

Topic Sheet

Materials and Products Substitutions



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When considering substitution of materials and products that cannot be eliminated or re-designed for reuse, it is key to avoid regrettable substitutions. Based on systems thinking and life-cycle approaches, this topic sheet provides guidance to identify trade-offs and prevent burden shifting when substituting materials or products in the market. It draws upon key learnings from the Life Cycle Assessment (LCA) meta-studies developed by UNEP and the Life Cycle Initiative on [single-use plastic products and their alternatives](#).

Overall, reusable or returnable products, regardless of the material, are usually the better option from an environmental perspective, when reused multiple times and cared for efficiently (e.g. efficient reverse logistics with short return distances; low energy use in washing during use-phase). Therefore, the priority would be to shift to reusable alternatives (which should also be recycled or composted at the end of their useful lives), with a next priority to opt for alternative materials where they can demonstrate superior sustainability credentials based on LCAs (for example coupled with socio-economic analyses).

How to avoid trade-offs when considering a material or product substitution?

The best practice is to conduct a LCA comparing the impacts of the materials or products in scope, so to avoid regrettable substitutions.

LCAs highlight hotspots along a value chain (i.e. showing areas of highest potential impact), and highlight trade-offs between different impacts. For instance, a new alternative might have less climate impacts but prove worst on other fronts (for instance it might have high water depletion or land degradation impacts). Depending on the local context (e.g. if we are considering the product/material

substitution in a water scarce country), having such type of information would allow for transparent and informed decisions. Understanding these trade-offs is a prerequisite towards improving the sustainability of products and systems¹.

The international standards on LCA, ISO 14040 and ISO 14044, respectively specify the principles and framework for LCA and requirements and guidelines. Key elements of a life-cycle approach to addressing plastics pollution are available on the [Life Cycle Initiative](#) website.

What should LCA studies look at?

The principal strength of an LCA is its systems perspective. However, LCA studies still do not cover some important aspects that may be relevant when comparing plastic products and their alternatives, and therefore it is important to base comparisons on a broad evidence-base for fully informed policymaking. For instance, aspects seldom covered by LCAs are food safety (chemical leaching to food, including differentiation of potential human health impacts by age and gender) and terrestrial and marine littering and related impacts on ecosystems².

Many LCA studies don't include end-of-life as the scope is often cradle-to-gate. Consumer behaviour, social impacts as well as gender analysis and considerations are also aspects not addressed by environmental LCAs that need careful attention when comparing different alternatives to plastic materials and products and their use².

¹ UNEP. (2021a). [Single-use face masks and their alternatives: Recommendations from life cycle assessments](#).

² UNEP. (2021b). [Addressing single-use plastic products using a life cycle approach](#).

