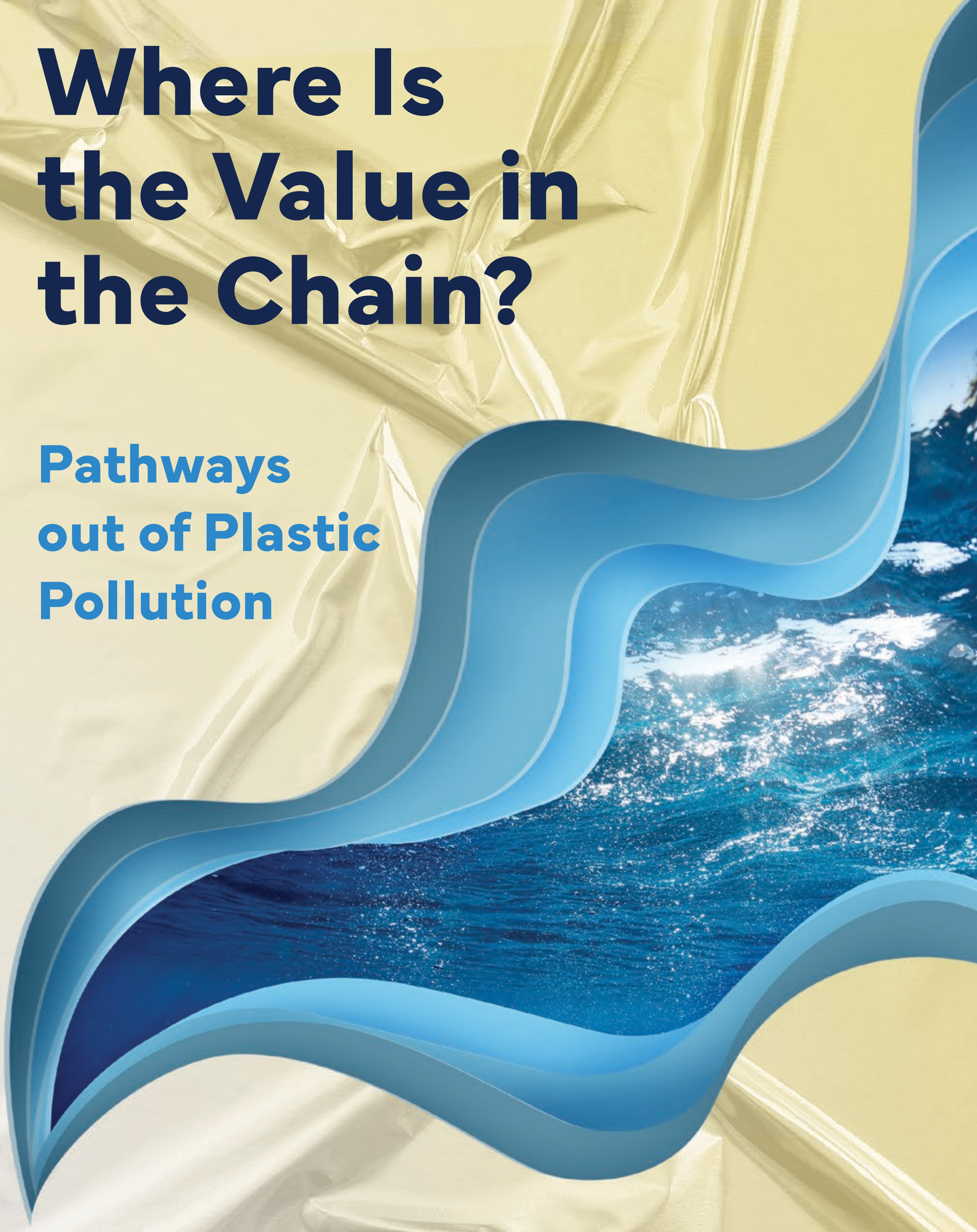
Where Is the Value in the Chain?

Pathways out of Plastic Pollution



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Foreword

Plastic waste is omnipresent—it is in the air we breathe and the fish we eat, and it is overwhelming our oceans. More than 98 percent of plastic waste accumulates on land, where it then progressively pollutes inland waterways leading to the ocean. With no action, the annual flow of plastic into oceans will nearly triple by 2040. Plastics have had many positive impacts on development—from use in medical care to construction and in transport—but today, these are increasingly outweighed by the negative consequences on the health of people and the environment.

Over the past decade, the public and private sectors have pioneered policy reforms to reduce plastic pollution. However, these efforts are insufficient against the current production volume, let alone in addressing the discarded plastics of prior decades that already contaminate our planet. And this comes at a price: Plastic pollution could trigger annual financial risk to businesses amounting to US$100 billion in 2040. Moreover, plastic production is expected to triple by 2050.

Tackling plastic pollution needs bold action. A critical first step was the resolution adopted by 175 countries in March 2022 at the United Nations Environment Assembly (UNEA) to take coordinated action to address the full life cycle of plastic. The goal of the UNEA is to develop an international legally binding instrument by 2024 to end plastic pollution from source to sea.

This is a vital step, and we at the World Bank stand ready to support countries in this effort. But commitments need to turn into action and will require the following:

- **First, a clear understanding of the policy landscape and, critically, the tradeoffs to end plastic pollution:** Current efforts and policies to tackle plastic pollution are inconsistent and fragmented. Policy makers need better and more comprehensive tools in order to make meaningful progress. With this report, our aim is to offer policy makers transparent guidance for conversations with stakeholders that set concrete targets and develop evidence-based policies to incentivize behavior change upstream and downstream, challenging producers and consumers alike to rethink their choices. Two newly developed models inform the report and its policy recommendations by considering the tradeoffs between plastic items and their alternatives and analyzing the environmental and social impacts of various policy scenarios, their financial impacts on the plastic value chain, and the fiscal impact on government budgets.
- **Second, a much more comprehensive approach to addressing plastic pollution:** Current approaches to addressing plastic pollution are too narrowly focused on

the end of the life cycle, attempting to deal with plastic waste when it is already too late. Systems are struggling to handle the amount of waste being generated, which is exponentially increasing. Moreover, as plastic products are discarded, their value to the economy is also lost. A more effective approach to the issue should consider a mix of policy instruments along the whole plastic life cycle. That means also avoiding unnecessary plastics, increasing reuse and recycling, *and* reducing mismanaged waste. Such a comprehensive policy mix can only be developed gradually, seizing opportunities for quick wins while also working toward longer term, more circular solutions.

