Measuring Environmental Impacts of Food Packaging

Learnings from UNEP's LCA Meta-studies on Single-use plastic products

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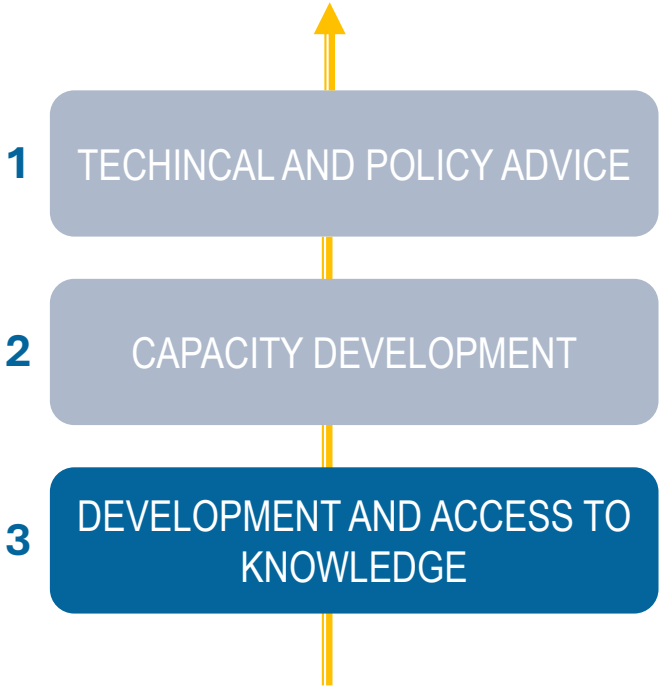
Life Cycle Initiative

