Nordic Council of Ministers

Towards Ending Plastic Pollution by 2040

15 Global Policy Interventions for Systems Change

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Objective and Scope

United Nations Environment Assembly Resolution 5/14, *End Plastic Pollution: Towards an International Legally Binding Instrument*, champions the goal of ending plastic pollution, including through 'sustainable production and consumption of plastics' (Resolution 5/14, paragraph 3b). The prospective introduction of an international, legally binding instrument on ending plastic pollution presents UN member states with a unique opportunity to scale the level of international action, coordination and collaboration needed to move towards this goal.

The paper *Potential options for elements towards an international legally binding instrument* – by the Intergovernmental Negotiating Committee (INC) ahead of INC-2 – presents diverse options for debate among negotiators.[a] However, it was not designed to provide negotiators and stakeholders with an understanding of potential environmental, social and economic implications of different policies. Questions such as, 'What would be the impact of a set of policies on the stocks and flows of plastics?', 'What would be the impact on virgin plastic production and greenhouse gas (GHG) emissions?' and 'How much could it cost to implement these policies?' were not meant to be covered by the INC-2 paper. The objective of this report is thus to contribute to the debate by **defining 15 far-reaching policy interventions across the plastic lifecycle and estimating its impact on plastic stocks and flows** (including virgin plastic production, consumption, circularity, controlled disposal, mismanaged plastics[b] and releases into the environment), **GHG emissions, costs and jobs.** The focus behind these policies is on minimising the negative impacts of mismanaged plastics and plastic releases into the environment – including microplastics – by 2040.

This report aims to provide a starting point for policy interventions to minimise impacts from plastic pollution

In this report, these 15 policy interventions are assumed to be adopted in all jurisdictions, with each policy calibrated for different local contexts. While these policies would be enacted at a national level, the report assumes that this level of global adoption **would be achievable only under a set of common**

a The Options Paper (UNEP/PP/INC.2/4) was developed by the United Nations Environment Programme at the request of UN member states, using state and stakeholder submissions as a basis.

b Mismanaged plastics, in the context of this report, refers to any macroplastic or microplastic volume that does not end recycled or disposed of in a controlled manner. It would include those in unsanitary landfills / dumpsites, burned in open pits, or released into land or water environments.

global rules set out in an international, legally binding instrument on ending plastic pollution. Without common global rules and harmonised action, coordination and collaboration, the plastics policy landscape would likely remain fragmented, the adoption of far-reaching policies limited and the system's ability to deal with complex international plastic value chains insufficient.

The scope of this report in relation to the broader issue of plastic pollution:

According to the Organisation for Economic Co-operation and Development (OECD), 'plastic pollution' encompasses **'all emissions and risks resulting from plastics production, use, waste management and leakage'.**[1] The authors of this report support this broad and holistic definition of 'plastic pollution', in recognition of the fact that solutions to end plastic pollution should address multiple areas. These include hazards from plastics and additives to human health and biodiversity across the plastic lifecycle; the contribution of plastic to climate change; impacts on the informal sector and local communities; as well as mismanaged plastics and releases into air, land and water environments.

The scope of this report is centred on the results of a modelling exercise that estimates the impact on plastic stocks and flows, GHG emissions, costs and employment of implementing 15 far-reaching policy interventions across all geographies. The report presents these policy interventions and their estimated effects, with a focus on minimising the impact of mismanaged plastics and plastic releases into air, land and water environments. Although not all elements of plastic pollution could be quantified in the model, aspects such as hazards to human health and biodiversity, and the impact on the informal sector, are presented qualitatively to provide relevant context to the reader when necessary.

The findings presented in this report should thus be complemented by further sources of insight on these additional aspects of plastic pollution. Put simply, this report aims to provide a starting point for policy interventions and their required scope, while recognising that further changes to the plastic system are needed to fully address all aspects of plastic pollution.

The model presents two alternative scenarios of how the plastic system could evolve by 2040:

- The **Business-as-Usual Scenario** shows the impact on plastic stocks and flows, virgin plastic production, mismanaged plastics, GHG emissions, financial costs and employment of continuing on the current trajectory of plastic consumption and waste management.
- The **Global Rules Scenario** assumes that common global rules set out in the international, legally binding instrument would trigger far-reaching policy interventions across the plastic lifecycle, adopted across all geographies. The Global Rules Scenario should not be understood as the only policy package that could achieve these outcomes, but rather as a modelling of a set of far-reaching policies to showcase the level of reach needed to make a significant impact.

The **model underlying this report covers all geographies and all main economic sectors and plastic applications,** including packaging, household and consumer goods, textiles, fishing and aquaculture, agriculture, construction, transportation and electronics. The model acknowledges the different local contexts in diverse parts of the world by conducting the analysis across eight geographic regions: 1) Europe, including Türkiye; 2) the USA and Canada; 3) Japan, the Republic of Korea, New Zealand and Australia; 4) Central and South America and the Caribbean; 5) China; 6) South/Southeast Asia and Eurasia (excluding countries in other groups); 7) India; and 8) Africa and the Middle East. The analysis also includes primary microplastics from paints, tyre abrasion, textiles, pellets and personal care products.

The model underlying this study has important limitations:

- The model is not designed to estimate hazards and impacts of plastic on human health and biodiversity. This is because these hazards can depend on factors such as the level and frequency of exposure to specific substances or toxins, or intrinsic properties of a chemical, and do not have a linear relationship to plastic stocks and flows, which is the focus of the model.
- The model does not include global production caps, moratoriums or quotas. Incorporating these into the model would have necessitated highly uncertain assumptions – for example, on how quotas would be allocated to producers or which markets would have to limit consumption once production was capped. Instead, the Global Rules Scenario includes targets for virgin plastic reduction, which could be achieved through different mechanisms, including production caps and virgin plastic fees applied to local producers. The Global Rules Scenario results in a reduction of virgin plastic production that could serve as ranges if global caps were to be implemented, as these policies are not exclusive to the policy interventions outlined in this report.
- The Global Rules Scenario would not achieve net-zero GHG emissions or alignment with the Paris Climate Agreement. While the model estimates the GHG emissions from both scenarios, it does not include additional levers such as further reducing virgin production, decarbonising energy sources, switching feedstock or capturing end-of-life emissions.
- The model does not feature the remediation of legacy plastics already in the environment, covering this qualitatively instead.

The model draws from available sources and past modelling exercises but also differs from previous models as explained in Box 1 below. The analysis and figures in this report are estimates and approximations for the purpose of the modelling exercise, and are not statistical reporting. Therefore, the figures in this analysis reflect directional model outputs, not precise measurements, and should be interpreted as such. Despite these limitations, the model results are informative of the extent of the problem and the general level of reach that will be required to meaningfully reduce mismanaged plastics.

Box 1

How this model differs from previous models?

Previous reports featuring modelling results:

A new model was developed for the analytics in this report. The model builds on previous stock and flow models presented in **Breaking the Plastic Wave**[2], **ReShaping Plastics**[3], and **Achieving Circularity**[4]. However, it incorporates the following innovations:

- a new policy layer that links the impact of specific policies to plastic stocks and flows across the system, estimating the environmental, economic and employment impacts of different policies (eg, modulated extended producer responsibility, mandated reuse targets, product bans);
- an expanded sectoral and geographical scope, while maintaining granularity. Unlike previous analysis, which focused mainly on packaging, this model covers all main economic sectors in which plastic is used; and it differentiates both between geographical regions and, where relevant, between rural and urban areas. The analysis on microplastics adds releases from paints in addition to tyre abrasion, pellets, synthetic textiles and personal care products, which were estimated previously.

Data availability for plastic stocks and flows is fragmented and limited. The analytics included in this modelling exercise draw from available sources and, when no data was available, assumptions were made in collaboration with experts in each specific topic. The Technical Annex to this report explains the methodology, approach and underlying assumptions.

Executive Summary

Plastics are used in a wide range of applications across the world due to their high versatility, durability and relatively low cost. The use of plastics can also reduce GHG emissions by, for example, extending food shelf life or reducing the weight of vehicles. However, the plastic industry has not borne the cost of plastic externalities; on the contrary, it has benefited from public subsidies, for example in regards to oil exploration.[5] In addition, adequate controls on how plastics are produced, used and managed have been lacking, generating hazards to human health and biodiversity across the plastic lifecycle; contributing to climate change; impacting the informal sector and local communities; and resulting in the release of large volumes of mismanaged plastics into the environment. With a legally binding instrument on plastic pollution now under negotiation, governments have a unique opportunity to address these systemic challenges through common global rules.

The objective of this report is to define a package of far-reaching policies and estimate how, if implemented globally and concurrently, this could minimise the impacts of mismanaged plastics and plastic releases into the environment, including microplastics, by 2040. Two scenarios – the **Business-as-Usual Scenario** (current trajectory) and the **Global Rules Scenario** – are presented to depict two possible states of the plastic system by 2040. The Global Rules Scenario represents a future in which common global rules based on the international legally binding instrument would trigger a far-reaching package of policy interventions across the plastic lifecycle, adopted in all geographies. The analysis estimates the impact of these policy interventions on plastic stocks and flows, as well as on environmental, economic, and social implications. These policy interventions are not presented as the only set of policies that could achieve similar outcomes. Instead, the Global Rules Scenario simply models a package of far-reaching policies to showcase the level of reach needed to make a significant impact.

This section presents the report's main insights from the modelled scenarios:

FAST FACTS

↑86%
increase in annual mismanaged plastic volumes by 2040
(Business-as-Usual relative to 2019)

↑66%
increase in annual virgin plastic production by 2040
(Business-as-Usual relative to 2019)

Business-as-Usual Scenario

Without global action, the annual levels of mismanaged plastics would continue to rise and could almost double from 110 million tonnes (Mt onwards) in 2019 to 205 Mt by 2040, a 86% increase. Annual production of virgin plastics would increase from 430 Mt in 2019 to 712 Mt by 2040, a 66% increase. GHG emissions from the plastic system could further increase from 1.9 gigatonnes of carbon dioxide equivalent ($GtCO_2e$) per year in 2019 to 3.1 $GtCO_2e$ by 2040, an increase of 63%. This trajectory is incompatible with the goals of the Paris Climate Agreement.

The world produced ~460 Mt of plastics (430 Mt estimated to be virgin and 29 Mt recycled) and generated 385 Mt of plastic waste[c] in 2019. The global plastic system is currently unable to manage this waste and thus approximately 28% of plastic waste ends up mismanaged, resulting in 110 Mt in 2019. Of this, it is estimated that 43 Mt ended up in dumpsites; 39 Mt were burned in the open; and 28 Mt were released into land or water environments. Packaging and consumer goods, microplastics and fishing and aquaculture are the main sources of mismanaged plastics, followed by agriculture and textiles.

In the Business-as-Usual Scenario, the annual volume of plastics entering the system could rise from 460 Mt in 2019 to 764 Mt by 2040 (712 Mt virgin and 52 Mt recycled). As production and consumption increase, annual plastic waste generation could grow from 385 Mt in 2019 to 646 Mt by 2040. This trend is driven by population and consumption growth, which are also proportionally higher in regions that currently lack the necessary resources and infrastructure to manage waste, thus exacerbating the consequences of an already flawed plastic system over time.

↓90%
reduction in annual mismanaged plastic volumes by 2040
(Global Rules Scenario relative to 2019)

Global Rules Scenario

A set of far-reaching policies across the plastic lifecycle, adopted globally, could reduce annual mismanaged plastic volumes in 2040 by 90% relative to 2019. This set of policies would reduce annual volumes of virgin plastic production in 2040 by 30% relative to 2019. A reduction of this level would be needed to address the issue of mismanaged plastics through solutions across the plastic lifecycle, rather than simply expanding waste management.

c Plastic waste, in the context of this report, encompasses any plastic volume that has ended its use-phase or that has been lost or released during any other phase. This would include any plastic no longer in use-phase, microplastic releases, mismanaged pellets, or loss of fishing / aquaculture gear.

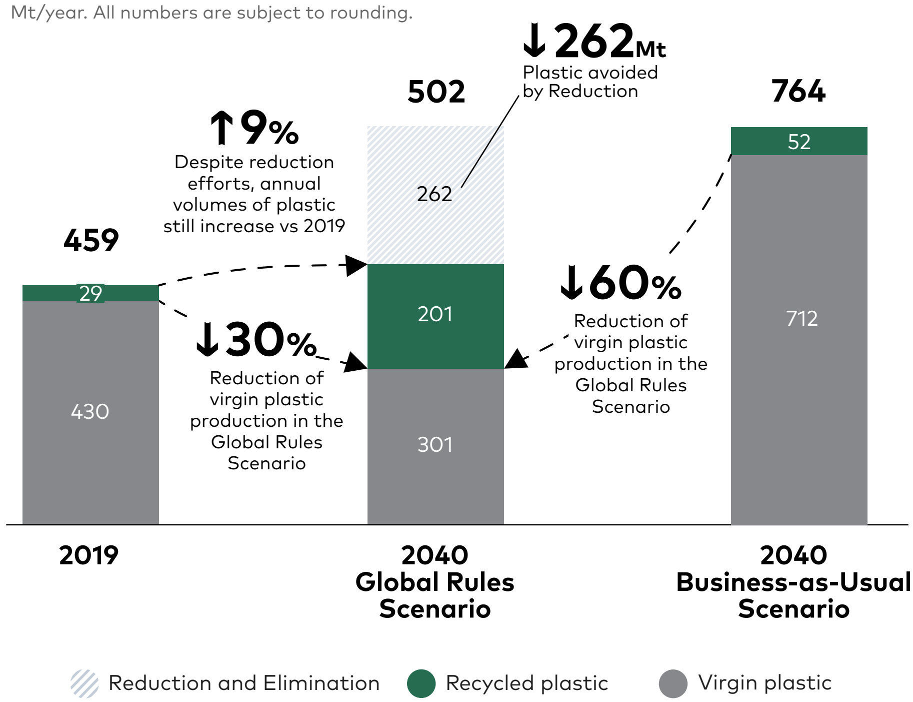
↓30%
reduction in annual virgin plastic production by 2040
(Global Rules Scenario relative to 2019)

The Global Rules Scenario would reduce annual volumes of virgin plastic production and consumption by applying targets, fees and demand reduction policies; eliminating avoidable single-use plastics on certain applications; mandating substitution where alternative materials would yield better impacts; and expanding safe reuse, recycling, durability and repair. By 2040, annual virgin plastic production would decrease by 30% relative to 2019 levels, equivalent to a 60% reduction relative to the 2040 levels in the Business-as-Usual Scenario. When counting both virgin and recycled plastics, annual production by 2040 would still result in a increase of 9% relative to 2019 levels (with a significant increase in the share of recycled plastics), as expected population and consumption growth outpaces reduction levers in some regions. Figure 1 below displays these results.

FIGURE 1 **Annual plastic production under the Business-as-Usual and Global Rules Scenarios**

The Global Rules Scenario would result in a 30% reduction in annual virgin plastic production by 2040 relative to 2019 levels.

Mt/year. All numbers are subject to rounding.



x7
increase in global recycling output by 2040
(relative to 2019)

The Global Rules Scenario would prevent 184 Mt of plastic waste annually by 2040. These policies could also result in an increase in recycling output to 201 Mt by 2040, relative to 29 Mt in 2019. This is equivalent to global recycling output increasing sevenfold by 2040. However, to achieve these results, the policy package laid out in the Global Rules Scenario would need to be implemented across all jurisdictions. If some large countries did not engage in this level of adoption, the result would significantly worsen.

Plastic volumes ending in controlled disposal

(2040 Global Rules Scenario relative to 2019)

↓46%

Declining in regions with well-developed infrastructure

↑74%

... but increasing where infrastructure is lacking today

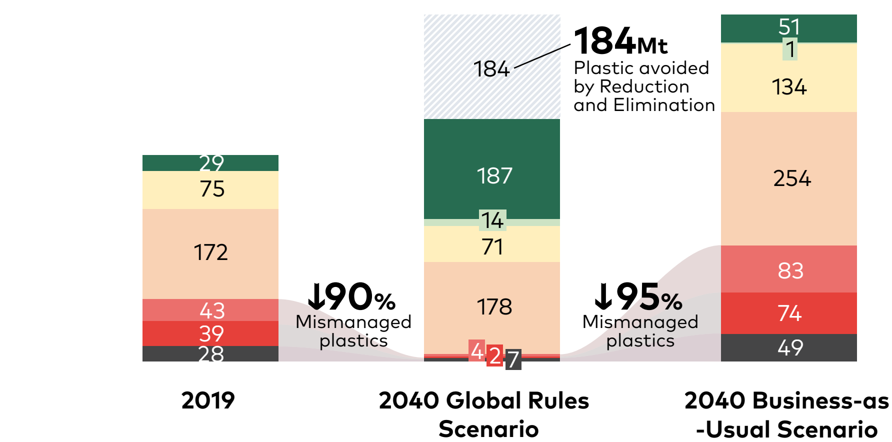
Despite the scale-up of reduction and recycling, some plastic waste still would not be prevented or recycled. This volume is estimated in the Global Rules Scenario at 249 Mt of plastic waste in 2040, which would thus be subject to controlled disposal.[d] The projected trends vary by region: controlled disposal volumes in Europe, the USA, Canada, Japan, the Republic of Korea and Oceania would decrease by 46% by 2040 relative to 2019 levels. However, annual controlled disposal volumes in other regions would increase by 74% by 2040 relative to 2019 levels, due to these regions already lacking waste management infrastructure.

The annual volumes of mismanaged plastics in 2040 would decrease by 90% relative to 2019 levels and by 95% relative to the 2040 levels in the Business-as-Usual Scenario. However, 13 Mt of mismanaged plastics would remain annually by 2040, with 4 Mt ending up in dumpsites, 2 Mt burned in the open and 7 Mt released into land or water. Out of these 7 Mt released into land and water environments, microplastics would represent 5 Mt. Figure 2 below displays these results.

FIGURE 2 **End of Life fate of plastic waste in 2019 and 2040 in the Business-as-Usual and Global Rules Scenario**

The Global Rules Scenario would result in a 90% reduction in annual mismanaged plastic volumes relative to 2019 levels

Mt/year. All numbers are subject to rounding



	2019	2040 Global Rules Scenario	2040 Business-as-Usual Scenario
Total Waste	**385**	**462**	**646**
Mismanaged plastics	**110** (28%)	**13** (<3%)	**205** (32%)
Recycling	**29** (<10%)	**201** (43%)	**52** (<10%)

Plastics never made: Reduction & Elimination

Recycled: Mechanical Recycling; Chemical Recycling

Disposed: Incinerated; Engineered Landfill

Mismanaged: Dumpsites / unsanitary landfills; Open burning; Released into land or water

d Controlled disposal prevents plastic waste from being mismanaged and includes engineered landfills (but not dumpsites), incineration with energy recovery and plastic-to-fuel technologies.

~0%

increase in GHG emissions by 2040 (Global Rules Scenario relative to 2019)

The Global Rules Scenario would result in an estimated 1.9 $GtCO_2e$ per year by 2040, which is equivalent to 2019 levels but would represent a mitigation of GHG emissions from the global plastic system of 40% relative to the 2040 levels in the Business-as-Usual Scenario (3.1 $GtCO_2e$). This decline in the Global Rules Scenario compared with the Business-as-Usual Scenario would mainly be driven by a decline in virgin plastic production. To achieve full alignment with the Paris Climate Agreement, further reduction in virgin production or additional decarbonisation levers would be needed beyond the reduction and circularity expansion outlined in the Global Rules Scenario.

A key driver to reduce plastic production and consumption is a shift away from single-use plastics

The results in the Global Rules Scenario would be achieved through a package of 15 far-reaching policy interventions across the plastic lifecycle, structured across five pillars. The set of policies selected draws on submissions from UN member states and other organisations ahead of INC-2, interviews and open consultations. The next infographic (see below) summarises these results and presents the policy interventions. This report's approach to determining the scale of each pillar is discussed in the report (see Box 5).

The Business-as-Usual Scenario would lead to a substantial increase in plastic production, mismanaged plastics and GHG emissions

Baseline 2019

- **430 Million tonnes** Virgin plastic produced
- **110 Million tonnes** Mismanaged plastic
- **1.9 Gigatonnes CO_2e** GHG emitted

Business-as-Usual 2040

- **712 Million tonnes** ↑66% vs 2019
- **205 Million tonnes** ↑86% vs 2019
- **3.1 Gigatonnes CO_2e** ↑63% vs 2019

The Global Rules Scenario involves 15 global policy interventions

Assumed to be legally-binding, concurrent, implemented across all regions, and across the plastic lifecycle:

The Global Rules Scenario would result in...

Global Rules Scenario 2040

- **301 Million tonnes** Virgin plastic produced ↓30% vs 2019
- **13 Million tonnes** Mismanaged plastic ↓90% vs 2019
- **1.9 Gigatonnes CO_2e** GHG emitted no increase vs 2019

↓90%
Annual mismanaged plastic volumes by 2040 relative to 2019
95% reduction relative to the Business-as-Usual Scenario

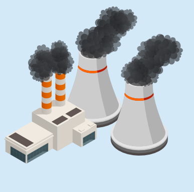
↓30%
Annual virgin plastic production by 2040 relative to 2019
60% reduction relative to the Business-as-Usual Scenario

↑7x
Increase in global recycling output
201Mt by 2040 relative to 29Mt in 2019

Despite all efforts, controlled disposal capacity would still be required‡

↓46% Declining in regions with well-developed infrastructure

↑74% ... but increasing where infrastructure is lacking today



0%
increase in GHG emissions vs 2019
↓1.2GtCO_2e relative to Business-as-Usual Scenario*

‡The Global Rules Scenario would result in controlled disposal (landfill and incineration) decreasing by 2040 relative to 2019 levels in regions that currently have well-developed waste management infrastructure. However, in regions currently lacking infrastructure, despite all efforts, the scenario would result in increased controlled disposal. * Further intervention is required to meet the targets set by the Paris Climate Agreement.

Pillar A

Reduce

virgin plastic production and consumption

Reduce plastic production and consumption

A significant reduction in virgin plastic production and consumption would be needed in order to substantially reduce mismanaged plastic levels. The Global Rules Scenario would result in a 30% reduction in annual virgin plastic production by 2040, relative to 2019 – equivalent to a 60% reduction relative to the Business-as-Usual Scenario. This would require policy interventions aimed exclusively at reducing virgin plastic volumes in the system.

The key policy interventions on which Pillar A is based are reduction targets, virgin plastic fees and application-specific demand interventions:

1 Targets to reduce virgin plastic volumes

calibrated by sector and local context

Targets to reduce virgin plastics volumes would signal the level of change needed to industry and governments. The reductions in virgin plastic achieved by 2040 under the Global Rules Scenario would vary geographically. Europe, the USA, Canada, Japan, the Republic of Korea and Oceania would see the highest reductions in consumption, since these regions are starting from high consumption per capita. In these regions, the Global Rules Scenario would result in a reduction in annual virgin plastics use of 51% to 63% by 2040 relative to 2019 levels. Regions such as China and Central and South America would see lower – although still significant – reductions in annual virgin plastics use, of 36% to 39% by 2040 relative to 2019 levels. This is due to lower consumption per capita today and their expected economic and demographic growth. Finally, regions with lower consumption per capita today but high forecasted economic and demographic growth – such as India, South and Southeast Asia, Africa and the Middle East – would see annual virgin plastics demand increase by ranges between 8% and 57% by 2040 relative to 2019 levels. These reductions could be aggregated to a global target, to signal the level of action required and communicate global action under a single objective.

2 Virgin plastic fees to fund solutions across the plastic lifecycle

with fees ranging from $1000 to $2000/tonne by 2040, calibrated by region

Virgin plastic fees to fund solutions across the plastic lifecycle could help to reduce the volume of virgin plastics in the system. This policy would level the playing field, internalise externalities and incentivise shifts away from virgin plastic. The Global Rules Scenario applies fees to virgin plastic volumes entering the system, calibrated by region and increasing progressively. The model follows the OECD's Global Ambition Scenario in its Global Plastics Outlook: Policy Scenarios to 2060, with adaptations by region and set to 2040. The modelled fees vary from US$500 per tonne to US$1,000 per tonne by 2030, and from US$1,000 per tonne to US$2,000 per tonne by 2040, depending on the region.

3 Application-specific levers to reduce plastic consumption

in textiles, fisheries and aquaculture, transportation and construction

Application-specific levers to reduce plastic consumption are included for certain sectors. For example, for textiles, the Global Rules Scenario assumes a ban on the destruction of overproduced and returned items. This is already underlined in the EU's Strategy for Sustainable and Circular Textiles,[6] which seeks to address overproduction in the apparel industry. For fishing and aquaculture, the Global Rules Scenario includes policies aimed at reducing intentional abandonment, unintentional gear losses and gear conflict, and introducing gear marking and tracking. For construction and transportation, the analysis leverages the Overseas Development Institute's (ODI) Phasing Out Plastics report on the potential opportunity to reduce plastic consumption.[7] When implementing policy interventions that could trigger the replacement of plastics with other materials, it would be necessary to run a comprehensive case-by-case analysis in the local context – for example, product lifecycle assessments (LCAs) – to prevent unintended consequences.[8]

Pillar B

Eliminate
avoidable and problematic plastics and chemicals

Eliminate avoidable and problematic plastics and chemicals

The Global Rules Scenario would eliminate certain avoidable single-use plastic applications through bans and reuse targets. Avoidable or unnecessary plastics include plastic applications that can be reduced or replaced with non-plastic alternatives or eliminated entirely without undesirable outcomes. In the case of problematic plastics – those which present hazards or risks to human health or biodiversity, or which hinder circularity – global criteria would be required in order to determine which substances should be phased out.

