.
A portfolio analysis enables the screening of packaging from a company-level perspective.

The framework enables comparability of packaging and delivery system options through the definition of a functional unit (FU) and an associated packaging taxonomy (meaning a packaging classification system).

To aid comparison and limit the scope of the assessment, the packaging taxonomy narrows down an infinite number of evaluation possibilities to the product level.

To build the packaging taxonomy, you must first select the product category – either food or non-food – under which the packaged product falls. See Figure 5 for a non-exhaustive list.

Once you select the product category (such as chocolate), you can define a functional unit (for example, "contains a 250 g bar of chocolate"). See Figure 6 for more examples.
The functional unit can be either the amount of product the packaging is designed to contain or the reason for which the non-food item is protected.
You should then define the functional unit in a relevant and consistent way.

Figure 5: Product categories

Figure 6: Defining a functional unit

Product category	BEVERAGE	DRY FOOD	ELECTRICALS
	↓	↓	↓
Functional unit	CONTAIN 500 ML OF COLD BEVERAGE	CONTAIN 1KG OF DRY CEREALS	PROTECT A FRAGILE ELECTRONIC ITEM

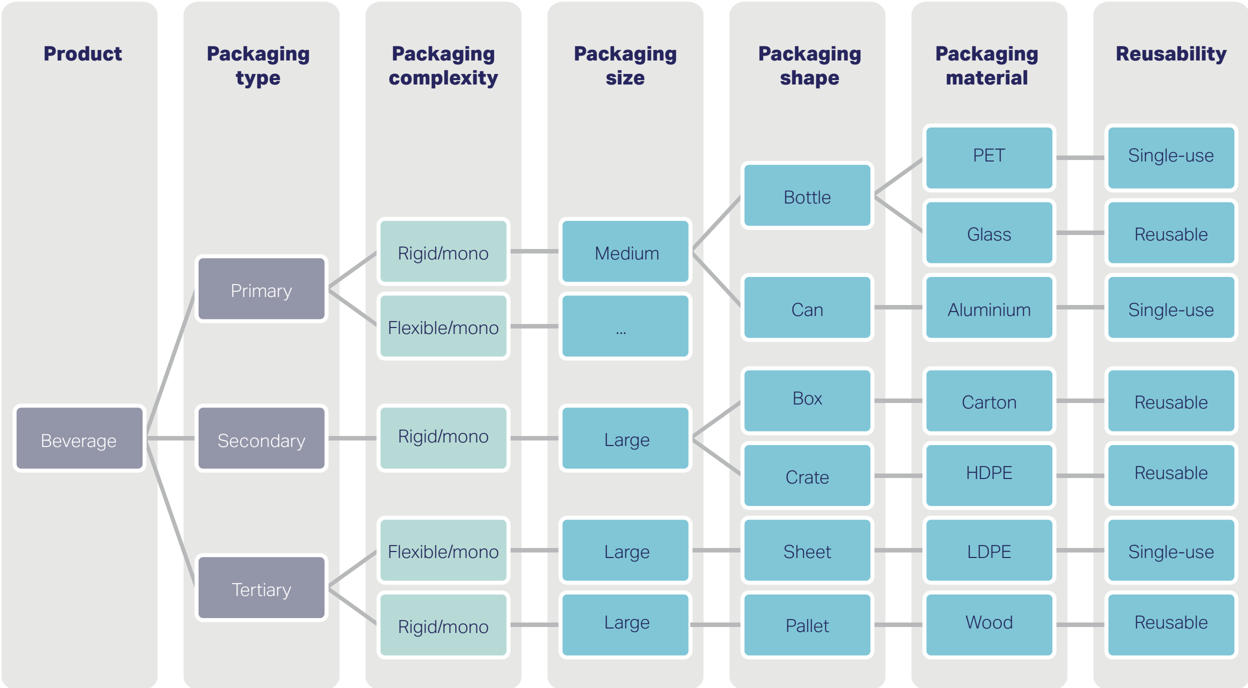
- A functional unit should be defined in an actionable way
- A packaging may have several functional units that are either complementary or embedded in one another (containment, protection, delivery…)
- Conversely, a functional unit may be tackled by different packaging options

Figure 7: Non-exhaustive list of packaging features

Packaging function priorities	Containment	Manufacturability	Protection	Delivery	Storage	Marketing	
	Usage	Handling	Information	Sortability	Recyclability		
Packaging type	Primary	Secondary	Tertiary				
Packaging complexity	Mono-material	Multi-Material					
	Additives	No-additives					
	Rigid	Flexible	Rigid/Flexible				
Size	Small	Medium	Large				
Shape / format	Bottle	Tray & Crates	Box	Can	Tube	Sachet	
	Film & Bags	Wrapper	Bowl	Pouch	Sleeve	Cushioning	
	Closure	Bulk	Sack	Label	Seal	Pallet	
Material types							
Plastic	PET	PP	LDPE	HDPE	PVC	PS	Other
Other	Paper	Carton	Liquid paperboard	Steel	Glass	Aluminium	Other
Reusability	Reusable	Single-Use					
Recoverability	Full (100%)	Partial (1-99%)	None (0%)				

Next, you can list all features that the packaging of choice should exhibit. This list should reflect all the features to consider in the packaging design phase (see Figure 7). You then use the chosen features to build a packaging taxonomy. Starting with the product category, each subsequent line of the taxonomy is a packaging feature (see Figure 8).

Figure 8: Illustrative packaging taxonomy for a beverage



Scoping the assessment using the packaging taxonomy approach considers packaging as a function of the product rather than something designed in a vacuum. This approach enables you to make decisions based on both the packaging's properties and sustainability performance.

9 Selecting methodologies

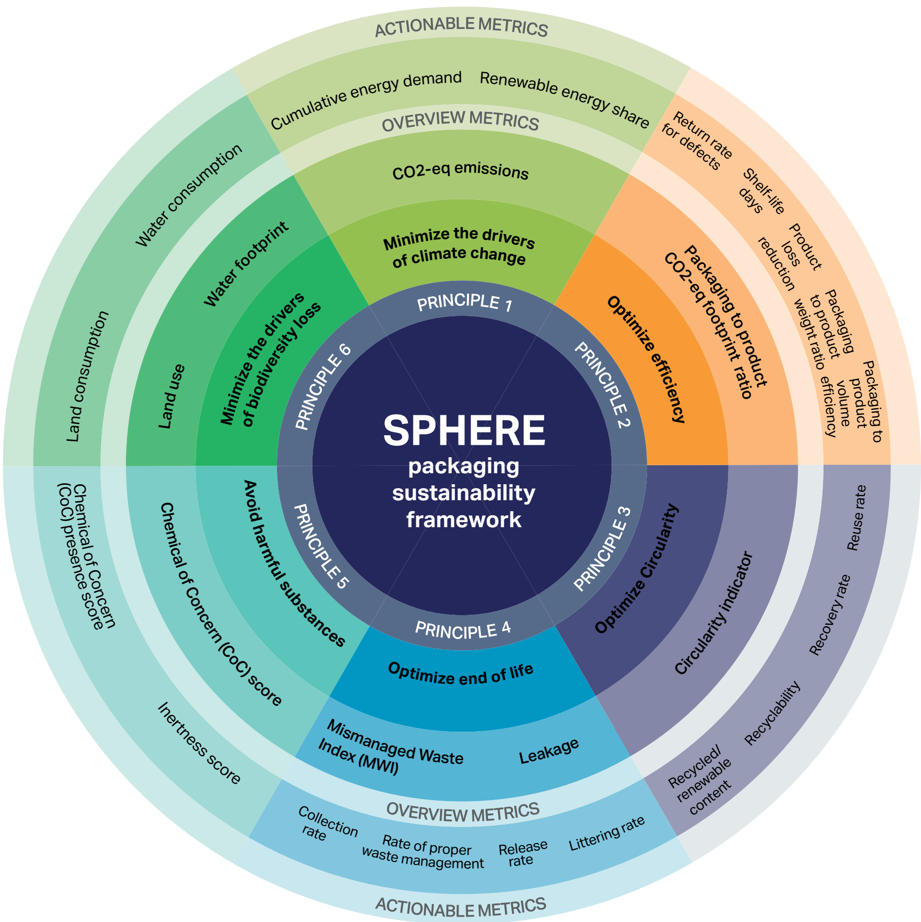
You need to use a metric, assessed by a methodology, to measure each of the six principles of the packaging sustainability definition using a metric. The list of metrics for the framework does not change. You must select at least one metric per principle, though you may also choose multiple metrics per principle. Metrics have allowed us to make a quantitative assessment and track performance. The ability to define a metric using a threshold was key to metric selection. To understand how we selected the metrics for the framework, please refer to Annex 2.

Metrics have two types: overview metrics and actionable metrics. Overview metrics provide a high-level picture based on a collection of other metrics (actionable metrics). For example, the overview metric "leakage" encompasses both the actionable metrics "collection rate" and "rate of proper waste management". Actionable metrics are measurements that can help you identify a tangible action to take.

By being more specific and disaggregated, actionable metrics address the more granular characteristics of a given packaging option (such as reusability).

Figure 9 summarizes the framework metrics.

Figure 9: The SPHERE framework



Once you have chosen the metrics, you associate a methodology with each metric. There is no limit to the choice of methodologies and datasets if it aligns with the criteria defined in the framework.

Annex 4 shows the methodologies and databases currently associated with each principle. You can choose one or more methodology from the table.

If you wish to use another methodology not listed below, the methodology must meet the criteria summarized in Table 3.