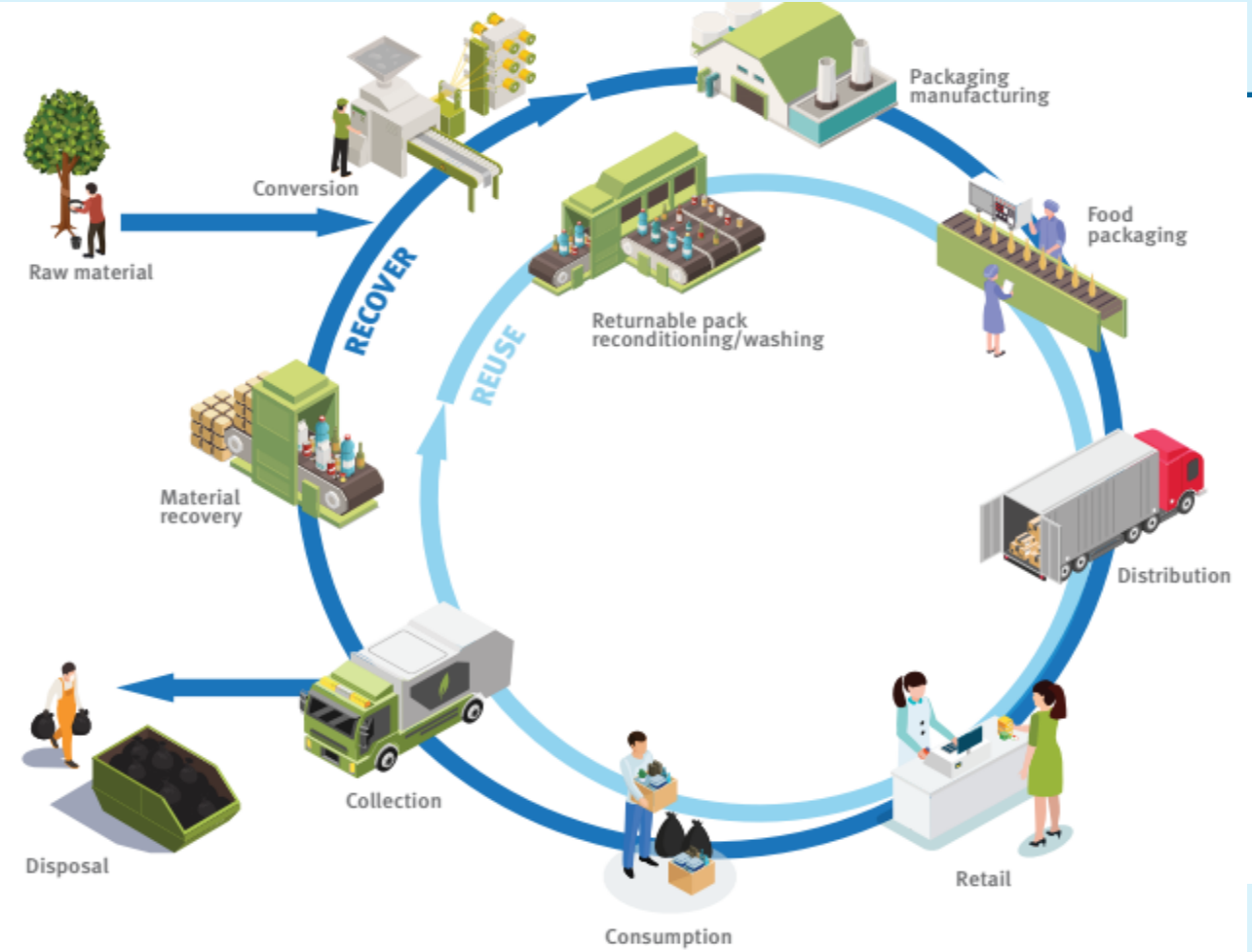
Food Packaging Forum

LIFE CYCLE WORK IN UNEP: FOCUS AREAS

- Public-private, multi-stakeholder partnership
- Global forum for LCA **science-based, consensus-building** processes
- Focus on high impact sectors: **plastics**, **textiles**, **buildings and construction,** and **mining**



Applying Life Cycle Thinking to Food Packaging



- LCA highlights the **areas of highest potential impact** along the value chain and helps to **identify trade-offs** amongst them
- It addresses important **concerns** surrounding the leaching of **chemicals** from **plastics** and those emitted when plastics are **burnt**

Single-use Plastic Products vs. alternatives

In response of the 4th session of the **UN Environment Assembly** (UNEA 4/9) in March 2019, the Life Cycle Unit has gathered info and proposed recommendations.

https://www.*lifecycleinitiative*.org/single-use-plastic-products-studies/

Overarching findings on SUPP

FROM A LCA PERSPECTIVE

1. The main issue is the **single-use nature of products**, rather than their material
2. Products should be **durable**, and usually the **lighter** a product's weight, the **lower its environmental impact**
3. Need to **keep resources at their highest value**, by **replacing single-use plastic products with reusable products**
4. There is **no one single solution to plastic products pollution**: it is context and country-specific, but taking a life cycle approach can help in taking the right decision

Meta-Study on Supermarket Food Packaging

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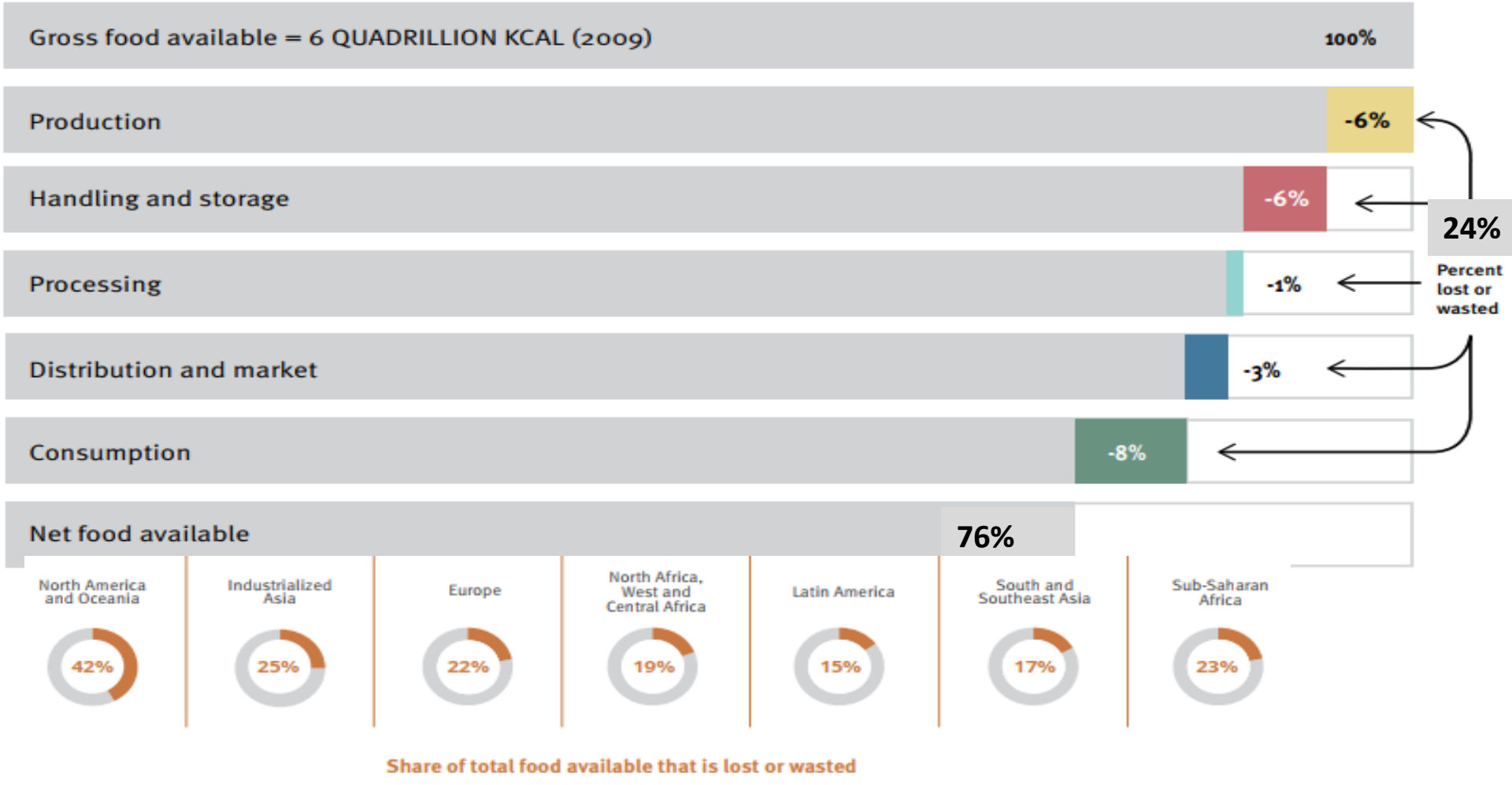
TGH THINK SPACE