- **Third, strong collaborations between the public and private sectors:** Bringing the private sector along will be vital to enabling countries to meet their global commitments while being effective within local economies. Preventing plastic pollution requires the creation of sustainable markets that bring economic actors together. This can be enabled by a comprehensive set of policy instruments, including incentives for the private sector to invest and innovate along the whole plastic life cycle, from changing product design to preventing leakage to the environment and improving solid waste management practices.

Today the World Bank supports efforts in more than 50 countries to help address short-term challenges of plastic pollution as well as the longer transition to a more circular economy. This work includes helping with the development of action plans, building capacity, and conducting the analytics necessary to identify solutions along the whole plastic life cycle. This report shares innovative scientific tools to better explain the complex, emerging field of plastic pollution management and help countries prepare for agreements and legally binding instruments to reduce plastic waste.

For countries, finding a pathway out of plastic pollution is not only about improving the quality of the environment and oceans. It is also about improving economies, public health, and livelihoods: helping to turn the tide for people and the planet.

Mari Elka Pangestu
Managing Director of Development Policy and Partnerships, World Bank

Preface

Where Is the Value in the Chain? Pathways out of Plastic Pollution aims to support policy makers in their efforts to address plastic pollution. By examining the economic and financial implications of plastic management, the report provides key recommendations on how to create a comprehensive approach to addressing plastic pollution and to help policy makers make informed decisions for plastic pollution management.

The report brings together new evidence from three analytical undertakings:

- **Tackling Plastic Pollution: Toward Experience-Based Policy Guidance (World Bank 2022c)**—A review of existing literature and a summary of findings from the ex post analysis of the effectiveness of plastics policies in 10 countries and states (Bangladesh, Bulgaria, Fiji, Italy, the state of Kerala in India, Malaysia, Morocco, Rwanda, St. Lucia, and Tanzania) and an evidence-based policy guidance aimed at policy makers and stakeholders involved in design, implementation, and evaluation of policies to manage plastic pollution.
- **The Plastic Substitution Tradeoff Estimator** (the Estimator, described in World Bank 2022b)—An innovative model that estimates the external costs of 10 plastic products and their alternatives along their entire life cycle, developed and piloted in five countries (Bangladesh, Mozambique, Nigeria, St. Lucia, and Vietnam). The Estimator can be applied in any country to identify what substitution materials—or what combination of them—would perform best in a given scenario, and to examine tradeoffs between plastics and alternatives to help establish targets for reduction and substitution.
- **The Plastics Policy Simulator** (PPS, described in World Bank 2022a)—A country-level, data-driven model for policy analysis to better describe the impacts of different policy instruments and policy packages on individual economic agents and on the plastic value chain at large. The PPS has been developed as a universal model and piloted in Indonesia. Its objective is to support policy makers and others in government, industry, and civil society in search of policy solutions to stem the flow of plastics by bringing an evidence-based approach to policy.

Where Is the Value in the Chain? Pathways out of Plastic Pollution is structured in five chapters:

- Chapter 1 presents the drivers of plastic pollution and market failures that led to it.
- Chapter 2 presents the key building blocks of the policy process.
- Chapter 3 focuses on the process of setting targets and how the Estimator contributes to it.
- Chapter 4 examines the selection of policy instruments and how the PPS can support policy makers in this choice.
- Chapter 5 presents results and lessons from this work.

The work consolidated in this report can help countries achieve a green, resilient, and inclusive recovery from the COVID-19 (coronavirus) pandemic. Understanding the impact of changes in plastic consumption and plastic waste generation can help countries identify opportunities for reconstruction. *Where Is the Value in the Chain? Pathways out of Plastic Pollution* identifies the external costs of such changes, helps prioritize policy targets in terms of life cycle phase and plastic product, analyzes policies, and simulates policy packages; the review of the experience and lessons from the development and implementation of policies to manage plastic pollution provides evidence-based policy guidance. The PPS builds on these policies and will help countries identify critical policy reforms and financing needs to improve sustainable plastic value chains by making them commercially viable for investors, fiscally sustainable for governments, and able to create good jobs.

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The World Bank Environment, Natural Resources, and Blue Economy Global Practice prepared the document in collaboration with the Urban, Rural, Land, and Resilience Global Practice; the Finance, Competitiveness, and Innovation Global Practice; and the International Finance Corporation's Manufacturing, Agriculture, and Services global team and Climate Strategy and Business Development global team.

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Executive Summary

Plastic Pollution, a Development Challenge Resulting from Multiple Market and Policy Failures

Plastics have been a development driver for decades but have turned into a development problem because of their omnipresence in the environment. Plastics have become ubiquitous in modern life, given their unique properties. In recent decades, however, the downside of plastic consumption to society has become apparent as plastic waste has incurred huge costs to the environment, biodiversity, livelihoods, and human health. In addition, the impacts of plastics on climate change are already considerable and are expected to increase.

Marine litter and plastic pollution have attracted much attention and many commitments from governments and the private sector alike in the past few years. The adoption in March 2022 of a resolution to establish an intergovernmental negotiating committee to develop a legally binding global instrument to end plastic pollution in the world's oceans, rivers, and landscape demonstrates willingness to act. The resolution has received broad support from the private sector.