Table 3: Methodology selection criteria

Transparency	Are the calculations and data used transparently reported?
Solution-oriented	Is the method change-oriented / solution-oriented?
Scalability	Can it cope with multi-application and multi-scale aspects?
Specific or generic	Can the method be used in generic cases or is it designed for specific cases?
Data availability	Are the data sources needed to apply the method available in the relevant context?
Ease of use	Is the methodology easy to apply and does it require any specific skills?
Tool accessibility	Is a tool available to apply the methodology? Is the tool accessible?

10 Setting thresholds

For the eco-design approach, the last step involves setting thresholds. Portfolio analyses are meant to inform on where to act in priority to address the identified hotspots (such as highest quantity of carbon emissions) in the packaging range; therefore, we do not apply thresholds to this approach. However, thresholds are crucial to applying the framework effectively for eco-design. Since the purpose of the framework is to enable more sustainable decision-making, you need to be able to set goals to work toward. Thresholds facilitate goal setting and help define the actions required to achieve each goal. They also help you visualize the performance of your packaging against each metric by showing whether the outcome is within set boundaries or overshoots it.

Each metric has a threshold set independently. To set the thresholds, there are three approaches, from highest to lowest priority: science-based target, best-in-class, self-declared (see Figure 10).

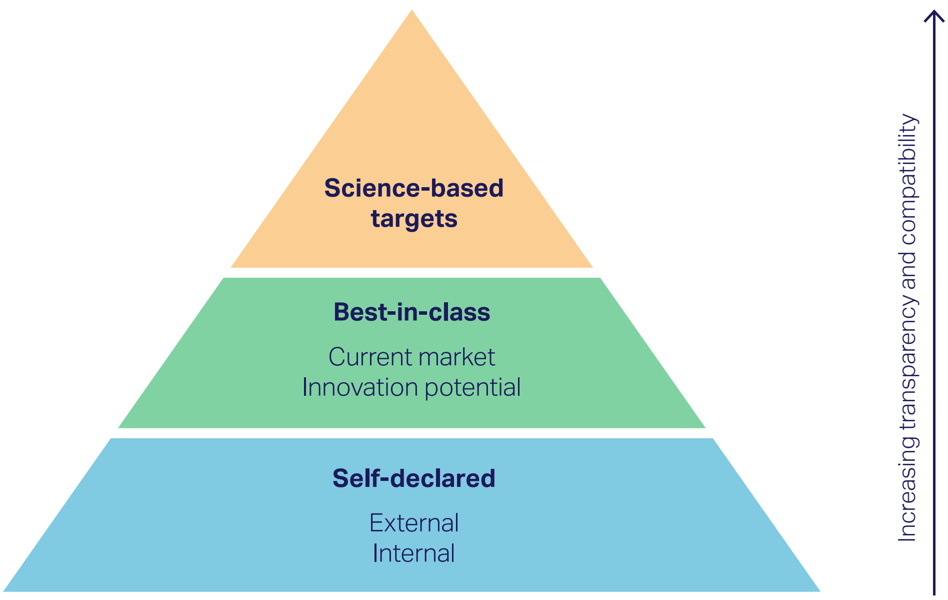
Science-based targets are thresholds set by the relevant scientific community, based on planetary boundaries for example. Though science-based targets are not available for all metrics, they are available for carbon and water. The challenge is in setting thresholds at a product level; therefore, it is necessary to divide science-based targets by sector, company and then product. Nevertheless, they remain the preferred option as they refer to a scientific reference.

The best-in-class threshold may either be a pioneering example already available on the market for a given product category or one that demonstrates a high degree of innovation potential. For example, you could look at the impact of the top 10 packaging and delivery system types used in the market of analysis and rank the 10 options to establish a lower and upper value of the impact of comparable packaging currently in use.

The target would then be set against the current market options by using the value at 50% of the scale; you could set a more ambitious target based on the innovation potential and use the value at 90%.

Internal or external goals define self-declared thresholds. Internal goals are those the company's sustainability strategy might reflect or that the team sets. External stakeholder pressure, for example non-governmental organizations or experts, drives external goals. The self-declared approach does not make use of a reference. The lack of reference does not affect the level of their ambition compared to the other approaches, but they often lack a theoretical baseline. Self-declared goals often express a relative increase or reduction, such as a 50% reduction in emissions, and apply directly to a product or packaging level.

Figure 10: Threshold setting prioritization

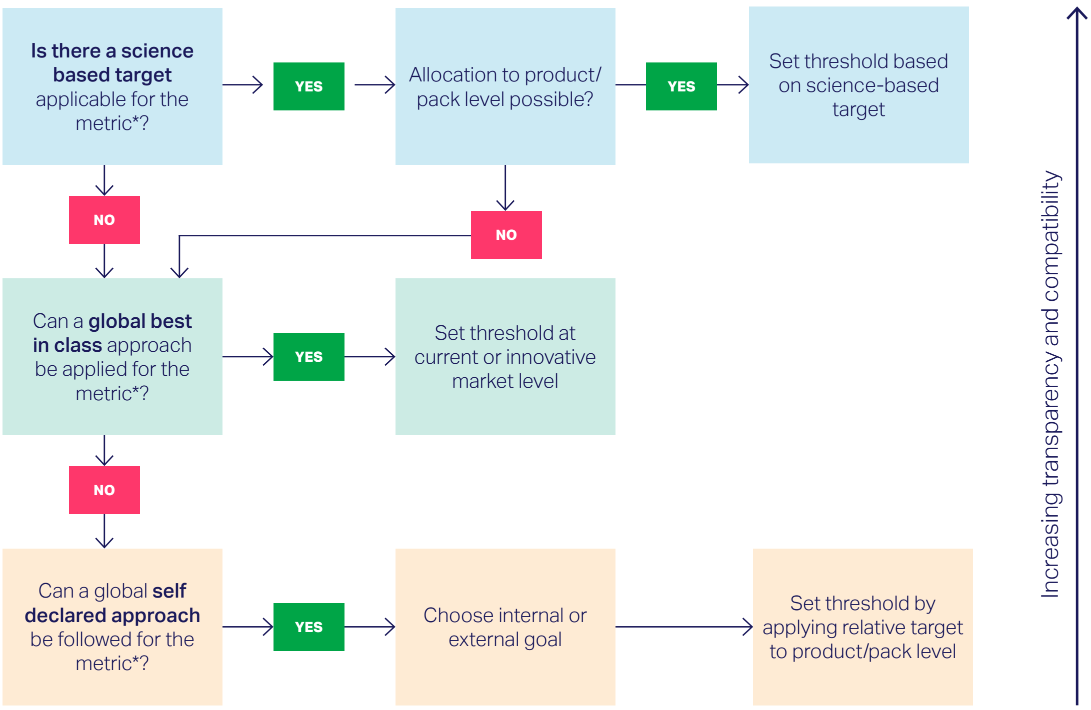


The threshold decision tree (Figure 11) serves as an aid to decide what thresholds to set. Thresholds should be set for "packaging per weight of content" for each specific product category per market. The three options (science-based targets, best-in-class, self-declared) are not mutually exclusive and may overlap. For example, a self-declared threshold might be the same as one with best-in-class innovation potential. Similarly, an internal goal might also be a science-based target.

Thresholds make it possible for you to benchmark against relevant internal or external boundary conditions to see if you are on track.

They are flexible and dynamic and you can update them over time as you make progress.

Figure 11: Decision tree for threshold setting



*Regional/geographical context

11 Framework results

The intended use of the framework is for either a packaging eco-design at the product-level or a portfolio-level analysis. When using the framework at the product level, it helps to inform decisions related to the sustainability of the product's eco-design, such as how a single product packaging fits within planetary boundaries.

Using a portfolio-level analysis allows for strategic decision-making on packaging beyond a specific product. The portfolio level considers additional factors such as sales volumes. Hence, it helps focus sustainability efforts and guide investment toward areas with greater impact potential. Both approaches are connected and can build on one another. For example, a portfolio analysis can serve to detect hotspots.

Building an eco-design analysis can then identify areas for improvement for the packaging option concerned to reduce the environmental impact of the packaging. You can then take the newly designed option back to the portfolio-level analysis to understand if you have addressed the hotspot. Through this iterative process, you can eventually address all hotspots.

PART 3
Case studies

We conducted four case studies to test the framework and highlight how you can evaluate packaging solutions for a variety of cases using the SPHERE framework. By choosing pilots across a diverse range of industries, delivery systems and data sources, the case studies bring the framework to life, showing how it can support decision-making in multiple scenarios.

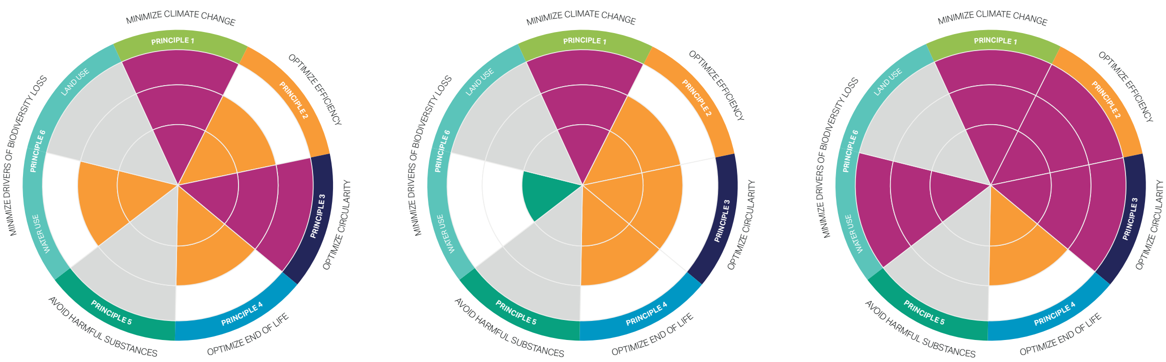
If you want to understand which of the packaging options performs best, for instance to select the most sustainable to scale, you will choose to perform an eco-design analysis. If you want to understand which packaging is the least sustainable across several markets to prioritize action, then you should use the portfolio approach. It is not necessary to compare the same functional units for the portfolio analysis.