Figure 4: Estimate of global food waste along the food supply chain. Source: Searchinger *et al.* (2019)



Food products Archetypes studied and Methodology

	Refrigerated Products	Fresh Produce	Pantry goods	Broadly applicable packaging
No. of studies	9	12	8	4
Geographies covered	Australia, Finland, Italy, Sweden and USA	Brazil, Canada, Finland, France, Germany, Italy, Netherlands, Spain, UK and USA	France, Germany, Italy, Spain, Sweden, Thailand	UK, Europe, USA, Thailand

Criterion	Conditions for inclusion in meta-study
Types of products covered	Study must consider more than one food packaging option, preferably including reusable alternatives and/or alternative materials to fossil-based plastic
Completeness – life cycle	Study must be a full LCA study, i.e. cover all life cycle stages (raw materials to disposal), preferably also considering food waste in the system boundary
Completeness – indicators	Study must consider a range of potential impacts, i.e. not just be a carbon footprint
Transparency	Sufficient information must be made available in the study report/article to interpret the study findings, including information on methodological assumptions, data sources and impact assessment methods
Age of study	Studies must be published within the last ten years, i.e. in the period 2011 to 2021
Peer review	Industry-commissioned studies must have undergone peer review. Academic studies published in peer-reviewed journals
Geographic coverage	Studies may be selected on geographical coverage in order for the meta-analysis to cover a range of countries and different levels of economic development
Language	Studies need to be available in English

SUPERMARKET FOOD PACKAGING: WHAT ARE THE BETTER OPTIONS BASED ON LIFE CYCLE ASSESSMENTS

Minimising food waste is a priority issue to be addressed through packaging

Food waste and packaging material are both important factors

Packaging should be minimized/avoided/refillable/returnable

Willing consumer and conducive legislative context

(consumers willing and able to change behaviour related to purchasing, returning and recycling packaging)