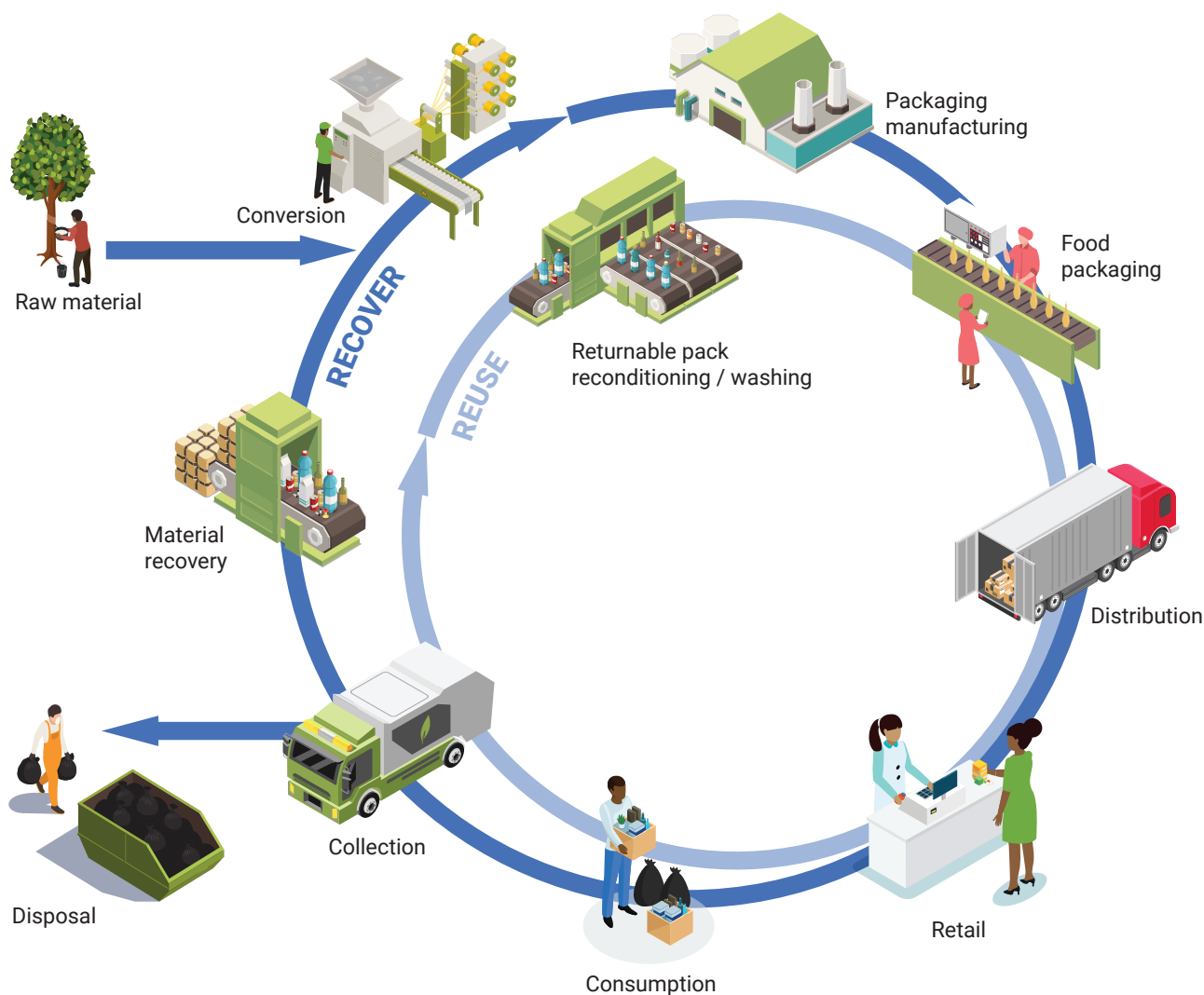


Figure 1: **'Closed loop' life cycle of plastic packaging, with an indication of actions to be prioritised at the various stages of the life of the packaging to reduce its environmental impacts, starting from designing for circularity and increased reusability**

Source: Adaptation of Life cycle of plastic packaging – UNEP 2022³

Global harmonised approaches could enhance sustainability of product and material substitutions

Having a common assessment method to identify which plastics can be substituted and acceptable alternatives is important to ensure fair comparisons:

- Independent institution / scientific body to support the application of sustainability assessments covering the full life cycle of plastic products and their alternatives.
- Focus on the function of the product being substituted, acknowledging potential means of delivering the function in a different way, e.g. a reusable product or without a product (e.g. tap water instead of bottled)
- Follow international guidance on the LCA method applied where available, including ISO standards and global recommendations for impact assessment⁴. Impact assessment should include as wide a set of environmental and socio-economic indicators as possible, including impacts on human health from chemicals used in plastics, impacts from litter in the environment etc.
- When studying biodegradable alternatives, it is important to understand that biodegradable plastic items often do not degrade in the environment and especially not in the ocean. Some may require exposure to prolonged high temperatures,

³ UNEP. (2022). Single-use supermarket food packaging and its alternatives: Recommendations from life cycle assessments.

⁴ E.g. UNEP's Life Cycle Initiative project GLAM.

above 50°C. Such conditions are met in industrial composting plants, but very rarely in the environment⁵. In any case, it is important that if biodegradable alternatives are used they meet the relevant standards for biodegradability (soil, marine and freshwater) and/or compostability (home and industrial).

- Investment in infrastructure, where relevant (e.g. segregate collection of organic waste and composting plants in the case of introduction of compostable products), should be developed before/alongside any

promotion of or support for new/alternative materials and products.

- Monitoring and enforcement are critical for implementing substitutions⁶.

Transitioning to more eco-friendly alternatives can be a lengthy process. In the meantime, strengthening circular thinking and waste management systems can successfully help in reducing plastics pollution⁵.

Table 1: **Selection of factors for policymakers when considering materials and products substitutions through policies**

Source: Summary of results of UNEP LCA-meta-studies on single-use plastics products and their alternatives and evolution of Figure 1 UNEP 2021b.