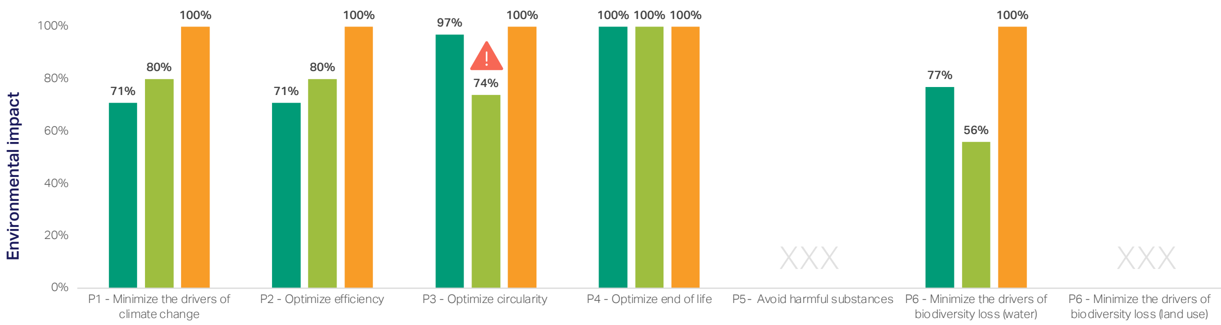
The main lessons drawn from the cases are:

- **Data collection:** When companies have not yet analyzed LCA and other impact areas, data collection can take time. You can save time by having the product design or packaging portfolio teams implement the framework instead of other departments or external consultants.
- **Different scopes or assumptions:** The different methodologies and datasets available for each principle are likely to use different scopes or assumptions. We recommend listing and tracking all assumptions throughout the exercise to check for consistency. Tracking assumptions is key for transparency on data treatment.
- **Defaulting to interpreting sustainability ratings:** Sustainability ratings have a high risk of using framework results, especially in relation to the thresholds. It is important to keep in mind that we designed this framework to support decision-making, not as a reporting framework for sustainability performance.
- **Water:** We removed the water footprint criteria to avoid confusion on Principle 6. Land use remains the main indicator for biodiversity loss. Refer to the section 'What are the potential limits in decision-making in principle 6?', Page 45 for further details.
- **LCA limitations:** LCAs typically account for cradle-to-grave. While accounting for Principle 1 (climate change impacts), additional data on emissions related to end-of-life management is welcome.
- **Difficult to control data quality:** Data quality relies on you and your responsible treatment of the data available. For comparisons to be feasible, data needs to be of a comparable quality. To allow for fair treatment of the data, it is highly recommended that you follow what the chosen methodologies ask for, as all methodologies are based on underlying International Organization for Standardization (ISO) norms.

Case study 1: Electronics packaging	
Use case	Evaluation of three packaging options for a Microsoft Xbox controller, retail purchase and online delivery: 1. Current packaging: retail carton structure 2. Retail carton structure with a higher recycled content ratio 3. E-commerce single package (not palletized) Note that the three options do not have the same function (retail versus e-commerce) and we conducted this pilot to test the framework methodology.
Type of analysis	Eco-design: The company wants to understand which packaging option is the most sustainable for product delivery to consumers worldwide.
Methodology	• Results showed that the highest recycled content packaging better meets the threshold targets across all metrics, even though it has a higher climate impact and a lower packaging efficiency than the current option. • There is an observable correlation between the business model and performance in the assessment at hand; the single executed (not palletized) packaging option shows the lowest sustainability performance. • Overall, the analysis shows that the most sustainable option is to implement the packaging with the highest recycled content ratio while optimizing the climate change impact and ensuring current circularity, end-of-life, and water use remain at the same level. Optimizing the climate change impact will simultaneously improve packaging efficiency, as the latter assesses the ratio of carbon footprint of the product versus the packaging.

1. Classic retail carton structure | **2. Classic retail structure with recycled content** | **3. E-commerce single packaging**





● 1. Classic retail carton structure ● 2. Classic retail structure with recycled content ● 3. E-commerce single packaging

To allow comparability despite different units, results across different packaging alternatives have been normalised within each principle by matching 100% with the worst result (for P1, the alternative with the highest CO_2-eq value would be set at 100%). Results are thus dimensionless.

For homogeneity reason, the logic behind the circularity score (usually the higher the better) has been reversed to match the way other principles read (the higher the worse).

Case study 2: Beverage carton portfolio	
Use case	A comparison of three beverage carton packaging solutions using market industry aggregates for a portfolio analysis in three European countries (Germany, France, Italy): 1. Beverage carton with perforation opening 2. Beverage carton with straw hole and glued straw 3. Beverage carton with cap opening
Type of analysis	Portfolio analysis (hence no thresholds were set): The company wants to understand where the hotspots are across the packaging range to prioritize action. Due to the limited primary data, we used public data as well to complete the dataset.
Insights for the company	• Packaging option one performed worst across all metrics due to high sales volume. Eco-design interventions for packaging option one would have the biggest impact to address this emission hotspot. • One of the markets (in this case Italy) has a relatively high score on the Mismanaged Waste Index (MWI), so packaging items sold in this market are more liable to leak into the environment. Actions to address leakage should focus on this market. • Collecting quality data on material ingredients and additives proved to be a challenge, reducing the value of the analysis on Principle 5. This shows the importance for companies to increase data transparency across the supply chain, in this example about the chemical composition of packaging materials.

Principle 1: Minimize climate change

Climate change kg CO_2/year

	FRANCE	GERMANY	ITALY
PACK 1	15842	14258	9505
PACK 2		3434	1145
PACK 3	10870		1631

Principle 2: Optimize efficiency

Packaging to product carbon footprint ratio

	FRANCE	GERMANY	ITALY
PACK 1	0.3	0.3	0.3
PACK 2		0.4	0.4
PACK 3	0.04		0.04

Principle 3: Optimize circularity

Circularity percentage

	FRANCE	GERMANY	ITALY
PACK 1	62%	62%	62%
PACK 2		57%	57%
PACK 3	56%		56%

Principle 4: Optimize end of life

MWI or leakage rate percentage

	FRANCE	GERMANY	ITALY
PACK 1	2%	5%	23%
PACK 2		5%	23%
PACK 3	2%		23%

Principle 5: Avoid harmful substances

Number of harmful chemicals

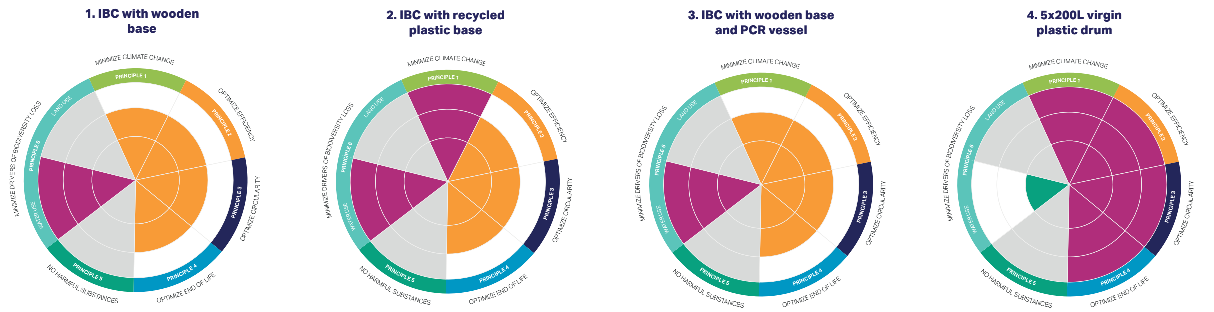
	FRANCE	GERMANY	ITALY
PACK 1			
PACK 2			
PACK 3			

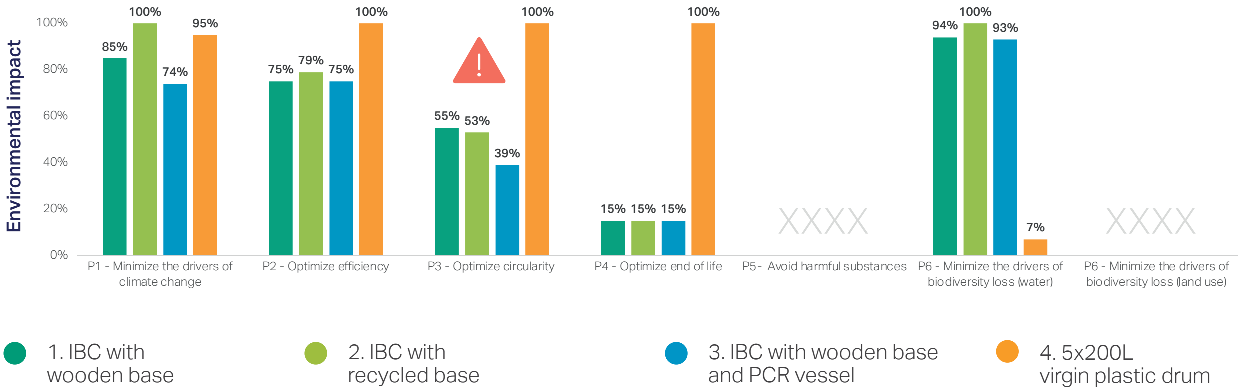
Principle 6: Minimize biodiversity loss

Water footprint or land use change m3/year or pt/year

	FRANCE	GERMANY	ITALY
PACK 1	1082	974	649
PACK 2		253	84
PACK 3	876		131

Case study 3: Bulk transport for chemical products	
Use case	Evaluation of four packaging options for bulk transport of a chemical product (1,000 L): 1. Intermediate bulk container (IBC) with a wooden base 2. IBC with a recycled plastic base 3. IBC with a wooden base and a post-consumer resin (PCR) vessel 4. 5x200-liter drum, virgin plastic We conducted this pilot with the support of Sustainable Plastics & Packaging Value Chains project members from the business-to-business packaging industry.
Type of analysis	Eco-design: The company wants to identify the most sustainable way to deliver a chemical product to their customer.
Insights for the company	• None of the packaging solutions perform within all thresholds, there is always a trade-off. • Overall, packaging solution 3 performs best, having the lowest impact on climate change and increased circularity due to a vessel made of post-consumer recycled resin. • The current results suggest using packaging solution 3. However, when considering biodiversity as a strategic indicator, the drums would be the preferred packaging solution due to lower water use. • Data requests do not always align with the company's internal accounting; therefore, it is sometimes necessary to complement primary data with publicly available data. It could be beneficial for companies to work across departments to tackle this challenge. • The material distribution in a packaging solution is not always available or clear. We used the dominant material for the analysis of Principles 3 and 4. A bill of material should be available for this type of assessment.