Policies to curb plastic pollution have had limited success in many developing countries because of various market and policy failures. These failures create a vicious cycle of distorted production patterns and consumer preferences, resulting in the entrenched linear, throwaway plastic value chain model. The challenges range from lack of data with which to properly understand the problem in the first place, to misaligned incentives and financing, to capacity constraints in implementing existing and new policies.

Policy and market failures create bottlenecks and broken links in the plastic value chain and prevent market-based investment and consumption decisions toward plastic circularity:

- There is a lack of incentives to influence decisions of producers and consumers of plastic materials and products before they become waste. Existing policies to address plastic pollution usually focus on waste management, although some countries try to ban or charge for the use of certain plastic products, and extended producer responsibility systems are emerging. While improving waste management systems is fundamental, it is not enough to prevent plastic pollution. Without incentives for upstream reduction of consumption of single-use plastics, the exponential volumes of waste overstretch downstream waste management systems.

This risk is even more acute in countries with weak capacity and governance in the solid waste management sector.

- Government interventions are often fragmented and incoherent. This results in limited success of policy instruments, excess burden on public budgets, and the risk of shifting the problem from one place to another rather than solving it comprehensively. An example is an upstream state support to plastic producers (such as subsidizing hydrocarbons used in the petrochemical industry) coexisting with downstream subsidies to waste management; they cancel each other's effects and waste public funds.
- Many governments do not consider the environmental and societal costs of plastics and their alternatives when formulating targets and developing policies. Unlike other pollution problems, the external costs of plastics are generated not only at different stages during production and consumption, but also in multiple places in the postconsumption phase, after the plastic product has become waste. This complexity, exacerbated by multiple interest groups operating along the plastic life cycle, often clouds the decision-making process.

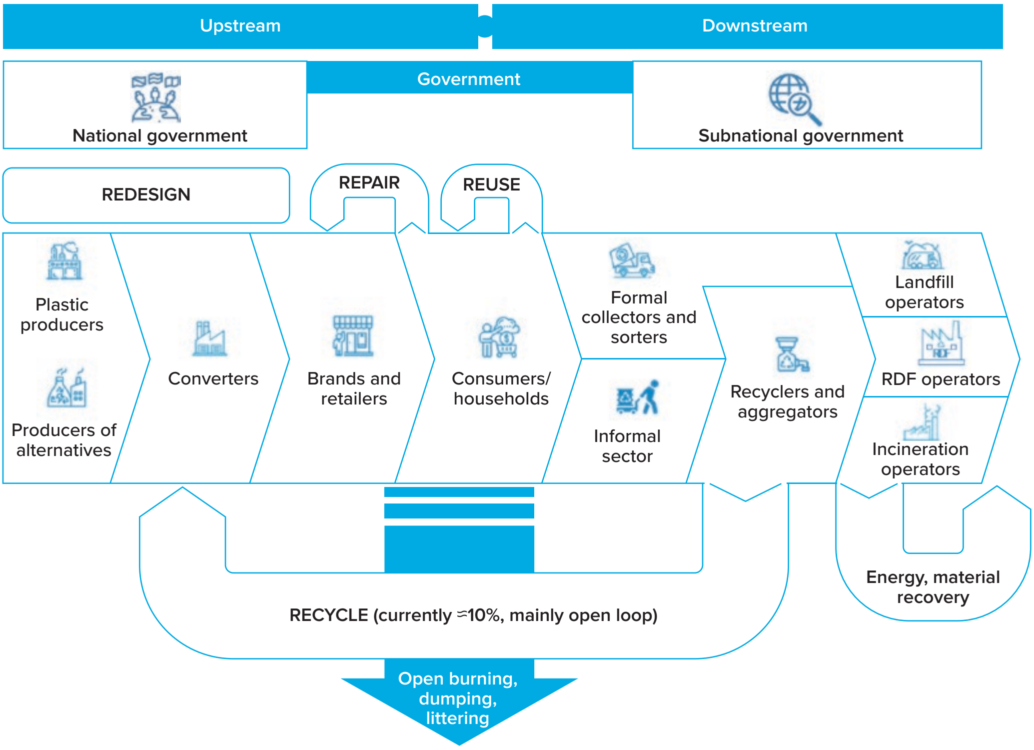
Need for Comprehensive Mixes of Coherent Plastic Management Policies

The Pathways out of Plastic Pollution (3P) analysis highlights that a comprehensive mix of coherent policy instruments is needed to prevent plastic pollution. In other words, policies should align incentives for multiple actors operating in the whole plastic life cycle to jointly contribute to sustainable solutions through voluntary market transactions. For example, taxes, product standards, and behavioral nudges should encourage consumers to request that upstream producers and brands deliver packaging and products that contain no plastic or are made of plastics that can be reused or easily recycled. This is a precondition for unlocking the commercial values in the plastic value chain, which is depicted in figure ES.1.

A comprehensive mix of coherent policies can turn the value chain from linear to circular and reduce the volume of plastic waste. Such policies reduce profits in the linear business models of upstream plastic producers, converters, and consumer goods companies while increasing profits of green business models. This attracts private investors and service providers, which reduces the need for public finance to mitigate plastic pollution. Circular solutions can also have positive effects on the climate and jobs. Upstream fiscal and financial circular policy interventions not only encourage less waste generated but also raise additional revenues that can be used in principle to offset negative impacts on poor and vulnerable households (see figure ES.3 later in this chapter).

The following key principles should guide the pathways out of plastic pollution and be tailored to the needs and capacity of each country.