Unwilling consumer and/or unfavorable context legislative

(consumers unwilling or not able to change behaviour related to purchasing,

FOOD ARCHETYPE		POOR WASTE MANAGEMENT (landfill and open dumping; poor/no clear intervention)	GOOD WASTE MANAGEMENT (high recovery and recycling rates)	POOR WASTE MANAGEMENT (landfill and open dumping; poor/no recycling or recovery)	GOOD WASTE MANAGEMENT (high recovery and recycling rates)
REFRIGERATED PRODUCTS	Meat products	**Minimize food waste** Packaging that extends shelf life*	**Minimize food waste** Packaging that extends shelf life AND Bio-based and biodegradable packaging to allow co-disposal of food waste	**Minimize food waste** Packaging that extends shelf life that doesn't affect consumer preferences leading to increased food waste Minimize packaging materials without increasing losses or breakages**	
	Dairy and its alternatives	**Minimize food waste OR reduce packaging materials** whichever results in greater benefits***			
	Desserts/ prepared foods	**Minimize food waste OR reduce packaging materials** whichever results in greater benefits			
FRESH PRODUCE	Fruit and vegetables: Ready-to-eat and easily damaged fresh fruits and vegetables.	**Minimize food waste** OR reduce packaging materials whichever results in greater benefits	**Minimize food waste** Packaging that extends shelf life AND Bio-based and biodegradable packaging to allow co-disposal of food waste with packaging	**Minimize food waste OR reduce packaging materials** whichever results in greater benefits	
	Whole fruit and veg, incl. transit packaging	**Avoid packaging** Fruit and vegetables sold loose; transported in reusable plastic crates	**Avoid packaging** Fruit and vegetables sold loose; transported in reusable plastic crates or cardboard boxes with high recycled content	**Minimize packaging** plastic bag or, for soft/ easily damaged produce PS tray and wrap; transported in reusable plastic crates	**High recycled content packaging** Plastic bag, or high-recycled content tray and wrap; transported in reusable plastic crates or cardboard boxes with high recycled content
PANTRY GOODS	Shelf-stable	**Returnable packaging**	**Returnable packaging** if returns are high and logistics optimized OR High recycled content packaging	**Minimize packaging** minimize materials and weight, e.g. plastic rather than glass or cardboard	**High recycled content packaging** that is itself recyclable
	Dry goods	**Avoid packaging** (product sold loose) provided bulk transport of product is material-efficient (e.g. reusable plastic crates)	**Avoid packaging** (product sold loose) provided bulk transport of product is material-efficient, e.g. reusable plastic crates or cardboard boxes with high recycled content	**Minimize packaging** minimize materials and weight. Avoid double packaging (e.g. bag in a box)	**High recycled content packaging** that is itself recyclable, e.g. cardboard carton

TYPES OF PACKAGING FOR REFRIGERATED PRODUCTS COVERED IN THE LCA STUDIES

Meat packaging

Plastic tray and wrap

Chub/tube

Modified atmosphere packaging (sealed plastic tray)

Skin packaging (vacuum sealed plastic)

L-board packaging (plastic and laminated cardboard)

Dairy and dairy-substitutes packaging

Laminate pouch (portion size)

Plastic bottle (PET)

6-pack plastic tubs (PS) (portion size)

Plastic tub (PP) (bulk size)

Returnable glass bottle

Sealed plastic wrap

Aseptic carton (liquid packaging board)

Plastic cup (PP) with aluminium cover

Prepared food packaging

Sealed tray and wrap (modified atmosphere packaging)

Preferred type of packaging for refrigerated food products depending on context

The content of the matrix is simplified and aims to summarise the narrative of this section. Please refer to the full narrative of Section 3.1 for details.

Willing consumer and conducive legislative context

(consumers willing and able to change behaviour related to purchasing, returning and recycling packaging)

Unwilling consumer and/or unfavorable legislative context

(consumers unwilling or not able to change behaviour related to purchasing, returning and recycling packaging)

	POOR WASTE MANAGEMENT (landfill and open dumping; poor/no recycling or recovery)	GOOD WASTE MANAGEMENT (high recovery and recycling rates)	POOR WASTE MANAGEMENT (landfill and open dumping; poor/no recycling or recovery)	GOOD WASTE MANAGEMENT (high recovery and recycling rates)
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Dairy and dairy alternatives	**Minimize food waste OR reduce packaging materials** whichever results in greater benefits***			
Desserts/ prepared foods	**Minimize food waste OR reduce packaging materials** whichever results in greater benefits			

Minimising food waste is a priority issue to be addressed through packaging

Food waste and packaging material are both important factors

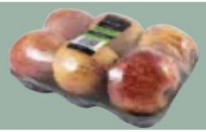
TYPES OF PACKAGING FOR FRESH PRODUCE COVERED IN THE LCA STUDIES

Packaging for ready-to-eat fresh fruits and vegetables

Plastic tub sealed with plastic film

Pillow bag (PP)

Supermarket packaging for whole fruits and vegetables



Plastic tray (PS)

Plastic bag (LDPE)

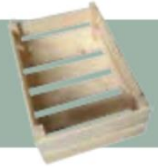
Clamshell (PET)

Plastic tray (OPS) and wrap

Plastic tray (PP or PLA)

Moulded pulp tray

Transit packaging for whole fruits and vegetables



Wooden crate

Plastic crate

Collapsible plastic crate

Cardboard box

Composite mango tray

Preferred type of packaging for fresh produce depending on the context

The content of the matrix is simplified and aims to summarise the narrative of this section. Please refer to the full narrative of Section 2.2 for details.