To allow comparability despite different units, results across different packaging alternatives have been normalised within each principle by matching 100% with the worst result (for P1, the alternative with the highest CO$_2$-eqvalue would be set at 100%). Results are thus dimensionless.

For homogeneity reason, the logic behind the circularity score (usually the higher the better) has been reversed to match the way other principles read (the higher the worse).

Case study 4: Soup packaging	
Use case	Evaluation of three packaging solutions for soup using public data: 1. Beverage carton 2. Glass bottle 3. Steel can
Type of analysis	Eco-design: The company wants to understand which packaging material is the best to sell tomato soup. Note that we designed the framework for use with primary data. We ran this pilot to explore the possibility of public data use.
Insights for the company	This pilot is inconclusive due to use of public data only. The variety of scopes and assumptions in publications makes it hard to combine data for the different principles in one analysis. Therefore, the results of this analysis are not reliable for solid decision-making. This pilot shows the necessity for companies to use consistent, preferably primary data, to inform on environmental footprint. We advise companies to track assumptions carefully, similarly to the good practice in life-cycle assessments.

PART 4
Guidance on the six principles

PRINCIPLE 1: Minimize the drivers of climate change

Why assess it?

Climate change jeopardizes both human communities and the complex ecosystems that sustain life on Earth. Humanity must achieve an exponential decrease in greenhouse gas emissions to limit the dramatic impacts that an increase in global temperatures will have on the Earth and its inhabitants.

What methodology to use?

Companies should apply a screening LCA methodology at a minimum to assess the "minimize the drivers of climate change" principle. Unlike an ISO-standard LCA that requires compliance with ISO 14040,[1] a screening LCA is a simplified approach that provides a fair estimate of the environmental impact of a product (or packaging) over its life cycle and identifies hotspots across the main life-cycle stages (production, transportation, use, end of life).

Which scope to assess?

You need to carefully consider key aspects before embarking on an LCA, namely the functional unit and the system boundaries. The functional unit is the reference unit that should reflect the performance of the packaging function; it closely ties in with the packaged good. An example of a function could be containing a good over a specific lifetime, protecting a good during distribution to consumers, or delivering a product while ensuring packaging manufacturability.

To ensure comparability for the different packaging options assessed, the functional unit should specify the quantity of the good packaged – by mass if it is a solid, by volume if it is a liquid, or by number of units or mass if it is an item.

When it comes to defining the system boundaries, the LCA practitioner can choose from several approaches, depending on data availability and their level of proficiency. Several approaches are possible, listed from best to acceptable:

1. Cradle-to-cradle: The system takes into account all stages – from material extraction to disposal – and the benefits – from looping materials to recovering energy at the end of life. The Product Environmental Footprint methodology suggested by the European Commission[2] provides detailed equations that enable the extension of system boundaries to include material and energy recovery. These equations, referred to as the circular footprint formula (CFF), are available in Annex C of the PEF methodology.[3]
2. Cradle-to-grave: The system takes into account all stages, from material extraction to the final disposal of the product, including possible benefits from energy recovery.
3. Cradle-to-gate: The system only takes into account stages from material extraction to delivery to markets, which are usually under direct company control.

Moreover, you should consider both the primary (1^{st}) packaging as part of the total packaging system and the secondary (2^{nd}) and tertiary (3^{rd}) packaging through an allocation rule. This rule can use the number of 1^{st} packaging elements that fit into one 2^{nd} packaging (2^{nd}-to-1^{st} ratio) as well as the number of 1^{st} packaging elements that fit into one 3^{rd} packaging (3^{rd}-to-1^{st} pack ratio) to allocate some mass of 2^{nd} and 3^{rd} packaging to the total packaging system.

For instance, consider a primary packaging element weighing 200 g from which five units would fit into a secondary packaging unit weighing 25 g (meaning a 2^{nd}-to-1^{st} ratio of 1/5 applied to 25 g, which allocates 5 g of 2^{nd} packaging) and 25 units would fit into a tertiary packaging weighing 500 g (meaning a 3^{rd}-to-1^{st} ratio of 1/25 applied to 500 g, which allocates 20 g of 3^{rd} packaging), the total packaging weight would equal 225 g.

When using the framework, you should preferably opt for the most comprehensive scope and align all background LCA data and computations based on the chosen scope, as this may have a significant influence on the validity of the results and their relevance for decision-making as an outcome of the framework application.

Which metric to evaluate?

Use the global warming potential[4] (100-year) indicator method to evaluate the climate change impact of the packaging over its life cycle. It is given in $kgCO_2$-eq/FU.

How to ensure comparability and consistency within a case study?

If possible, you should mention the main hypothesis and assumptions underlying the screening LCA to be able to identify the parameters influencing the outcome of the evaluation. It is your responsibility to ensure that the LCA assessment yields meaningful results in the context of applying this framework.[5]

PRINCIPLE 2: Optimize efficiency

Why assess it?

Packaging functionality is an important piece of the puzzle. For example, by extending a product's shelf life, packaging provides a potential reduction in product loss rates, especially for food products. Though consumers consider packaging waste to be a greater environmental issue than food waste, the packaging process itself only causes 3.0-3.5% (on average) of the climate impact of packaged food.[6] Nevertheless, it is crucial to balance those important considerations with efficiency in terms of the type or amount of material used to achieve the intended functionality.

What methodology to use?

The packaging-to-product carbon footprint ratio proposed in the list of metrics in this framework (Annex 4) enables you to draw conclusions on whether you should prioritize the reduction of content loss (when the ratio is low) or the reduction of the carbon footprint of the packaging through an eco-design approach (when the ratio is high).

Which scope to assess?

As with the scope for assessing the carbon footprint of the packaging (see Principle 1), you should consider the appropriate system boundaries and functional units to assess the product's carbon footprint (which includes both the packaging and its content).

Which metric to evaluate?

We suggest using the packaging-to-product carbon footprint ratio, varying from 0 to 1, as follows:

Ratio = **Packaging carbon footprint (kgCO_2-eq) / [Packaging carbon footprint (kgCO_2-eq) + Content carbon footprint (kgCO_2-eq)]**

A high score means the focus should be in reducing the carbon footprint of the packaging, while a low score means the focus should be on minimizing product or content loss.

Pauler et al. have proposed a similar ratio[7] where the authors insist on including packaging-related food losses and waste into the packaging LCA.

How to ensure comparability and consistency within a case study?

You should, where possible, mention the main hypothesis and assumptions underlying the screening LCA to identify the parameters influencing the outcome of the evaluation. It is your responsibility to ensure that the LCA assessment yields meaningful results in the context of applying this framework.[8]

PRINCIPLE 3: Optimize circularity

Why assess it?

Circularity or circular economy models are "a model of production and consumption, which involves sharing, leasing, reusing, repairing, refurbishing and recycling existing materials and products as long as possible."[9] The Ellen MacArthur Foundation (EMF) defines "circular economy" as an industrial economy that is restorative or regenerative by design and aim.[10] Maximizing the circularity of packaging, therefore, maximizes the efficiency in the use and exploitation of materials and resources while minimizing the waste generated.

What methodology to use?

1. WBCSD Circular Transition Indicators (CTI) framework
2. EMF Material Circularity Indicator (MCI) methodology

Which scope to assess?

The scope for circularity assessment of the packaging should follow a similar logic as for Principle 1 in terms of taking into account the different packaging levels. Take into account the relative material shares across all packaging levels (primary, secondary and tertiary) for the circularity assessment, following the allocation rules described above for Principle 1.

Which metric to evaluate?

We suggest two different metrics for the framework – you are free to choose the appropriate metric depending on the specifics of the use case.

For example, depending on the information available or whether there is an emphasis specifically on reuse properties, you should carefully evaluate which methodology is best suited for the assessment.

How to ensure comparability and consistency within a case study?

By using the specific tools provided by the two methodologies suggested, it is possible to ensure comparability from a methodological perspective. It is your responsibility to ensure consistency in the use of the metric for the case study when applying the framework (for example, in the eco-design analysis, to ensure comparability and draw meaningful conclusions on Principle 3, the choice of the metrics needs to be consistent throughout the different options under investigation).

PRINCIPLE 4: Optimize end of life

Why assess it?

Companies should ensure the appropriate management of the packaging they put on a specific market. Such management relies on waste collection systems so that waste does not eventually end up in the environment. Principle 4 is complementary to Principle 3 as it looks at how the markets where non-recycled packaging waste ends up deal with it.

Which metric to evaluate?

1. Mismanaged Waste Index (MWI): As a general approach, a company should first assess the overall MWI of the packaging option across the different markets it ends up in as waste. The MWI is the ratio between mismanaged waste and total waste generated, with the mismanaged waste defined as the sum of uncollected and improperly disposed waste. Its value is given as a percentage.