FIGURE ES.1 **Key Economic Actors Operating in the Plastic Value Chain and Circularity Pathways**



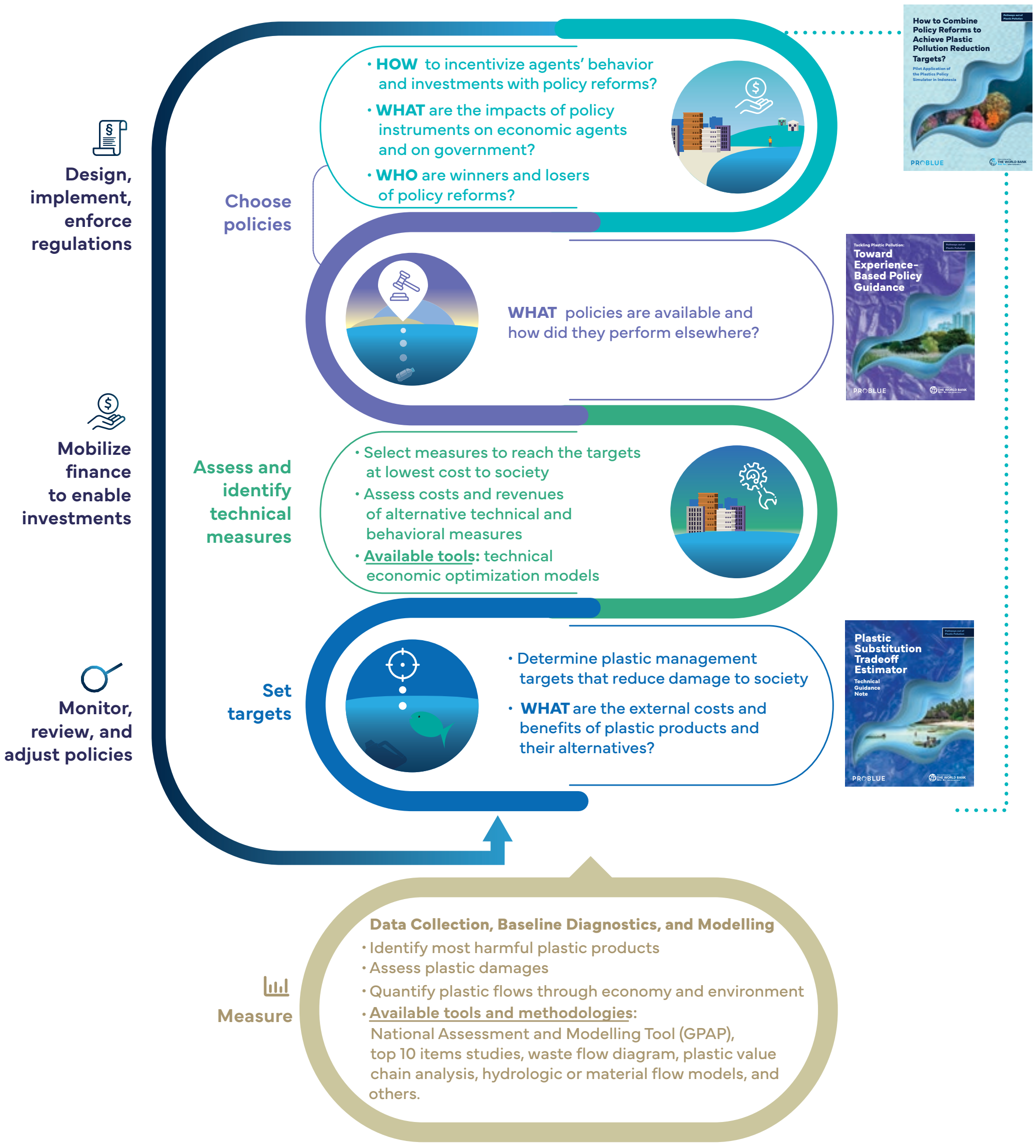
Source: Adapted from World Bank 2022a.
Note: RDF = refuse-derived fuel.

Develop Strategies and National Action Plans Tailored to Country Context

Under the forthcoming global legally binding instrument to end plastic pollution, countries may need to develop action plans to manage plastic pollution.

Such plans should combine traditional solid waste management solutions with those closer to pollution control, including industrial and product policies. Building blocks of national action plans (figure ES.2) include (a) measuring (collecting data and running baseline diagnostics), (b) setting targets to manage plastic pollution, (c) identifying and assessing technical and behavioral measures to reach the targets, (d) choosing a mix of policy instruments to encourage implementation of these measures, (e) designing, implementing, enforcing, and monitoring policies, as well as providing economic

FIGURE ES.2 Building Blocks of Plastic Pollution Management



Design, implement, enforce regulations

Mobilize finance to enable investments

Monitor, review, and adjust policies

Choose policies

- **HOW** to incentivize agents' behavior and investments with policy reforms?
- **WHAT** are the impacts of policy instruments on economic agents and on government?
- **WHO** are winners and losers of policy reforms?

WHAT policies are available and how did they perform elsewhere?

Assess and identify technical measures

- Select measures to reach the targets at lowest cost to society
- Assess costs and revenues of alternative technical and behavioral measures
- **Available tools**: technical economic optimization models

Set targets

- Determine plastic management targets that reduce damage to society
- **WHAT** are the external costs and benefits of plastic products and their alternatives?

Measure

Data Collection, Baseline Diagnostics, and Modelling

- Identify most harmful plastic products
- Assess plastic damages
- Quantify plastic flows through economy and environment
- **Available tools and methodologies:**
National Assessment and Modelling Tool (GPAP), top 10 items studies, waste flow diagram, plastic value chain analysis, hydrologic or material flow models, and others.

Source: World Bank.
Note: GPAP = Global Plastic Action Partnership.

actors with access to alternatives and to finance, and (f) reviewing and evaluating the performance and adapting the policy mix to changing conditions.

The simulations of financial, social, and fiscal impacts of alternative policy instruments on firms, households, and government help avoid mistakes in later implementation.

Through ex ante simulations of policy impacts, policy makers can understand how economic actors could react to various policy instruments, as a preamble to more detailed policy design. Simulations are beneficial in early stages of strategy development because they provide a broad view of the plastic life cycle and a way to compare possible policies, their interactions, and sequencing. The Plastics Policy Simulator (PPS) was developed under the 3P analysis to meet that objective.