	Willing consumer and conducive legislative context (consumers willing and able to change behaviour related to purchasing, returning and recycling packaging)		**Unwilling consumer and/or unfavorable legislative context** (consumers unwilling or not able to change behaviour related to purchasing, returning and recycling packaging)	
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Ready-to-eat and easily damaged fresh fruit and vegetables	**Minimize food waste** OR reduce packaging materials whichever results in greater benefits	**Minimize food waste** Packaging that extends shelf life AND Bio-based and biodegra-dable packaging to allow co-disposal of food waste with packaging	**Minimize food waste OR reduce packaging materials** whichever results in greater benefits	
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Packaging should be minimized/avoided/reusable

Food waste and packaging material are both important factors

TYPES OF PACKAGING FOR PANTRY GOODS COVERED IN THE LCA STUDIES

Shelf-stable foods supermarket packaging


Single-use glass bottle


Plastic bottle (PET)


Plastic bottle (PET) with shrink sleeve


Plastic bottle (HDPE)


Aseptic carton (liquid packaging board)


Multi-layer pouch (doypack)


Glass jar

Steel can

Plastic wrap (PP)

Aluminium foil and kraft paper

Aluminium foil and cardboard

Steel can with aluminium pull-tab

Plastic cup (PP)

Laminate pouch


Returnable glass jar

Dry goods supermarket packaging


Pillow bag (PP)


Plastic bag in cardboard box

Plastic bag in cardboard box


Plastic bag (LDPE)


Mixed plastic bag


Gravity bin dispenser (for loose purchase of dry goods)

Preferred type of packaging for shelf stable and dry goods depending on context

The content of the matrix is simplified and aims to summarise the narrative of this section. Please refer to the full narrative of Section 2.3 for details.

Willing consumer and conducive legislative context

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Packaging should be minimized/avoided/reusable

Recommendations for Reusable Packaging

- **Washing/distribution plants should be widespread** rather than a single, centralized plant
- Encourage **standardization of packaging**, as this facilitates pooling and deposit return schemes
- Reusable food packaging systems **must be competitively priced** with single-use ones
- Reusable food packaging systems **must be accessible and convenient to consumers**

Single-use Packaging

RECOMMENDATIONS

- Packaging material **collection and recycling rates** should be **drastically improved**
- When **changes** to packaging are made it is important to consider its **acceptability** by **consumers**
- Packaging **alternatives** that seek to address marine plastic impacts should not be **at the expense** of addressing **climate change impacts**

Single-use supermarket food packaging and its alternatives: Recommendations from Life Cycle Assessments

What are Bio-plastics?

Source: UNEP 2021; From Pollution to Solution

UN environment programme

Bio-plastics

Plastics made from polymers that are either bio-sourced, biodegradable or both. For this reason, the term "bio-plastic" should never stand alone and it is necessary to specify, each time this word is used, the plastic's origin (bio-based or not) and end-of-life (biodegradable or not).

Bio-based / bio-sourced plastics

Plastics made from polymers derived from renewable resources (plants or animals). The sources of raw materials can vary and can include everything related to biomass and organic matter, in particular starches, sugars and vegetable oils. The polymers can be directly synthesized by plants or animals such as polysaccharides (starch, cellulose, chitosan, etc.), proteins (collagen, gelatin, casein, etc.) and lignins, or synthesized from biological resources such as vegetable oils (rape, soybean, sunflower, etc.). Other biopolymers, such as PHA, are produced by microorganisms through fermentation from sugars and starch.

Biodegradable plastics

Plastics made from polymers that are biodegradable under specified environmental conditions and above a specified degradation time as per accepted industry standards. Accepted industry standard specifications include, but are not limited to: ASTM D6400, ASTM D6868, ISO 17088 and EN 13432. **Most biodegradable plastics do not breakdown in the natural environment** but only under the controlled conditions found in industrial composting facilities (see Figure 15).

Compostable plastics

Plastics made from polymers capable of being biodegraded at elevated temperatures in soil under specified conditions and time scales, usually only encountered in an industrial composter. For industrial composting, standards apply: ISO 17088, EN 13432, ASTM 6400. This is in contrast to domestic or home

Bio-based and Biodegradable Single-use Packaging

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Managed Facilities

Natural Environments

- Biodegrades
- Does not biodegrade
- Unknown

INDUSTRIAL COMPOSTING	ANAEROBIC DIGESTION	HOME COMPOSTING	MARINE	FRESHWATER	ANAEROBIC AQUATIC DIGESTION	SOIL
6-12 weeks 50-70°C	Single-stage 14 days Two-stage 15-40 days	3-6 months 28°C	30°C	21°C	35°C	25°C