2. Plastic leakage to water bodies: If packaging consists of or contains plastic, a company can further assess how much of the mismanaged plastic waste will end up in rivers, lakes and oceans.

   Typically, the absolute value of assessing leakage is in tons or kilotons but you can also apply the relative value in percentage – called "leakage rate" and defined as the ratio between leakage and total waste generated.

What methodology to use?

To assess the MWI of a given packaging, we recommend you to refer to the MWI of the different countries that represent the product's end-market.

Researchers have developed several methodologies to evaluate MWI values by country for all waste, such as:

- Plastic waste inputs from land into the ocean[11]
- Future scenarios of global plastic waste generation and disposal[12]
- The Plastic Leak Project[13]

For generic information on national-level waste management and MWI of municipal solid waste we suggest you use the What a Waste v2.0 dataset.[14]

The PLASTEAX data platform[15] provides a more detailed approach for plastic packaging only.

In the case of a plastic leakage assessment, we recommend using the methodology developed by the Plastic Leak Project.[16]

Which scope to assess?

The MWI and plastic leakage values should mainly focus on the end-markets of the packaged product. To this end, it is necessary to know the market distribution shares to ensure an accurate assessment. A methodology to assess plastic waste mismanagement and leakage from exported packaging waste is still under development.

How to ensure comparability and consistency within a case study?

You should ensure you apply the same methodology across the different packaging options under investigation and mention which one you chose within the specific case study.

PRINCIPLE 5: Avoid harmful substances

Why assess it?

In LCA, the quantification of the potential hazards to human health due to the ingestion of chemical compounds leaching from packaging and contaminating food is still poorly documented, although it is a growing research area. Despite the complexities related to this topic, it is of utmost importance to start using some indicators, even if incomplete, to pave the way for safer chemistry in food contact materials. For this reason, we integrated the presence and toxicity of chemicals of concern (CoC) into the framework. CoC are toxic chemicals associated with harm to humans and the environment, with properties including carcinogenic, mutagenic, endocrine disruptive, and others.

What methodology to use?

The methodology developed by the Single-Use Material Decelerator (SUM'D)[17] for the Understanding Packaging (UP) Scorecard tool[18] enables you to score the potential presence and migration propensity of CoC in food ware and food packaging. You can also use it to assess potential exposure to hazardous chemicals.

We derived the CoC score applied in this framework from this methodology. The UP Scorecard also applies it. It aims to provide an approach for considering the presence of CoCs that can have adverse impacts on human health and ecosystems. This metric aims to increase transparency across the material supply chain regarding the presence of CoCs and ensure that circular practices generate safer materials. Ultimately, the goal is to ensure that food contact materials contain no hazardous chemicals.

Which scope to assess?

While food packaging is the primary focus of the CoC score within the UP Scorecard it is possible to extend it to non-food products. The CoC score does not score secondary or tertiary packaging; however, it is possible to adapt or apply the methodology to these products.

Which metric to evaluate?

You should evaluate the CoC score, ranging from 2 to 20 (the higher score the better) based on the following equation:

CoC score =
CoC presence score + Inertness score

This score depends on:

1) the "CoC presence score", which corresponds to the presence of intentionally added chemicals of concern and the reliability of the information provided; and

2) the "inertness score", which considers the inertness of the food contact material as a proxy for the propensity for any present chemicals of concern to migrate from the product into food and the environment.

Evaluate the "CoC presence score", which ranges from 1 to 10, based on the analysis of two factors:

1) the tiered compliance with the Food Chemicals of Concern (FCOC) list of packaging (see Table 4) and

2) the level of disclosure for claimed compliance of the packaging within three chemical tiers (see Table 5).[19]

Table 4: Criteria used to define chemicals within each of the three tiers

Tier	Description
0	Not compliant for chemicals of concern identified in Tier 1.
1	Does not intentionally contain any of the chemicals of concern identified by Environmental Defense Fund (EDF) (Environmental Defense Fund, 2021). EDF has identified chemicals in food packaging and food handling equipment where the potential health impacts from their migration into food raises serious concerns. These chemicals in virgin materials may also contaminate the recycling stream and undermine their recyclability.
2	Does not intentionally contain any of the chemicals of concern identified in Tier 1 plus chemicals of concern identified by the Food Safety Alliance for Packaging (FSAP) brand owners' working group document: Food Packaging Stewardship Considerations v1.0 (Food Safety Alliance for Packaging, 2018) that have been screened against the Food Packaging Forum's (FPF) Food Contact Chemicals database (FCCdb) for relevance (Food Packaging Forum, 2021).
3	Does not intentionally contain any of the chemicals of concern identified in Tiers 1 and 2 or any of the priority food contact chemicals identified in the Food Contact Chemical database (FCCdb) developed by the FPF (Food Packaging Forum, 2021).

Table 5: Levels of disclosure for claimed compliance with the chemical tiers

Level	Description
0	Supplier is unable to provide information about in-scope chemicals of concern in the materials within the foodware or packaging product.
1	Supplier self-reports compliance of all in-scope chemicals of concern within the tier.
2	Supplier provides a statement on their website or written declaration from an officer level representative of the company to demonstrate compliance with all in-scope chemicals of concern within the tier.
3	Supplier provides third party verified certificates of analysis (CoA) and/or approved certification program equivalent for all in-scope chemicals of concern within the tier.

Table 6: Scoring matrix used to determine the CoC presence score based on compliance with the set tiers and the level of disclosure used to prove this compliance

		DISCLOSURE			
		LEVEL 0	LEVEL 1	LEVEL 2	LEVEL 3
FOOD CONTACT CHEMICALS OF CONCERN LIST (FcCoCL) COMPLIANCE	TIER 0	1	1	1	1
	TIER 1	1	2	3	4
	TIER 2	1	3	5	7
	TIER 3	1	4	7	10

You can then determine the CoC presence score based on a bi-dimensional matrix in Table 6 that considers both the compliance and disclosure levels as determined in Table 4 and Table 5.

The second component of the CoC score is the "inertness score", which also ranges from 1 to 10. The "inertness score" assesses the migration propensity of the different food contact materials. As no data on inertness is available for most materials, the score is based on a multi-expert consultation carried out by SUM'D of the inertness of various common food contact materials. The results from this consultation, including the assigned inertness scores by material type, are available in the appendix of the UP Scorecard methodology document.[20]

How to ensure comparability and consistency within a case study?

In the case of multi-layer, multi-material packaging for food products, you should apply the inertness score based on the first material layer in direct contact with food. You should calculate the CoC presence score considering all intentionally used chemicals contained in all the different material layers between the food contact layer and the barrier layer (if present).

Aluminum is an example of a barrier layer often used in multilayer food packaging as it prevents chemicals from migrating from the outer packaging layers into the food. The European Union officially recognizes it as a barrier layer.

In the case of packaging non-food products, you might apply the inertness score based on the layer that is most likely to be in contact with either a packaged product (if sensitive to the uptake/transfer of chemicals) or a user (such as skin) and/or the environment if leaked.
If a product (such as fertilizers, household detergents, etc.) contaminates the packaging, you should treat this as special hazardous waste and address it using other risk management approaches and regulations. Consequently, companies should not recycle it into most products as a principle of safe circular practice. However, if the content is hazardous, it should not change the CoC score of the packaging during the intended use. If the company washes the packaging before disposal, this becomes a water treatment issue that is beyond the scope of this framework.

How to overcome data collection gaps in Principle 5?

Packaging can contain thousands of different intentionally added chemicals, many of which can be hazardous to human and environmental health. For companies, it can be challenging to collect the data needed to push beyond current regulatory requirements and better manage this wide range of chemicals present in their packaging. To move ahead, actors within the packaging supply chain need to improve communication with one another about the chemicals used across production steps.

Although it is of utmost importance to address chemicals of concern within this framework, the CoC score suggested to assess the "Avoid harmful substances" Principle 5 might currently prove challenging to use and evaluate due to the additional data required. When this data is available, you are invited to assess the "Avoid harmful substances" principle and lead the way forward in your sector towards safer products for your customers. If the data is not currently available, Principle 5 can be left unassessed without affecting the validity of the results from the framework (since Principle 5 is independent from other principles). In this case, we encourage you to begin having more conversations with the upstream suppliers of your packaging to work towards closing this critical data gap.

Principle 6: Minimize the drivers of biodiversity loss

Why assess it?

For several decades, biodiversity has been declining with unprecedented speed. However, in the era of globalization, biodiversity damage typically occurs far away from the consumption stage. Packaging can impact biodiversity if mismanaged and degrades in the open environment. For example, WWF estimates that it is already possible to detect the impact of plastic pollution in most species groups and that plastic pollution is putting the productivity of many marine ecosystems at risk.[21]

As it is not possible to directly assess extinction rates of species, we recommend quantifying the main drivers of biodiversity loss not covered by the other principles (such as climate change and harmful chemicals).

Additionally, due to the general trend of switching to renewable alternatives for fossil-based materials in the packaging space, you should take agricultural practices leading to land transformation into account and (together with water) regard them as one of the main drivers of biodiversity loss in this context.

Which metric to evaluate?

A metric combining different LCA impact indicators to reflect the main drivers of biodiversity loss is currently under development. You should apply it once the underlying methodology has been published. In the meantime, we suggest that you assess both land use and, when available, water use impacts to capture relevant drivers of biodiversity loss for the packaging in scope.

What are the potential limits in decision-making in Principle 6?

To use the results in Principle 6 as an input for robust decision-making, take the following limits into account:

Look at water use impacts generated by the production of packaging materials in a local/regional manner. Because the conclusion on the impacts can differ highly by region or specific locality (such as impacts from water use in a water scare regions vs in a water rich region), decision-making and subsequent governance may become difficult when not taking a regional specific view (which requires, for example, using regionalized data as input).