The key policy interventions on which Pillar B is based are bans and reuse targets for single-use applications and phaseout criteria for problematic plastics:

4 Bans on avoidable single-use plastics

to incentivise elimination, shift to reuse models and substitution

Bans on avoidable single-use plastics would shift certain packaging applications to safe multi-serve formats, reuse or refill alternatives; or replace plastic for other materials with superior environmental performance. In the Global Rules Scenario, these bans are applied to a broad range of applications such as single-use plastic bags; food service disposables and takeaway items; pots, tubs and trays for fruit and vegetables; plastics in logistics and business-to-business applications (eg, films to wrap pallets, e-commerce plastics); and multi-material/multi-layer sachets where better alternatives exist. Before banning a single-use plastic application, it would be necessary to run a comprehensive case-by-case analysis that considers the local context to prevent unintended consequences. To this end, product LCAs could be conducted to determine whether the alternatives will improve overall environmental, health and social impacts across their full lifecycle.[e]

5 Reuse targets for avoidable single-use plastics

between 15% to 100%, calibrated by applications

Reuse targets for avoidable single-use plastics would promote the scaling of new delivery models that replace single-use plastic packaging with alternatives that are used across multiple consumption cycles. The Global Rules Scenario leverages similar ranges to those reuse targets discussed under EU Packaging and Packaging Waste Regulation drafts,[9] for example, assuming reuse targets for 2040 between 15% and 25% for beverages containers (sodas, water, alcohol) and household products (eg, cleaning, personal care). The scenario assumes higher targets than those in the European Union drafts for other categories, for example, 100% for plastics used in logistics and transport packaging. Takeaway food and beverage containers (which also fall within the scope of single-use bans) either would be eliminated or would shift to safe reuse models. These targets would rest with final distributors (retailers and food service providers).

6 Phaseout criteria for problematic plastics, polymer applications and chemicals of concern

including bans and moving to 'safe lists' progressively

Problematic plastic products, polymer applications and chemicals of concern would be phased out according to common global criteria encompassing all those that create hazardous conditions, pose a risk to human health or the environment, impede safe reuse or recycling, or have high likelihood of releasing into the environment. For example, for several groups of chemicals used in plastic products (eg, bisphenols, flame retardants and phthalates), there is evidence pointing to human health hazards.[10] Other examples in packaging include problematic labels, adhesives and pigments (eg, carbon black or pigmented polyethylene terephthalate (PET) bottles); as well as polystyrene, polyvinyl chloride (PVC), polyethylene terephthalate glycol (PETG), polylactic acid (PLA), intentionally added per- and polyfluoroalkyl substances, and oxo-degradable additives[11,12].

e Conducting LCAs was not part of this report, which instead leveraged past studies to determine what bans would be applicable and whether the outcome would be elimination, shift to reuse or substitution

Pillar C

Expand Safe Circularity

via reuse, durability and recycling

Expand safe circularity via reuse, durability and recycling

Products would be redesigned for safe reuse, durability, repair, and recycling with common design rules, adjusted for local contexts. In the Global Rules Scenario, the world's recycling output would increase sevenfold by 2040 relative to 2019 levels, requiring collection rates to be over 95% globally by 2040 and recycling rates to range between 15% and 67% for specific plastic applications. To support this, extended producer responsibility (EPR) schemes would be implemented, with fees designed to operate on a net cost basis towards the development of the necessary infrastructure. These policies could impact the livelihoods of workers in the informal sector, so controls would be required for a just transition.

After reducing the volumes of plastic in the system (Pillars A and B), the Global Rules Scenario prioritises the expansion of circularity in those plastics that remain. The key policy interventions on which Pillar C is based are product design rules, waste collection targets, EPR schemes and protections for the informal sector:

7 Design rules for safe reuse, repair, durability and cost-effective recycling

calibrated by application and by local context

Design rules for safe reuse, durability, repair and cost-effective recycling in local contexts would be introduced under the Global Rules Scenario. These rules should ensure that plastic products in all sectors of the economy are designed for safe reuse and recycling. The rules would differ by plastic application. For example, for packaging, the Global Rules Scenario assumes improvements in sorting and recyclability due to better designs following the Golden Design Rules,[13] along with local calibrations that reflect differences in systems and infrastructure (eg, the guidelines of the Association of Plastic Recyclers in the USA and RecyClass in Europe). For durable applications, better designs would include improved repairability of electronics; a shift to recyclable mono-materials; the phaseout of additives that inhibit recyclability; and an overall increase in durability and lifespans in electronics, agriculture and fisheries and aquaculture applications.

8 Targets for collection and recycling rates

including segregated collection for plastics

Targets for collection and recycling rates would seek to maximise collection of plastic waste and increase the supply of recycled plastics. The Global Rules Scenario would result in waste collection rates of more than 95% across all geographies for all sectors considered. In low and middle-income countries, substantial development and resources would be needed to reach these levels. Globally aligned targets towards this goal would send an important signal to central governments, local authorities and the private sector.

The Global Rules Scenario prioritises safe mechanical recycling as the main method of recycling (prioritised over chemical recycling), resulting in a global plastics recycling rate of 43% by 2040 (compared to less than 10% in 2019). The Global Rules Scenario would expand recycling infrastructure capacity to 201 Mt globally (compared to 29 Mt in 2019). Chemical recycling technologies are still in development and present drawbacks such as higher energy consumption, lower material-to-material yields, increased GHG emissions and greater investment requirements that could create 'lock-in' effects, disincentivising better solutions in the future. For plastic waste that is not suitable for mechanical recycling, the Global Rules Scenario includes limited use of chemical recycling, which would account for approximately 3% of the total plastic waste generated in 2040. Because of the risks and uncertainty associated with chemical recycling, a Global Rules Scenario without chemical recycling was also modelled (see Box 4).

9 Modulated EPR schemes applied across sectors

with fees of $300 - $1000/tonne calibrated by region and by product

Modulated EPR schemes applied across all sectors are applied under the Global Rules Scenario, calibrated by region and product, to promote better designs and fund solutions across the plastic lifecycle. Fees should be defined to account for the costs of infrastructure in the local context, calibrated by application, and should operate on a net cost basis, to incentivise better designs and penalise the use of hard-to-recycle materials or designs. The fees modelled vary per product and region, but range from US$300 per tonne to US$1,000 per tonne by 2040, starting in 2025 and increasing gradually. Common rules within a global framework would also help to harmonise national approaches while still allowing for context-specific adaptation.[14]

10 Controls for a just transition for the informal sector

enhancing their labour and human rights

Controls for a just transition for the informal sector would enhance workers' labour and human rights, as global, national and local interventions – especially the adoption of policies such as EPR and deposit return schemes – could disrupt the livelihoods of these communities. Therefore, the Global Rules Scenario assumes the adoption of these policies to ensure a just and inclusive transition for the informal sector. These should be defined through close collaboration between governments and stakeholders to ensure the inclusion of the informal sector in the waste management system and in relevant policy discussions; and to facilitate the formulation of effective policies to improve incomes and working conditions, and protect the health and human rights of this community.[15]

Pillar D

Controlled disposal

of waste that cannot be prevented or safely recycled

Ensure the controlled disposal of waste that cannot be eliminated, reduced or safely recycled

Some plastics in use feature intricate designs that can hinder safe recycling, while some plastic waste may not be collected properly segregated to allow for recycling. In these cases, controlled disposal is the last resort to avoid mismanagement. The Global Rules Scenario would result in a 46% reduction in annual controlled disposal volumes in Europe, the USA, Canada, Japan, the Republic of Korea and Oceania by 2040 relative to 2019 levels. However, in regions[f] that currently lack waste management infrastructure and where population and consumption growth is expected to outpace the speed at which better solutions can be rolled out, there would still be an 74% increase in annual controlled disposal volumes by 2040 relative to 2019 levels.

The key policy interventions on which Pillar D is based are export restrictions on plastic waste, global standards on controlled disposal and removal programmes for legacy plastic:

11 Restrictions on plastic waste trade

to prevent exports to areas with limited capacity

Restrictions on plastic waste trade would prevent the export of plastic waste to regions with limited capacity or resources. In the Global Rules Scenario, trade restrictions are assumed to expand beyond the Basel Convention to all plastic waste exports, to prevent the transfer of responsibility from advanced waste management systems to underdeveloped systems. Exemptions may exist in the case of shared agreements and small countries and islands without sufficient capacity or scale to develop their own infrastructure.

f In low, middle and upper-middle income regions in Central, South America and the Caribbean; China; South/Southeast Asia and Eurasia; India; and Africa and the Middle East

12

Standards on the controlled disposal of waste that cannot be prevented or safely recycled

as last resort option to prevent plastic mismanagement

Standards on the controlled disposal of waste that cannot be prevented or safely recycled would be fully implemented globally to ensure that waste is not mismanaged. Landfill and incineration are the main options for controlled disposal; with landfills considered preferable in the Global Rules Scenario given lower GHG emissions and costs in comparison to incineration. Incineration of plastics can create 'lock-in' effects, as plants require a constant input of plastic waste to provide returns on investment over time, which can disincentivise recycling. Also, there is evidence of negative environmental impacts from incinerators due to inadequate emission controls of pollutants.[16] Controlling these requires extensive management, which can be problematic in areas with limited resources or regulation.[17] Landfills also require environmental standards, for example to include systems to capture liquids and gases, and to prevent land usage to impact biodiversity. The Global Rules Scenario assumes the split between engineered landfills and incineration that each region has today, prioritising landfills in regions without incineration when new capacity is required.

13

Mitigation and removal programmes for legacy plastics in the environment

although still prioritising solutions that prevent releases in the first place

Mitigation and removal programmes for legacy plastic in the environment should be pursued, however the Global Rules Scenario priority is on addressing the root causes of mismanagement and focuses on solutions that prevent releases to the environment in the first place. Removal programmes for legacy plastics would still have a role to play: For example, beach clean-ups are an effective way of raising awareness and may be an enabler for prevention. Data obtained from clean-ups can identify the items that are most likely to end up mismanaged and can inform policy accordingly.

TRANSVERSAL PILLAR E

Microplastics

Prevent the use of microplastics and reduce microplastics releases into the environment

Prevent the use of microplastics and reduce microplastics releases into the environment

An estimated 9 Mt of primary microplastics were released into the environment in 2019; and without effective policy, this figure is projected to increase to 16 Mt by 2040 under the Business-as-Usual scenario. Through a series of policies to prevent the use of microplastics and capture emissions, the Global Rules Scenario would see microplastic releases fall to 5 Mt per year by 2040. Although this represents an important improvement relative to 2019, further solutions and innovation would be required.

The analysis includes primary microplastics from personal care products, pellets, tyre abrasion, paints and textile use; but excludes secondary microplastics.

14

Upstream policies to reduce microplastics use and emissions

through bans, substitution, better product designs, preventive maintenance, and behavioural change

Upstream policies to reduce microplastics use and emissions should be introduced. The analysis assumes microplastics from personal care products are completely eliminated through bans on intentionally added primary microplastics. The model also estimates reduction of microplastics creation and emissions through better designs in textiles and tyres. Finally, the estimate assumes enforcement of a wide range of upstream interventions, such as practices and technologies for the application, maintenance and removal of paints.

15

Downstream policies to capture microplastics, followed by controlled disposal

prioritising capture at source over capture through wastewater treatment systems

Downstream policies to capture microplastics, followed by controlled disposal would avoid the release of microplastics into the environment. The model prioritises capture of microplastics at source, estimating the potential of enforcing certain technologies and industry practices – for example, practices to prevent the release of pellets, microplastic filters in washing machines and paint removal technologies. If capture at source is not possible, the analysis estimates the potential of downstream capture through waste and wastewater systems, although this is left as a last resort option due to requiring substantial infrastructure and investment.

Costs and employment implications

The Global Rules Scenario would yield important savings in public expenditure relative to the Business-as-Usual Scenario. The cumulative[g] public expenditure from 2025 to 2040 in the Global Rules Scenario would total US$1.5 trillion, compared to US$1.7 trillion in the Business-as-Usual Scenario. The savings would mainly accrue from reductions in plastic volumes, resulting in less plastics to collect and manage. However, this would primarily apply to regions with well-developed infrastructure; other regions would still need to invest more in expanding their waste management systems.

US$**1.5tn**
cumulative public expenditure from 2025 to 2040 (Global Rules Scenario)

The analysis estimates both public expenditure for governments and costs and investments required from the private sector in the Business-as-Usual Scenario and the Global Rules Scenario. Public expenditure in this analysis accounts for the costs of collecting, sorting and disposing of plastic waste. The Global Rules Scenario would result in lower public expenditure relative to the Business-as-Usual Scenario, mainly due to reductions in plastic use, and thus in the volumes to collect and manage.

g Present value, using a discount rate of 3%.

However, the trends would differ by region. For regions with well-developed infrastructure,[h] public expenditure in the Global Rules Scenario is estimated at US$0.8 trillion (2025 to 2040 present value); whereas the equivalent figure for the Business-as-Usual Scenario is US$1.1 trillion.

For regions that currently lack infrastructure,[i] public expenditure in the Global Rules Scenario is estimated at US$0.7 trillion (2025 to 2040 present value) – a slight increase on the US$0.6 trillion estimated in the Business-as-Usual Scenario. These estimates however do not include cost implications from mismanaged legacy plastics or any other externalities from plastics, and therefore these estimates could bring savings if those externalities were accounted for.

With regard to employment, it is estimated that both the Business-as-Usual Scenario and the Global Rules Scenario would support 12 million jobs globally by 2040. This suggests that the Global Rules Scenario could be achieved without any decrease in global employment. However, it would require a shift in jobs away from virgin plastic production; a shift in industry towards new business models (eg, reuse) and alternative materials; and improved recycling, collection and waste management systems. Importantly, this transition may not be balanced from a geographical perspective; and it would be essential to put in place controls to ensure a socially just transition, particularly in relation to vulnerable communities.

Priorities for further innovation, research and data

The extent of the issue is such that, even after implementation of the 15 far-reaching policy interventions in the Global Rules Scenario, 13 Mt of plastic would remain mismanaged annually by 2040, requiring further solutions, research, data gathering and innovation.

In the Global Rules Scenario, the impact of the 15 policy interventions is limited by technological, economic and behavioural constraints. By 2040, the scenario would still lack solutions for 13 Mt of annual mismanaged plastic, of which it is estimated that 4 Mt would end in dumpsites, 2 Mt would be burned in the open and 7 Mt would be released into land or water. Out of these 7 Mt released into land and water environments, microplastics would account for 5 Mt; this therefore remains a key area in which solutions are lacking. Innovation would thus be required to improve the design of tyres, paints and textiles to minimise microplastics emissions. The remaining mismanaged plastic volumes would comprise a mixture of all other sectors. To address this, further solutions would need to be incentivised – for example, scaling recycling and collection systems in rural areas of low and middle-income regions to overcome the challenges of remoteness and low population density. Reuse models would require private sector innovation to further reduce costs and GHG emissions. Sorting and recycling technologies should focus on improving yields. Innovation on alternative materials with better impacts and possessing comparable properties to plastic should also be explored.

h Europe; the USA and Canada; and Japan, the Republic of Korea, New Zealand and Australia.

i Central and South America and the Caribbean; China; South/Southeast Asia and Eurasia; India; and Africa and the Middle East.

Further access to information and scientific guidance and research would also be needed. The establishment of a harmonised knowledge base for taking informed action, measuring progress and refining policies would require a globally coherent approach to monitoring and reporting. At present, much of the approach to managing plastics is based on incomplete information, which constrains effective action and the scale-up of solutions. A scientific panel with the appropriate mandate could be instrumental in facilitating such harmonisation.

Paints and tyre abrasion are estimated to be the main sources of microplastic releases

Concluding Remarks

To be effective, the 15 policies in the Global Rules Scenario should be complemented by enablers that would close governance and institutional gaps globally, regionally and nationally. These could relate to financial assistance, capacity building, technical assistance and technology transfer, as well as national action plans, national reporting, compliance and periodic assessment and monitoring. The results presented assume that these would be put in place; otherwise, it is unlikely that the assumptions around compliance, enforcement and effectiveness of policies estimated in the analysis could be achieved.

> **These 15 far-reaching policy interventions could take us a long way towards ending plastic pollution by 2040, requiring further efforts to address it fully**

It is clear the current approach to tackling global plastic pollution is not working and incremental policy improvements will be insufficient to solve the problem. While most of the policy interventions proposed in this report would be taken at a national level, unlocking the necessary global adoption and international collaboration would require **global rules.**

It is also crucial to acknowledge that plastic pollution is a broad problem; and that critical issues such as health risks, chemicals of concern and negative impacts on biodiversity – which are not discussed in detail in this report – must also be addressed. **Hence, the Global Rules Scenario is intended merely a starting point for systems change in the global plastics system, rather than as a comprehensive solution.**

Yet this report shows that implementing 15 far-reaching policy interventions could take us a long way in the journey towards ending plastic pollution by 2040.

Business-as-Usual Scenario

Without global action, annual levels of mismanaged plastic volumes will continue to rise and could almost double from 110 Mt in 2019 to 205 Mt by 2040. Annual production of virgin plastics would increase from 430 Mt in 2019 to 712 Mt by 2040. Meanwhile, GHG emissions from plastic could increase from 1.9 $GtCO_2e$ in 2019 to 3.1 $GtCO_2e$ in 2040.

Plastic delivers high versatility, durability and convenience for thousands of applications at low cost. Its use started to gather pace in the 1950s and since then consumption has grown significantly year on year.[18] The best available data indicates that the world used 460 Mt of plastic in 2019.[19,20,21,22]. More than 40% of this was utilised in single-use or short-lived products that become waste within one year of first use.[23] Geographically, plastic use is disproportionately greater in high-income countries: the average consumption of plastic per capita in the USA, Europe and Japan is more than three times that in low and middle-income regions.

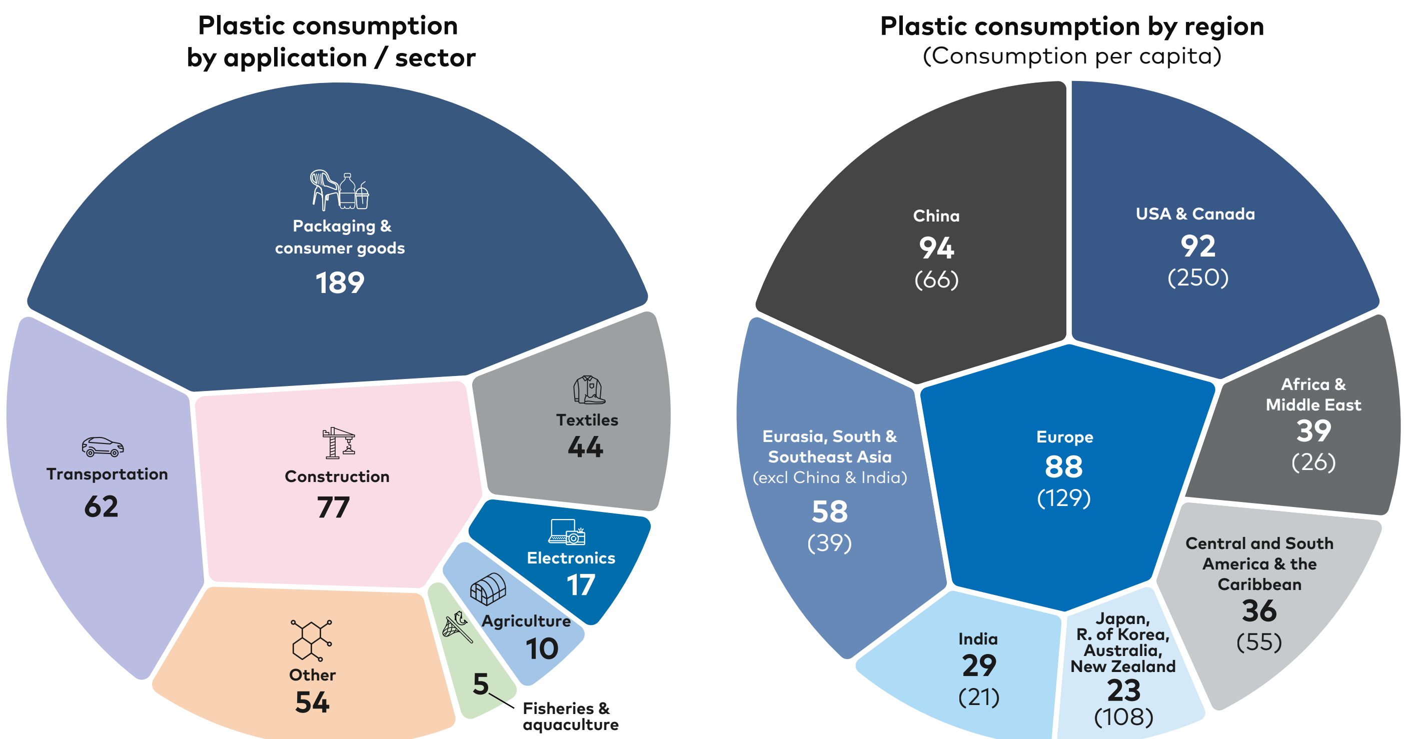
The **Business-as-Usual Scenario** models the plastic system today and estimates the impact by 2040 of maintaining the current trajectory (as population and consumption per capita grow) on plastic stocks and flows across the value chain, including production and consumption; plastic waste; mismanaged plastic volumes; plastic releases into air, land or water; and GHG emissions.

The model segments the analysis both by region[j] and by all main economic sectors in which plastic is used, and includes primary microplastics. Figure 3 shows the total plastic volumes in 2019 by sector (left) and by region (right).

FIGURE 3 **Breakdown of plastic consumption in 2019**

Plastic is used across a broad variety of economic sectors and applications around the world

Mt/year, 2019. Consumption per capita in Kilos of plastics consumed / year. All numbers are subject to rounding.



Plastic consumption per capita estimates for the modelling include all plastics consumed in a given region, including those from industry.
Source: OECD Global Plastic Outlook, FAO, Environmental Action, UN population data, Systemiq analysis.

The analysis applies product lifespans across applications to estimate when material will become waste. From the annual waste volumes, the model estimates end-of-life fate by modelling the stocks and flows of plastic across the plastic lifecycle, using available data on collection, sorting, recycling etc. Of the estimated 385 Mt of plastic waste generated in 2019, 29 Mt were recycled; 246 Mt ended up in controlled disposal through incineration with energy recovery or landfill; and 110 Mt (28%) were mismanaged. Of the total mismanaged volume, it is estimated that 43 Mt ended up in dumpsites, 39 Mt were burned in the open and 28 Mt were released into land or water environments.

Circularity was marginal, with reuse and recycling rates of below 10% globally. This was driven by multiple factors, including product designs that do not account for end of life; the complexity and variety of polymers and their

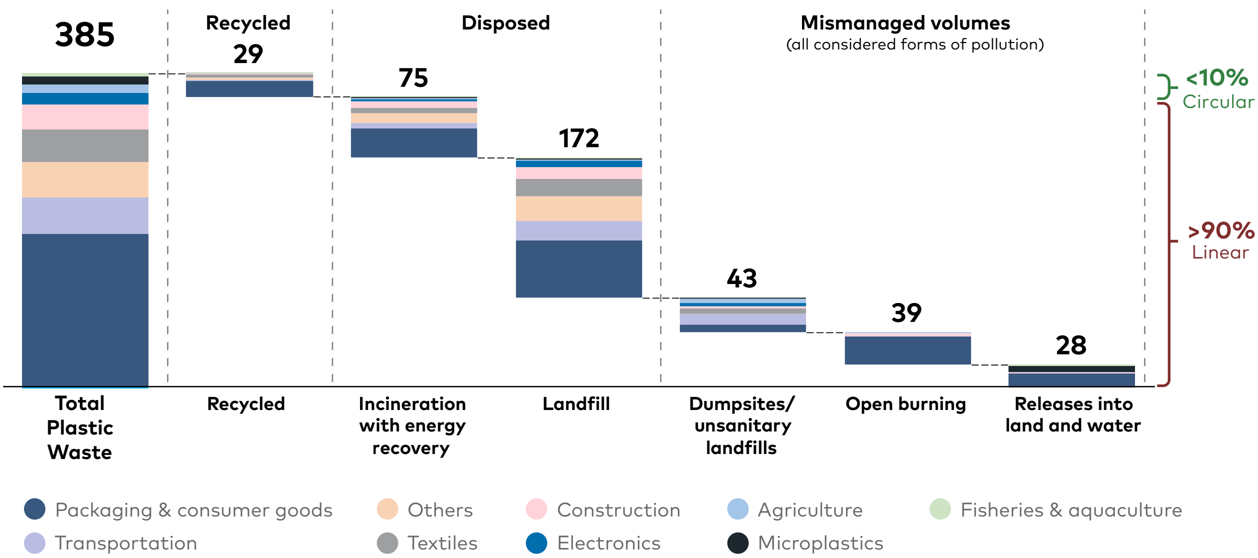
j The model segments the analysis by eight geographic regions: 1) Europe, including Türkiye; 2) the USA and Canada; 3) Japan, the Republic of Korea, New Zealand and Australia; 4) Central and South America and the Caribbean; 5) China; 6) South/Southeast Asia and Eurasia (excluding countries in other groups); 7) India; and 8) Africa and the Middle East.

applications; a lack of collection and recycling infrastructure; and the absence of economic incentives to accelerate solutions. Most managed waste ends up in controlled disposal, via incineration with energy recovery and landfill. Figure 4 summarises the estimates for 2019.

FIGURE 4 **End-of-life fate of plastic waste in 2019 by sector**

Out of the 385m Mt of plastic waste generated, less than 10% was recycled and 28% was mismanaged.