Renewable Materials

		INDUSTRIAL COMPOSTING	ANAEROBIC DIGESTION	HOME COMPOSTING	MARINE	FRESHWATER	ANAEROBIC AQUATIC DIGESTION	SOIL
PLA	Polylactic acid	Does not biodegrade	Does not biodegrade	Does not biodegrade	Does not biodegrade	Does not biodegrade	Does not biodegrade	Does not biodegrade
PHA - PHB	Polyhydroxybutyrate	Biodegrades	Biodegrades	Biodegrades	Biodegrades	Biodegrades	Biodegrades	Biodegrades
PBS	Polybutylene succinate	Does not biodegrade	Does not biodegrade	Does not biodegrade	Does not biodegrade	Does not biodegrade	Does not biodegrade	Does not biodegrade
TPS	Thermoplastic starch	Biodegrades	Biodegrades	Biodegrades	Biodegrades	Biodegrades	Biodegrades	Biodegrades

Fossil fuel-based raw materials

		INDUSTRIAL COMPOSTING	ANAEROBIC DIGESTION	HOME COMPOSTING	MARINE	FRESHWATER	ANAEROBIC AQUATIC DIGESTION	SOIL
PBAT	Polybutyrate adipate terephthalate	Biodegrades	Unknown	Biodegrades	Does not biodegrade	Unknown	Unknown	Unknown
PCL	Polycaprolactone	Biodegrades	Biodegrades	Biodegrades	Does not biodegrade	Does not biodegrade	Does not biodegrade	Biodegrades

Source: UNEP 2021

Biobased and Biodegradable Single-use Packaging

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RECOMMENDATIONS

- For food packaging that is **contaminated** with food waste, **bio-based** and **biodegradable** plastics could present a **solution** for co-disposal of food waste and packaging.
- <u>BUT</u> imperative that:
  - **Infrastructure** needed for the co-disposal of food and biodegradable plastic packaging **is developed before/alongside any promotion** of or support for bio-based and biodegradable food packaging.
  - Any promotion/support of bio-based and biodegradable packaging must come with **regulations around labelling** and **education of consumers**, so that biodegradable plastics do not disrupt conventional plastic recycling systems or end up littered or in landfills.
  - From an LCA perspective, bio-based and biodegradable packaging that ends up littered or in the general waste stream will have the same or even higher impacts than conventional plastics

Examples of food packaging types that require redesign and innovation

	EXAMPLES	SHARE OF PLASTIC PACKAGING MARKET % BY WEIGHT
SMALL-FORMAT lids, tear-offs, caps, sachets & generally all items smaller than 40 - 70mm		about **10%**
MULTI-MATERIAL packaging with inseparable layers of different materials		about **13%**

	EXAMPLES	SHARE OF PLASTIC PACKAGING MARKET % BY WEIGHT
PROBLEMATIC MATERIALS PVC, EPS & PS		about **10%**
NUTRIENT-CONTAMINATED meat packaging and packaging for prepared foods		**NOT QUANTIFIED**

Source: UNEP (2022) Supermarket Food Meta-study. Image adapted from World Economic Forum and Ellen MacArthur Foundation (2017)

The Packaging Relative Environmental Impact (PREI)

(Lucciardello 2017)

UN environment programme

Contribution of packaging to the overall environmental impact can be significant or negligible compared to the environmental impacts associated with the food itself.

Useful to understand the importance of packaging in unpacking environmental burdens.

HIGH PREI FOODS: choice of packaging highly influences overall environmental impact, irrespective of the impact of the food itself.
E.g., carbonated cooldrinks, wine and beer, which are typically packaged in glass or aluminum cans, and other tinned foods or foods in glass jars.

LOW PREI FOODS: foods **with high environmental impacts for their production** and for which the choice of packaging should be to minimize the possibility of food ending up as waste. Packaging for these foods has a small impact on their overall environmental impact relative to the food itself. This category includes for instance meat, coffee, freshly squeezed juices and butter.

INTERMEDIATE PREI FOODS: foods with moderate environmental impacts for their production as well as their packaging. Often trade-off between waste and packaging impacts. E.g, breakfast cereals, pasta and yogurt.

Key Messages

ASSESSED IN THE SUPERMARKET FOOD META-ANALYSIS

Need for **policy alignment** (economic measures, standards, and legislation).

Wherever the food type allows it (Intermediate PREI), **food should be sold unpackaged** or in **reusable packaging**, as this is **almost always environmentally preferred** to food in single-use packaging.