Contrary to water-use impacts, the land-use impacts are more globally applicable and comparable.

For example, switching to bio-based packaging materials always requires the use of a certain area of land and therefore impacts assessed are more globally comparable in terms of subsequent decision-making and governance.

Therefore, we recommend prioritizing insights on land-use impacts for conclusions on Principle 6 in decision-making whenever regionalized data is lacking.

Which methodologies to use?

Land use

Land-use impact should reflect the amount of land used by activity and how the company uses the land (which type of natural land it transformed to pursue an activity). The Soil Quality Index, which is a dimensionless aggregated indicator measured in points (pt) based on the LANCA model, encompasses both impacts.[22] Although we recommend the use of the Soil Quality Index, you could alternatively apply the "agricultural and urban land occupation" indicator, which represents the amount of agriculture or urban land occupied over a period of time in m^2 x year.[23]

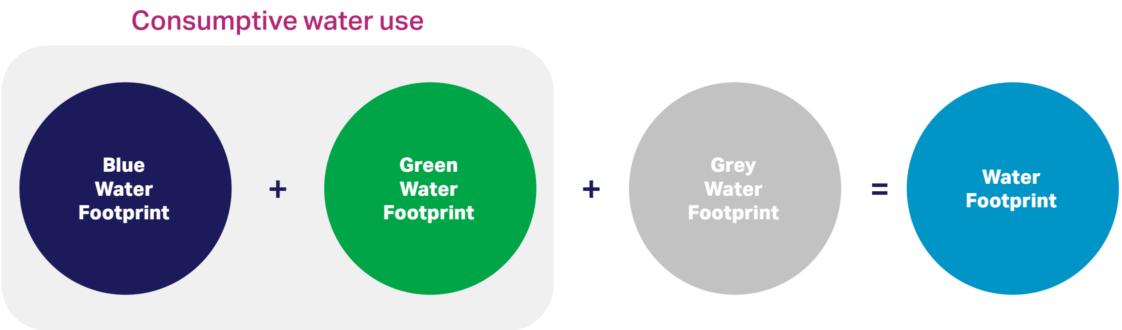
Water use

The water footprint of a product or system is the combination of the following footprints:[24]

Blue water footprint: Amount of water sourced from freshwater (surface or groundwater) resources and evaporated, incorporated into a product, or taken from one body of water and returned to another (or returned at a different time).

Green water footprint: Amount of water from precipitation stored in the root zone of the soil and that plants evaporate, transpire or incorporate.

Figure 13: Consumptive water use



Grey water footprint: Amount of freshwater required to assimilate pollutants to meet specific water quality standards. The discharged water alters the temperature and/or quality of the water returned to the environment.

However, the impact assessment of water use requires distinguishing between consumptive water use (blue and green water footprints) and degradative water use (grey water footprint). Indeed, consumptive water use will enable a quantitative assessment while degradative water use will instead enable a qualitative assessment. Within the context of the framework, you should assess consumptive water use as an indicator of the water-use impact.

For more details on how to assess water use in LCA, please refer to the water footprint standard ISO 14046[25] and "Ecoinvent 3: assessing water use in LCA and facilitating water footprinting".[26]

Furthermore, we do not address water scarcity. After applying to case studies, we realized that we needed to refine this methodology. It is a work in progress and we will update it in a future iteration of the framework.

Which scope to assess?

The scope for the water-use and land-use impact assessments of the packaging should follow the same logic used for Principle 1 in terms of system boundaries and the inclusion of different packaging levels.

Take into account the relative material shares across all packaging levels (primary, secondary and tertiary) for these metrics, following the allocation rules described above for Principle 1.

How to ensure comparability and consistency within a case study?

If possible, you should mention the main hypothesis and assumptions underlying the screening LCA to identify the parameters influencing the outcome of the evaluation. It is your responsibility to ensure that the LCA assessment yields meaningful results in the context of applying this framework.[27]

PART 5
Recommendations for the future

A novel approach to assessing the sustainability of packaging, the SPHERE framework has brought together best-in-class science under a single meta-framework, nesting all existing tools and methodologies. We hope that the framework can serve as a guide for compiling existing assessments to support packaging decision-makers in choosing delivery systems that have a lower environmental impact.

The pilot applications of the framework have highlighted that there are still gaps in the science behind some assessment tools. The underlying issue is that science-based targets are not available for all metrics. For example, there is no widely accepted methodology for assessing the impact of waste on biodiversity.

Once a methodology for biodiversity impact assessment is developed, it can easily be incorporated into the framework. Furthermore, the use of LCA data makes it difficult to draw comparisons as data assumptions leave too much freedom for interpretation of conclusions. Until science-based industry standards are widely adopted, organizations can control for assumptions by using primary data for LCAs. Ultimately, the lack of science-based targets for all methodologies – and the total lack of methodologies for some metrics – emphasizes the need to establish industry standards.

Industry needs to be part of the development in setting science-based industry standard. Participation is twofold. First, industry needs to adopt the best-in-class science for sustainability metrics when making packaging decisions.

Second, industry needs to participate in the development of science-based targets to bridge the existing gap. By participating in the adoption of the existing blocks and building the missing ones, industry has the power to shift the needle of the packaging narrative towards positive environmental impact.

The dynamic nature of the SPHERE framework allows us to update it regularly to incorporate new targets as the science and the social and economic pillars of sustainability evolve. We hope that this guide will support a collective step forward in environmental action for all actors involved in packaging decision-making.

Glossary

Blue water footprint: Amount of water sourced from freshwater (surface or groundwater) resources and evaporated, incorporated into a product or taken from one body of water and returned to another (or returned at a different time).

Carbon footprint: Total amount of carbon dioxide (and other greenhouse gasses, weighted in carbon dioxide equivalents) emitted by all activities of an individual, company, event or other.

Criteria: Rules or principles for evaluating the relevance of certain metrics found in the literature (as well as their associated methodologies) to the framework.

Dataset: A collection of related data.

Eco-design analysis': A benchmark of different options for a single product category with the same functionality.

Functional unit: Quantified description of a function of a product or service used as reference in calculating and comparing sustainability performance.

Framework: Sets out procedures and goals to support the selection of the appropriate metrics, methodologies and data sources needed to evaluate a product design over its full life cycle.

Green water footprint: Amount of water from precipitation stored in the root zone of the soil and that plants evaporate, transpire or incorporate.

Grey water footprint: Amount of freshwater required to assimilate pollutants to meet specific water quality standards. The discharged water alters the temperature and/or quality of the water returned to the environment.

Indicator: A specific output resulting from the evaluation of a metric based on a specific methodology.

Methodology: A structured guideline underlying the design and evaluation of a metric.

Metric: A measure of quantitative assessment commonly used for assessing, comparing and tracking the performance of one or multiple products.

Packaging taxonomy: Packaging classification (e.g., food, non-food, product category, material type, function) allowing to set coherent functional units for comprehensive sustainability assessments.

Portfolio analysis: Screening of and identifying hotspots in a packaging portfolio from a company-level perspective (covering all functionalities, all geographies – plastic packaging as example).

Principles: A sub-component of the "packaging sustainability concept" that is quantitatively measurable using one or several metrics.

Renewable content: Content derived from sustainably grown bio-based resource that will replenish through a natural process to replace the portion depleted by usage and consumption

Thresholds: Values defined to determine the performance and outcome of the evaluation of each metric. Thresholds can be based on scientific targets, self-declared goals or market average performance.

Tool: Facilitates the calculation of one or several metrics using a specific methodology, yielding one or several indicators.

Annex 1: Team and financiers

Located under WBCSD Pathway "Products & Materials", the Sustainable Plastics & Packaging Value Chains project has a dedicated workstream focusing on circular sustainability assessment for packaging. Representatives from Trivium Packaging and Deloitte chair the group of companies (Table 7) in the workstream. After identifying that a common framework to assess sustainability in packaging was missing, the workstream commissioned the development of the SPHERE framework.

The framework is a missing piece in the puzzle of integrating circular economy principles into packaging design.

We commissioned a consortium of environmental consultants and experts in packaging sustainability. South Pole, Environmental Action and Quantis came together to integrate their decades of experience into one cohesive framework.

For a critical eye, we created an advisory group to conduct a technical review of the framework development process (see Table 8). The advisory group has played a crucial role in challenging the scientific foundation and the practical applicability of the framework.