Mt/year. All numbers are subject to rounding.



The main sources of mismanaged plastic are packaging and consumer goods, microplastics and fishing gear. Most open burning is estimated to come from plastic waste from packaging and consumer goods. Of the estimated 28 Mt of plastic released into land and water environments in 2019, packaging and consumer products accounted for 17 Mt, microplastics for 8-9 Mt and fishing and aquaculture plastics for 1-2 Mt. Other critical sources include textiles and agricultural applications, although the available data is generally limited.[24]

All these volumes would increase substantially if the current trajectory continues. The analysis suggests that the annual production of plastics would increase from ~460 Mt in 2019 (430 Mt estimated to be virgin and 29 Mt recycled) to 764 Mt by 2040 (712 Mt virgin and 52 Mt recycled). Annual volumes of plastic waste would increase from 385 Mt in 2019 to 646 Mt by 2040 and annual volumes of mismanaged plastic would almost double, from 110 Mt in 2019 to 205 Mt by 2040. Annual GHG emissions from the plastic system would rise from 1.9 $GtCO_2e$ in 2019 to 3.1 $GtCO_2e$ in 2040.

The Business-as-Usual Scenario considers forecasts on demographics and economic growth (and hence consumption per capita growth) to estimate future plastic demand by region and sector. Regions such as Europe, the USA, Canada, Japan, the Republic of Korea, New Zealand and Australia have high consumption per capita, but limited forecasted population growth. In regions such as India and African countries, both population and economic development – and thus consumption per capita – are projected to increase. In

China it is expected that the population will remain relatively stable by 2040, but consumption per capita will increase.

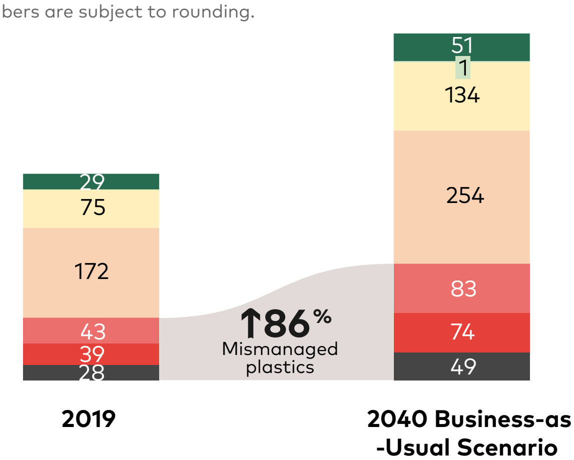
The regions where demographic and relative economic growth is higher, also tend to lack infrastructure and have less resources to manage waste generated today. This would exacerbate the consequences of an already flawed plastic system over time.

The Business-as-Usual Scenario would see annual volumes of plastic waste generation reach 646 Mt by 2040 (see Figure 5). Policies to reduce or eliminate plastics would not be implemented, including no scaling of new delivery models such as reuse. Recycling growth would be limited, increasing from 29 Mt per year in 2019 to 52 Mt per year by 2040, as systems to collect, sort and recycle plastics would not develop significantly. The increase in plastic waste would also lead to higher volumes ending up in incineration (from 75 Mt in 2019 to 134 Mt in 2040) and landfills (from 172 Mt in 2019 to 254 Mt in 2040). Finally, as plastic volumes increase in regions that lack the infrastructure or resources to develop management systems, volumes of mismanaged plastic would rise from 110 Mt in 2019 to 205 Mt in 2040.

FIGURE 5 **End-of-life fate of plastic waste in 2019 and in 2040 under the Business-as-Usual Scenario**

The current trajectory could see annual volumes of mismanaged plastic almost double by 2040 relative to 2019 levels

Mt / year. All numbers are subject to rounding.



	2019	2040 Business-as-Usual Scenario
Total Waste	**385**	**646**
Mismanaged plastics	**110** (28%)	**205** (32%)
Recycling	**29** (<10%)	**52** <10%

Recycled
- Mechanical Recycling
- Chemical Recycling

Disposed
- Incinerated
- Engineered Landfill

Mismanaged
- Dumpsites/unsanitary landfills
- Open burning
- Released into land or water

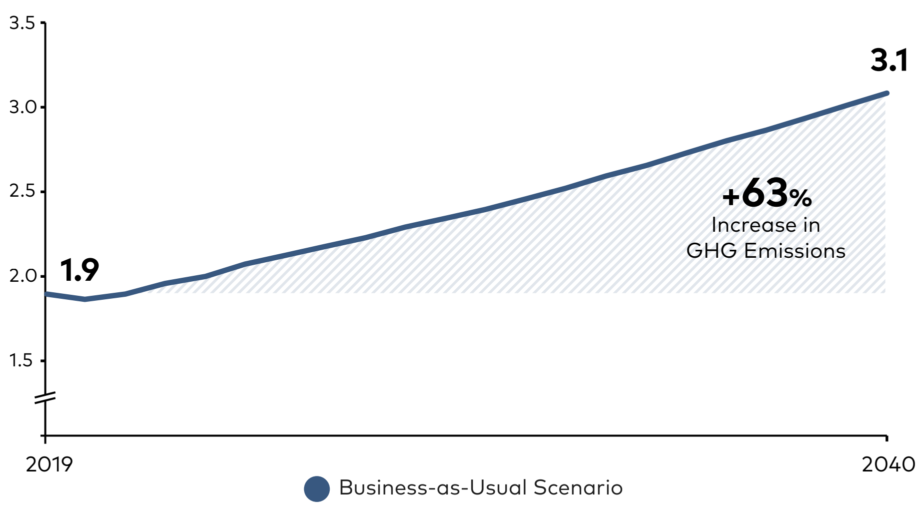
Production and conversion of virgin plastics is the main driver for GHG emissions in the Business-as-Usual Scenario

GHG emissions in the Business-as-Usual Scenario would be mainly driven (more than 80%) by the production and conversion of virgin plastics.[k] GHG emissions across the plastic lifecycle would rise from an estimated 1.9 $GtCO_2e$ per year in 2019 to 3.1 $GtCO_2e$ per year by 2040, due to increased virgin plastics production, incineration and open burning. This would constitute a 63% increase in annual emissions – a trajectory that is incompatible with the Paris Climate Agreement (see Figure 6).

FIGURE 6 **GHG emissions from the plastic system under the Business-as-Usual Scenario**

The current trajectory could lead to a 63% increase in annual emissions from the plastic system

$GtCO_2e$/year. All numbers are subject to rounding



In addition to mismanaged plastic volumes and GHG emissions, hazards to health and biodiversity are a serious concern across the plastic lifecycle. While the health and environmental impacts of plastic have not been quantified in the model underlining this report, and are not the report's main focus, Box 2 below summarises some of the known hazards and risks on human health and on the environment qualitatively, at different stages of the plastic lifecycle.

k This estimate does not account for emissions from the extraction of fossil fuels, which would further increase the weight of production in overall plastic emissions.

Box 2

Health and environmental hazards, risks and impacts of plastics and associated chemicals in the Business-as-Usual Scenario

Overall, more than 13,000 chemicals associated with plastics and plastic production have been identified to date. Of these, 7,000 have been analysed for hazardous properties, with **over 3,200 identified as chemicals of concern**. Hazardous properties in this context include associated effects such as cancer risks, mutagenicity, reproductive toxicity, endocrine disruption and ecotoxicity to aquatic organisms, impacting both human health and biodiversity[25].

Plastic production: Virtually all plastic is made from fossil sources such as crude oil, natural gas and coal. The environmental concerns associated with these industries are thus closely linked to plastic production – for example, negative impacts on workers exposed to hazardous substances; and on biodiversity through contaminated water from fossil fuel extraction and spillage, and through the release of toxins during production. There is also evidence of production plants exposing surrounding communities to hazardous substances and possibly causing adverse health effects.[26]

Plastic Use: Consumers are continuously exposed to plastics and plastic-associated chemicals. For example, of 419 chemicals found in children's plastic toys, 126 were identified as of potential concern; also, over 1,000 chemicals have been found to migrate into food.[27]

Mechanical recycling: Studies underline the need for further research on the possible negative impacts of mechanical recycling on human health and biodiversity, including the risk of reintroducing chemicals of concern as unwanted contaminants during the sorting and recycling process.[28] These studies indicate that informal workers are especially vulnerable to health impacts through unprotected exposure to heated plastics, plastic dust and fine particles, and chemical pollution in the air. Finally, recycling facilities – especially at the washing stage – can end up releasing microplastics into wastewater systems which, without filtration and controlled disposal, could make their way into oceans and waterways.[29]

Chemical recycling:[I] Two main concerns have been raised regarding the potential negative impact of chemical recycling on human health: first, the emissions and discharge from chemical recycling processes contain hazardous chemicals; and second, substances of concern from feedstock waste can be reintroduced into output recyclates. Further research on both issues is needed.[30]

Incineration: Historically, there is evidence that incinerators contribute to environmental impacts due to inadequate emission controls.[31] This can involve the release of pollutants (eg, dioxins, furans, polycyclic aromatic hydrocarbons) linked to a range of adverse health effects. Well-managed incinerators can minimise emissions by controlling combustion temperature, input composition, material flow speeds and gas flow cleaning;[32] but this requires extensive management, which can be problematic in regions with limited resources or regulation.

I In this report, 'chemical recycling' refers to plastic-to-plastic conversion technologies such as pyrolysis, gasification and depolymerisation.

Landfill: Although macroplastics are unlikely to breach landfill liners, microplastics may pass through; and even the most modern sanitary landfills carry the risk of leachate contaminating groundwater. The long-term stability of landfill liners is unknown, but they are unlikely to fully function beyond 100 or 200 years.[33]

Plastic alternatives: Plastic alternatives are not without risk. Therefore, if plastics are to be substituted with other materials, a case-by-case analysis to prevent unintended consequences in each local context would be required.[34] As best practice, product LCAs should be run to measure the overall environmental, health and social impacts. This is also the case for safe **reuse and refill models**, and food-contact materials that may go through multiple use cycles.

Microplastics: Microplastics also present a health risk, and have been detected within human placentas, blood and breast milk.[35, 36] Although the precise impact of this exposure remains unclear, the evidence calls for further examination of the potential threats that microplastics pose to human health. Ingested microplastics have been shown to induce alterations in gene and protein expression, inflammation, disrupted feeding behaviour, growth inhibition, modifications in brain development and impaired filtration and respiration rates. Studies also suggest that nano-plastics[m] may pose even greater hazards than microplastics, due to their higher likelihood of translocating beyond the gastrointestinal tract and acting as transmitters for chemical contaminants.[37, 38]

In addition, extensive accumulation of plastic in the oceans and land poses threats to **biodiversity**. Marine plastic pollution is reported to negatively affect over 800 species.[39] From coral reefs to deep sea trenches and from remote islands to the Poles, plastic alters habitats, harms wildlife and can damage ecosystem functions and services. Macroplastic waste in the environment can lead to fatalities, injuries and indirect harm such as malnutrition through ingestion or entanglement. Microplastics have been forecasted to cause pervasive ecological damage if current or increased levels of plastic waste released into the environment persist.[40]

If plastic pollution continues at current levels and production continues to grow as per the Business-as-Usual Scenario, the negative impacts on health and biodiversity could increase. Given the existing evidence – and the lack of transparency in, and limited regulation of, the plastic industry – policies to address plastic pollution should take into account these risks throughout the plastics value chain.

m Plastic particles which are smaller than microplastics, usually within a size range of 1 nanometre to 1 micrometre.

Global Rules Scenario

A set of far-reaching policies across the plastic lifecycle could reduce annual mismanaged plastics by 90% and annual virgin plastic production by 30% by 2040 relative to 2019 levels – equivalent to a 95% reduction in annual mismanaged plastics and a 60% reduction in annual virgin plastic production relative to the Business-as-Usual Scenario.

The **Global Rules Scenario** seeks to define and estimate the impact of a package of far-reaching policies that, if implemented concurrently across all jurisdictions, could minimise mismanaged plastics and microplastic emissions by 2040, while also mitigating GHG emissions. The Global Rules Scenario is not the only possible package that could achieve a similar outcome. The mechanics of the model estimate the combined effect of 15 policy interventions on plastic stocks and flows across the value chain, as well as on GHG emissions, costs and employment. Importantly, efforts are needed across the plastic lifecycle, with policies mutually reinforcing each other – for example, the redesign of plastics is critical to enable a high-value recycling economy.

The Global Rules Scenario would reduce plastic volumes in the system; eliminate avoidable single-use plastic applications; expand circularity via safe reuse, recycling and durability; and facilitate the controlled disposal of waste that cannot be prevented or recycled.

The package of policies selected draws on submissions from UN member states and other organisations ahead of INC-2, interviews and open consultations. The Global Rules Scenario includes 15 policy interventions to be implemented globally and concurrently, grouped under five pillars (See Figure 7). This report's approach to determining the scale of each pillar is discussed later in the report (see Box 5).

FIGURE 7 **15 policy interventions in the Global Rules Scenario**

PILLAR A

Reduce virgin plastic production and consumption

1
Targets to reduce virgin plastic volumes

calibrated by sector and local context

2
Virgin plastic fees to fund solutions across the plastic lifecycle

with fees ranging from $1000 to $2000/tonne by 2040, calibrated by region

3
Application-specific levers to reduce plastic consumption

in textiles, fisheries and aquaculture, transportation and construction

PILLAR B

Eliminate avoidable and problematic plastics and chemicals

4
Bans on avoidable single-use plastics

to incentivise elimination, shift to reuse models and substitution

5
Reuse targets for avoidable single-use plastics

between 15% to 100%, calibrated by application

6
Phaseout criteria for problematic plastics, polymer applications and chemicals of concern

including bans and moving to 'safe lists' progressively

PILLAR C

Expand Safe Circularity via reuse, durability and recycling

7
Design rules for safe reuse, repair, durability and cost-effective recycling

calibrated by application and by local context

8
Targets for collection and recycling rates

including segregated collection for plastics

9
Modulated EPR schemes applied across sectors

with fees of $300 - $1000/tonne calibrated by region and by product

10
Controls for a just transition for the informal sector

enhancing their labour and human rights

PILLAR D

Controlled disposal of waste that cannot be prevented or safely recycled

11
Restrictions on plastic waste trade

to prevent exports to areas with limited capacity

12
Standards on the controlled disposal of waste that cannot be prevented or safely recycled

as last resort option to prevent plastic mismanagement

13
Mitigation and removal programmes for legacy plastics in the environment

although still prioritising solutions that prevent releases in the first place

TRANSVERSAL PILLAR E

Microplastics Prevent the use of microplastics and reduce microplastics releases into the environment

14
Upstream policies to reduce microplastics use and emissions

through bans, substitution, better product designs, preventive maintenance, and behavioural change

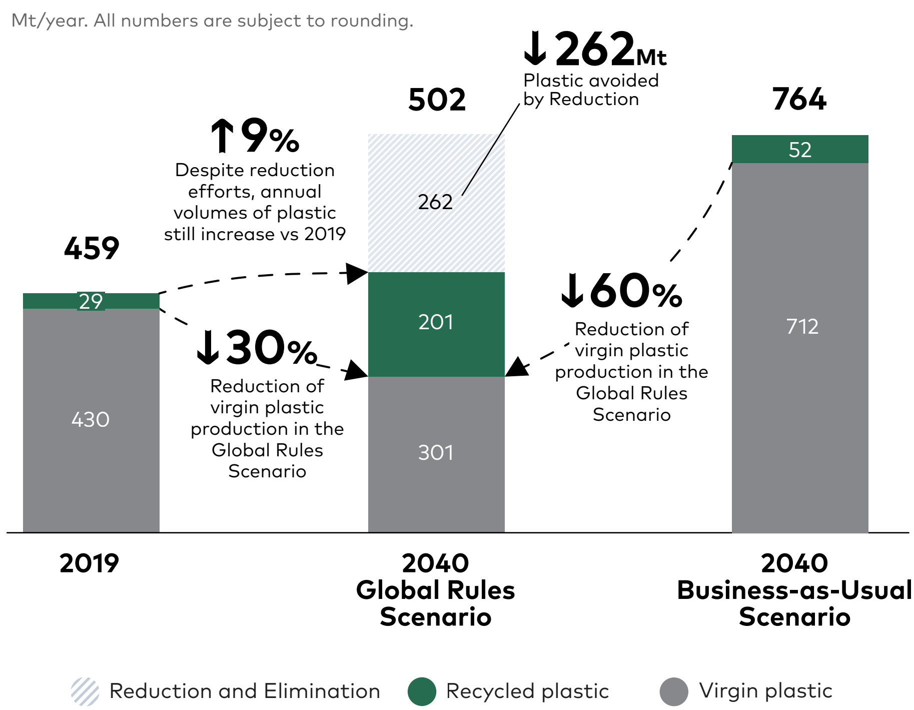
15
Downstream policies to capture microplastics, followed by controlled disposal

prioritising capture at source over capture through wastewater treatment systems

The Global Rules Scenario would result in a 30% reduction in annual virgin plastic production relative to 2019 levels – equivalent to a 60% reduction by 2040 relative to the Business-as-Usual Scenario.

The Global Rules Scenario estimates the impact of all policy interventions in Figure 7 on the annual production of virgin plastics, resulting in the levels of reduction displayed in Figure 8. When looking at total plastic production and consumption (both recycled and virgin plastics), the Global Rules Scenario would result in an increase of 9% in 2040 relative to 2019 levels (with a significant increase in the share of recycled plastics). This is due to the fact that in some regions and sectors, the expected growth in population and consumption would outpace the impact of reduction and elimination policies.

FIGURE 8 **Annual plastic production under the Business-as-Usual and Global Rules Scenarios**
The Global Rules Scenario would result in a 30% reduction in annual virgin plastic production by 2040 relative to 2019 levels.



The Global Rules Scenario would result in a 90% reduction in annual mismanaged plastic volumes relative to 2019 levels – equivalent to a 95% reduction by 2040 relative to the Business-as-Usual Scenario.

The drop in annual mismanaged plastic volumes would be driven by reduced production and consumption and increased circularity (via design, safe reuse and recycling), with scaled controlled disposal where necessary for waste that could not be prevented or safely recycled. In the Global Rules Scenario, the reduction in plastic production and consumption outlined above would prevent 184 Mt of plastic waste annually by 2040. Moreover, as collection and sorting increased, more feedstock would become available for recycling; and scaling capacity would also be incentivised through recycling targets and fees on virgin plastics. Recycling output in the Global Rules Scenario would grow from 29 Mt in 2019 to 201 Mt by 2040 (187 Mt via mechanical recycling and 14 Mt via chemical recycling). Mechanical recycling is prioritised over chemical recycling – the latter would be used only for a few limited types of waste that cannot be processed through mechanical recycling (see Box 4).

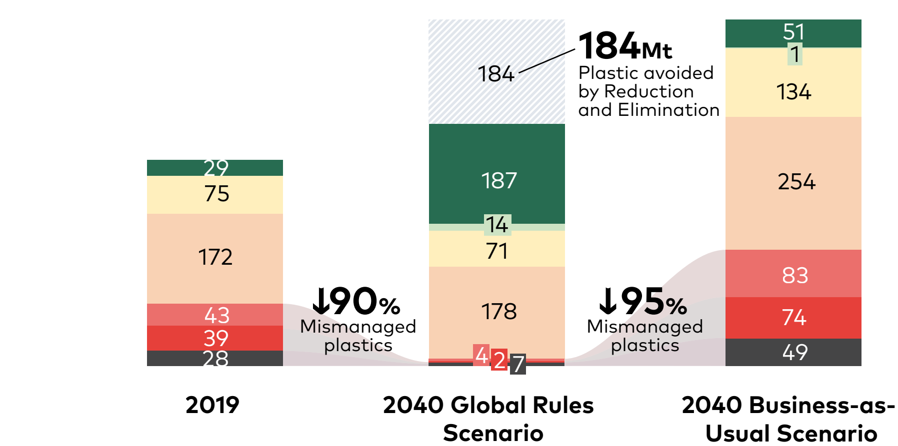
Despite all efforts and policies to reduce waste and increase circularity, the Global Rules Scenario would still result in significant volumes of plastic waste that cannot be either prevented or recycled.[n] Controlled disposal would thus be required for 249 Mt of plastic waste (178 Mt via landfill and 71 Mt via incineration). The overall result would be a total reduction in annual mismanaged plastic volumes of 90% by 2040 relative to 2019 levels and 95% relative to the Business-as-Usual Scenario.

This notwithstanding, 13 Mt of plastic volumes would still end up being mismanaged annually by 2040; an estimated 4 Mt would end up in dumpsites, 2 Mt burned in the open and 7 Mt released into land and water environments. Out of these 7 Mt, microplastics would represent 5 Mt. Figure 9 shows the end-of-life fate of plastic waste by 2040, comparing the Business-as-Usual Scenario and the Global Rules Scenario, as well as relative to 2019 levels.

FIGURE 9 **End of Life fate of plastic waste in 2019 and 2040 in the Business-as-Usual and Global Rules Scenario**

The Global Rules Scenario would result in a 90% reduction in annual mismanaged plastic volumes relative to 2019 levels

Mt/year. All numbers are subject to rounding



	2019	2040 Global Rules Scenario	2040 Business-as-Usual Scenario
Total Waste	**385**	**462**	**646**
Mismanaged plastics	**110** (28%)	**13** (<3%)	**205** (32%)
Recycling	**29** (<10%)	**201** (43%)	**52** (<10%)

Plastics never made: Reduction & Elimination

Recycled: Mechanical Recycling; Chemical Recycling

Disposed: Incinerated; Engineered Landfill

Mismanaged: Dumpsites / unsanitary landfills; Open burning; Released into land or water

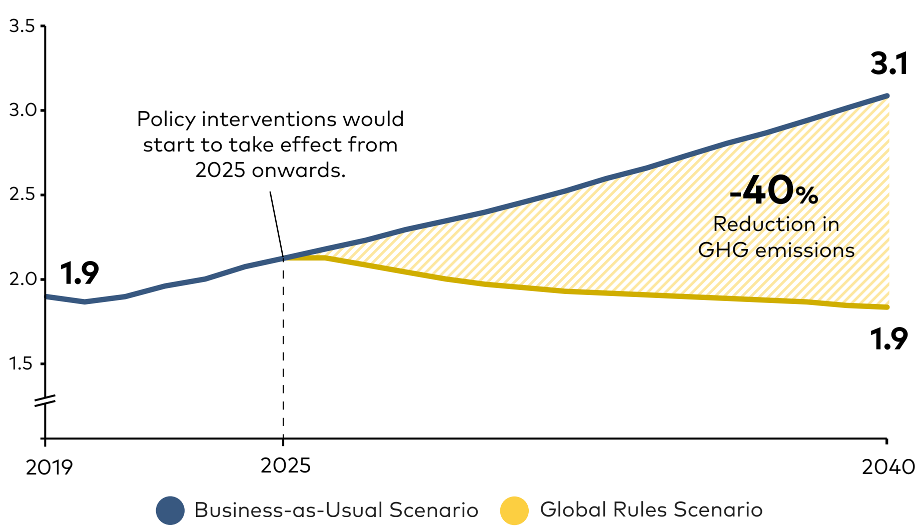
n Due to solutions not scaling in time or being outpaced by population and economic growth; and due to plastic waste from applications with long lifespans that are already in use or designs that hinder recycling.

The Global Rules Scenario would result in estimated GHG emissions of 1.9 $GtCO_2e$ per year by 2040 – an equivalent level to 2019 (1.9 $GtCO_2e$ per year), but representing a reduction in emissions from the global plastic system of 40% relative to 2040 levels in the Business-as-Usual Scenario (3.1 $GtCO_2e$ per year) as shown in Figure 10. This would be driven mainly by a decline in virgin plastic production due to reduction, elimination and recycling. The Global Rules Scenario would thus not be aligned with the Paris Climate Agreement, so further reduction of virgin plastics production and additional decarbonisation levers would be needed beyond the Global Rules Scenario.

FIGURE 10 **GHG emissions from the plastic system in the Business-as-Usual and Global Rules Scenario**

The Global Rules Scenario would result in the same annual GHG emissions by 2040 relative to 2019 levels; however, this would be a 40% reduction relative to the Business-as-Usual Scenario.

$GtCO_2e$/year. All numbers are subject to rounding



The following sections explain the impacts of the policies set out in the Global Rules Scenario, and the key learnings and considerations for their implementation.

PILLAR A

Reduce

virgin plastic production and consumption

Previous studies have highlighted that it is essential to reduce virgin plastic production and consumption in order to solve the problem of mismanaged plastics.[41, 42] Research also indicates that current levels of plastic production and consumption are exceeding the planetary boundaries.[43] Reduction can also be an important lever in addressing climate change, as the fossil fuel industry relies heavily on the petrochemicals used for virgin plastic production as a growth engine.[44]

Reducing virgin plastic volumes is essential to reduce waste management infrastructure and reduce GHG emissions

Recognising that plastics have valuable uses in many sectors, the analytical approach adopted in this report assesses virgin plastic reduction opportunities against key environmental and social constraints. After applying these constraints, the overall reduction in virgin plastic volumes in the Global Rules Scenario would be 30% relative to 2019 levels and 60% by 2040 relative to the Business-as-Usual Scenario, as result from the implementation of all policies listed in Figure 7. To estimate the opportunity for plastic reduction or substitution in specific applications without creating unintended consequences, the report leverages previous analyses on technological, financial and behavioural constraints – for example, in relation to municipal solid waste plastics[45] and durables[46] – as well as expert consultations on fishing gear and aquaculture.