For **foods** associated with **high environmental impacts** in their production (Low PREI) packaging design should **prioritize minimization of food waste.**

For **foods** associated with **lower environmental impacts** in their production (high PREI), packaging should be **minimized** and/or **eliminated** wherever feasible**.**
LCAs **covering full value chain** and **include product losses** are needed to determine if minimising, avoiding or using returnable or recyclable packaging leads to lowest environmental impacts overall.

Chemicals in Plastics

FOOD CONTACT MATERIAL

An overview

The USEtox Tool

Life Cycle Initiative

Food Contact Material USEtox - Interface

THE UNEP/SETAC SCIENTIFIC CONSENSUS MODEL

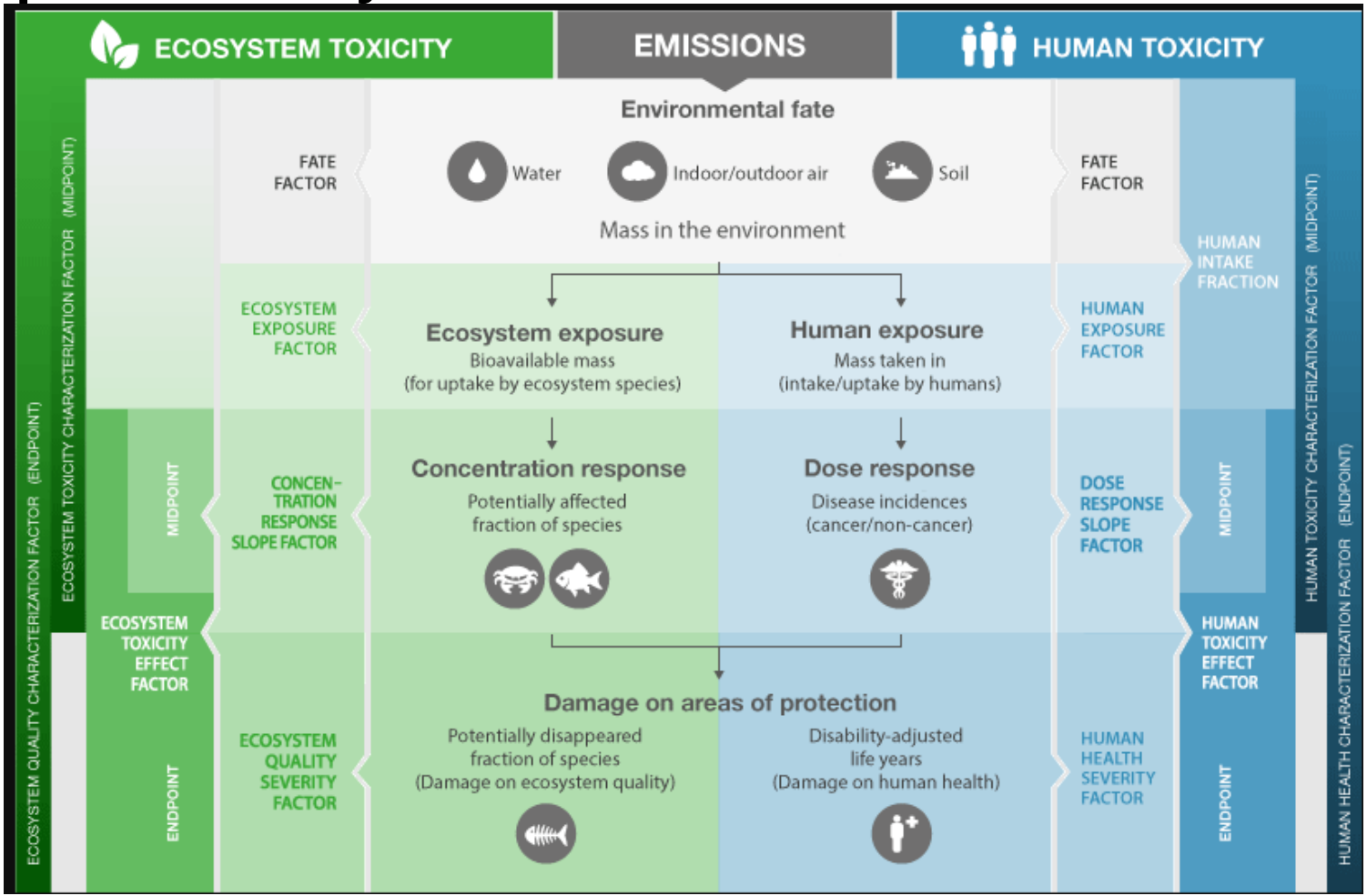
- **FCM USEtox interface** assesses the **human** and **ecotoxicological impacts** of **chemicals** in food contact materials (FCM)
- Counts **23 default products** in its platform, including PVC film for pork, PET bottle for water, HIPS cup for yogurt, etc.