Table 7: Workstream member companies and representatives

Circular Sustainability Assessment for Packaging Workstream team	Member company	Role
Erwan Harscoet	Deloitte	Co-chair
Jenny Wassenaar	Trivium Packaging	Co-chair
Robin Jenkins	Corteva Agriscience	Working group lead
Jeff Loth	Microsoft Corporation	Working group lead
Michele Del Grosso	Aptar Group	Member
Laurent Sebire	Corteva Agriscience	Member
David Dombrowski, Zoe Newton	GlaxoSmithKline	Members
Morishima Takashi	Mitsubishi Chemical Holdings Corporation	Member
Pascal Eveillard	Saint-Gobain	Member
Leslie Cook	Sealed Air	Member
Vijay Fernandes, Jumana Khalifeh, Tarun Mathur	The Kuwaiti Danish Dairy Company	Members

Table 8: Advisory group members and organizations

Advisory group member	Organization
Kerstin Dobers	Fraunhofer Institute for Material Flow and Logistics IML
Anna Schulte	Fraunhofer Institute for Environmental, Safety and Energy Technology UMSICHT
Ernst Krottendorfer & Manfred Tacker	Circular Analytics/University of Vienna
Jeff Wooster	The Dow Chemical Company

Annex 2: Building the framework

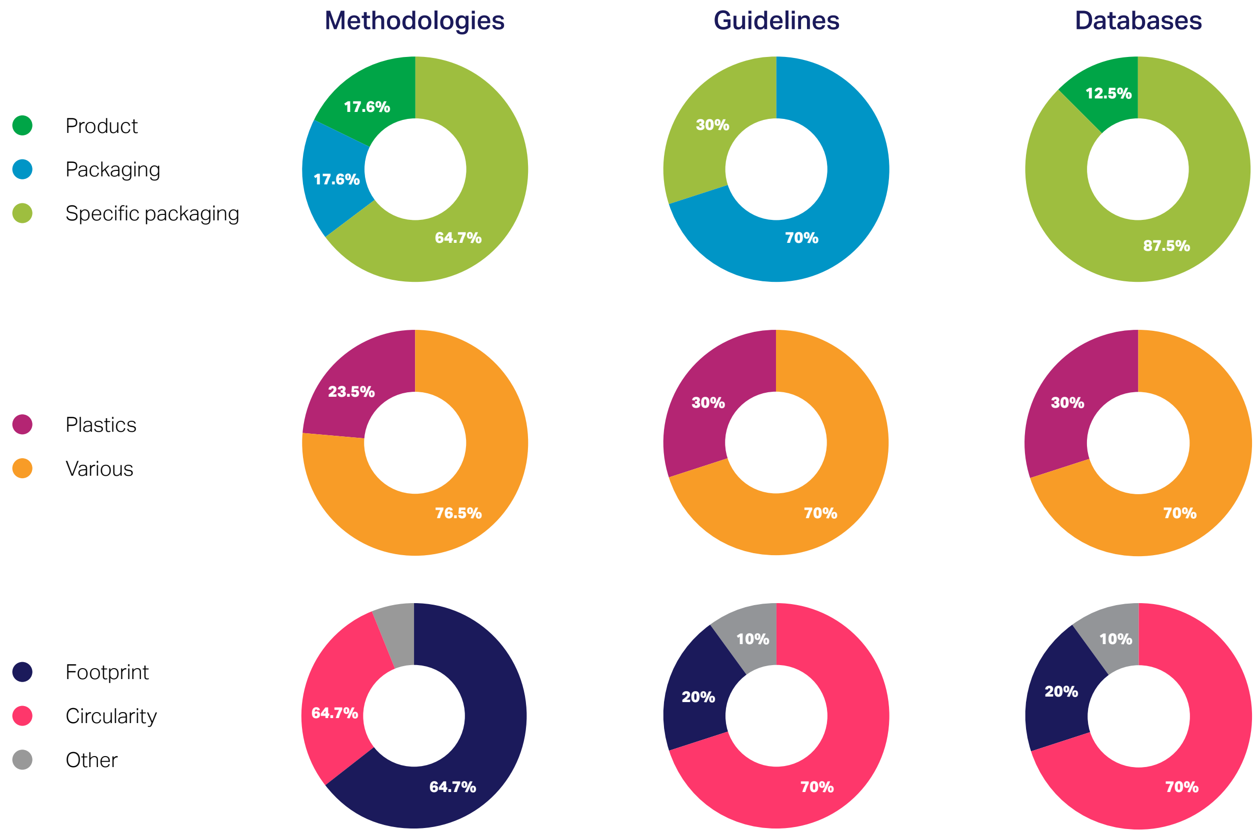
We have worked on a holistic view of the environmental impacts of packaging and have extensively considered the balance between scientific foundations versus accounting practices. The actionable purpose of this framework required a variety of methodologies to measure multiple impacts.

During the case studies, the framework came to life for their owners and generated a series of debates about the visual representation of results and data collection, and the useability of the conclusions.

Creating this framework builds on a systematic literature review analyzing over 50 existing methodologies, guidelines and databases.

The systematic literature review showed that the scope of different methodologies varies from general product impact to packaging, or specific packaging applications. Most literature is material-agnostic, though some focuses specifically on plastics. To respond to the intention of the framework, the study also included environmental impact assessments and an eco-design and circularity assessment. Figure 17 below summarizes the scope of distribution of the literature reviewed.

Figure 17: Scope of distribution of the literature reviewed



The purpose of this research was twofold:

1. Analyze existing metrics measuring the sustainability of packaging; and
2. Assess methodologies and databases to incorporate into the framework.

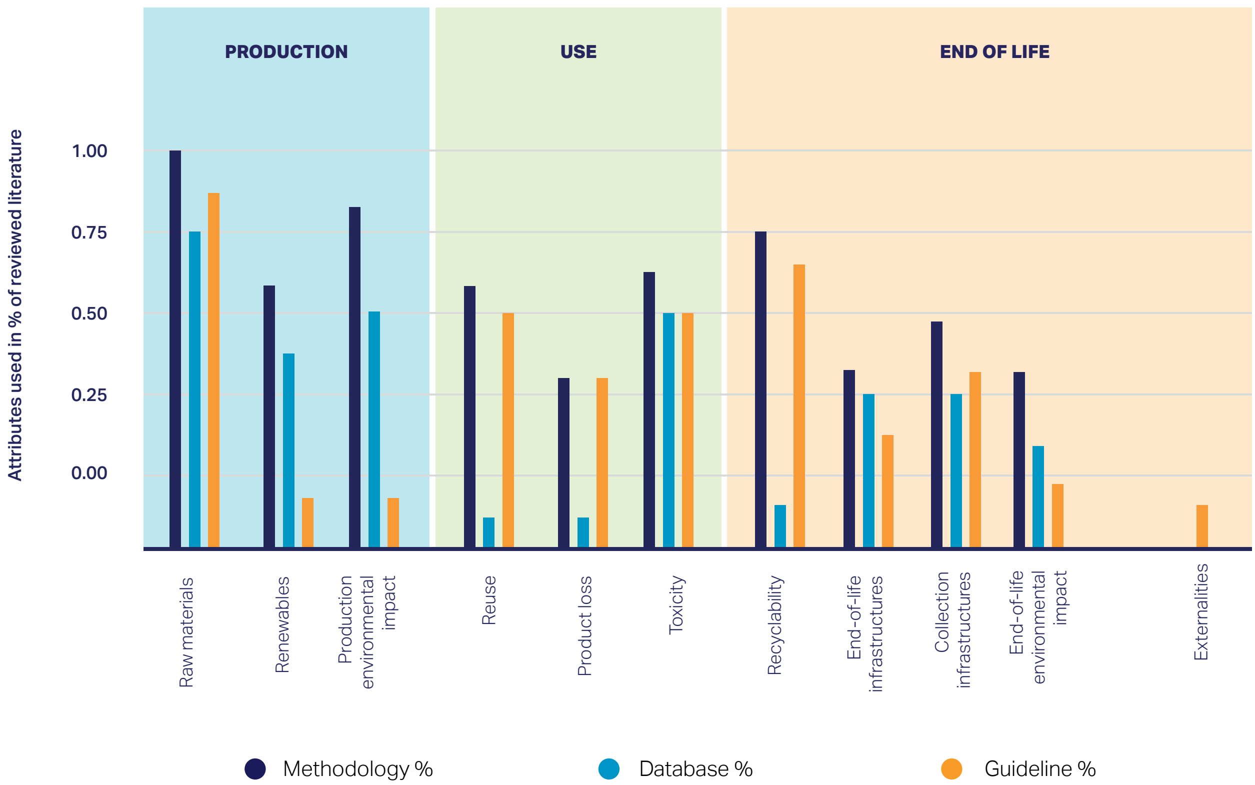
First, we defined 11 attributes of packaging sustainability divided over three life-cycle stages. Then we analyzed all methodologies, guidelines and databases to determine if it was necessary to include the attributes and what metrics to use to measure performance.

Table 9: List of packaging sustainability attributes and associated metrics

LIFE CYCLE STAGE	SUSTAINABILITY ATTRIBUTES FOR PACKAGING		POTENTIAL METRICS
PRODUCTION	Is it made from recycled/ renewable/ bio-sourced material?	→	Recycled / renewable content, Circularity
	Does its production use renewable input?	→	Renewable share, Carbon footprint
	Does the production and the delivery of the pack generate heavy environmental impacts?	→	Carbon / water footprint
USE	Can it be used or repurposed?	→	Eco-design
	Does it allow to reduce the product/food loss?	→	Environmental functionality
	Is there a risk for substance of concern to migrate in the product?	→	Toxicity / Migration rate
END-OF-LIFE	Can it be recycled or composted?	→	Actual recyclability
	Is there enough regional infrastructure in place to recycle or compost it ?	→	Waste management, Leakage
	Does its end-of-life treatment generate heavy environmental / social impacts?	→	Waste management footprint
	Does it have a high probability of ending up in the ocean?	→	Plastic footprint
	Are externalities internalized? (e.g. EPR)	→	Funding mechanism

Figure 18 shows the distribution of the 11 attributes across the literature. End-of-life is clearly underrepresented, especially when it comes to matching packaging design with regional waste management infrastructure.

Figure 18: Distribution of the 11 attributes across the reviewed literature



The systematic literature review has provided a list of methodologies and databases to employ when using the framework (see Annex 3). In addition, the following conclusions drawn from the literature review guided the framework design:

- Environmental footprint metrics and recycling metrics are rarely part of one methodology. We prioritized finding a way to combine and compare these metrics in the framework.
- Recommendations are a scarce output of the methodologies, which focus more on impact ratings. Thus, including actionable metrics became a priority for framework development.
- It is difficult to find data sources on leakage, regional end-of-life infrastructure, and extended producer responsibility (EPR) legislation as existing methodologies typically do not integrate them well. It is necessary to support region-specific data.
- Based on the results of the systematic literature, we redefined the 11 attributes into the six principles that compose the framework. These principles form the foundation of the framework and each is related to a range of metrics. Some principles cover all value chain steps, while others apply to a specific step.