The policy interventions in Pillar A include virgin plastic reduction targets, which would seek to reduce virgin plastic consumption and hence demand for production; virgin plastic fees to further disincentivise the use of plastics; and application-specific policies to reduce consumption, including substitution mandates, policies to reduce fishing gear losses and bans on the disposal of overproduced textile stock, among other things. The Global Rules Scenario assumes the implementation of policies to reduce demand for plastics across all sectors of the economy. The analysis suggests that without a significant reduction in consumption, it is unlikely that the problem of mismanaged plastic volumes could be resolved by 2040.

POLICY INTERVENTION 1

National targets to reduce virgin plastics volumes

calibrated by sector and local context

Virgin plastic reduction targets would send a strong signal to industry regarding the level of change needed. **The reduction in virgin plastic volumes that could be achieved in the Global Rules Scenario would vary significantly by geography.** The largest reductions would be required in regions that are predominantly composed of high-income economies (ie, Europe, the USA and Canada, Japan, the Republic of Korea and Oceania). In these regions, the Global Rules Scenario would result in a reduction in virgin plastic volumes of 51% to 63% relative to 2019 levels – equivalent to a 65% to 73% reduction by 2040 relative to the Business-as-Usual Scenario. These regions already have high consumption and low demographic/economic growth. They also have advanced infrastructure that would allow for greater avoidance of plastics, greater scaling of reuse models (and the reverse logistics involved), and better controls to avoid regrettable substitutions (eg, sustainable sourcing of safe alternative materials).

> **High-income economies, with high levels of consumption, would require a larger reduction in plastic volumes**

The projections differ for other regions, such as China and upper-middle-income countries in Central and South America and the Caribbean. In these regions, economic growth, and therefore consumption per capita, are forecast to increase – especially for applications such as textiles and durables; although demographic growth will be limited. The Global Rules Scenario would result in a reduction in virgin plastic volumes by 2040 in these regions of 36% to 39% relative to 2019 levels – equivalent to a 60% reduction by 2040 relative to the Business-as-Usual Scenario. These regions have important differences when it comes to urban and rural regions, with urban areas having more advanced infrastructure to accommodate reduction levers (eg, reuse models).

Finally, regions such as India, South and Southeast Asia and Africa and the Middle East are forecasted to have high relative economic and consumption per capita growth, starting from low levels today. High demographic growth is also expected. Low and middle-income countries in these regions face greater challenges in scaling reduction levers: for example, the lack of advanced water supply systems in some areas could hinder the scale of safe reuse and refill models; and small single-use sachets cannot easily be banned given the strong reliance on day-to-day purchasing and consumption in low-income households. Given this economic and demographic growth, and the challenges of reducing plastics without creating negative social impacts, these regions would see plastic consumption increase relative to 2019 levels in the Global Rules Scenario. In these regions, the Global Rules Scenario would result in an increase in virgin plastic consumption of 8% to 57% relative to 2019 levels – equivalent to a 38% to 48% reduction by 2040 relative to the Business-as-Usual Scenario.

The reduction in virgin plastic consumption would also vary by sector and application, depending on multiple factors. The model behind this analysis considers the projected growth for a specific sector or application; the available (or potential) alternatives to plastic – whether alternative materials with better environmental performance or other models (eg, safe reuse, repair and the use of recycled content); the capacity to change designs to reduce plastic use; and the requisite product characteristics (eg, barriers, resistance, flexibility).

Governments would set binding targets on virgin plastic reduction as part of their environmental strategies

To implement this policy intervention, national governments would set national targets for virgin plastic reduction as part of their plastic, industrial or environmental strategies. As an example, reduction targets of 15% to 20% by 2040 for plastic waste generation per capita are currently under discussion in the European Union.[47]

The required reduction could be aggregated to a global target, to signal the level of action required and communicate global action under a single objective.

POLICY INTERVENTION 2

Virgin plastic fees to fund solutions across the plastic lifecycle

with fees ranging from $1000 to $2000/tonne by 2040, calibrated by region

A virgin plastic fee would impose a charge on virgin plastics at a specific stage of the plastic lifecycle. In the Global Rules Scenario, this fee would be applied at the national level – most likely to national plastic producers (if the country produces plastic) and importers of products containing virgin plastic. The fee would have two main objectives. First, it would aim to discourage virgin plastic use and promote new business models, the use of substitute materials and/or recycled plastics. Virgin plastic fees represent an opportunity to level the playing field with other materials and models by internalising plastic's economic externalities (ie, environmental and human health impacts). Second, the fee would raise significant funds that could be reinvested in solutions across the plastic lifecycle. This could be accomplished by establishing national or regional funds to collect and invest such resources.

Virgin plastic fees can level the playing field by internalising plastic's economic externalities

In theory, a virgin plastic fee could reduce plastic demand over time; however, the analysis found no publicly available data to provide estimates. Therefore, the model behind this analysis does not assume any impact on plastic demand from the application of a virgin plastic fee, even though this may be the case in reality. However, when applying fees to virgin plastics, the model does assume that recycled plastics will gain market share over time. Empirical evidence indicates that the market share of recycled plastics may grow at the expense of virgin plastics,[48, 49, 50] even when recycled plastics are traded at a premium relative to virgin plastics (eg, some types of recycled plastic in the US have traded at prices that are 10% to 20% higher than those of virgin plastic[51]).

When applying a virgin plastic fee, the main questions to consider include the following:

- **Should the fee apply to virgin plastic only, or also to recycled content?** The Global Rules Scenario would apply the fee to virgin plastic only, rather than all plastic, to increase circularity while also raising funds for solutions across the plastic lifecycle.
- **What part of the value chain should pay the fee?** If the fee were applied only to producers, fewer companies would fall under its scope, thus reducing the complexity of policy implementation. However, implementing the fee further downstream (eg, on converters and/or companies that sell plastic products) would allow for modulation (ie, the imposition of a higher fee for more problematic plastics).
- **What should be the fee level and should it change over time?** Table 1 sets out the fees in the Global Rules Scenario, which are differentiated by region and would increase progressively. The model leverages ranges from the OECD's Global Ambition Scenario in its Global Plastics Outlook: Policy Scenarios to 2060, adapted to a 2040 timeline and with some modifications. The Global Rules Scenario assumes the application of this fee to virgin plastic.

TABLE 1 **Virgin plastic fees under the Global Rules Scenario**

US dollars

Region	Modelled virgin plastic fee	
	By 2030	By 2040
Europe, USA & Canada, Japan, Republic of Korea, Oceania	$**1,000**/tonne	$**2,000**/tonne
China, Central & South America & the Caribbean	$**750**/tonne	$**1,500**/tonne
India, Eurasia, South & Southeast Asia, Africa, Middle East	$**500**/tonne	$**1,000**/tonne

- **What solutions should the funds raised be deployed towards?** In the Global Rules Scenario, it is assumed that the funds would be invested nationally across the value chain, including in new business models (eg, reuse), changes in design, infrastructure, sorting and controlled disposal. To simulate this, the model compares the revenues raised against the investment and operational costs of different solutions (eg, the cost of scaling collection systems) to estimate the impact of this policy in each region and the increased capacity of these solutions.

Before implementing these policies, local studies should be conducted to determine the right level of fees to impose. There are concerns that raising the cost of virgin plastic could increase consumer prices. In high-income regions, costs passed on to consumers may not have a major impact. However, in low and middle-income regions, this unintended consequence should be monitored and ideally prevented. For example, a US$1,000 fee per tonne of virgin plastic would translate into an incremental cost of 2.5 cents for a 500-millilitre PET bottle. When applied to the retail price of a top-selling soft drink, this would increase retail prices by 1% in the UK and by 6% in Indonesia.[o]

There are few existing instances of virgin plastic fees, particularly for packaging producers. Examples include Spain's plastic packaging tax, introduced in 2023 and applicable to virgin plastic (€450 per tonne of plastic)[52]; the UK's plastic packaging tax, introduced in 2022 and applicable only to plastic packaging products that contain less than 30% recycled content (£200 per tonne of plastic)[53]; and Ghana's application of a 10% excise tax on imported plastic and plastic products, with revenues partially invested in solutions to manage waste.[54]

o One 500-millilitre PET bottle can include 25 grams (g) of PET plastic. A fee of US$1,000 per tonne applied to 25gr would translate to an incremental cost of 2.5 cents. The average retail price for a top-selling 500ml PET bottle of soft drink in 2022 was US$2 in the UK and US$0.39 in Indonesia.[55]

POLICY INTERVENTION 3

Application-specific levers to reduce plastic consumption

in textiles, fisheries and aquaculture, transportation and construction

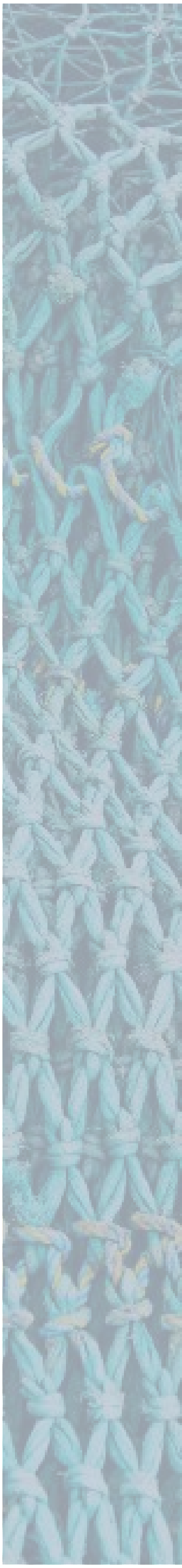
This section focuses on policies to reduce plastic volumes in specific sectors. For each sector, multiple policies are assumed in aggregation, combined with other policies in the Global Rules Scenario such as design rules that would enhance durability. Although there is an overlap with other policies and pillars, these policies are presented separated as they cover sector transformations such as eliminating overstocks in textiles and shared mobility in transportation.

Policy interventions could be applied to specific applications in order to reduce plastic use (and hence production), resulting in plastic being eliminated, reduced or replaced by other materials. When introducing policies that could trigger the replacement of plastic with other materials, a comprehensive case-by-case analysis should be conducted that considers the local context, supply chains, viable substitutes and climate impacts, to avoid unintended consequences. To this end, best practice is to conduct product LCAs, to demonstrate that the alternatives will improve overall environmental, health and social impacts. Alternative materials should ensure product safety as well as better collection and recycling rates, responsible sourcing, responsible waste management, no deforestation etc.

Textiles

The textiles industry faces specific issues when it comes to plastic use. For instance overproduction and overstock constitute a chronic problem in the industry. There is limited data available about the scale of overproduction, however one study estimated it to account for as much as 30% of the total volume of production.[56] Most overproduced stock is ultimately disposed of in landfills or incinerated. Overproduction is driven by the declining lifespan of clothing, which decreased by 36% between 2000 and 2015,[57] connected to fast-fashion consumer trends and a fall in product quality.[58] Of these discarded items, the volume sent to secondary markets is uncertain, as data availability is limited. However, it is estimated that 40% of used apparel exported to secondary markets is discarded, deemed unusable due to poor quality and sent to dumpsites or landfills.[59]

The Global Rules Scenario would include **bans on the disposal of unsold items – from both overstock and returns** – following the example of the EU Strategy for Sustainable and Circular Textiles.[60] Prohibiting the disposal of overstock and returned items could reduce production via improved demand forecasting systems and secondary and reuse markets. This would be in addition to expanded lifespans from better designs (Policy Intervention #7). Given the estimated overproduction in the textiles industry, the **Global Rules Scenario assumes that these policies would reduce annual plastic production by 30% by 2040 relative to the Business-as-Usual Scenario.** Brands and manufacturers would be held accountable for adherence to these bans, in order to improve demand planning, disincentivise fast fashion and promote reuse and secondary markets. One potential example is the EU's ReSet the Trend campaign, which promotes better designs through initiatives such as minimum quality standards to extend product life, facilitate reuse and minimise material usage.[61]



Any loss of fishing gear generally translates in a direct release of plastic into the ocean, in addition to creating new demand to replace the lost gear. By preventing abandoned, lost and otherwise discarded fishing gear (ALDFG), production would decrease and negative impacts on wildlife and the environment would be reduced.

Intentional gear abandonment presents persistent challenges, particularly in lower and middle-income regions. Losses from intentional gear abandonment vary depending on the type of gear used, the attitude of the fishers and their willingness to recover lost gear. Gillnets, traps and pots are some of the most common types of ALDFG that contribute significantly to plastic releases into the ocean.[62] Beyond awareness campaigns to make fishers aware of the impacts of ALDFG, one effective policy to disincentivise fishers from abandoning gear overboard could be gear marking and tracking. The Food and Agriculture Organization (FAO) has developed Voluntary Guidelines on the Marking of Fishing Gear, which could potentially become mandatory in all regions. Gear marking and tracking applied in all countries at the point of sale could be linked to fishing licences and vessels, to facilitate inventory control, reporting of fishing gear losses, gear recovery and the traceability of materials for recycling.[63] This policy should be complemented by the introduction of appropriate mandatory gear storage facilities into new fishing vessels, so that fishers would no longer face space or weight constraints that can lead to the disposal of gear at sea.

Additional efforts to combat the intentional discharge of rubbish and gear from ships at sea have been made through the International Maritime Organization and its MARPOL Annex V policy. However, the effective implementation of this policy may have been limited. A globally enforced and legally binding policy based on MARPOL and extended to smaller fishing vessels could support the effort to reduce the release of plastic from fishing gear into the environment.

Although some gear loss is inevitable during regular usage, several policies could help to prevent unintentional gear loss, such as reduced gear conflict, improved maintenance and the use of appropriate gear for prevailing weather conditions. One of the most common causes of gear loss – gear conflict and entanglement with other fishing or maritime equipment, or with the seabed (dolly ropes) – could be addressed through spatial and temporal fishing restrictions imposed by policies such as the EU Maritime Spatial Planning Directive and through the use of alternative materials or fishing methods.[64] Mandatory gear tracking and the use of clear visibility tools (eg, flags, lights, buoys) would also be effective at signalling the presence of fishing gear.[65] Good gear maintenance practices and appropriate replacement at recommended intervals (set through lifespan limits) would prevent severe abrasion, which increases the likelihood of breakage. Finally, the gear selected should be appropriate for potential rough seas and extreme weather. Aquaculture – in particular offshore aquaculture – would benefit from the adoption of mandatory gear standards to ensure that gear is adapted to extreme weather.[66]

Fisheries & Aquaculture

To maximise the likelihood of success of these policies, support should be provided to fishers during this transition through awareness campaigns and education programmes on best practices and policies.

By including policies to reduce unintentional gear losses and prevent intentional gear abandonment, the Global Rules Scenario assumes a reduction of 40% in annual plastics demand from fisheries and aquaculture by 2040 relative to the Business-as-Usual Scenario. The analysis also considers ratios of gear losses[67] and how these policies could reduce these (see Technical Annex for details).

Construction

The ODI's *Phasing Out Plastics* report analysed how much plastic could be substituted by changing construction designs by 2050.[68] The report suggested that the large majority of plastics (97%) could be phased out by 2050 through dematerialisation, reuse and material substitution compared with the ODI's business-as-usual scenario. Dematerialisation and reuse reductions would mainly be achieved through an urbanisation policy that would pivot away from large, single-occupancy buildings that are demolished before the end of their useful life towards compact cities that prioritise renovation and refurbishment. In terms of substitution, the report highlights non-plastic alternatives which are available today, demonstrating that it would be technically possible to significantly reduce demand for plastic materials by 2050. Examples include materials such as wood, steel and aluminium for profiles; different materials for pipes, tubes, gutters and fittings; environmentally friendly options for flooring; and non-plastic materials for insulation.

The ODI's analysis highlights that the improved impacts presented by alternative materials would result from longer product lifespans and lower whole-life costs. These substitutions would have to be assessed on a case-by-case basis to avoid unintended consequences or regrettable substitutions. Best practice would be to conduct product LCAs to demonstrate that the alternatives would improve overall environmental, health and social impacts.

The Global Rules Scenario considers a partial realization of these estimates by 2040, assuming a **40% reduction in annual plastic demand from the construction sector relative to the Business-as-Usual Scenario.** To encourage renovation and refurbishment, governments and municipalities could implement urban planning practices that promote compact cities which reduce demand for plastic materials per building unit. Governments could also restrict developers' choice of building materials. The ODI report **Phasing Out Plastics** suggests that sustainability certification schemes and public procurement policies could pave the way towards the implementation of these changes.

Transportation

The ODI's *Phasing Out Plastics* report also analysed how much plastic could be substituted by changing the design of automotive products by 2050.[69] The report suggests that 17% of plastics could be phased out by 2050, primarily through dematerialisation, with a smaller reduction contribution coming from reuse and material substitution, compared with the ODI's business-as-usual scenario.

By incentivising the adoption of ridesharing, car-sharing, mobility-as-a-service and managed fleets of shared vehicles, governments could encourage increased vehicle utilisation, occupancy and lifespan, and thus a reduction in total cars sold by 2040 compared with the ODI's business-as-usual scenario, resulting in lower demand for plastics. The Global Rules Scenario considers a partial realization of these estimates by 2040, **assuming a 10% reduction in annual plastic demand from the transportation sector relative to the Business-as-Usual Scenario.** The substitution of plastics in the transportation sector is not considered, as plastics may be needed for light-weighting and innovative vehicle design.

PILLAR B

Eliminate

avoidable and problematic plastics and chemicals

While Pillar A focused on reducing plastic consumption, particularly of virgin plastic, Pillar B focuses on eliminating avoidable or unnecessary plastic, and phasing out problematic plastic products, polymers and chemicals of concern. Defining 'avoidable', 'unnecessary' and 'problematic' is complex, as there are millions of plastic products that trade internationally. For this reason, the first step would be to establish globally accepted criteria for defining these terms. There are already some high-level directions on what these criteria should focus on, with this report considering the criteria displayed in Box 3 below.

Box 3

Defining 'avoidable', 'unnecessary' and 'problematic' plastics

These would include plastic or plastic products that meet any of these points:

- They contain hazardous chemicals or create hazardous conditions that pose a risk to human health or the environment (applying the precautionary principle) during their production, use or waste management.
- Their use can be avoided (or replaced by a reuse model or materials with better sustainability performance) while maintaining utility, with a focus on single-use applications.
- They are not reusable or recyclable.
- They hinder or disrupt the circularity of other items.
- They have a high likelihood of ending up as litter or in the natural environment.

Alternative materials to replace plastic should be assessed towards equivalent criteria.
(Adapted from the Ellen MacArthur Foundation's Global Commitment Criteria.[70])

Global harmonisation of the criteria would be required, to make it effective in international markets. However, important regional and national differences must be taken into consideration when applying these criteria. In particular, it is important to differentiate by application, to ensure that any prohibition of a substance or format does not have unintended consequences from a social and environmental perspective. Criteria would therefore require scientific input and expertise from different local contexts. Based on the criteria, the focus would then be on elimination through bans and the gradual phaseout of problematic plastic products, polymer applications and chemicals of concern.

Pillar B addresses this through bans and reuse targets on avoidable single-use plastic, and through a phaseout criteria for problematic plastic products, polymer applications and chemicals of concern.

POLICY INTERVENTION 4

Bans on avoidable single-use plastics

to incentivise elimination, shift to reuse models and substitution

Avoidable or unnecessary plastics include 'products that can currently be reduced or substituted with non-plastic fit-for-purpose substitutes and/or can be eliminated entirely without compromising the consumer's access to the product, inability to meet health or safety regulations, or causing undesirable environmental outcomes'[71]. **The Global Rules Scenario assumes a series of bans on single-use plastic applications** which would result in the complete elimination of certain plastics; a shift to multi-serve, reuse or refill safe alternatives; or substitution with other materials with superior environmental performance. These bans would also trigger changes in product design and the exploration of new product concepts that offer the same functionality with better impacts. The Global Rules Scenario also assumes bans on intentionally added microplastics (see Policy Interventions #14 and #15). **The Global Rules Scenario does not consider** substitution of current plastics with bio-based plastics, biodegradable plastics, or compostable plastics (except for some specific applications in agriculture). Uncertainty remains as to the role of these solutions in the future and caution is required based on the available evidence.[72]

> **Bans on single-use plastic applications would result in the elimination of plastics, a shift to reuse models, or substitution with less impactful materials**

In the Global Rules Scenario, a specific list of plastic applications is assumed to be in scope for these bans. As a starting point, the analysis includes bans on single-use plastic applications under the EU Single Use Plastic Directive,[73] both enacted and under discussion. These include plastic applications such as bags, straws, cutlery, takeaway containers and microbeads. The Global Rules Scenario also includes additional bans on applications not presently covered by the EU regulations, where alternatives could be developed by 2040. To select appropriate applications, the Global Rules Scenario builds on past analysis of technological, financial, performance and behavioural constraints.[74] For instance, in the Global Rules Scenario, flexible multi-layer sachets would be gradually phased out, assuming that more sustainable alternatives could be developed (eg, reuse, mono-material films, other materials) which provide equivalent barrier properties with a superior environmental impact.

The Global Rules Scenario assumes the imposition of bans by 2040 on:

- food service disposables and food and beverage takeaway single-use plastic applications (eg, straws, stirrers; on-premises food service disposables; off-premises plastic cups, lids, containers, clamshells and cutlery);
- plastic pots, tubs and trays for fruit and vegetables (not applied to dairy, meat or ready meals);
- single-use plastic bags
- logistics and business-to-business single-use plastic applications (eg, films to wrap pallets and single-use crates for beverages); and
- multi-material/multi-layer sachets, should better choices become available (eg, mono-materials, other materials).

To estimate the potential reduction in plastic consumption that would result from these bans, the analysis assumes global implementation by 2040 and compares the relative volume impacted versus the total consumption of plastic in a household, differentiated by region. The impact of these bans is estimated together with that of reuse targets (see Policy Intervention #5) that may affect the same products (see Figure 11). For those volumes impacted, the analysis assumes the most likely outcome of the ban – elimination, a shift to safe reuse models or replacement with other materials – based on past analysis.[75] Please refer to the Technical Annex for further details.

Before imposing bans on single-use plastic applications, it would be necessary to conduct a comprehensive case-by-case analysis that considered the local context, supply chains, viable substitutes and climate impacts, to avoid unintended consequences or regrettable substitutions. For example, miscalculations on which single-use packaging applications should be banned could end up increasing food waste. Also, banning small single-serve sachets in applications without alternatives could negatively impact on the livelihoods of those reliant on day-to-day consumption due to low purchasing power. To conduct such analysis – particularly in the case of bans that may result in replacement with other materials – best practice would be to undertake **product LCAs**, to demonstrate that the alternatives would improve overall environmental, health and social impacts. Safe alternative materials should ensure better performance over the entire lifecycle of the material, including collection and recycling rates, positive social impacts (eg, responsible sourcing of raw materials, responsible waste management practices) and positive environmental impacts (eg, no deforestation).

When imposing bans on avoidable single-use plastic applications, governments should consider the timeframes needed for industry adaptation. Bans should be reviewed over time to ensure that the applicable regulations reflect advances in product design, recycling technologies and waste management infrastructure.

There are already examples of bans on certain single-use plastic applications around the world.[76] For example, Rwanda banned plastic bags in 2008; Zimbabwe banned the use of polystyrene food containers in 2017; a number of Caribbean countries have effectively banned or announced bans on bags and products made of Styrofoam; and India has banned plastic plates, cups, cutlery, straws, trays, and certain wrapping films. The EU has also banned various single-use products, including cutlery and straws; while the UK and Canada banned products containing microbeads in 2018.

POLICY INTERVENTION 5

Reuse targets for avoidable single-use plastics

between 15% to 100%, calibrated by application

Reuse models are new delivery models that replace avoidable single-use plastic with alternatives that can be used across multiple rotation cycles. They encompass diverse solutions[77] such as refillable containers (where the refill product is purchased in store or delivered); refill on the go (eg, reusable bottles for water dispensers); return at home (where the product is delivered at home while returning empty packaging); and return on the go (where the empty packaging is returned in store). Some of these models need reverse logistics or new designs to be developed by fast-moving consumer goods companies or retailers, and could be incentivised and supported by regulation. This section therefore only covers the distinct reuse models for packaging; reuse or repair models in other sectors are covered in the policy interventions relating to plastic reduction and product durability (Policy Interventions #3 and #7 respectively).

Reuse targets, in the context of the Global Rules Scenario, are policies under which final distributors – such as retailers and food service providers – are mandated to cover a percentage of their sales volumes through safe reuse models. The Global Rules Scenario includes reuse targets for beverage containers, food service and business-to-business (eg, logistics) applications; and, in certain regions, incentives for reusable sanitary and female hygiene products. To select the appropriate reuse target levels for each plastic application, the Global Rules Scenario builds on past analysis to accommodate for technological, financial, performance and behavioural constraints.[78] In addition, it leverages current targets under discussion for the proposed EU Packaging and Packaging Waste Regulation[79] and reuse targets that have already been introduced in France.[80] The Global Rules Scenario assumes lower targets for low and middle-income countries to accommodate for specific challenges in scaling safe reuse and refill models, depending on the local context. For example, if the quality of the water supply is poor, solutions that require consumers to carry and refill reusable bottles would not be feasible. While these challenges would not necessarily prevent reuse models from scaling, transitional costs may be higher and adoption slower. Reuse targets for sanitary products in high-income economies are also included in the Global Rules Scenario, assuming that they would be accompanied by incentives for adoption or taxation on single-use alternatives.

> **The scenario includes reuse targets for beverage containers, food service and business-to-business applications**

To encourage the adoption and implementation of new models, **governments** would need to introduce reuse targets for these applications as a set percentage of total sales volumes.