The 3P models also help assess the climate and employment impacts of policies proposed by various stakeholders at the national level.

The PPS estimates direct greenhouse gas emissions across the whole plastic life cycle in the business-as-usual scenario with alternative policy reform packages. The results indicate that a circular comprehensive policy package could mitigate climate change by keeping greenhouse gas emissions at current levels, compared with a significant increase in the absence of any policy action. These policy reforms also have the potential to shift employment from low-skilled jobs in waste management to more productive and knowledge- and technology-intensive jobs across the plastic value chain. Furthermore, substituting single-use plastics with locally produced alternatives could have similar positive effects on employment, as also demonstrated by the Plastic Substitution Tradeoff Estimator.

Setting targets should be informed by the full social costs of plastics and their alternatives.

An estimation of the tradeoffs and footprint of the various products is recommended to identify the costs and benefits of single-use plastics and possible substitutes. Decision-makers can use the Plastic Substitution Tradeoff Estimator to understand this better.

Combine Policy Instruments in a Coherent Way

Policy coherence is about (a) fostering synergies across the plastic value chain, (b) managing tradeoffs, and (c) aligning objectives of critical actors. The following elements of a comprehensive and coherent policy package are essential:

Preventing plastic pollution requires the creation of sustainable markets.

Markets emerge when economic actors get together driven by individual self-interests to cooperate. Circular-economy markets do not emerge spontaneously because of several market failures. Thus, markets need to be enabled by a comprehensive set of coherent policy instruments. These policy instruments combine upstream emission control policies, new product policies, incentives to change consumer behavior, and incentives for the private sector to invest and innovate along the whole plastic life cycle to prevent leakage to the environment and improve solid waste management practices. A wide range of instruments can be tailored to specific conditions, whether regulatory (for example, bans, standards, input thresholds, or limits), economic (for example, taxes and fees, subsidies, extended producer responsibility, and deposit-refund schemes), or behavioral (for example, awareness-raising campaigns, consumer education, environmental labeling, or "nudges," such as making single-use plastic products less accessible to retail customers).

Tailoring policy interventions to manage political economy issues between winners and losers among economic actors is a crucial condition for sustainable market creation. Not every sector or firm gains equally from introducing policies against plastic pollution, and policies have different distributions of impacts. Some companies operating upstream in the plastic value chain (plastic producers, converters, some consumer goods companies, and retailers) may experience a decrease in revenues and profit margins because of circular measures. Waste management companies, recycling businesses, and waste pickers in the informal sector, on the other hand, could profit from circular policies that move profit centers to the downstream part of the value chain. New centers of value and profit could also be created around design, new materials, reuse services, and delivery models.

In any suite of policy instruments, upstream incentives for producers and consumers are essential for circularity.

Upstream policy interventions make product substitution, reuse, repair, and recycling commercially viable. They incentivize more sustainable materials, products, and business models. Product standards and fiscal incentives to design products for greater durability and easier repair and recycling increase demand and profit margins of circular activities. Upstream instruments, such as extended producer responsibility fees, can also be designed to provide revenues to improve solid waste management systems (for example, to ensure sustainable cost recovery of collection and sorting). This in turn can attract commercially driven private investments, induce innovation, and create productive jobs in circular plastic economic activities, such as sorting, closed-loop recycling, and material recovery.

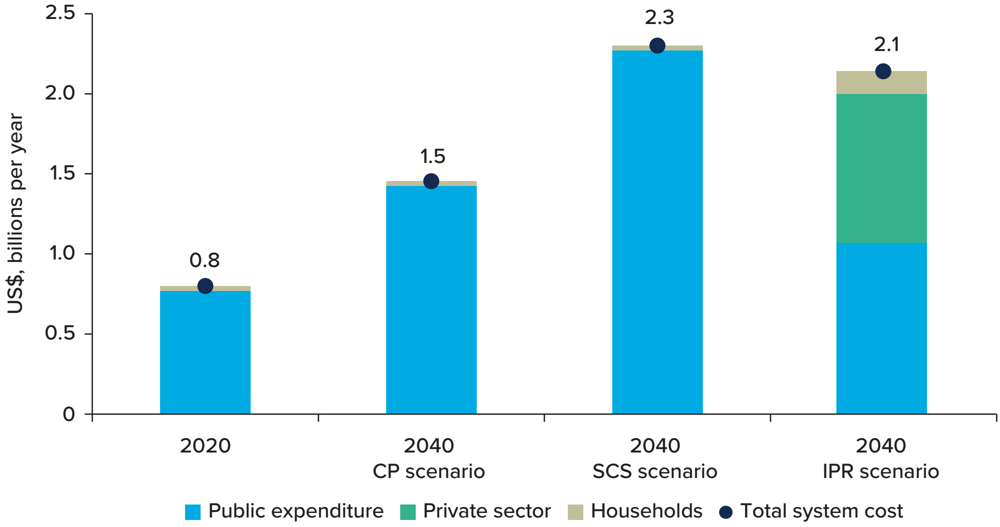
The suite of policy instruments must be coherent, since fragmented and misaligned plastics policies create confusing incentives that aggravate the plastic pollution problem while wasting public funds. An example is subsidizing hydrocarbons used to produce virgin plastics and subsidizing waste management systems. Identifying multiple policy instruments that coherently address different market and policy failures supports sustainable outcomes, with economic actors finding it commercially and privately attractive to switch to circular, environmentally sustainable production and consumption patterns.

A comprehensive approach must include improving solid waste management systems.