Considerations	Questions one should ask
Balance trade-offs and burden-shifting	<p>Are all relevant environmental impacts identified? Evaluate all potentially relevant environmental impact categories, and combinations of policies to manage trade-offs and risks of burden-shifting between environmental impacts. Example: Banning single-use plastic bags (SUPBs) while favouring other single-use alternatives can result in environmental trade-offs. Single-use paper bags have less impact of littering, compared to SUPBs, but often have higher impact on most other environmental categories (climate change, acidification, eutrophication, ozone depletion and land use change). When considering materials and products substitutions, these trade-offs should be evaluated in the specific geographical context.</p>
Promote Reuse	<p>Can you reduce the use of single-use products and incentivise reuse, whatever the material? Reuse practices have lower environmental impacts regardless of the material. Policymakers should incentivise reuse systems, and high reuse rates (including consideration on transportation from the customer back to the retailer (modes and distances), washing technologies and practices etc.). Example: Reusable cups need to be reused between 20 and 70 times for the global warming potential to be lower than single use alternatives, and between 20 and 40 times before fossil fuel resource depletion is lower than Polyethylene terephthalate (PET), Polypropylene (PP) and polylactic acid (PLA) cups respectively⁷.</p>
Design, function and material innovation	<p>How can the design of products help reduce environmental impacts? Are there functional differences that need consideration? Lighter durable products can reduce environmental impacts. Innovative design can incentivise acceptability of reusable alternatives. Consider co-benefits (e.g. designs which help to cut down food waste, or reduce water use in washing)⁷. Design changes can/will impact on recyclability or disposal. Example: The use of bio-based plastics generally leads to lower environmental impacts if there are appropriate collection and recycling infrastructure in place (i.e. industrial composting facilities). In contexts where there is a need for single-use cups options, for instance, the least environmentally problematic choice would be to use paper cups (PLA lining), which would be recycled, rather than landfilled⁷.</p>
Geographical context and Information gaps	<p>Do you have robust data and information that are context-specific? Evaluating different materials or product systems requires understanding and availability of country-specific information and data, particularly on the waste-management system and end-of-life practices, the weight of the product and the number of times they are used. Other aspects that are geographically dependent are the availability of feedstocks for bio-based materials, power generation technology and consumer behaviour regarding reuse and recycling.</p>

⁵ UNEP. (2018a). Single-Use Plastics: A Roadmap for Sustainability. <https://www.unenvironment.org/resources/report/single-use-plastics-roadmapsustainability>.

⁶ UNEP. (2018b). A Summary of Legal Limits on Single-Use Plastics and Microplastics: A Global Review of National Laws and Regulations.

⁷ Lifecycle Initiative. (2021). Single-use beverage cups and their alternatives: Recommendations from Life Cycle Assessments. <https://www.lifecycleinitiative.org/library/single-use-beverage-cups-and-their-alternatives-lca>.