The reuse targets envisaged in the Global Rules Scenario would apply to the following single-use plastic applications:

- **Beverages containers (sodas, water, alcohol):** Safe reuse models would account for 25% of sales volumes in high-income regions and 15% in low and middle-income regions.
- **Household products (eg, cleaning, personal care):** As for beverages.
- **Logistics packaging and business-to-business plastics:** Plastic uses such as films to wrap pallets and single-use crates would shift to 100% reuse designs.
- **Takeaway food and beverage containers:** As these applications also fall within the scope of the single-use plastic bans discussed in Policy Intervention #4, 100% of these designs would either be eliminated or shift to safe reuse models.

Accountability for meeting these reuse targets would be placed on **final distributors**, including retailers and food service providers (eg, hotels, restaurants and caterers).

When implementing these targets, governments should incentivise the development of infrastructure to facilitate the operation of safe reuse systems; regulate reusable packaging designs; and introduce standards to avoid any negative impact on health or the environment, including standards for usage, collection, washing, storage, handling and filling, and elements controlling the operation and performance of the reuse system.[81] **Key drivers for the positive environmental and economic performance of reusable systems, in the context of packaging, include the following:**

- **A sufficient number of rotation cycles and return rates:** To achieve 10 to 15 rotation cycles – the threshold for minimum economic viability – a return rate for reusable packaging of at least 90% is required, to reduce production and conversion costs and prevent GHG emissions. To this end, packaging systems should be designed to maximise consumer understanding and convenience, and should provide incentives to achieve economic savings and enhance environmental benefits.[82] Additionally, reuse packaging systems perform optimally above a minimum viable population density and thus work best in urban areas rather than more dispersed communities. Governments could support this by specifying a minimum number of rotation cycles in the definition of reuse systems.
- **Shared infrastructure to incentivise collaboration across the value chain:** The system infrastructure that would require development relates to drop-off networks, return logistics, washing facilities, redistribution, item tracking, customer refunds and employee training. Increased adoption of safe reuse models is critical to achieve economies of scale for collection points and reverse logistics. This would require industry to collaborate through one or a limited number of reuse networks which would localise sorting and cleaning infrastructure, reduce transport distances and lower logistics costs and emissions. Governments could support this by investing in or incentivising the development of this infrastructure, including all

infrastructure assets described above. Channelling EPR fees to fund this infrastructure would be one possibility.

- **Optimised and standardised reusable packaging designs:** Analysis shows that packaging design which is optimised for safe reuse systems can reduce cost per unit through highly standardised collection, sorting, washing, storage and filling systems. Interoperability can be enhanced by standardised 'universal' designs that facilitate the acceptance of packaging across different reuse schemes. Design can also positively impact on transportation costs and emissions rates, which depend on the density of filling, sorting and cleaning infrastructure and the specialisation of filling lines. If implemented effectively, standardised designs could also enable smaller players to access economically competitive reuse logistics. Governments could support this by requiring and encouraging the adoption of these common standards, and by incentivising durable products and 'universal' designs.

Reuse models can replace avoidable single-use plastics in favour of alternatives used over multiple cycles.

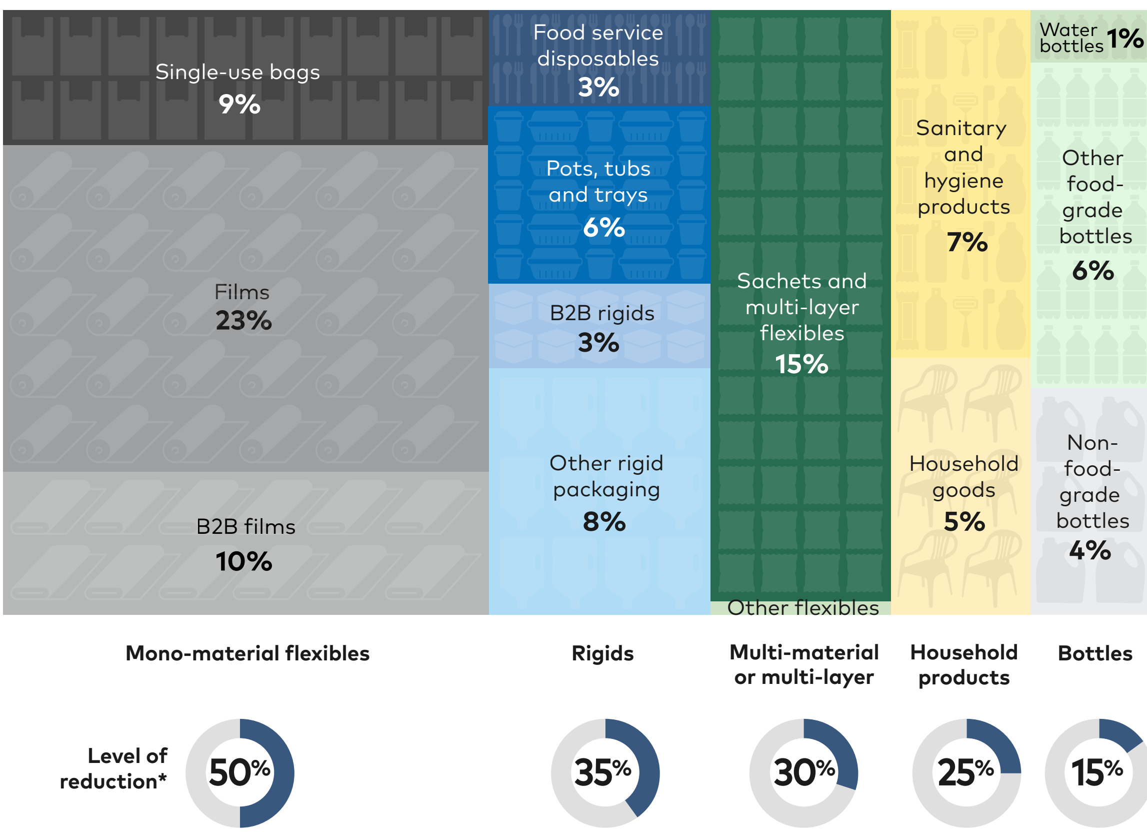
Existing examples of reuse targets could help to shape the implementation of this policy in other regions. For example, the **EU Packaging and Packaging Waste Directive** (94/62/EC) lays down plans to prevent the production of packaging waste and promote the reuse of packaging. The 2023 draft revision proposes concrete reuse targets for certain packaging applications, including cold and hot beverages (80% by 2040), takeaway and ready-prepared food (40% by 2040) and logistics (90% by 2030).[83] Other examples of mandatory reuse include the **German** reuse mandate for packaging, which requires final distributors that meet certain thresholds (in terms of size and number of employees) to offer and visibly advertise reuse packaging options at cost parity to single-use alternatives. It also requires these organisations to take back at least their own containers.[84] **France** has linked EPR to its reuse mandate by requiring that a minimum share of EPR funds be allocated to achieving the targets of 5% reused packaging by 2023 and 10% by 2027.[85, 86] Early examples are also emerging outside of Europe and are expected to accelerate in the near future.

Please note the list of single-use applications assumed to be impacted by bans and reuse targets was compiled only for the purpose of modelling the Global Rules Scenario. When deciding on which bans or reuse targets to apply, specific analysis for each local context would be required, as stated elsewhere in this report. Figure 11 presents an example of the estimated plastic consumption in packaging and consumer goods in an average household (the analysis is differentiated by region). In the model, the impact of bans and reuse targets from Policy Interventions #4 and #5 is estimated in aggregate, since bans and reuse targets overlap in scope. Further details on this estimate can be found in the Technical Annex.

FIGURE 11 **Household plastic consumption composition and reduction by 2040 in the Global Rules Scenario vs the Business-as-Usual Scenario**

Reuse targets and bans should be applied to avoidable single-use plastics, in addition to other policies to reduce plastic production and consumption.

Modelled estimates of the average format composition of household plastic consumption. All numbers are subject to rounding.



*Global Rules Scenario relative to Business-as-Usual Scenario by 2040.

B2B plastics: Plastics in logistics and single-use applications (eg, films to wrap pallets, single-use crates for beverages).

POLICY INTERVENTION 6

Phaseout criteria for problematic plastics, polymer applications and chemicals of concern

including bans and moving to 'safe lists' progressively

Global common criteria and the phaseout of problematic plastic products, polymer applications and chemicals of concern have not been quantified; instead, they are addressed qualitatively (see 'Objective and scope').

This policy intervention would aim to eliminate plastics that are considered problematic. As mentioned in Box 3, problematic plastics include those that contain hazardous chemicals, create hazardous conditions that pose a significant risk to human health or the environment, and/or hinder reusability or recyclability. Studies and publications have developed insights on potential criteria to assess problematic plastics.[p] These reports call for criteria to define and assess problematic substances based on their toxicity, stability, integrity and circularity potential; the application of the precautionary principle; and the assessment of substances in groups rather than individually, where possible. Available data and testing would need to be enhanced – out of 13,000 chemicals identified in plastics, 6,000 have not been risk assessed. Regulation is also lacking: of the remaining 7,000 chemicals that have been assessed, 3,200 chemicals have been categorised as chemicals of concern, but only 4% of those are covered by multilateral environmental agreements.[87]

> **Phasing out problematic plastics and chemicals would reduce health and environmental risks**

Plastics Pact initiatives have created lists of problematic plastics that should be banned in different local contexts, with a focus on packaging applications.[88,89] The Global Rules Scenario assumes bans on these items, including problematic labels, adhesives and inks (eg, carbon black or pigmented PET bottles); as well as polystyrene, PVC for packaging applications, PETG, PLA, intentionally added per- and polyfluoroalkyl substances and oxo-degradable additives. The individual impact of phasing out each of these substances has not been modelled; instead, the Global Rules Scenario assumes overall improvements in sorting and recycling yields over time from a blanket ban on these items. A phaseout could include groups of chemicals where the scientific consensus is high; existing studies suggest that this could apply to bisphenols, (brominated) flame retardants, phthalates,[90,91] chlorinated paraffins, polyaromatic hydrocarbons, alkylphenols and stabilisers.[92]

Moving forward, **these lists should be expanded to cover other applications, informed by guidance and research from the scientific community.** However, it is possible that the molecular structure of banned substances could be changed in order to circumvent a ban. Therefore, **establishing criteria for categorising certain categories and groupings of polymer applications and chemicals of concern as 'safe'** could be the optimal approach in the long term.[q] Commonly accepted testing protocols,[r] **improved data availability, transparency and resources for testing could be needed to resolve this issue.**

p The Global Governance of Plastics and Associated Chemicals;[93] Troubling Toxics.[94]
q In this report, 'safe' would mean no risks to health and biodiversity, and no hindering of circularity.
r As an example, the Tiered Protocol for Endocrine Disruption provides a method to identify endocrine-disrupting chemicals.[95]

PILLAR C

Expand Safe Circularity

Expansion of safe circularity via reuse, durability and recycling

After reducing the volume of plastics in the system, with a focus on virgin plastics (Pillar A), and eliminating avoidable and problematic plastics (Pillar B), the Global Rules Scenario prioritises the expansion of circularity in those plastics that remain. Circularity is essential in preventing the release of plastics into the environment, replacing linear disposal models (Pillar D) and reducing demand for virgin plastic through safe reuse and recycling. To this end, the Global Rules Scenario estimates the impact of improved product design on reusability, recyclability and product lifespans; sets formal waste collection targets for local authorities; designates revenues raised from EPR fees for investment in infrastructure; and controls for a just transition for vulnerable communities that could be affected.

> **The elimination of problematic plastics and better product designs would enable higher reuse and recycling rates**

The Global Rules Scenario assumes important changes in product design, resulting, for example, in the phaseout of a large proportion of multi-layered/multi-material flexible packaging; a shift from flexible to rigid packaging; and the expansion of the lifespans of certain types of plastic fishing gear by 2040. The Global Rules Scenario would also result in the scaling of waste collection rates to above 95% by 2040 across all regions for municipal solid waste, as well as waste streams from construction, fishing and aquaculture, transportation and agriculture. Recycling rates would increase to between 15% and 67% for specific plastic applications such as packaging and consumer goods, transportation, fishing and aquaculture, and agriculture. EPR fees of between US$300 per tonne and US$1,000 per tonne, depending on the product and region, would raise revenues to support the development of the solutions described in Policy Interventions #7 and #8. As these policies – especially EPR, deposit return schemes and formalised waste management systems – could disrupt the livelihoods of waste pickers and other informal workers, the Global Rules Scenario would require controls and financing to ensure a just transition.

The expansion of collection infrastructure would mainly be needed in low and middle-income countries, as in high-income regions rates have already reached over 95%. In the Global Rules Scenario, improved recycling capacity would yield 201 Mt globally by 2040, compared to 29 Mt in 2019 – a sevenfold increase. **The Global Rules Scenario would result in collection rates above 95% in all regions and a global recycling rate of 43% by 2040,** compared to a global recycling rate of below 10% in 2019.

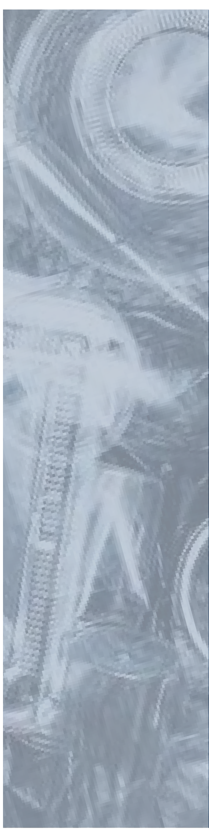
POLICY INTERVENTION 7

Design rules for safe reuse, repair, durability and cost-effective recycling

calibrated by application and by local context

The Global Rules Scenario would mandate a shift from multi-material packaging to mono-material packaging; impose bans on materials and additives that impede safe recycling; and introduce sector-specific design requirements. These design rules would ensure that plastic products in all sectors of the economy are designed to reduce volumes, to promote safe reuse and to allow for cost effective recycling in local contexts. Achieving high rates of circularity would require global rules on design standards, to facilitate industry adoption and enable governments to develop the right infrastructure.

When setting rules on the replacement of plastics with alternative materials, it would be necessary to run a case-by-case analysis that takes into account the local context to avoid unintended consequences or regrettable substitutions – for example, via product LCAs. These assessments should demonstrate that the alternatives would enhance overall environmental, health and social impacts.

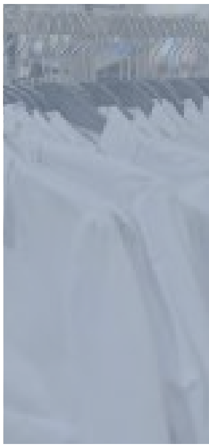


Packaging & Consumer Goods

The Global Rules Scenario assumes that design rules would be introduced across all regions, differentiated by local contexts that reflect differences in systems and infrastructure, with the aim of increasing recycling rates and shifting away from multi-material and multi-layer designs. Initiatives such as the Golden Design Rules,[96] propose common rules to increase the recyclability and value of used materials by eliminating excess, unnecessary and/or non-recyclable polymers, additives, dyes and other materials; and by imposing minimum requirements on purity.

Central governments would establish appropriate labelling and claims requirements and definitions to help consumers make the right choices and factor sustainability into their purchases. Regulations would preclude the use of claims that could confuse or potentially mislead consumers, while also specifying how labels could assist consumers in their efforts to sort and recycle plastic products.

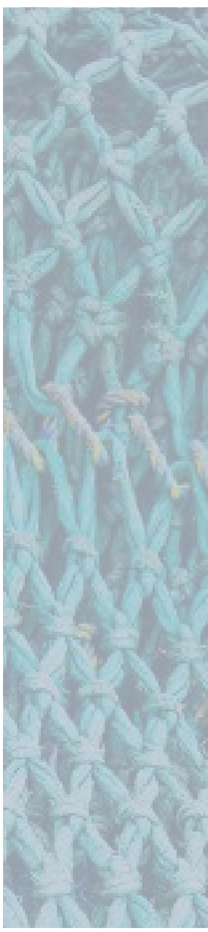
While definitions should be harmonised, labelling should ensure that a product can be appropriately segregated at home or in sorting centres. Indeed, ambiguous definitions (eg, 'compostable', 'biodegradable', 'bio-based') can misleadingly suggest to consumers that a product has certain properties, when in reality these can be realised only under special conditions and/or may interfere with recycling processes.[97]



Textiles

Better designs could not only expand product lifespans and durability, but also improve sorting and recycling yields, since the blending of different plastic fibres (eg, PET with elastane or nylon), and the mixture of plastic fibres with cellulosic fibres such as cotton or protein fibres such as wool, introduce further complexity into separation and recycling processes.

The impact of better textile design, particularly in relation to apparel, is interlinked to Policy Intervention #3, as the Global Rules Scenario assumes that governments would introduce similar rules to those set out in EU guidelines[98] to ensure that textiles last longer and are easier to repair and recycle, as well as requirements on minimum recycled content.



Fisheries & Aquaculture

Fishers would benefit from more durable and high-specification gear designs which – albeit more expensive to purchase – could increase the recycling potential of gear and reduce the economic and environmental impact of shorter lifespans. The average lifespan of fisheries gear could quadruple globally, while the lifespan of aquaculture gear could be at least doubled when compared with the Norwegian average.[s, 99] The Global Rules Scenario assumes a 40% reduction in plastics demand by 2040 relative to the Business-as-Usual scenario, while also enhancing recycling.

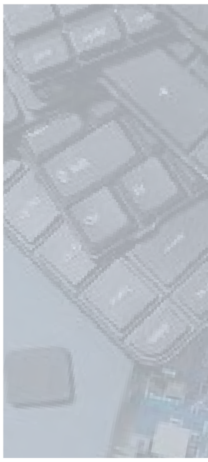
Currently, fishing gear presents recycling challenges due to gear composition, degradation and biofouling. To enhance recycling, clear and harmonised design rules could simplify gear structure and composition. Fishing gear is often comprised of multiple materials – such as plastic mixed with lead or copper, or with other plastics such as PVC, polystyrene or ultra-high molecular weight polyethylene – which makes it difficult to recycle. Fishing gear producers should adhere to clear recycling rules, focused on maximising the creation of mono-material and single-polymer gear, especially using highly recyclable and durable polymers. The design should also be fit for end-of-life disassembly and recycling, which is especially relevant for aquaculture.[100, 101]

By 2024, the European Committee for Standardisation will have developed a circular design standard for fishing and aquaculture gear in the EU (CEN/TC466) that could be used as the basis for a global standard,[102] which would in turn enhance recycling potential.

Electronics

The ODI's *Phasing Out Plastics* **report suggests that 60% of plastics could be reduced by 2050 compared with the ODI's business-as-usual scenario.**[103] This could be achieved by changing designs for modularity and disassembly to facilitate reuse, repair and extend lifespans; and by replacing plastics with other materials – for example, metals, wood and ceramics could replace the use of polypropylene and polyethylene for structural uses and casings, and the use of polyurethane and polystyrene for insulation. The Global Rules Scenario

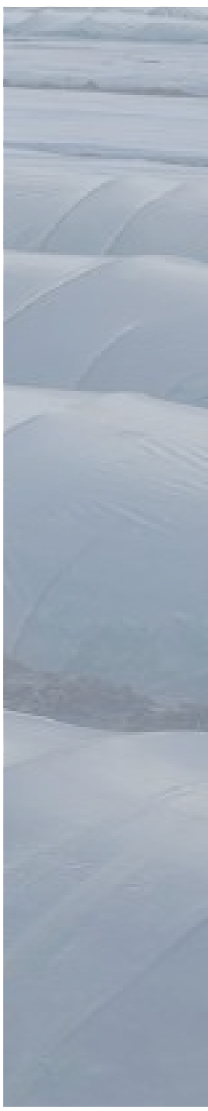
s These numbers diverge considerably between types of fisheries and aquaculture methods and gear types (eg, collar, feeding pipes, nets).



Electronics

considers a partial realisation of these estimates by 2040, **assuming a 40% reduction in annual plastic demand from the construction sector relative to the Business-as-Usual Scenario.**

To reduce plastic consumption in electronics, governments could incentivise or introduce policies such as the Right to Repair;[104, 105] a mandatory repairability index, such as that introduced in France;[106] and a shift towards modular design for remaining plastic applications. Banning the destruction of unsold/returned items[107, 108] would also help to reduce plastic demand. To maximise their effectiveness, these policies could be accompanied by mandates that require manufacturers to provide spare parts and offer battery exchange services[109].



Agriculture

The Global Rules Scenario assumes that design rules would extend the lifespans of certain plastic applications in agriculture, with the aim of reducing demand. Plastics in agriculture pose high potential for dispersion and contamination in soil. Products that present the greatest risks include polymer-coated fertilisers, mulching films, pesticide containers, bale films and nets, and irrigation drip tapes.[110] Agricultural plastics are also often burned in the open, which releases contaminants such as persistent organic pollutants into the atmosphere.[111]

One solution could be to increase the **thickness of mulching films**. Thin films are more prone to tearing and can thus become single use. The Global Rules Scenario assumes that governments will enact standards on agricultural products such as mulching films. In 2017, for example, China introduced standards imposing a minimum thickness for mulching films which could enable reusability and increase lifespans. China is also promoting the management of agricultural plastic film waste to improve soil conservation in its Human Rights Action Plan.[112] Governments could also enact regulations to prohibit the burning of agricultural plastics; mandate collection and recycling; implement EPR schemes; and reduce use overall.

In addition, **natural or biodegradable alternatives to agricultural plastics and standards could be explored for products that are likely to be left in fields,** such as coatings for fertilisers and seeds, or mulching films.[113] Biodegradable plastics should be used only if degradation occurs under the conditions in which these plastics would be used. The EU product standard for biodegradable mulch films (EN 17033) is one example of how to certify performance.[114] Standards on these biodegradable plastics should prevent microplastics releases and the absorption of potentially toxic substances used in farming.[115]

POLICY INTERVENTION 8

Targets for collection and recycling rates

including segregated collection for plastics

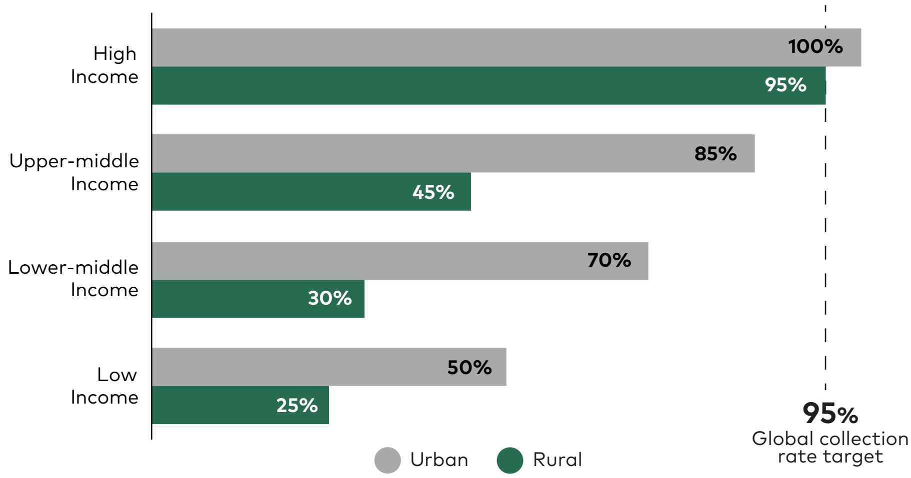
The system should expand waste collection, segregated collection of plastics and recycling infrastructure to reduce mismanagement and increase recycling rates and recycled content in all regions. Most high-income regions (eg, Europe, the USA, Japan) already have waste collection rates above 95% for municipal solid waste.[116] This means that high-income regions can prevent most macroplastic waste mismanagement within their own waste streams. This contrasts with upper-middle income regions and low- and lower-middle income regions, where waste collection rates range from 45% to 85% and from 25% to 70% respectively (see Figure 12). The lower ends of these ranges mostly represent rural areas, where the expansion of waste collection systems is more difficult from an economic and operational perspective. Waste which is not collected is mostly mismanaged and ends up released into land or water environments, or burned in the open.

Other policy interventions would also have a critical impact on waste collection and recycling. Reductions in problematic materials (Policy Intervention #6) and simplified and improved plastic product designs (Policy Intervention #7), in particular, would improve the economics of recycling and therefore incentivise collection and recycling infrastructure. By strictly adhering to design rules for recyclability and coupling them with segregated collection, the economic viability of recycling would be enhanced and the quality of recycled content improved.

FIGURE 12 **Collection rates of municipal solid waste in 2019**

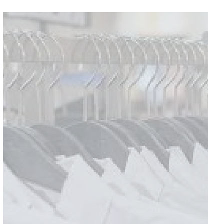
The model leverages estimates of collection rates of municipal solid waste from the World Bank's What a Waste 2.0.

All numbers are subject to rounding.



The Global Rules Scenario would result in waste collection rates of more than 95% across all regions for all sectors considered. Currently, these collection levels are achieved only in high-income countries which have the resources to develop the necessary infrastructure. In low and middle-income countries, **this represents a substantial challenge, as they lack the resources and innovation needed to reach these levels.** Targets adopted by all regions would send an important signal to mobilise central governments, municipalities and the private sector. To support the expansion of efficient collection and sorting systems, modulated EPR fees and revenues from virgin plastic fees would be deployed simultaneously to cover the cost of collection and sorting and the necessary infrastructure investment across different geographies.

In addition to expanding waste collection, the segregated collection of plastics (sometimes referred to as 'collection for recycling') **would be critical in facilitating recycling.** This would include models for segregating waste at home, segregated kerbside collection and deposit return schemes. The main objective of these schemes is to collect plastics separated from other waste, to prevent contamination and increase feedstock quality for recycling. For example, the EU has already set targets for mandatory segregated collection for most plastic products, including 90% for plastic beverage bottles by 2029.[117] For all plastic waste that is not collected through segregation, mixed waste sorting technologies could represent an opportunity to further increase volumes collected for recycling, however its financial feasibility would need to be assessed in each local context.[118] In certain sectors, specific collection channels may be required, as follows.