Improving solid waste management includes three key steps: (a) establishing waste collection services and ending illegal dumping to protect public health, (b) improving waste treatment and disposal to provide environmental protection, and (c) implementing systems and incentives to enable the transition to sustainable resource management that follows the waste hierarchy principles. Moving up the waste management hierarchy from uncontrolled dumping to safe disposal to energy recovery and recycling is expensive, because it requires investments in improved infrastructure and results in higher operational costs for collection, sorting, and waste treatment. However, focusing only on improving solid waste management will not result in a sustainable reduction of plastic pollution in the long term, as shown in this report. It can also significantly increase the financing burden for public budgets and households. Upstream measures, such as standards, taxes, and fees on hard-to-recycle, single-use plastic products, can be designed to convert these fiscal liabilities in waste management into private sector assets by creating enabling conditions for commercially viable investments in circular business models. Upstream policy measures also minimize waste volumes in the long term, thereby reducing the downstream costs for waste management.

Figure ES.3 illustrates that for Indonesia, the continuation of current policies would almost double the cost of solid waste management (SWM) while increasing plastic pollution by nearly 75 percent. Traditional ways of addressing the problem through public financing of downstream waste management systems (collection, sorting, and landfilling) would almost triple the SWM costs (to US$2.3 billion per year in 2040) and put an enormous strain on public budgets while still not reversing the trends of increasing plastic pollution. A comprehensive mix of integrated (coherent) upstream and downstream plastic management policies would reduce plastic pollution by 70 percent below 2021 levels at a lower total system cost (US$2.1 billion per year) than traditional counterfactual policies because upstream product taxes, standards, and bans would reduce the volume of plastic waste that SWM systems must handle. This would also attract commercial private financing to downstream sorting and recycling activities, reducing the pressure on public budgets.

FIGURE ES.3 **Total Plastic Waste Management System Cost and Financing Sources under Different Policy Scenarios in Indonesia**



Source: Adapted from World Bank 2022a.
Note: 2020 price level. CP = current policies; IPR = integrated policy reforms; SCS = subsidies for collection and sorting.

Comprehensive policy packages can only be implemented step by step, and sequencing matters.

Although best results are achieved when combining policy instruments, transitioning to a comprehensive approach will take time, especially in countries with weaker institutions and capacity. A journey toward a circular economy requires sequencing, starting with quick-win regulations (for example, fighting littering and preventing the most harmful and problematic plastic products from entering the economy). This report stresses that even if policy coverage is not comprehensive, it is important to ensure that fragmented policy instruments are also coherent and complementary to prevent conflicting incentives faced by economic agents.

Consider the True Cost of Plastics and Alternatives to Society

Phasing out single-use plastics requires considering alternatives and their availability, and substitution choices should be informed by their external costs and benefits compared with the plastic product they would replace. Understanding the true costs of plastics and substitutes allows policy makers to examine tradeoffs between different products.

Comparing the full life cycle costs of single-use plastic products and their alternatives enables better decision-making and facilitates agreements on priority goals to be achieved.

A transparent comparison will also counterbalance possible influences from product manufacturers and other interest groups, promoting their preferred products and materials as least harmful to the environment and society. Choosing between single-use plastic products and their alternatives requires considering all tradeoffs, including on employment and greenhouse gas emissions, and considering possible interventions that would encourage the development of new materials. It is possible to minimize costs of damages by improving product design and selecting more sustainable alternatives. Improving design can lead to reducing external costs of plastic products while maintaining their functionality. When alternatives do not exist, it is possible to choose policy instruments to enable design changes (for example, on weight) to make products reusable, repairable, and recyclable; to influence consumer behaviors; and to create markets for alternatives.

When deciding how to substitute plastic items, it is essential to compare the benefits of action (such as avoided damages caused by pollution) to the costs of achieving those benefits and the costs of alternatives.

Such cost-benefit considerations underpin choices on where to start, how ambitious plastic pollution reduction can be, and whether substitutes to disposable plastic products are appropriate in a country context. Other issues, such as feasibility, costs, food security, hygiene, and other concerns related to substituting plastic products with alternatives, also need to be considered. Policy targets, especially those related to substitution with alternative products and materials, must be tailored to local social, economic, and cultural conditions.

Filling Knowledge and Methodology Gaps

Pathways out of Plastic Pollution provides new analysis of accumulated experience from policies already applied in countries (World Bank 2022c) and forward-looking decision-making tools (World Bank 2022a, 2022b) to address key market and policy failures as outlined in this summary. Pathways out of Plastic Pollution is intended to support policy makers and technical experts in their efforts to address plastic pollution by bringing transparency and evidence into often-difficult plastic management dialogues among stakeholders who have limited information, diverging interests, and entrenched habits. It brings insights from the development of two models:

- The Plastics Policy Simulator helps address key market and policy failures, including the upstream-downstream incentive gap as well as policy fragmentation and incoherence.
- The Plastic Substitution Tradeoff Estimator increases the understanding of the external costs and environmental footprint of plastic products and their substitutes or alternatives.

Uncovering the Value in the Chain: The Plastics Policy Simulator

The PPS offers policy makers a data-driven decision-support model to better understand the likely impacts of various policy instruments and their interactions *before* they are implemented. The model is designed to support policy makers and other stakeholders in government, industry, and civil society in search of mutually agreeable and coherent policy solutions to address plastic pollution. It helps align self-interests of firms and households along the plastic value chain and establish commercially viable markets for circularity and sustainable plastic management businesses. Policy makers can use the PPS to navigate public consultations about complex policy reforms by identifying potential winners and losers, and hence political economy and social concerns to address during implementation.

The PPS traces the flow of the 20 most problematic plastic products from production of virgin resin to waste; identifies the corresponding financial flows among economic actors, households, and the government; and simulates how alternative policy instruments could redirect these material and financial flows within the plastic value chain. Policies can change the relative commercial attractiveness of technical and behavioral plastic management measures to each group of economic actors, thereby shifting the flow of plastic products and profit centers from polluting to circular activities. Because policies naturally interfere and interact with one another, the PPS captures potential synergies and conflicting incentives between different instruments. The PPS also estimates who gains and who loses from alternative designs of policy reforms. It allows users to choose from a wide menu of 24 policy instruments to simulate their impacts implemented individually or jointly, and applied immediately or in a more sequenced fashion, depending on their country's capacity and political reality.