HUMAN AND ECOSYSTEM EXPOSURE OCCURS IN THE FOLLOWING WAY

DIRECT INGESTION OF THE FOOD

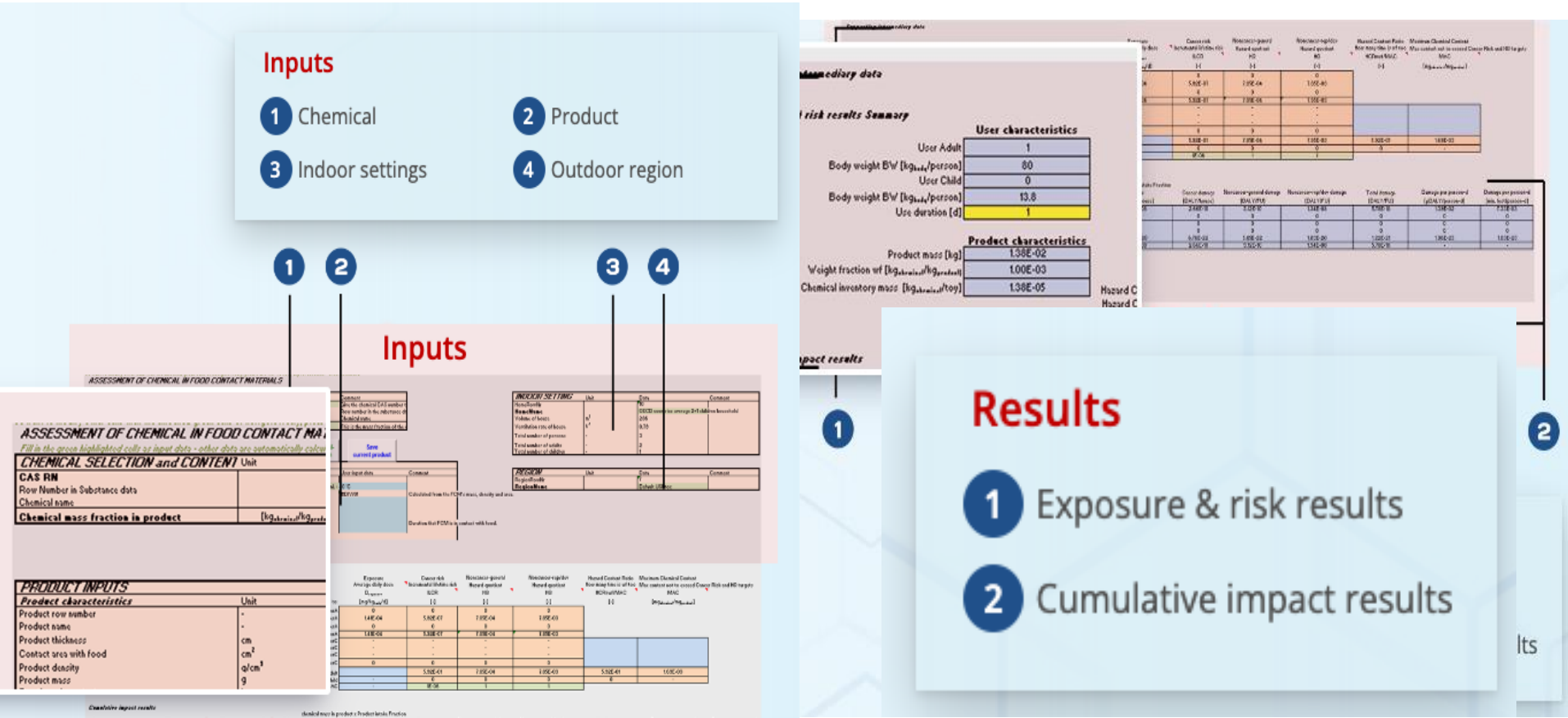
VOLATILIZE TO AIR AND LEACH INTO FRESHWATER

Impact Pathways considered in the USETOX model



FMC USEtox Interface

UN environment programme



Relevant Resources:

- Comparison tables for Single-use Plastic Products (SUPP) and their Alternatives
- Single-Use Plastic Products (SUPP) and their alternatives LCA meta-studies: Recommendations from Life Cycle Assessments
- USEtox interface – Food Contact Material (FCM) User Manual

Thank you!

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