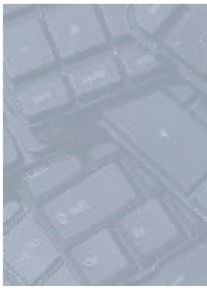


Textiles

Textiles collection has been proven to work in various formats, such as kerbside collection, in-store collection and drop-off textile containers located across cities. Germany and Switzerland have achieved high collection rates of up to 65%, mostly through textile containers.[119] Studies also estimate significant volumes collected through the informal sector in India.[120]

Fisheries & Aquaculture

In addition to disincentivising the abandonment of fishing gear, a **global gear passport with mandatory gear marking could incentivise collection and support sorting.** Gear marking and tracking applied in all countries at the point of sale could be linked to a fishing licence system for owners and vessels to facilitate inventory control, reporting of fishing gear losses, gear recovery and the traceability of materials composition for recycling.[121] In addition to the FAO Voluntary Guidelines on the Marking of Fishing Gear, the EU has developed advanced regulations on gear marking.[122] To facilitate smooth collection, **ports should also have available, accessible and affordable collection points** based on the size and number of vessels that they serve. Gear collection could further be supported by a mandatory EPR system.[123]

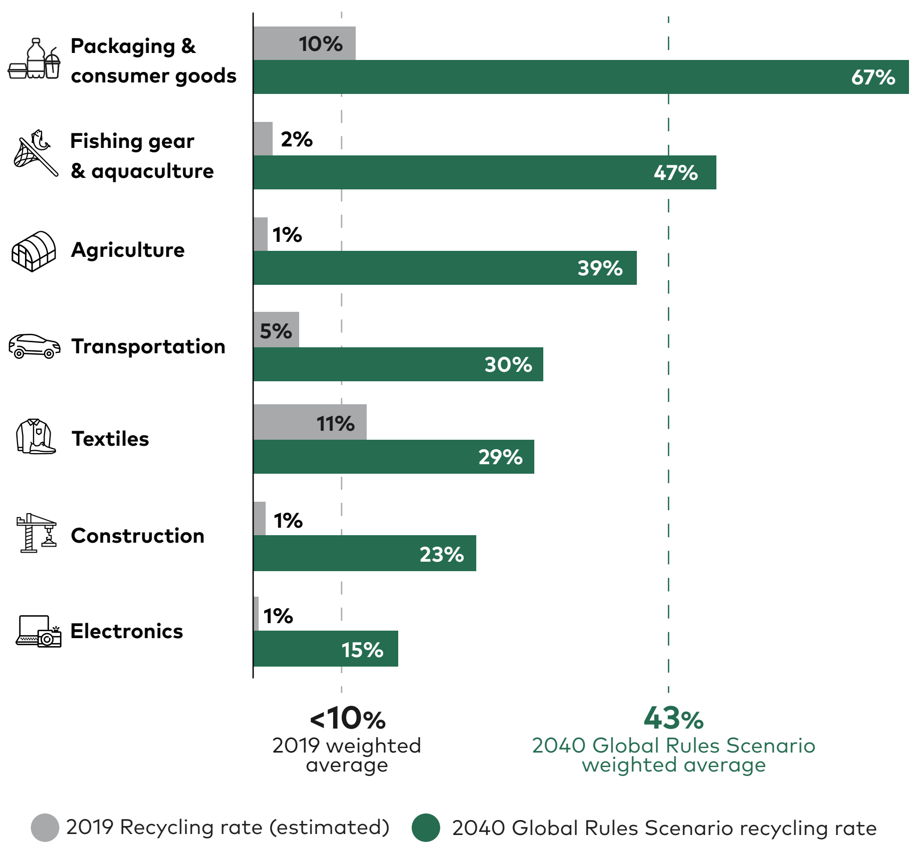


Electronics

Electronics are attractive for collection, as they contain valuable metals; this can be done through central municipal waste collection points or retail outlets. Electronics are mostly collected only for the valuable metals they contain; the plastics that they incorporate are often discarded or burned. Many countries, including Nigeria and South Africa, are starting to implement policies to support the management of e-waste.[124, 125]

FIGURE 13 **Plastic recycling rates by sector in 2019 and under the Global Rules Scenario in 2040**

The Global Rules Scenario would require a substantial increase in the recycling rates of all plastic applications.



In the Global Rules Scenario, mechanical recycling would be prioritised over chemical recycling. Of the total recycling output in 2040 under this scenario, >90% would be mechanical recycling. The rest would be chemical recycling for certain types of plastic waste that mechanical recycling cannot process. All numbers are subject to rounding.

The Global Rules Scenario would result in a global plastic recycling rate of 43% by 2040, compared to a rate of under 10% in 2019. This rate would vary by sector (see Figure 13 above) due to multiple factors, including the resins used, product design and the levels of contaminants and additives in products. Policy interventions such as bans on problematic additives and pigments, rules on improved design, segregated collection schemes and deposit return schemes would be critical to increase safe recycling, and especially closed-loop recycling. The EU has set a plastic packaging recycling target of 55% by 2030 in its Packaging and Packaging Waste Directive; while the Global Rules

Scenario would result in a 67% plastic packaging recycling rate by 2040 globally. **The Global Rules Scenario would expand mechanical recycling infrastructure to reach 187 Mt of output globally, compared with 29 Mt in 2019 – a roughly sevenfold increase.**

Targets for increasing collection and sorting aim to provide feedstock towards recycling

The Global Rules Scenario focuses on mechanical recycling over chemical recycling, as mechanical recycling results in lower GHG emissions and better cost performance than chemical recycling.[126] In the Global Rules Scenario, mechanical recycling would account for 93% of recycled volumes by 2040, with the rest accounted for by chemical recycling. In terms of mechanical recycling, closed loops are considered preferable to open loops,[t] to facilitate the creation of high-quality recycled content. This is particularly important for applications such as bottles, as bottle-to-bottle closed loops can generate food-grade recycled content – especially as regulators are increasingly allowing recycled plastics to be classified as food grade, as long as the safety and quality requirements are met.[127] In the Global Rules Scenario, mechanical recycling within the same sector would be prioritised to facilitate the development of closed-loop recycling. In the Global Rules Scenario, the large majority of the close-loop recycling is from bottles and rigid packaging, followed by plastics from durables and aquaculture. For other applications, the creation of closed loops can be more challenging – for example, in textiles, where recycled content mostly originates from recycled PET bottles.[128] Similarly, the Global Rules Scenario does not consider closed-loop mechanical recycling of fishing nets, due to degradation and contamination; but these could be used in the textiles industry.

Collection and recycling targets could increase the supply of recycled plastics, while minimum recycled content targets would motivate demand from industry, simultaneously incentivising supply and demand to create a market for recycled plastics. For example, the Global Rules Scenario would result in ranges of recycled content in bottles and rigid packaging between 30% and 80%, and ranges of recycled content in flexible packaging between 30% and 60%, depending on the region. Policy examples are already underway – for example, the European Union is expected to mandate recycled content targets of 65% for all plastic beverage bottles and 50% for contact sensitive plastic packaging by 2040.[129]

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t 'Closed loops', in the context of this model, refers to mechanical recycling where the recycled content is used towards the same application; compared with open loops, where the recycled content is used in other applications.

Box 4

Chemical recycling in the Global Rules Scenario

Chemical recycling[u] encompasses a set of emerging technologies, with mainly pilot plants in operation and a growing number of larger-scale plants in the pipeline.[v] However, the debate on the role that these technologies could play in the waste management system remains ongoing; for example, in 2023, the Basel Convention Technical Guidelines refrained from including chemical recycling as an environmentally sound waste management method while further research on its environmental impact is awaited.[130]

Chemical recycling technologies are still under development and have certain drawbacks. One concern often raised is the output of these technologies is not only plastic-to-plastic conversion, but also the production of fuel and chemicals from plastics (in this report, only plastic-to-plastic yields are counted as 'chemical recycling'). Some chemical recycling technologies result in in higher energy consumption and GHG emissions per tonne recycled relative to mechanical recycling. They also require more investment,[131] which could create 'lock-in' effects as larger volumes of plastic waste must be fed into chemical recycling plants in order to ensure a return on investment. This could present a risk of outcompeting mechanical recycling for feedstocks or disincentivising better solutions that may emerge in the future. There are also questions regarding the health impacts of emissions from chemical recycling processes if strict emission controls are not followed, and regarding the management of chemical additives.

On the other hand, mechanical recycling has technical limitations in terms of the feedstock it can process, the number of loops it can recycle and the quality of its output (which in many cases is inferior to virgin plastic and is not usually certified as food grade, except for specific cases).[132] To overcome these problems, the first step should be to change the product design; but this is not always possible. For example, at present, there are limited solutions to make textiles mechanically recyclable into high-value products with a sizeable market, or to produce food-grade certified mechanically recycled content for applications where recycled plastic is in high demand (eg, polypropylene, polyethylene and PET applications beyond bottles).

The Global Rules Scenario applies chemical recycling to a few of the plastic waste types mentioned above, to prevent these volumes from ending up in landfill or incineration, and to reduce the production of virgin plastic. In the Global Rules Scenario, the output of chemical recycling in 2040 would be 14 Mt, representing 3% of the 462 Mt of plastic waste generated annually.

Because of the risks (see Box 2) and uncertainty associated with chemical recycling, a Global Rules Scenario without any chemical recycling was also modelled (see Figure 14). The results show that if the Global Rules Scenario were to exclude chemical recycling altogether, these volumes would probably end up in controlled disposal through incineration with energy recovery and/or landfill. Of the 14 Mt that are chemically recycled in the Global Rules Scenario, the analysis suggests that an estimated 11 Mt could end up in landfill and 3 Mt in incinerators if chemical recycling were excluded. Not using chemical recycling would decrease the recycling rate by 2%, increase virgin plastic production by 14 Mt and negatively impact GHG emissions. However, these impacts may be worthwhile if the risks associated with chemical recycling are proven and cannot be mitigated through R&D and/or the use of different technologies.

u In this report, 'chemical recycling' refers to the plastic-to-plastic output of technologies such as pyrolysis, gasification and depolymerisation

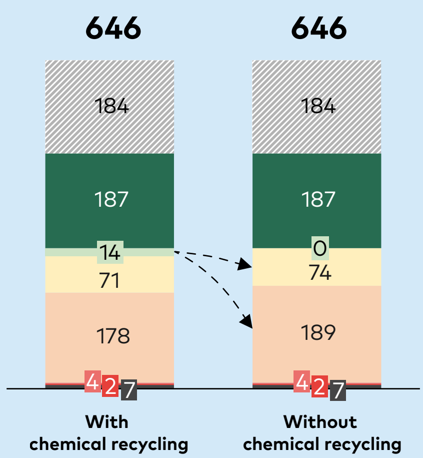
v European plastics manufacturers have announced investments of €7.2 billion in chemical recycling by 2030.[133]

FIGURE 14 **Because of the risks and uncertainty associated with chemical recycling, a Global Rules Scenario without any chemical recycling was also modelled.**

Taking chemical recycling out of the Global Rules Scenario would result in a limited increase in annual virgin plastic production, GHG emissions and volumes landing in controlled disposal, as well as a minor decrease in recycling rates.

All numbers are subject to rounding

Global Rules Scenario with and without chemical recycling
End-of-life fate of plastic waste by 2040
Mt/year



When chemical recycling is not present in the Global Rules Scenario, the volumes no longer sent for chemical recycling would likely be incinerated or landfilled. Levels of mechanical recycling and mismanagement would likely remain unchanged.

Impact of chemical recycling in the Global Rules Scenario 2040
(Without vs with chemical recycling)

Virgin plastic production	**+14** Mt/year (+5%)
GHG	**+31** $MtCO_2eq$/year (+2%)
Recycling rate	**-2%**
Incineration	**+3** Mt/year (+4%)
Landfill	**+11** Mt/year (+6%)
Cost	Limited change, balanced between industries
Employment	Limited change, balanced between industries

The resulting decrease in recycled content availability would drive an increase in virgin plastic production and total GHG emissions. The estimated impact on total systems costs and employment would be minimal.

Plastics never made
- Reduction & Elimination

Recycled
- Mechanical Recycling
- Chemical Recycling

Disposed
- Incinerated
- Engineered Landfill

Mismanaged
- Dumpsites/unsanitary landfills
- Open burning
- Released into land or water

POLICY INTERVENTION 9

Modulated EPR schemes applied across sectors

with fees of $300 - $1000/tonne calibrated by region and by product

EPR schemes require industry players that place products containing plastics on the market to pay a fee which is then used to fund the collection, sorting, recycling or disposal of waste plastic materials, as well as solutions to scale new delivery models, such as reuse. EPR schemes are often considered as a practical implementation of the 'polluter pays' principle[134]. EPR schemes are regarded as effective policies for achieving circularity targets – especially if the fees are modulated to reflect the difficulties and net cost associated with collection, sorting and disposal of a given application, to incentivise design improvements and penalise the use of hard-to-recycle materials or designs. They can also be an effective way to raise significant funds that can be deployed towards solutions.

In the Global Rules Scenario, EPR fees would be applied across all sectors, not only packaging. Regional calibration of EPR fees would make it easier for companies to design their products to meet the requirements of multiple markets. It is assumed that fees would be collected and invested at the national level, and would also cover the administration costs of the EPR scheme itself. The levels of effectiveness are differentiated by region to account for the management of EPR schemes and the less advanced infrastructure of low and middle-income countries. In the Global Rules Scenario, fees would increase over time and would be calibrated across regions, depending on income levels. It is assumed that in high-income regions, fees would be invested in expanding sorting and recycling capacity; while in low, middle and upper-middle-income regions, fees would be invested in developing collection, sorting, recycling and disposal infrastructure. The share of investment that each part of the value chain would receive under the model is in direct proportion to its cost. It is assumed that investments in recycling infrastructure and reuse models would mainly be made by the private sector, as private sector players would generate profits from such investments. However, the revenues from these fees could be used to support the expansion of reuse models, to de-risk investment and accelerate adoption. The Global Rules Scenario assumes that regions that already have deposit return schemes – particularly for bottles – would also introduce EPR schemes.

> **Modulated EPR schemes can incentivise better product designs and fund infrastructure**

A position paper published by the Ellen MacArthur Foundation and endorsed by dozens of organisations across the value chain indicates that the benefit of EPR funding is that it is 'dedicated, ongoing and sufficient' – which is what makes it so effective. This allows governments to rely on this revenue and use it to fund infrastructure at scale over time. For more information, see the Ellen MacArthur Foundation's paper on EPR.[135]

To set the right EPR fees, specific studies should be conducted for each given local context. For the purpose of the Global Rules Scenario, the analysis models fees of US$300 to US$1,000 per tonne of plastic by 2040, increasing gradually from 2025. These fees would vary both by region, depending on income levels and affordability; and by application, penalising those designs that are difficult to recycle. Please see the Technical Annex for full details.

In practice, the implementation of EPR schemes would require central governments to establish systems to administer the funds and set concrete targets for collection, recycling and recycled content. The EPR fees would be paid by economic actors that place plastic products on the market – most likely manufacturers and importers. The fees would be raised and invested by local municipalities through producer responsibility organisations to cover the collection, sorting and disposal of plastic waste. EPR fees should be set at a level that accounts for the costs of infrastructure in the local context; should be calibrated by application; and **should operate on a net cost basis**.[w] Common rulebooks within a global framework would also help to harmonise national approaches while still allowing for context-specific adaptation.[136]

The Consumer Goods Forum sets out practical principles for modulation for plastic packaging that could be followed in this context. An modulation system should be designed 1) as simply and practically as possible; 2) with clear objectives and criteria to show which improvements in the waste management and recycling system it is targeting; 3) with a focus on net cost to include the 'net cost' of collection, sorting and recycling of a material stream to provide the optimal set of incentives for design and production; 4) with investment in systems improvement to expand the development of infrastructure, technology and consumer education to enable recycling of such materials; 5) with full transparency and consultation of all stakeholders through dialogue with industry; and 6) with harmonised and consistent criteria implemented across markets and jurisdictions for a level playing field wherever possible. For more details, see the report entitled Guiding Principles for the Eco-modulation of EPR Fees for Packaging.[137]

Existing EPR schemes can serve as examples for expanding this policy into new regions. The EU has mandated that all member states deploy EPR schemes for plastic packaging.[138] In France, an modulated EPR scheme aims to encourage companies to switch to clear PET bottles instead of coloured ones, to disincentivise complex packaging structures and to penalise the use of PVC in packaging by applying higher fees to this polymer application.[139] EPR schemes have also yielded results for plastic applications beyond packaging: for example, in France, EPR schemes for textiles led to a 40% increase in used textiles collection rates through voluntary drop-off points over a seven-year period, to achieve a recycling rate of 33% for all textiles materials.[140]

EPR schemes have been well established in some European countries for decades and the adoption of such schemes is increasing worldwide. For example, the Republic of Korea, Vietnam, the Philippines, India, Chile and South Africa have implemented various mandatory EPR schemes.

w Net cost basis, in this context, suggests that EPR policies should set EPR fees at a level that would fully fund the net cost of collecting, sorting and recycling plastic waste.

POLICY INTERVENTION 10

Controls for a just transition for the informal sector

enhancing their labour and human rights

Controls for a just transition and protections for waste pickers have not been quantified in the modelling exercise; they are rather addressed qualitatively (see 'Objective and scope').

Waste pickers in the informal sector are reliant on this activity for their livelihoods. These communities of workers operate in informal set-ups and play a crucial role in the recycling system by collecting, sorting and selling recyclable material waste. However, working conditions are often hazardous and waste pickers regularly face social stigma and discrimination. Earnings are low, and waste pickers have limited bargaining power in the market and are generally excluded from formal waste management operations and decision-making.[141]

Waste pickers play a crucial role in recycling efforts, but are generally excluded from formal waste management operations and decision-making

Policies such as EPR schemes, segregated collection targets and deposit return schemes on recyclable products such as bottles would directly impact the livelihoods of communities in the informal sector. In the modelling exercise behind this report, the share of plastic waste collected by the informal sector is kept constant; however, this would be under the assumption that controls to enhance the labour and human rights of these communities would be in place. Otherwise, the implementation of these policies would present risks to a just transition. Governments could ensure a just and inclusive transition by protecting labour and human rights in the informal sector[142] through measures such as the following:

- including the informal sector in policy and decision-making processes and discussions on waste management or which would otherwise impact on their livelihoods;

- integrating their activities within the broader waste management system, including EPR schemes, by facilitating the purchase of plastic waste collected by the informal sector at a fair price (including a 'service fee' for the environmental service they provide by collecting this waste, in addition to the material value of the recyclables);
- establishing and enforcing specific regulations to safeguard the health and safety of waste pickers, including rules on the handling of hazardous waste, the provision of protective equipment and training in occupational hazards;
- providing legal recognition to informal workers to improve their incomes, working conditions and ability to organise, and establishing social welfare programmes to mitigate the economic risks and vulnerabilities faced by these communities; and
- supporting informal workers and waste pickers in moving up the value chain by enabling access to finance and providing training programmes and capacity-building initiatives. These programmes could enhance their skills, productivity and competitiveness, enabling them to access better employment opportunities and potentially to transition to more formalised sectors.

The important contribution of the informal sector to the global plastic recycling system is largely unrecognised and underpaid. An increase in the value of plastic material through design for recycling and the integration of the informal sector within the broader waste management system would significantly increase the retained value for waste pickers and help to promote social justice.

Specific policies and approaches would vary based on the local context and the needs of individual communities. Governments should work closely with relevant stakeholders, including community representatives and civil society organisations, to design and implement effective policies that would protect the health and human rights of the informal sector and waste picker communities. The impact of the policies outlined in this section has not been estimated as part of the modelling exercise for this report.

PILLAR D

Controlled Disposal

Ensure the controlled disposal of waste that cannot be prevented or safely recycled

Once Pillars A, B and C have been deployed to their feasible limits, policies are needed to ensure that all remaining plastic is managed through controlled disposal methods. While controlled disposal is not a desirable outcome, it can be a last resort option to prevent plastic waste from being mismanaged.

The Global Rules Scenario would result in a 46% decrease in volumes of plastic waste managed via landfill or incineration in Europe, the USA, Canada, Japan, the Republic of Korea and Oceania by 2040 relative to 2019 levels. However, in the rest of the world, despite all efforts, there would still be large volumes of plastic waste to be managed through controlled disposal (see Figure 15). In these regions, the Global Rules Scenario would result in a 74% increase in volumes managed via landfill or incineration by 2040 relative to 2019 levels. This means that globally, the volumes of waste ending up in controlled disposal in 2040 would be similar to the figures for 2019.

After maximising reduction, elimination and circularity, controlled disposal is the last resort to prevent mismanagement

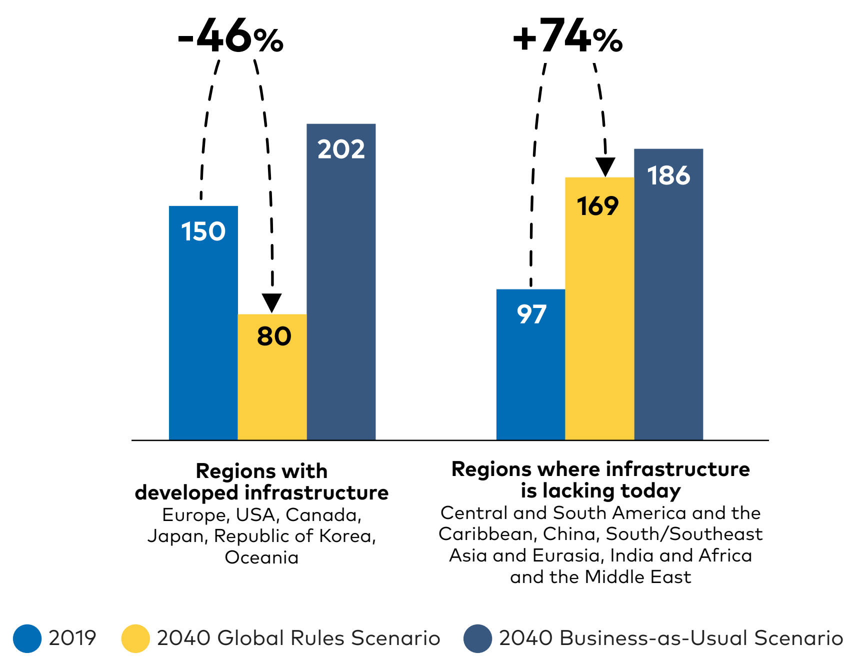
The main reasons for this are that low and middle-income regions already lack the necessary infrastructure to manage the waste that is generated today, and have higher forecasted growth in population and consumption per capita; and the reduction and circularity proposed in the Global Rules Scenario would not be enough to address all applications by 2040. For instance, the plastics used in construction, transportation, textiles and electronics have long lifespans (five to 30 years, depending on the application), and can include complex designs (eg, the blending of different polymers/materials) and formulations (eg, fire retardants and other additives) that hinder recycling. In these cases, controlled disposal is the next best available solution, as a final alternative to mismanagement.

To ensure that disposal would be controlled and managed according to the best available environmental practices, the Global Rules Scenario assumes the imposition of restrictions on the export of plastic waste and global application of controlled disposal standards. The Global Rules Scenario primarily focuses on preventing annual mismanagement of plastic rather than removal and management of legacy mismanaged plastics.

FIGURE 15 **Plastic waste volumes ending in controlled disposal**

The Global Rules Scenario would result in a 46% decrease in controlled disposal by 2040 relative to 2019 levels in regions that have advanced infrastructure today. However, in regions that lack such infrastructure, despite all efforts, there would be a 74% increase in controlled disposal by 2040 relative to 2019 levels.

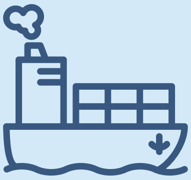
Mt/year. All numbers are subject to rounding.



Disposal volume changes between 2019 and the 2040 Global Rules Scenario in geographies balance globally:

The volumes of plastic waste ending in controlled disposal in the Global Rules Scenario entail a reduction in countries with existing waste management infrastructure, and an increase in those lacking infrastructure today. However, in global terms, the volumes ending in controlled disposal by 2040 result in similar levels to 2019 but changing in geographies.

Disposal type Mt / year	**2019**	**2040 Global Rules Scenario**	**2040 Business-as-Usual Scenario**
Engineered landfill	172	178	254
Incineration with Energy Recovery	75	71	134
Total	**247M**	**249M**	**388M**



POLICY INTERVENTION 11

Restrictions on plastic waste trade

to prevent exports to areas with limited capacity

In the Global Rules Scenario, countries would manage their own waste by developing local infrastructure. Plastic waste exports from high-income regions to low, middle and upper-middle-income regions can result in the transfer of responsibility from advanced waste management systems to developing waste management systems. Although China's waste import ban[x] has reduced plastic waste exports to China,[143] a proportion of these exports have been redirected towards other countries which may lack adequate waste management infrastructure. There is evidence that these waste exports can displace domestic recycling capacity and increase the pressure on the waste management infrastructure of receiving countries.[144, 145]

Restrictions on plastic waste trade would prevent the export of waste to regions with limited capacity or resources

Controls are already in place through the Basel Convention, which regulates the movement of plastic waste across international borders, particularly of any waste deemed hazardous. Through the Basel Convention Plastic Waste Amendments, its controls are also expanding. The Global Rules Scenario assumes that these restrictions would be extended to apply globally to all plastic waste exports, while acknowledging that there could be exemptions – for example, in the case of shared agreements between countries (eg, the EU Single Market) on joint infrastructure; or in the case of small countries or islands that do not have the space or critical scale to develop infrastructure. The Global Rules Scenario assumes this policy intervention so that recycling and waste management capacity would increase where consumption and waste is generated.

x China's waste import ban entered into force in 2018 as part of the Chinese National Sword Regulation.