The PPS estimates the impact of different policy scenarios on

- Volumes and types of plastic and plastic products that are reduced, reused, collected, recycled, landfilled, imported, and exported, and those that are burned or dumped into the environment;

- Fiscal revenues and expenditures of national and subnational governments;
- Financial flows affecting firms and households;
- Greenhouse gas emissions; and
- Direct employment.

The PPS can support policy makers in combining policy instruments in a coherent way, prioritizing and sequencing their implementation. It will support the transition to more circular solutions and can be used as an "umbrella" tool at different stages of the policy process, providing a big picture of the possible options before they are designed and implemented. It does not replace detailed policy design.

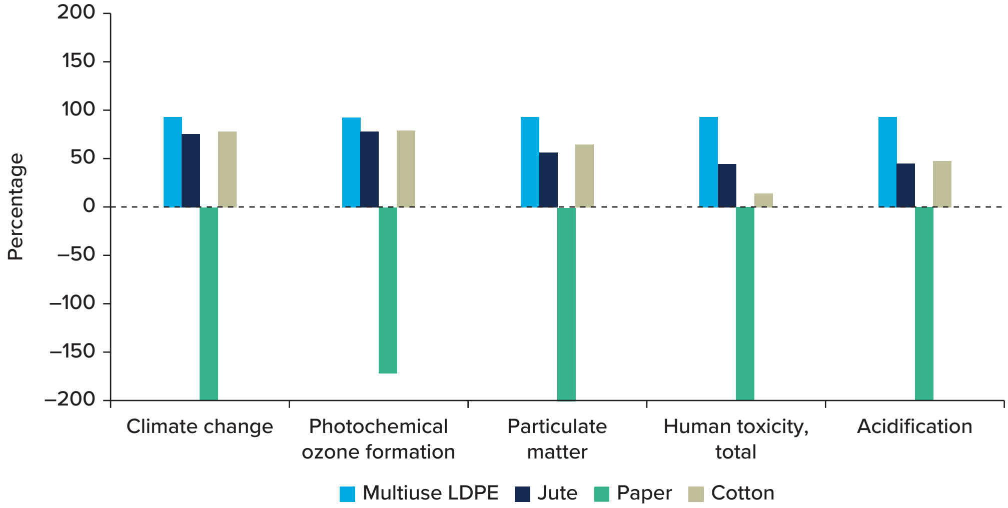
Choosing between Plastic Products and Their Alternatives: The Plastic Substitution Tradeoff Estimator

The Plastic Substitution Tradeoff Estimator helps decision-makers understand the true societal and environmental costs of plastics and their alternatives. It provides decision-makers with answers to critical policy questions on the external costs and benefits of phasing out certain single-use plastic products given available substitutes. This benefit reduces uncertainty and increases transparency of decision-making about plastics policy targets.

The model compares 10 plastic products and their alternatives and examines tradeoffs. In terms of tradeoffs, it considers greenhouse gas emissions and employment effects to support target setting for reduction and substitution. It considers the entire plastic product life cycle and ascertains which life cycle stage has the largest external costs; it takes into consideration a total of 30 potential environmental impact variables for 10 plastic products and their alternatives. The impacts range from global warming potential to flood risks caused by clogged drains, and they capture local circumstances by accounting for the distance that plastic products and their alternatives travel and for differences in plastic flows, end-of-life fate, and population density. Selected examples of tradeoffs between different impacts in figure ES.4 show that the choice between single-use plastic products and their alternatives is not always straightforward.

The model combines monetary valuation techniques with nonmonetary, quantitative, and qualitative assessments and compares single-use plastic products and their alternatives, either side by side or in scenarios that cover several products. The Estimator was piloted in five countries that represent diverse conditions and geographies to help contextualize possible plastic management choices.

FIGURE ES.4 **Example of Selected Tradeoffs Identified through Comparison of Single-Use Plastic Shopping Bags and Their Alternatives**



Source: Adapted from World Bank 2022b.
Note: A positive percentage represents an improvement compared to the base product (single-use LDPE shopping bag in this case). The opposite applies to a negative percentage. Percentages greater than 200% are not reflected in this figure. LDPE = low-density polyethylene.

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Abbreviations

3P	Pathways out of Plastic Pollution
COVID-19	coronavirus disease 2019
CP	current policies
EPR	extended producer responsibility
Estimator	Plastic Substitution Tradeoff Estimator
GHG	greenhouse gas
HDPE	high-density polyethylene
IPR	integrated policy reform
LCA	life cycle assessment
Mt	million tons
$MtCO_2e$	million tons of carbon dioxide equivalent
OECD	Organisation for Economic Co-operation and Development
PET	polyethylene terephthalate
PPS	Plastics Policy Simulator
PRO	packaging recovery organization
RIC	Resin Identification Coding system
Rp	rupiah
SCS	subsidies for collection and sorting
SWM	solid waste management
t	ton
US$	United States dollar
VPT	virgin plastic tax

1

Understanding the Drivers of Plastic Pollution

Plastic Pollution Is a Development Issue

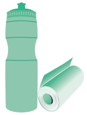
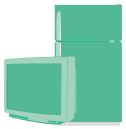
Plastics have been an important development enabler for decades. Because of their unique properties (for example, durability, impermeability, strength, flexibility, lightness, and versatility), combined with low manufacturing costs, plastics have revolutionized every aspect of modern life. Mass produced from waste gases from processing crude oil and natural gas since the 1930s, plastics became a miracle material for industry and consumer goods. Mass consumption began after the Second World War, when plastics began to replace the more expensive paper, glass, and metal used in packaging materials and to be used in a wide range of consumer, industrial, construction, health care, power, and transport applications. Plastics have become building blocks of many value chains. In 2015 it was estimated that, from the 400 million tons of plastics produced every year, more than a third was plastic packaging and single-use material designed for immediate disposal (Geyer, Jambeck, and Law 2017).