Provision of education and accessibility to alternatives	<p>How can consumers behaviour during the use phase be influenced?</p> <p>Clear consumer information, sensitisation and communication need to be in place for consumers to reduce or avoid the use of single-use products, to minimise the littering of short-lived plastics, as well as dumping and open burning. Alternatives need to be accessible and affordable to all consumers.</p>
Production	<p>How can impacts be reduced at production stage?</p> <p>Production is often a big contributor to environmental impacts of plastic products. Consider factors such as the amount and type of energy used, whether it is fossil or renewable, as well as the availability of feedstocks. Also consider differences within categories and between material categories e.g. the choice between using fossil-based, recycled or bio-based resources.</p>
Future solutions and surrounding systems	<p>What is the potential for change? What is the level of technological maturity of solutions?</p> <p>Consider future changes in production technologies or end-of-life practices. The current performance of a novel/new solution may not be representative of future environmental performance. Future scenario assessments as a complement to studies on current (and past) product systems can help inform the viability of the product/material substitutions and decisions.</p> <p>Example: Recycling technologies for certain types of packaging (e.g. PLA) are developing rapidly. And power generation systems, transportation and recycling processes may change over time.</p>
End-of-Life practices	<p>What are the end-of-life practices in your location?</p> <p>There are large differences in the environmental impact of products depending on collection, recycling and reuse rates, and to what extent materials are eventually landfilled or incinerated with energy recovery. End-of-life waste treatment is an important contributor to environmental impact, especially whether it is homogenous (e.g. compostable products with food waste) or heterogeneous (e.g. plastic products with food waste). Recycling/composting or a combination of recycling/ composting with incineration and/ or landfill is better than just landfill. Consider full cradle-to-grave assessments and ensure that each material is assessed considering the most feasible end-of-life option.</p> <p>Example: Biodegradable packaging shows environmental benefits when industrial composting or anaerobic digestion is chosen as end-of-life option.</p>
Collection and recycling capability	<p>The higher the collection and recycling rate the lower the environmental impact.</p> <p>In countries with under-developed waste-management systems and poor infrastructure for collection and recycling, the arguments against single-use plastics are stronger because littering and associated environmental impacts are greater. Reusable and degradable alternatives should be considered as options to reduce these impacts. Collection and sorting systems need to be able to effectively segregate degradable plastics from non-degradable and use corresponding processing and recycling technologies for effective treatment.</p> <p>Example: Increasing the current EU aluminium recycling rate from 54% to 75%, as per the EU 2025 proposal, might reduce GWP from production of aluminium containers by 23% compared to the current situation.</p>
Incineration capability	<p>Bio-based materials with no fossil co-polymers have the advantage of climate-neutral incineration. They might have a lower total impact on the climate compared to conventional single use plastics, particularly when the materials are produced with renewable process energy and the products are sufficiently reused.</p>
Sources of Information	<p>Are a range of information sources being used?</p> <p>A range of resources to best characterise environmental and social impacts, particularly those impact categories not covered by LCA is recommended, e.g. impacts from littering or microplastics, gender analysis. Policies and decisions on products and materials substitutions must be based on several sources of information for environmental impact. Aspects seldom covered by LCAs are food safety (chemical leaching to food), health impacts of packaging materials, terrestrial and marine littering and the subsequence effects on ecosystems.</p>

Case examples for materials and products substitution

Substituting single-use plastic products (SUPP)

- **Colombia:** In 2022, the Colombian Congress approved a law introducing the ban and gradual substitution of 14 single-use plastic products. In preparing the law, the plastic materials to be banned and possible substitutes were evaluated and compared by using standardized LCA protocols based on the Colombian Technical Standard under ISO 14040.
- Actions to support material substitution include the design of eco-labelling strategies, support to industry to innovate, policies, along with a national communication campaign. <https://oab.ambientebogota.gov.co/senado-aprueba-la-eliminacion-de-plasticos-de-un-solo-uso-en-colombia/>.
- **Europe:** The 2019 European Parliament and Council Directive 2019/904 restricts Member States from placing in the market single-use plastic products, products made from oxo-degradable plastic and fishing gear containing plastic. Directive 2019/904 was preceded, among others, by an LCA study⁸, and an impact assessment to identify existing alternatives to SUPP and compare the LCA impacts of SUPP with reusable and single-use non-plastic alternatives.

Substituting plastic microbeads in cosmetics

- **Unilever:** In 2014 Unilever stopped using plastic microbeads as a scrub material and replaced them with natural alternatives. This recommendation built on voluntary initiatives by companies in the cosmetics and personal care industry. <https://www.unilever.com/brands/whats-in-our-products/your-ingredient-questions-answered/microplastics/>. The availability of biodegradable and natural alternatives to plastic microbeads such as jojoba beads, apricot seeds and powdered nut shells, are cited as reasonable substitutes for plastic microbeads⁶.

Assessing new alternatives

- **New Zealand: Rethinking Plastics** (2019) suggests using life cycle thinking to provide insights and uncover trade-offs when considering alternative materials to plastics. The report recommends that any introduction of new plastics or alternative materials needs to be guided from a system/life cycle perspective. When introducing a new material to replace problematic plastics, questions to address include: Is it safe? Is this a better alternative for the environment? What might be the unintended consequences? How does it fit into the current and future system of circular materials?
- The types of alternative materials (including textiles) that the study suggests considering include bio-based plastics, biodegradable and compostable plastics, next-generation plastics and non-plastic alternatives.

Economic incentives for the uptake of alternatives

- **Saint Lucia:** The Government of Saint Lucia banned styrofoam and selected single-use plastic foodservice containers in 2019. One of the key challenges was the unavailability of better and cheap alternatives. To reduce the burden on consumers the Government decided to abolish import duties on sustainable alternatives foregoing 5–20 per cent of revenue.

⁸ Cambridge Econometrics. (2019). Life Cycle Inventories of Single Use Plastic Products and their Alternatives.

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