POLICY INTERVENTION 12

Standards on the controlled disposal of waste that cannot be prevented or safely recycled

As last resort option to prevent plastic mismanagement

The Global Rules Scenario assumes global implementation of standards on the controlled disposal of waste in all geographies. For plastic waste sent to controlled disposal through landfill or incineration, the analysis assumes the split between these technologies that each region has today. This means that in regions which currently do not have incineration, the Global Rules Scenario would rely on engineering landfills when new disposal capacity was required.

This is because incineration with energy recovery can produce higher GHG emissions per tonne of plastic waste managed, as well as incurring higher costs relative to landfill.[146] Incinerators produce electricity and heat, which can be used as an alternative energy source to fossil fuels. With a lifespan of about 25 years, incinerators can create 'lock-in' effects, requiring a constant input of plastic waste to provide financial returns. This can disincentivise the use of better alternatives such as reduction, redesign and recycling; and can act as competition for recycling feedstock. Moreover, while modern gas cleaning systems are effective at reducing harmful emissions from incinerators, they might not be installed in regions where expenditure, regulatory standards and enforcement are inadequate. Without such systems, incinerators release pollutants that may increase health risks. In the Global Rules Scenario, incineration is applied only in those regions where incineration plants already exist or where projects have already been commissioned, such as Europe, China, the USA and Japan.

> **The Global Rules Scenario requires enforcement of environmentally sound controlled disposal of plastic not prevented or not recycled**

In the case of landfill, environmental standards are also important – for example, to ensure the establishment of impervious top and bottom layers, and reinforcements against toxic liquids that could contaminate groundwater[147] and the emission of gases such as methane. To manage these risks, drainage systems are required to capture liquids and gases, with these liquids cleaned through wastewater treatment. In addition, landfills can be hundreds of metres deep and, despite adapted structures and placement, can pose a risk of land collapse. Therefore, engineered landfills should be monitored for decades. By contrast, dumpsites and unsanitary landfills are areas where waste materials are deposited without controls. This can result in the release of toxic gases and liquids into the environment, creating risks to health and biodiversity. In those regions where new capacity for controlled disposal is required, the analysis assumes the engineering of unsanitary landfills (dumpsites) and the development of new engineered landfills that adhere to environmental standards.

POLICY INTERVENTION 13

Mitigation and removal programmes for legacy plastics in the environment

although still prioritising solutions that prevent releases in the first place

Mitigation and removal programmes for legacy plastics have not been modelled quantitatively (see 'Objective and scope').

The Global Rules Scenario primarily focuses on preventing incoming annual mismanagement of plastics volumes rather than removal and management of legacy mismanaged plastics. It does so in order to address the root causes of this mismanagement, aiming to prevent the Business-as-Usual Scenario estimate of annual plastics released to land and water environments growing from 28 Mt in 2019 to 49 Mt by 2040. The Global Rules Scenario focuses on minimising mismanagement and releases, assuming that the allocation of resources and capital towards such activities would have the greatest impact. The reasons for this focus include the substantial costs associated with some clean-up programmes for legacy plastics and the inability of current clean-up technologies to remove small particles from oceans.[148] Put simply, the focus of the Global Rules Scenario is on investing in solutions that would prevent the release of plastic into the environment in the first place. One exception however, is the legacy mismanaged plastics deposited in dumpsites, that the policy intervention #12 would manage through the engineering of these dumpsites into engineered landfills.

Given the cost of removing legacy plastics, the Global Rules Scenario would focus on preventing the release of new plastic volumes

Notwithstanding this priority, however, removal programmes for legacy plastics could still have a role to play, even where the root problem has not yet been resolved. For example, beach clean-ups are an effective way to raise awareness and may be an enabler for prevention. Data obtained from clean-ups can identify the items that are most likely to end up as mismanaged and inform policy accordingly. [149]

Transversal Pillar E

Microplastics

Prevent the use of microplastics and reduce microplastics releases into the environment

The analysis in this report includes primary microplastics from personal care products, pellets, tyre abrasion, paints and textiles, as these are regarded as the main sources of primary microplastics.[150, 151, 152] Secondary microplastics were excluded from the analysis, as they originate from the breakdown of macroplastics, already addressed in Pillars A to D. Research and data on microplastics is limited, and direct evidence of the efficacy of some of the suggested policies is lacking. The analysis estimates the theoretical potential of policy interventions depicted in table 2, based on best available data and expert interviews. However, further evidence and learnings from actual implementations are required. Other potential sources of microplastics, such as plastics used in agriculture, were not included due to a lack of available data.

Microplastics are a complex group of mismanaged plastics, for which solutions are currently lacking

Annual primary microplastics emissions were estimated at 9 Mt in 2019; and without effective policy measures, these could increase to 16 Mt by 2040 under the Business-as-Usual Scenario[y]

Microplastics are challenging to collect and capture, given their size, the diversity of sources from which they originate and their ubiquity. Some microplastics emissions result from the intentional incorporation of microplastics within specific products (eg, microbeads added to personal care products); others from product mishandling (eg, pellets emissions throughout the supply chain). By comparison, microplastics emissions from paint, tyres and textiles are more complex to prevent or control, as they are largely driven by abrasion and wear and tear during the use and/or washing of plastic products.

y These results build on analysis from previous reports such as Breaking the Plastic Wave[153], while expanding the scope to encompass microplastics from paints.

TABLE 2 **Policies to explore for microplastics**

Policy area	Sub-area	Policy	Paints	Tyres	Pellets	Textiles	PCP*
Upstream policies to reduce microplastics use and emissions		**Bans on intentionally added** microplastics/microbeads.					✓
		Replacement of plastic-based coating with mineral or biodegradable paint for architectural applications where this does not compromise product protection and lifespan.	✓				
		Mandatory implementation of **existing technology** that prevents microplastics releases (eg, high-precision paint guns).	✓				
		Preventive maintenance to prevent corrosion from paint wear and tear.	✓				
		Behaviour change through better driving and shared mobility to reduce tyre abrasion.		✓			
		Better industrial product design and **thresholds on microplastics** to prevent releases from tyre abrasion and textiles.		✓		✓	
Downstream policies to capture microplastics, followed by controlled disposal	**Microplastic collection at the source**	**Manufacturing and safe handling practices** using best available technology to prevent microplastics releases	✓		✓		
		Mandatory **capture filters** in domestic/commercial washing machines and in pellet production.			✓	✓	
	Downstream microplastic capture through wastewater and waste management	Mandatory **financial and operational responsibility** across the plastic supply chain to clean up mismanaged pellets using globally agreed upon disaster response protocols			✓		
		Measures to upgrade **wastewater and sewage** treatment to capture and manage microplastics. 1. Mandatory porous asphalt capture, cleaning and road sewage systems. 2. Upgraded and expanded secondary wastewater treatment in industries, commerce and households (paint, textiles).	✓	✓		✓	
		Controlled disposal of microplastics after at-source and downstream capture, including a ban on distribution of sludge and road runoff to soil.	✓	✓	✓	✓	

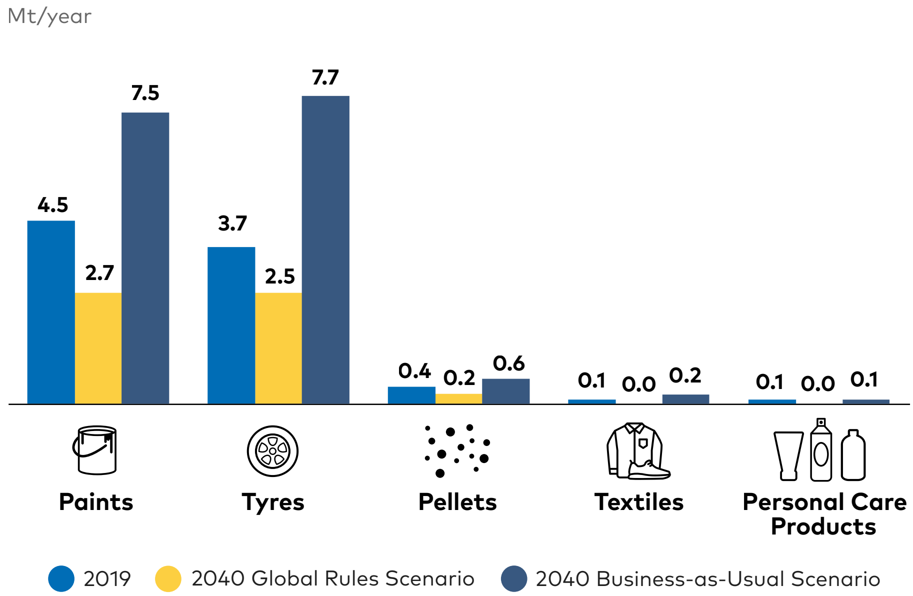
*PCP = Personal Care Products

Microplastics emissions are expected to increase by 2040 due to higher consumption of products that generate them. Tyres and paints alone accounted for more than 90% of microplastics emissions in 2019. Although today high-income countries produce more microplastics, the growing consumption forecast in upper and lower-middle-income countries by 2040 is expected to lead to increased pellet handling, increased use of tyres and increased use of paint for infrastructure. Hence, microplastics emissions are estimated to grow from 9 Mt in 2019 to 16 Mt by 2040 under the Business-as-Usual Scenario.

Figure 16 compares the volumes of microplastics emissions from each of the five sources of microplastics included in the analysis, in 2019 and in 2040 for the Business-as-Usual Scenario and the Global Rules Scenario.

FIGURE 16 **Microplastic releases into the environment by source**

The Global Rules Scenario would not fully solve the problem of microplastic releases by 2040, despite the policies considered; 5 Mt would still be released into the environment annually.



Under the Global Rules Scenario, 5 Mt of microplastics would still be released into the environment annually by 2040. While this figure is lower than the 9 Mt in 2019 and the 16 Mt projected under the Business-as-Usual Scenario, this is still an area that requires further solutions.

The reduction in microplastics emissions under the Global Rules Scenario would be achieved through:

- prevention of the use of microplastics at source and interventions to reduce microplastics emissions through policies that incentivise elimination, design improvement and behaviour change; and
- policies to capture microplastics both at the point of emission and through downstream wastewater management.

The 5 Mt of microplastics that would still end up being released into the environment would be mainly due to wear and tear of paint and tyre abrasion.

POLICY INTERVENTION 14

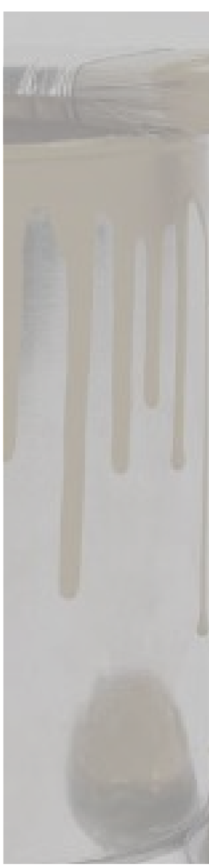
Upstream policies to reduce microplastics use and emissions

through bans, substitution, better product designs, preventive maintenance, and behavioral change

Upstream policies to reduce the production of microplastics would involve a large range of policies, such as bans on intentionally added microplastics, substitution, better product design, preventive maintenance, new technologies and behaviour change.

Personal Care Products

Although these represent a small proportion of overall microplastics emissions, the Global Rules Scenario assumes a global ban on intentionally added primary microplastics. Many countries have already taken this step: full or partial bans on microplastics in personal care products have been introduced in the USA, Canada, the EU, the UK, New Zealand, the Republic of Korea, China and Taiwan, among others. A global ban on intentionally added primary microplastics in personal care products would have little impact on the functionality of these products.[154, 155, 156] Although a ban on intentionally added microplastics is particularly relevant for personal care products, it is also relevant for other products, such as fertilisers and detergents.[z]



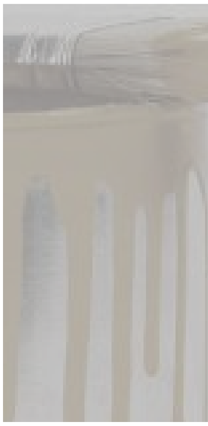
Paints

The largest range of interventions are aimed at reducing microplastics emissions from paint at source, due to the broad range of applications for paint (eg, architectural, marine, industrial, road markings) – most of which are essential to protect and increase the lifespan of building and materials.[157] The Global Rules Scenario assumes the **elimination of plastic-based paint for architectural applications; technology to reduce losses from paint applications; and preventive maintenance to reduce microplastics emissions from wear and tear.** Most of these solutions are currently either nascent or in early development, and there is thus limited understanding of their impact.

A proportion of microplastics emissions from paint could be eliminated through a shift from plastic-based to non-plastic-based paint. This could apply to a large majority of architectural paint applications, where it would have less impact on products, protection and lifespans.[158] Where elimination is not possible, rules on paint composition could be helpful to reduce the impact of microplastics emissions.

Beyond elimination, reducing microplastics emissions from paint would involve solutions to prevent releases both during application and from wear and tear. While better industrial technology and practices (eg, the use of high-precision spray guns) could help to reduce releases during application, solutions are lacking for releases from wear and tear – by far the main source of microplastics emissions.

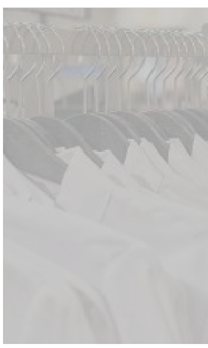
z The EU has adopted the REACH Committee's proposal to impose restrictions on a broader range of products containing intentionally added microplastics, such as fertilisers, detergents and medical devices.[159]



Paints

Although there is little evidence of the potential of these interventions, the adoption of maintenance and prevention measures in paint applications (architectural, marine, industrial, transportation, road markings) could help to prevent wear and tear. For industrial applications in particular, nascent preventive technologies can detect small corrosions, enabling a restricted area to be maintained instead of the corrosion spreading and causing further wear and tear, necessitating the removal and reapplication of paint.

However, paint wear and tear is hard to control and will remain the primary challenge in reducing microplastics emissions.



Textiles

In addition to the transition towards sustainable fashion highlighted in previous sections, clear design rules for textiles and better production practices (eg, cutting methods) are important interventions to address microplastics emissions from textiles. These could significantly reduce the release of microplastics during production,[160] use and washing.[161] In the Global Rules Scenario, better textile design would reduce microplastics emissions based on a combination of factors, such as material composition, fabric structure, fibre type and twist, and hairiness.[162, 163]

Tyre abrasion

The Global Rules Scenario accounts for reductions associated with better driving behaviour,[aa] lower per-capita vehicle use through shared mobility solutions and optimised tyre designs. While maintaining all safety and energy efficiency criteria, better tyre designs aimed at reducing microplastics emissions have already been tested by various industry brands.[164] The Global Rules Scenario assumes better designs across the global tyre industry. In practice, this could require the definition and implementation of better design requirements, including microplastics thresholds; increased lifespans; and bans on hazardous substances and certain designs (eg, studded tyres), based on scientific and harmonised tests.[165] Several other factors could help to prevent tyre abrasion, including a reduction in kilometres travelled, smoother road surfaces, lighter vehicles and better vehicle maintenance.[166] Changes in road surfaces or car weights were not factored into the analysis because data on their potential impact is limited, and because any efforts to reduce vehicle weight may potentially be counterbalanced by increments on the weight of electric batteries.

aa Better driving behaviour involves the adoption of environmentally friendly practices such as driving at lower speeds, maintaining the recommended air pressure in tyres and avoiding abrupt acceleration and braking to reduce fuel consumption and tyre abrasion.

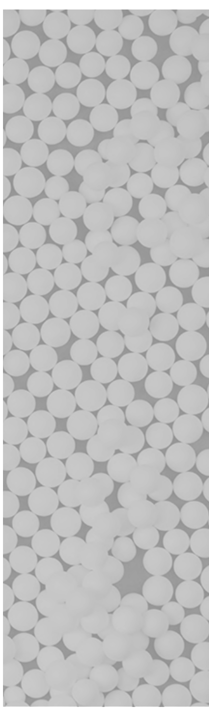
POLICY INTERVENTION 15

Downstream policies to capture microplastics, followed by controlled disposal

prioritising capture at source over capture through wastewater treatment

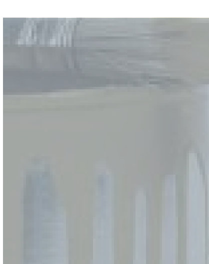
Where microplastic prevention is not possible and microplastics are emitted, their capture at the point of emission should be prioritised over downstream capture through waste and wastewater systems, which would require substantial infrastructure and investment. The captured microplastics should then be disposed of in a controlled manner. Together, these two sets of policy interventions applied in the Global Rules Scenario would lead to 49% of microplastics emissions ending up in controlled disposal, compared to 11% in 2019.

Downstream policies to capture microplastics at the point of emission



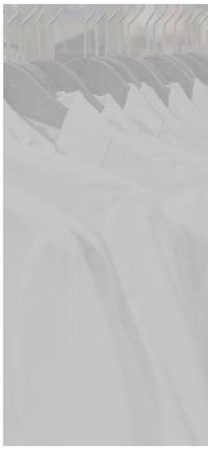
Pellets

Although a reduction in virgin plastic consumption (see Pillar A) would automatically result in a reduction in pellet production – and, by extension, in the risk of plastic pellet releases – an increase in recycling could increase the risk of releases during the recycling process unless clear actions are taken.[167] Pellet mismanagement could be substantially eliminated through better industry management and improved logistics practices to ensure safe handling at every stage of the value chain. The European plastics industry has already issued guidance on how to minimise pellet release through on-site technical solutions such as catch trays at loading valve points, central vacuum systems in handling facilities and bulk-handling equipment, as well as thorough cleaning practices, fine water filtration and storm drain screens to capture any pellets that may be inadvertently released during operations.[168] Industrial and recycling facilities handling pellets should also be required to ensure safe logistics by using impact and marine-resistant packaging for pellets in order to prevent spills. The industry guidance should become mandatory; and a robust monitoring and reporting mechanism should be introduced, including regular evaluation of operators and notification of significant or repeated failures to meet these standards.



Paints

Microplastics emissions during paint removal could be reduced through the mandatory adoption of vacuum assist sanding technology in combination with dust extraction systems for indoor removal.[169] Although indoor removal is not possible for large structures or vessels, it should be applied where physically possible. The microplastics captured should be disposed of appropriately through the solid waste treatment system.

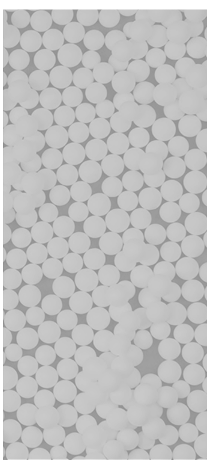


Textiles

While improvements in textile design should be the priority, the implementation of filters and capture systems in washing machines could help to mitigate microplastics emissions from textiles.[170] For example, in France, filters will become mandatory by 2025 for all new washing machines, capturing most emissions from washing.[171] Adaptable filters could also be fitted to existing washing machines – a solution which is particularly relevant as washing machine uptake increases globally. Naturally, however, this would not reduce emissions from handwashing; and filters are effective only if they are properly cleaned and the microplastics captured are disposed of safely in the general waste. Cleaning the filter under the tap would reintroduce the microplastics into the wastewater system.

Downstream policies to capture microplastics through wastewater management

If microplastics cannot be captured at source – which is commonly the case for microplastics from wear and tear of tyres, textiles and paint - capture through waste and wastewater systems followed by controlled disposal remains a last resort option. However, this would require significant infrastructure and investment, and is less realistic and feasible in terms of implementation.

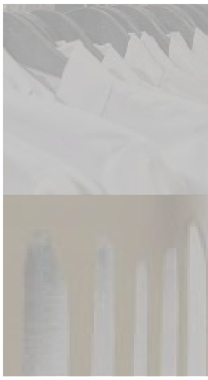


Pellets

In the unfortunate event of a pellet transport accident or industrial mishandling, it is essential that producers and their supply chains are held financially and operationally responsible for cleaning up the pellet release using globally agreed disaster response protocols. As international frameworks and national policies have not yet sufficiently addressed this problem,[172] an EPR scheme for pellets could be explored; although the Global Rules Scenario does not include this policy. To this end, data gathering on pellet production and supply chain traceability to ensure accountability for pellet mismanagement, as well as third-party performance audits and certification, can be key enablers that would simultaneously incentivise best pellet management practices.

Tyre abrasion

The capture of microplastics from tyre abrasion through porous asphalt roads and their collection through bi-yearly road vacuuming or water cleaning is one of the few ideas proposed in this space.[173, 174, 175] While this solution requires further test assessment, its effectiveness would also depend on the establishment of a mixed/combined sewage system in urban environments. This would capture microplastics that enter the wastewater system through rain or street cleaning and prevent them from reaching surface waters.



Paints & Textiles

In addition to broader positive health benefits, upgraded wastewater systems would improve the management of microplastics emissions from paints and textiles in particular. Even with the extensive policy measures described above, a relevant share of microplastics would still end up in the wastewater system (eg, from areas that are not connected to the wastewater system), where the volumes that can be captured vary between primary, secondary and tertiary systems.[bb, 176] Upgrading and expanding to at least secondary wastewater systems (except in more remote rural areas) could capture around 90% of microplastic emissions that enter the system.

Finally, sewage sludge containing microplastics captured through wastewater systems should be prevented from re-entering the environment through land applications (eg, agriculture)[177]. All microplastics captured either at source or through downstream systems should end up in controlled disposal.

Despite these policy interventions, the Global Rules Scenario would not fully eliminate microplastics releases. An estimated 5 Mt of microplastics would still be released annually into the environment by 2040 – primarily from tyre abrasion and paint wear and tear – making microplastics a main source of plastic releases into the environment for which insufficient technical solutions exist.

While the Global Rules Scenario would dramatically reduce plastic mismanagement, further solutions would be required for those microplastics that still end up being released into the environment by 2040 – primarily from paint and tyre wear and tear, but also from textiles, especially due to open-water handwashing (in areas where washing machine ownership rate is low) and in areas with limited wastewater systems.[178]

Such actions would be particularly important as the scientific evidence confirms that microplastics and environmental toxicants can have a negative impact on wildlife through ingestion, on plant growth and on human health through the food chain (see Box 2). While further research is required to precisely estimate the extent of their impact on human health, the precautionary principle should nonetheless be applied.

bb Wastewater systems are classified based on the effectiveness of their treatment and filtering levels, with primary systems (often found in lower-income or rural areas) being the least efficient at capturing microplastics and tertiary systems (most common in higher-income, urban areas) the most efficient.

Box 5

This report's approach to prioritising each pillar

When determining the optimal scale and priority of different solutions across the plastic lifecycle, a number of constraints and trade-offs must be considered in regards to their economic, environmental, and social impacts.

PILLAR A **Reduce virgin plastic production and consumption**	
Why is this pillar included?	Past studies[179, 180] have shown that a **substantial reduction in virgin plastic volumes is required** in order to significantly reduce mismanaged plastic volumes. Such a reduction would also have benefits in terms of GHG emissions and risks to health and the environment.
What are the limitations when scaling this pillar?	These solutions would result in the elimination of plastic, a shift to less consumption-intensive models or the replacement of plastic with other materials of equivalent utility. Options to reduce virgin plastics can be limited by their **technical and economic feasibility.** For instance, the ramping up of reuse models can be limited by the economics and the pace of deploying reverse logistics infrastructure at scale. If other materials replace plastics, better environmental, health and social performance should be ensured – for example through case-by-case LCAs. If this is overlooked, there is a risk of forcing **regrettable substitutions** and unintended consequences (eg, higher GHG emissions, food waste, and land or water use). Finally, **limitations can also be social or behavioural** if affordability, safety or convenience is compromised; or if livelihoods are negatively impacted.
Approach in this report	**Reduction of virgin plastic volumes should be maximised** as long as regrettable substitutions are avoided and a just transition is ensured.

PILLAR B **Eliminate avoidable and problematic plastics and chemicals**	
Why is this pillar included?	In addition to posing direct risks to human health and the environment, avoidable and problematic plastics and chemicals can hinder circularity and have a higher likelihood of being mismanaged. If plastic production increased as projected in the Business-as-Usual Scenario, these impacts would heighten.
What are the limitations when scaling this pillar?	The elimination of avoidable plastics has similar constraints to those outlined in Pillar A, requiring that regrettable substitutions be avoided and a just transition ensured. The phaseout of problematic plastics and chemicals should also ensure product safety (eg, performance of fire retardants or tyres); and time and resources would be required to test substances through a scientific process to identify which should be classified as problematic and phased out.
Approach in this report	The Global Rules Scenario calls for the introduction of common global criteria and the **phaseout of avoidable and problematic plastics.**

PILLAR C
Expand safe circularity via reuse, durability, and recycling

Why is this pillar included?	Expanding a product's use phase through reuse models or durable designs prevents plastic waste. Once a product has become waste, the alternatives are either collection and recycling or controlled disposal through engineered landfills or incinerators. Recycling is preferred over controlled disposal as it prevents the production of new virgin plastic, emits less GHG and requires less capital and operational costs.
What are the limitations when scaling this pillar?	The main constraint to scaling circularity is **inadequate product design**, which often hinders reuse or recyclability. Another constraint is the **speed at which collection and sorting systems can grow and recycling capacities scale,** driven by investment and the viability of the recycled plastic market (today only certain polymers in some markets are economically recyclable).
Approach in this report	**Collection, sorting and recycling should be maximised for all plastics not prevented,** to minimise controlled disposal and reduce virgin plastic volumes.