Table 10: Principles

Principle 1	**Minimize the drivers of climate change**	Minimize climate change impact over the packaging life cycle
Principle 2	**Optimize efficiency**	Optimize packaging efficiency while ensuring content integrity
Principle 3	**Optimize circularity**	Maximize circularity (including considering recycled content, renewable content, reuse, repair, recycling rate, etc.)
Principle 4	**Optimize end of life**	Ensure optimized end-of-life footprint (including proper waste management solution in place and at scale in each market, plastic leakage, littering rate, etc.)
Principle 5	**Avoid harmful substances**	Avoid the presence of harmful substances
Principle 6	**Minimize the drivers of biodiversity loss**	Minimize other drivers of biodiversity loss (in terms of land use, water footprint)

Annex 3

Table 11: Landscape of methodologies, guidelines and databases

SOURCE TYPE	METHODOLOGIES	GUIDELINES	DATABASES
Academia	Circular Economy Indicator Prototype (CEIP), University of Bath Oil point, Technical University of Denmark Environmentally Extended Input-Output Analysis (EEIOA) Alpen-Adria-University Retained Environmental Value (REV), ETH Zürich Maturity Grid Assessment, Lund University Product Sustainability Index (ProdSI), Lappeenranta University of Technology EnvPack, Netherlands Institute for Sustainable Packaging (KIDV)	Circular Packaging Design Guide, FH Campus Wien (University of Applied Sciences, Austria) Circular Economy Toolkit, KES Transactions on Sustainable Design and Manufacturing	Food Contact Chemicals Database, Food Packaging Forum Ecoinvent database, Ecoinvent Centre Multi-Regional Input Output database, e.g., Eora, Exiobase
Consultancy	Plastic Leak Project (PLP), Quantis	Recyclability by design, RECOUP The 3R Initiative – Guidelines for Corporate Plastic Stewardship Applying Systems Thinking to Recycling (ASTRX), Sustainable Packaging Coalition & The Recycling Partnership Circular Product Design Framework, Circle Economy	Plasteax
Industry	Circular Transition Indicators (CTI) v2.0, WBCSD Material Circularity Indicator (MCI), Ellen MacArthur Foundation (EMF) RecyClass APR Design Guide, The Association of Plastic Recyclers Plastic IQ, SYSTEMIQ & The Recycling Partnership Bilan Environmental des Emballages (BEE), CITEO & Adelphe Sustainable Packaging Initiative for Cosmetics (SPICE), L'Oréal & Quantis	GreenScreen, Clean Product Action Global Protocol on Packaging Sustainability, Consumer Goods Forum EcoDesign Guidelines, Eco Design of Plastic Packaging Round Table	Pharos, Healthy Building Network Granta CES/ MetrialUniverse Chemical Hazard and Alternatives Toolbox (ChemHAT), Bluegreen Alliance Life Cycle Inventory (LCI) database, Plastics Europe

Public institution	European Product Environmental Footprint, EU Joint Research Center JRC Plastic LCA ReCiPe LCA method, Dutch National Institute for Public Health and the Environment (RIVM)	Social Life Cycle Assessment (S-LCA), United Nations Environment Programme Sustainable Packaging Guidelines, Australian Packaging Covenant Organization	Eurostat
NGO	ReSource, World Wildlife Fund (WWF)		What a Waste, The World Bank

Annex 4

Table 9: Methodologies and databases per principle

PRINCIPLE	METRIC	ASSOCIATED METHODOLOGIES	ASSOCIATED DATABASES	OTHER
Minimize the drivers of climate change	Greenhouse gas (GHG) emissions Cumulative energy demand Renewable energy share	Circular Transition Indicators (CTI) v2.0, WBCSD, Sustainable Packaging Initiative for Cosmetics (SPICE), L'Oréal & Quantis, Product Sustainability Index (ProdSI), Lappeenranta University of Technology, JRC Plastic LCA, Bilan Environmental des Emballages (BEE), CITEO & Adelphe, Environmentally Extended Input-Output Analysis (EEIOA) AlpenAdria-University, Circular Economy Indicator Prototype (CEIP), University of Bath, Oil Point Method, Technical University of Denmark	Ecoinvent database, Ecoinvent Centre, Multi-Regional Input Output database, e.g. Eora, Exiobase, Life Cycle Inventory (LCI) database, Plastics Europe	
Optimize efficiency	Packaging-to-product CO2-eq ratio Packaging-to-product volume efficiency Packaging-to-product weight ratio Product loss reduction	Maturity Grid Assessment, Lund University, JRC Plastic LCA		Internal data
	Shelf-life days			Global Protocol on Packaging Sustainability, Consumer Goods Forum
	Return rate for defects			Internal data

Optimize circularity	Circularity indicator Reuse rate Recyclability Recovery rate Renewable content Recycled content	Circular Transition Indicators (CTI) v2.0, WBCSD Plastic IQ, SYSTEMIQ & The Recycling Partnership, Sustainable Packaging Initiative for Cosmetics (SPICE), L'Oréal & Quantis, Product Sustainability Index (ProdSI), Lappeenranta University of Technology, JRC Plastic LCA, Bilan Environmental des Emballages (BEE), CITEO & Adelphe, Environmentally Extended Input-Output Analysis (EEIOA) Alpen-Adria-University, Circular Economy Indicator Prototype (CEIP), University of Bath, Oil Point Method, Technical University of Denmark, Material Circularity Indicator (MCI), Ellen MacArthur Foundation (EMF) ReSource, World Wildlife Fund (WWF), RecyClass, Retained Environmental Value (REV), ETH Zürich, Maturity Grid Assessment, Lund University	Plastic IQ, SYSTEMIQ & The Recycling Partnership, Food Contact Chemicals Database, Food Packaging Forum, Life Cycle Inventory (LCI) database, Plastics Europe	Circular Economy Toolkit, KES Transactions on Sustainable Design and Manufacturing, Global Protocol on Packaging Sustainability, Consumer Goods Forum
Optimize end of life	Leakage Mismanaged Waste Index (MWI) Collection rate Rate of proper waste management Release rate Littering rate	Plastic Leak Project (PLP), Quantis , ReSource, World Wildlife Fund (WWF)	Plasteax, Eurostat, What a Waste, The World Bank	Applying Systems Thinking to Recycling (ASTRX), Sustainable Packaging Coalition & The Recycling Partnership

Avoid harmful substances	CoC score CoC presence score Inertness score	Circular Transition Indicators (CTI) v2.0, WBCSD JRC Plastic LCA, Recyclability by design, RECOUP, RecyClass, Chemicals of Concern Score (from the UP Scorecard Methodology), Food Packaging Forum	Pharos, Healthy Building Network, Life Cycle Inventory (LCI) database, Plastics Europe , Granta CES/ MetrialUniverse	GreenScreen, Clean Product Action
Minimize the drivers of biodiversity loss	Land use Resource depletion Water footprint Land consumption Water consumption	ReCiPe LCA method, Dutch National Institute for Public Health and the Environment (RIVM), Sustainable Packaging Initiative for Cosmetics (SPICE), L'Oréal & Quantis, Environmentally Extended Input-Output Analysis (EEIOA) Alpen-Adria-University, JRC Plastic LCA	Ecoinvent database, Ecoinvent Centre, Granta CES/ MetrialUniverse, JRC Plastic LCA, Ecoinvent database, Ecoinvent Centre, Multi-Regional Input Output database, e.g. Eora, Exiobase	Global Protocol on Packaging Sustainability, Consumer Goods Forum

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DISCLAIMER

This report is released in the name of WBCSD. Like other reports, it is the result of collaborative efforts by WBCSD staff and experts from member companies. Participants of the workstream Packaging Sustainability Assessment reviewed drafts, ensuring that the document broadly represents the majority of Sustainable Plastics & Packaging Value Chains project members. It does not mean, however, that every member company of WBCSD agrees with every word. Please note that the data published in the report are as of December 2021.

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About Sustainable Plastics & Packaging Value Chains

The way we produce and consume plastics and packaging presents an unprecedented challenge for climate, nature and people. Today, there is a growing demand to transform plastic value chains by shifting to circular business models and decarbonizing the plastic lifecycle, while protecting biodiversity and ensuring that no one is left behind. In our Sustainable Plastics and Packaging Value Chains project, we support businesses in accelerating their transition towards sustainable and circular plastics and packaging.

We enable this transition through the development, promotion, and harmonization of metrics and methodologies. This includes frameworks for packaging sustainability assessment and plastic disclosure & reporting; a discussion platform on the UN Treaty on plastic pollution; and a roadmap to support the B2B chemical sector in its transformation. Learn more about Sustainable Plastics and Packaging Value Chains here.

ABOUT WBCSD

WBCSD is the premier global, CEO-led community of over 200 of the world's leading sustainable businesses working collectively to accelerate the system transformations needed for a net zero, nature positive, and more equitable future.

We do this by engaging executives and sustainability leaders from business and elsewhere to share practical insights on the obstacles and opportunities we currently face in tackling the integrated climate, nature and inequality sustainability challenge; by co-developing "how-to" CEO-guides from these insights; by providing science-based target guidance including standards and protocols; and by developing tools and platforms to help leading businesses in sustainability drive integrated actions to tackle climate, nature and inequality challenges across sectors and geographical regions.

Our member companies come from all business sectors and all major economies, representing a combined revenue of more than USD $8.5 trillion and 19 million employees. Our global network of almost 70 national business councils gives our members unparalleled reach across the globe. Since 1995, WBCSD has been uniquely positioned to work with member companies along and across value chains to deliver impactful business solutions to the most challenging sustainability issues.

Together, we are the leading voice of business for sustainability, united by our vision of a world in which 9+ billion people are living well, within planetary boundaries, by mid-century.

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