PILLAR D
Ensure controlled disposal of waste not prevented or recycled

Why is this pillar included?	Controlled disposal methods (engineered landfill and incineration with energy recovery) are linear solutions that lead to higher resource use and worse environmental impacts (eg, GHG emissions, land use, risk of water/land contamination if improperly managed) and health impacts. However, for waste that cannot be prevented or recycled, controlled disposal would remain the **last resort to prevent mismanaged plastic waste.**
What are the limitations when scaling this pillar?	The pace at which collection and controlled disposal infrastructure can scale limits control disposal. Trade-offs between incineration with energy recovery (GHG emissions, cost, "lock-in" effects) and engineered landfills (land utilisation) are presented in Policy Intervention #12.
Approach in this report	**Controlled disposal would be used only for plastic waste that cannot be prevented or recycled,** assuming the same split between landfill and incineration for each region as of today. Regions without incineration would rely on engineering landfill for any incremental capacity needed.

PILLAR E
Prevent the use of microplastics and reduce microplastics releases into the environment

Why is this pillar included?	Microplastics present **hazards and risks to humans and wildlife, as well as a high probability of being released into the environment.**
Limitations to scaling this pillar?	There is a **lack of available solutions** to prevent microplastics releases, or at least to maximise capture, as well as enough data and research.
Approach in this report	**The priority is on preventing the use of microplastics and reducing microplastic releases.** Where microplastic emissions cannot be reduced, capture at source is considered the most efficient and less costly option, leaving capture through downstream wastewater management systems as a last resort.

Costs & Employment

The Global Rules Scenario would yield important savings in public expenditure relative to the Business-as-Usual Scenario. The cumulative public expenditure from 2025 to 2040 in the Global Rules Scenario would total US$1.5 trillion, compared to US$1.7 trillion in the Business-as-Usual Scenario. The savings would mainly accrue from reductions in plastic volumes, resulting in less plastic waste to be collected and managed. However, this would primarily apply to regions with well-developed infrastructure; other regions would still need to invest in expanding their waste management systems.

Implementing the Global Rules Scenario would still require important investments from the public and private sectors.

This analysis estimates the investment requirements for annualised operating expenses (OpEx) and capital expenses (CapEx) at each step of the plastic lifecycle, as well as for alternative materials. These costs are then compared with total volume flows at each step of the plastic lifecycle or alternatives. However, the model does not include the costs of managing legacy plastics; the costs relating to externalities to health or biodiversity; or the impact of mismanaged plastics on industry (eg, fisheries, tourism, infrastructure). In addition, it does not include estimates for the investments required to launch solutions for microplastics, due to a lack of available data.

The Business-as-Usual Scenario would require significant investments from 2025 to 2040 to expand plastic production and conversion capacity. The overall cumulative estimate for the Business-as-Usual Scenario, considering OpEx and CapEx from 2025 to 2040, is US$20 trillion at present value (see Figure 17).

By contrast, the Global Rules Scenario would require lower levels of investment: **the cumulative estimate for the Global Rules Scenario, considering OpEx and CapEx from 2025 to 2040, is US$17 trillion at present value.** The main drivers would be the operational costs of virgin plastic production and conversion industries (to cover the remaining virgin plastics in the Global Rules Scenario); investments in production capacity for alternative materials; investments in expanding new business models (eg, reuse models); and investments in scaling collection, sorting, recycling and disposal infrastructure.

Of this US$ 17 trillion in the Global Rules Scenario, it is estimated that US$15.4 trillion would be covered by the private sector and US$1.5 trillion by governments.[cc] In this analysis, governments would cover the costs of expanding collection, sorting and disposal infrastructure; while the private sector would cover investment in the production of virgin plastics and alternative materials, recycling infrastructure and the expansion of new business models.

Reducing plastic production, and hence waste to be collected and managed, would decrease public expenditure

The comparison of cumulative public expenditure between the Business-as-Usual Scenario and the Global Rules Scenario (see Figure 17) presents a different trend for regions that currently have well-developed waste infrastructure[dd], and for regions where infrastructure is lacking today.[ee] For the first group – regions with well-developed infrastructure – public expenditure in the Global Rules Scenario is estimated at US$0.8 trillion (2025 to 2040 present value); whereas the equivalent figure for the Business-as-Usual Scenario is US$1.1 trillion. For the second group – regions where infrastructure is lacking today – public expenditure in the Global Rules Scenario is estimated at US$0.7 trillion (2025 to 2040 present value), an increase relative to the US$0.6 trillion estimated in the Business-as-Usual Scenario. However, as this analysis does not include cost implications from externalities, further savings could be estimated if those externalities were

cc Public spending is presenting as a total cost estimate, without balancing that cost versus revenues from EPR schemes or other policies.
dd In the analysis, Europe, the USA, Canada, Japan, the Republic of Korea and Oceania
ee In the analysis, Central and South America and the Caribbean, China, South/Southeast Asia, Central Asia, India and Africa and the Middle East.

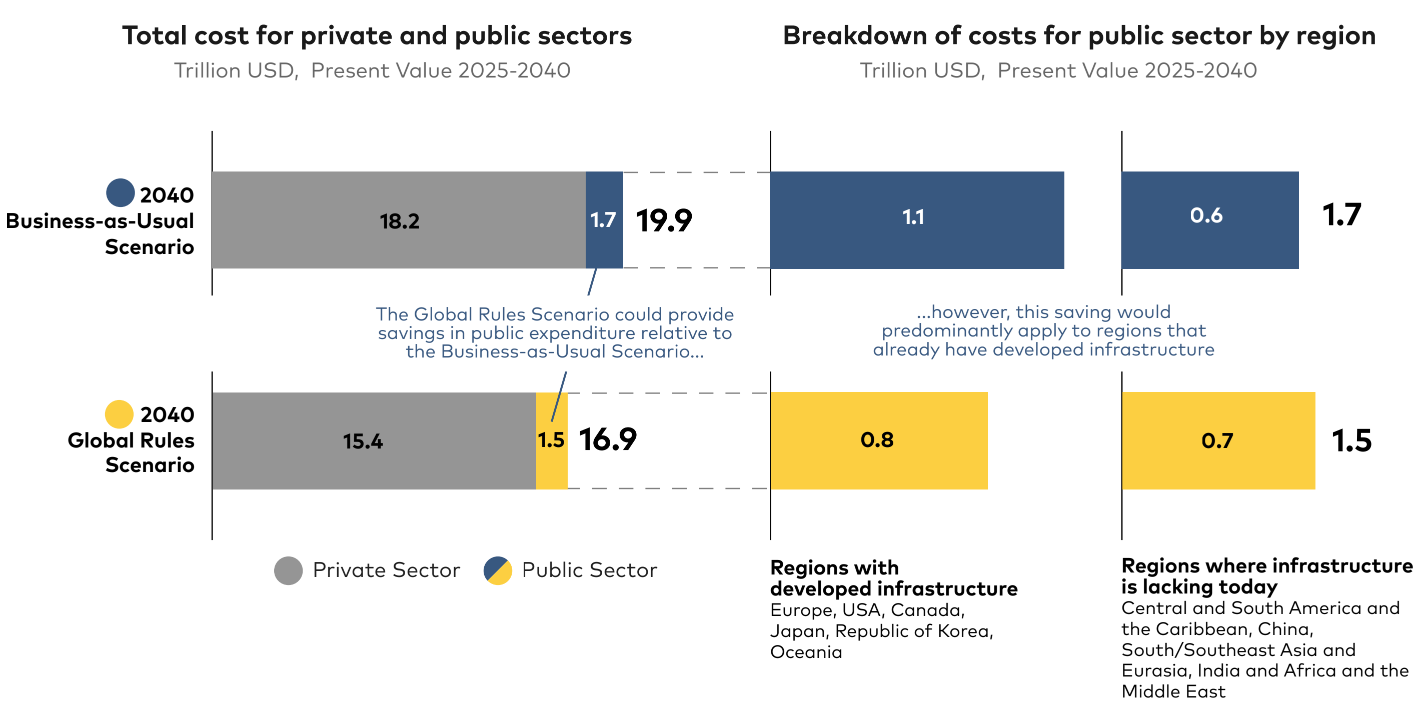
accounted for. Nevertheless potential savings, these costs would still represent a significant budgetary burden for local authorities, especially as waste management already accounts for a large part of their expenditure. For instance, in low and middle-income countries, between 10% and 20% of the budgets of municipalities is spent on waste management.[181]

The Global Rules Scenario would also require a lower level of investment from the private sector than the Business-as-Usual Scenario. This reduction would mainly be driven by lower production and conversion of virgin plastic, which require high investments. **However, some of the investments in the Global Rules Scenario would be in new businesses or models (eg, reuse) that have yet to prove their economic viability and would thus have higher risk.** Implementing the right policies across the five pillars discussed in this report would de-risk these investments and allow private capital to flow into the required solutions, such as reuse, material substitution, recycling and advanced sorting.

In the Global Rules Scenario, virgin plastic fees and EPR schemes would operate on a net cost basis. This means that fees would be set at a level that fully funds this public expenditure cost, while also allocating revenues for solutions across the plastic lifecycle. In practical terms, however, each region implementing these policies would need to conduct specific studies to ensure that fees are set at the right level in the local context, in order to account for

FIGURE 17 **Estimated costs by scenario**

Public expenditure from 2025–2040 in the Business-as-Usual Scenario would equate to $1.7 trillion at present value; while that under the Global Rules Scenario would equate to $1.5 trillion. This saving, however, would predominantly apply to high-income regions that already have well-developed infrastructure.



Figures show the net present value of OpEx and CapEx from 2025–2040 in the Business-as-Usual Scenario and the Global Rules Scenario, divided between the public sector (collection, sorting and disposal systems) and the private sector (production of plastic and substitute materials, recycling capacity, new business models such as reuse). All numbers are subject to rounding.

any unintended consequences. In addition, these funds could be deployed to cover important areas that are not modelled in this study, such as research and innovation, testing to prevent health and biodiversity risks, and support for vulnerable communities.

New business models, substitute materials and recycling systems would generate employment through a shift away from virgin plastic

The Global Rules Scenario would have a net-neutral impact on employment at the global level. However, it would require a transition in labour between regions and industries from virgin plastic production to other materials and new models (eg, reuse).

The analysis estimates annual employment by forecasting the number of jobs required at each stage of the plastic lifecycle for a given tonne of plastic. It also includes estimates for when plastic is substituted with other materials. However, the analysis does not provide an estimate of the regions in which most of these jobs will be created, as jobs linked to production would rely on international supply chains that are not modelled here. The analysis does not include estimates of how automation over time would impact employment creation by unit of output, by industry.

The Business-as-Usual Scenario would result in 12 million jobs by 2040. Most of these (80%) would be in the virgin plastic production and conversion industries, with the remainder in waste management. The Global Rules Scenario, with its virgin plastic reduction targets and uptake in recycled plastics, as well as new sustainable business models, would result in an equivalent number of 12 million jobs. These would be distributed among virgin plastic production and conversion (40%), new models such as reuse (16%), production of other materials (20%) and waste management (24%). Thus, the Global Rules Scenario would result in a **transition of labour from plastic production and conversion to the production of other materials and new business models.** This transition would not be balanced between industries or sectors; and importantly, it would not be balanced from a geographical perspective – some regions could end up losing employment. It would thus be critical to put in place controls to ensure a socially just transition, as this scale of change could have unintended consequences for livelihoods – particularly among vulnerable communities.

Priorities for further innovation, research and data

Even after the implementation of the policies in the Global Rules Scenario, 13 Mt of plastic would end mismanaged annually by 2040, requiring further research, data gathering and monitoring, and innovation – starting immediately.

It is assumed that the policies proposed in the Global Rules Scenario would be applied concurrently across all geographies. However, the Global Rules Scenario is limited by technological, economic and behavioural constraints; and by 2040, 13 Mt of plastic would still end up mismanaged, out of which it is estimated that 4 Mt would end up in dumpsites, 2 Mt would be burned in the open and 7 Mt would be released into land and water.

Of this 7 Mt of plastic volumes released into land and water, microplastics emissions would account for 5 Mt, with the remaining mismanaged plastic comprising a mix of macroplastics from all sectors. This section identifies areas for research, data gathering and innovation to bridge this gap and further mitigate the release of plastic volumes into the environment. The impact of these potential innovations has not been modelled, given the high levels of uncertainty.

Further research and innovation are needed to reduce microplastics emissions, scale reuse models, improve safe recycling, expand collection in rural areas, and develop and evaluate safe alternative materials.

Eliminate, or at least capture, all microplastics emissions (see Figure 15): As discussed, research, evidence and solutions to prevent microplastics emissions are currently lacking. Innovation is needed to improve the design of tyres, paints and textiles to minimise the release of microplastics without having to rely on more complex downstream solutions such as wastewater capture systems. Examples include further research and development of innovations such as adhesive or peelable paints – especially marine paints – to reduce wear and tear, and to control their removal and disposal; and new solutions to tyre abrasion, such as devices that capture tyre particles at source, low-wear tyres, stormwater road management and road sweeping, and standardised measurements of wear and tear to support better design requirements and thresholds.[182] Other sources of microplastics emissions (eg, agricultural plastics, textiles during use) should also be investigated, to broaden our understanding of the field and develop policies and technical solutions to tackle these new sources.

Scale reuse models to further reduce plastic volumes (see Figure 7): Reuse models have the potential to reduce consumption and waste, but they lack scale. Private sector innovation to reduce costs and GHG emissions associated with reverse logistics, and to develop solutions that promote greater consumer take-up, would significantly enhance the adoption and success of these new models. Public incentives to promote this innovation would support the scaling of these models.

Improve sorting and recycling to expand recycling beyond the 43% global rate in the Global Rules Scenario (see Figure 12): Advances in sorting – including mixed waste sorting – could improve system yields through solutions such as sensors, tracking technologies, artificial intelligence recognition and automation, ensuring better sorting and recycling to complement improvements in design. Innovation could also be required for mechanical recyclers to expand sources of viable feedstock. For instance, there is currently a lack of closed-loop mechanical recycling systems for textiles, with chemical recycling emerging as a possible solution for textiles-to-textiles recycling.

Expand collection in rural areas to achieve collection rates of 95% or above (see Figure 11): While the establishment of waste collection systems may be viable in densely populated regions with support from financial mechanisms such as EPR schemes, extending such systems to low-density rural areas presents economic challenges, particularly in low and middle-income countries. Developing technologies and solutions to improve the economics of collection systems and to better integrate the informal sector into those systems would help to resolve an important challenge in the plastic system.

Develop and evaluate safe alternative materials to reduce plastic production and consumption and to increase circularity: New substitutes that are degradable and/or highly recyclable, while offering the same barrier properties, cost advantages and versatility as plastics, could reduce reliance on plastics in current applications. For example, materials could be developed to further replace multi-layer packaging, such as sachets. Areas for exploration could include highly recyclable fibre-based materials and seaweed-based materials. Similarly, research is needed on opportunities for the use of biodegradable plastics in agriculture, as well as in some relevant applications in fisheries and aquaculture. New substitutes should be developed only if their evaluation has confirmed that there is no risk of unintended consequences or negative impact (eg, on GHG emissions, land use, water use or human rights).

Beyond specific areas for innovation, further knowledge, research and data would be required.

Currently available data is limited and fragmented, requiring better data collection, transparency and accountability throughout the supply chain. In the context of stocks and flows, there is limited available data and transparency regarding plastics placed on markets, production, trade flows, consumption, waste generation and post-use patterns. There is a lack of field data measuring plastic stocks and flows throughout the value chain; and many parameters have high levels of uncertainty.

Data on plastic use, stocks and flows is particularly lacking in relation to certain applications in sectors such as fisheries and aquaculture, textiles, transportation and agriculture. For example, data on fisheries and aquaculture gear losses and waste is limited and is mostly based on small samples; while no data was found on plastic use in the fast-growing seaweed sector.[183] Similarly, in the textiles sector, virtually no data was available on the fate of exported, unsold or returned items. Data is also lacking on the end-of-life fate of used vehicles exported to secondary markets. On plastic used in agriculture, limited data is available on potential impact of levers on consumption and design (eg, the thickness of mulching films) as well as waste generation. On microplastics, limited data on emissions from plastics and fertilisers in the agriculture sector; and on emissions from textiles during the use phase.

Available data is limited and fragmented, requiring better systems to monitor performance and develop solutions

There is also a need to expand data and transparency in relation to plastic formulations, chemicals and additives, and their possible impact on human health and biodiversity. Private companies could be required to become more transparent and accountable in key areas – for example, by providing data on plastic composition and chemical formulations in products (including polymers, chemicals and additives used); and data inventories of plastic volumes produced, traded (eg, volumes of pellets mismanaged) and incorporated into products.

> **Scientific guidance would be required on further solutions and policies**

Finally, information on subsidies that benefit the plastic industry may also be needed, in order to inform fossil fuel subsidy reform.[184] Studies indicate that governments provide support to fossil-fuel production through grants or tax breaks in at least 45 countries;[185] while government mediated loans and loan guarantees – as subsidy equivalents – add up to several tens of billions of dollars annually.[186]

As policy interventions are considered, scientific guidance to ensure effectiveness and the avoidance of unintended consequences would be required. Effective policies to tackle the challenges within the plastic system should be developed through equitable and inclusive processes involving diverse stakeholders and communities. Scientific guidance would be instrumental in ensuring that policy decisions are taken with the right context and understanding of the current evidence and data, as well as in identifying further areas for research and monitoring.

Examples of issues on which the scientific community could further support policy decisions include **sustainable levels of production and consumption of primary plastic polymers needed to ensure alignment with the Paris Climate Agreement;** the impact of plastic and micro/nano-plastics on human health and biodiversity; inventory, evaluation and risks of plastics and chemicals of concern; and economic analysis of the level and impact of virgin plastic fees and EPR fees to identify the right level of fee by country.

Data monitoring and reporting systems should also be required to evaluate performance and compliance once policy implementation begins. Systems that gather and track data from the public and private sectors would be critical in facilitating understanding, calibrating policies and identifying the most suitable solutions. Efforts should be made to develop a globally harmonised data monitoring and reporting mechanism, and to collaborate on capacity building and governance to support lower-income countries in developing and funding this mechanism.

Policy analysis would also be needed on health and toxicity to develop lists of substances that should be phased out and substances that can be classified as safe. As previously outlined in Box 2, many substances used in plastic production have been identified as of concern due to their possible impact on both human health and biodiversity across the plastic lifecycle. Moving forward, lists of problematic polymer applications and chemicals to phase out could be expanded; and criteria could be established for categorising specific classes of polymer applications and chemicals of concern as 'safe'. Currently, information, data and transparency regarding chemicals of concern are lacking, with producers not disclosing the formulations and chemicals used in their processes. The lack of access to such information hinders sufficient risk assessment and control by regulators and health and safety authorities.[187] **Guidance from the scientific community would thus be needed to formulate the right approach to the phaseout of problematic plastics and additives, in addition to increased data availability, transparency and testing across the plastic value chain.**

Concluding remarks

Given the systemic nature of plastic pollution, global and coordinated action is needed across the plastic lifecycle to drive real systems change. The potential introduction of an international, legally binding instrument on ending plastic pollution gives UN member states and stakeholders a unique opportunity to scale the necessary action, international coordination and collaboration towards this goal.

The Global Rules Scenario shows how the implementation of far-reaching policies across all geographies, concurrently and across the plastic lifecycle, could significantly reduce plastic production and consumption and mismanaged plastics by 2040, while also mitigating GHG emissions. **The establishment of common global rules through an international, legally binding instrument presents a unique opportunity to make this a reality.** This would require transformations in our economies and societies; changes in consumer behaviour and industry design; major expansions of public and private infrastructure; substantial investments; and transitions in labour markets. The Global Rules Scenario assumes the mandatory application of these policies across all regions; but even then, the analysis shows that plastic mismanagement would remain an issue for the most complex sources of pollution, such as microplastics. Thus, to have a real chance of solving this challenge, global legally binding rules and international frameworks will be needed to coordinate and enable this transition.

> **15 far-reaching policy interventions could take us a long way in the journey towards ending plastic pollution by 2040**

To be effective, the 15 policy interventions highlighted in the Global Rules Scenario should be complemented by implementation enablers to address governance and institutional gaps globally, regionally and nationally. These could relate to financial assistance, capacity building, technical assistance and technology transfer – as defined by the INC Options Paper ahead of INC-2 – as well as national action plans, national reporting, compliance and periodic assessment and monitoring. The results presented assume that these would be put in place; otherwise, it is unlikely that the assumptions around compliance, enforcement and effectiveness of policies estimated in the analysis could be achieved.

It is also crucial to acknowledge that plastic pollution is a broader problem; and that critical issues such as health risks, chemicals of concern and negative impacts on biodiversity – which are not addressed in detail in this report – must also be tackled. **Hence, the Global Rules Scenario is intended merely as a starting point for systems change in the global plastics system, rather than as a comprehensive solution. The policies outlined in this report should thus be complemented by further levers to align the global plastics system with the Paris Climate Agreement, address health concerns, ensure a just transition and reduce negative impacts on biodiversity.**

Yet this report shows that implementing 15 far-reaching policy interventions could take us a long way in the journey towards ending plastic pollution by 2040.

Glossary

Capital expenditure (CapEx)	Funds used by an organisation to acquire or upgrade assets such as property, buildings, technology or equipment.
Closed-loop recycling	In the context of this model, the recycling of plastic into new plastic products within the same application (eg, packaging to packaging; textiles to textiles).
Dumpsites	Central locations where collected waste is deposited but is not controlled through daily, intermediate or final cover, thus leaving the top layer free to escape into the environment through wind and surface water.
Engineered landfill	Central locations where collected waste is deposited and controlled through daily, intermediate and final cover, thus preventing the top layer from escaping into the environment through wind and surface water.
Incineration with energy recovery	The destruction and transformation of material to energy by combustion.
Informal sector	Individuals and enterprises involved in private-sector recycling and waste management activities that are not sponsored, financed, recognised, supported, organised or acknowledged by the formal solid waste authorities.
Mechanical recycling	Operations that re-process after-use plastics through mechanical processes (eg, grinding, washing, separating, drying, re-granulating, compounding) without significantly changing the chemical structure of the material.
Microplastics	Primary microplastics are those originally produced or directly released into the environment as micro-sized particles (less than 5 millimetres in size). Secondary microplastics are micro-sized fragments originating from the degradation of large plastic waste into smaller plastic fragments once exposed to the environment.
Mismanaged plastics	In the context of this report, refers to any macroplastic or microplastic volume that does not end recycled or disposed of in a controlled manner. It would include those in unsanitary landfills / dumpsites, burned in open pits, or released into land or aquatic environments.
Mono-material packaging	Items made from a thin single plastic polymer, such as plastic wraps and bags.
Multilayer/multi-material packaging	Items made of multiple plastic polymers that cannot be easily and mechanically separated, or items made of plastic and non-plastic materials (eg, thin metal foils or cardboard layers) that cannot be easily and mechanically separated.
Open burning	Waste that is combusted without emissions cleaning.

Open-loop recycling In the context of this model, the recycling of materials for use in a different application (eg, packaging to textiles, textiles to benches, durables).

Plastic pollution Broadly, all emissions and risks resulting from plastics production, use, waste management and leakage (follows definition from OECD).

Plastic-to-plastic conversion Petrochemical feedstock produced through chemical conversion technologies that can be reintroduced into the petrochemical process to produce recycled virgin-like plastic.

Plastic waste in the context of this report, encompasses any plastic volume that has ended its use-phase or that has been lost or released during any other phase. This would include any plastic no longer in use-phase, microplastic releases, mismanaged pellets, or loss of fishing / aquaculture gear.

Recycling rate In this report, the (effective) recycling rate of a region or sector refers to the volumes of recycling output divided by the total volume of plastic waste generated in that region or sector.

Region The geographical groups by which the model segments the data and analysis, as follows:

- Europe;
- the USA and Canada;
- Japan, Republic of Korea, New Zealand and Australia;
- Central and South America and the Caribbean;
- China;
- South/Southeast Asia and Eurasia (excluding countries in other groups);
- India; and
- Africa and the Middle East.

(See the Technical Appendix for further details).

Rigid packaging An item made from a single plastic polymer that holds its shape, such as a bottle or tub.

Single-use plastic A product that is made wholly or partly from plastic and that is used once (or for a limited period of time) before being discarded. Single-use plastic is not conceived, designed or placed on the market to accomplish, within its lifespan, multiple rotation cycles by being returned to a producer for refill or reused for the same purpose for which it was conceived.

Virgin plastics In the context of this report, refers to plastics manufactured from fossil-based (e.g. crude oil) or biobased (e.g. corn, sugarcane, wheat) feedstock that has never been used or processed before (follows definition from OECD).

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Towards Ending Plastic Pollution by 2040

15 Global Policy Interventions for Systems Change

'Towards Ending Plastic Pollution by 2040' was commissioned by the Nordic Council of Ministers for the Environment and Climate and produced by Systemiq. The report presents a set of 15 far-reaching policy interventions towards ending plastic pollution by 2040. If universally adopted and supported by comprehensive globally binding rules in the upcoming international instrument on ending plastic pollution, these could cut annual mismanaged plastic volumes by 90% and annual virgin plastic production by 30% by 2040 relative to 2019 levels. Yet, the report highlights that more ambitious efforts are needed to align with the Paris Climate Agreement and holistically address plastic pollution.

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