Plastic products are made from different types of polymers. At the end of the 1980s, the Plastic Industry Association developed the Resin Identification Coding system (RIC), now administered by ASTM International. The RIC is a set of symbols (see figure 1.1) appearing on plastic products that identify the plastic resin out of which a product is made. It includes seven types of plastics, broadly indicating their recyclability, although this depends strongly on the local context. For example, bottles from polyethylene terephthalate (PET) and high-density polyethylene (HDPE) are often economically recyclable, whereas food containers made from Styrofoam, included in code 6, are barely collected or recycled in most countries. Most polymers used in the production of single-use products include low-density polyethylene (for example, bags), HDPE (for example, shampoo bottles), PET (for example, water bottles), polystyrene (for example, cutlery), expanded polystyrene (for example, hot drink cups), and polypropylene (for example, flexible sachets and wraps).

Plastics revealed their downside to society a few decades later as plastic waste became omnipresent in the environment, not just on land but increasingly in bodies of water, having a wide range of impacts on public health, economies, ecosystems, and biodiversity. Those effects can occur during each stage of the plastic life cycle, from the extraction of raw materials to production and use through to end of life. The chemical properties of plastics that make them so attractive as consumer products also make them problematic at the end of life.

Knowledge about global sources and pathways out of plastic pollution has increased in the past few years, in particular after 2015, when the quantity of plastic entering the ocean from waste generated on land was first estimated (Jambeck et al. 2015). Sources of plastic pollution are diverse and come from inland and marine-based production and consumption activities. Early 2000s estimates indicated that

FIGURE 1.1 Resin Identification Coding System

Polymer name	**Polyethylene terephthalate**	**High-density polyethylene**	**Polyvinyl chloride**	**Low-density polyethylene, Linear low-density polyethylene**	**Polypropylene**	**Polystyrene**	**Other, such as acrylic, nylon, polycarbonate, and polylactic acid and multilayer combinations of different plastics**
Resin Identification Code	♳ 1	♴ 2	♵ 3	♶ 4	♷ 5	♸ 6	♹ 7
Abbreviation	PETE or PET	HDPE or PE-HD	PVC or V	LDPE or PE-LD	PP	PS	O
General recyclability	Commonly recycled	Commonly recycled	Sometimes recycled	Sometimes recycled	Sometimes recycled	Sometimes recycled	Rarely recycled
Use examples	Water and soft drink bottles, plastic lumber applications, headlight lenses, and safety shields 	Detergent bottles, grocery bags, milk jugs, recycling bins, agricultural pipe 	Pipe, window profile, siding, fencing, flooring, shower curtains, lawn chairs, nonfood bottles, children's toys, wrapping 	Plastic bags, various containers, dispensing bottles, tubing, wrapping 	Yogurt containers, sachets, auto parts, industrial fibers, furniture, luggage 	Cafeteria trays, plastic utensils, coffee cup lids, toys, videocassettes and cases, expanded polystyrene foam products (e.g., Styrofoam™) 	Baby bottles, plastic lumber applications, headlight lenses, and safety shields/glasses 

Sources: ASTM International 2022; Polychem USA 2017.

most of marine litter sources were land-based, with less than one-quarter originating at sea. Those estimates have been broadly confirmed, with many single-use plastics such as bags, cups, or polystyrene pieces from food packaging found along rivers and beaches; but they vary depending on country context, major economic sectors and locations, and marine sources such as fishing nets or buoys are also commonly found on beaches in some countries (World Bank 2021b).

Observations of microplastics in rain and ice in the past few years have also shed light on other sources of plastics, directly from the production of plastic pellets or manufactured items, but these pathways are not clearly identified and there are only a few estimates of such emissions from industry (Boucher and Friot 2017). Lack of access to solid waste management services largely explains waste and plastic waste dumping to the environment: uncollected waste is responsible for 75 percent of leakage into the ocean (Ocean Conservancy and McKinsey & Company 2015). The role of rivers as main pathways to the ocean has been widely acknowledged (Lebreton et al. 2017; Schmidt, Krauth, and Wagner 2017), and countries like Indonesia and China have started to model the transfer and leakages at the scale of river basins as the basis for policy reform and action (World Bank 2021b).

Damages caused by plastic pollution are diverse, from ecosystem and biodiversity to human health, climate change, clogged water and wastewater infrastructure, and tourism (Dalberg Advisors 2021; Deloitte 2019). Most of these impacts have been documented for the downstream part of the plastic life cycle, in particular on ecosystems and biodiversity, where plastics are a threat to marine life through entanglement, starvation, and toxicological harm (UNEP 2021). Exposure to chemicals and pathogens associated with decaying or burning plastics has direct impacts on human health (Hermabessiere et al. 2017) and may also have endocrine-disrupting and carcinogenic effects on wildlife and humans (Flaws et al. 2020). The health implications of microplastic deposits in human bodies are still uncertain because clinical trials of long-term exposure have been difficult to conduct (as reflected, for example, by Directorate-General for Research and Innovation 2019); the science is rapidly evolving, but uncertainty remains. Impacts on the economy have been difficult to quantify. The environmental cost of plastics in the consumer goods sector was estimated to be US$75 billion per year in 2014, two-thirds of this attributed to emissions released during the production of plastic packaging, accounting for greenhouse gas (GHG), water, air, and land impacts, while ocean plastic pollution costs an estimated US$13 billion per year in environmental damage (17 percent of the total), including financial losses incurred by fisheries and tourism as well as beach cleanups (UNEP 2014). According to UNEP, with no action, annual flow of plastic into the ocean will nearly triple between 2016 and 2040. The untamed plastic pollution could trigger annual financial risk to businesses amounting to US$100 billion in 2040

(Pew Charitable Trusts and SYSTEMIQ 2020), while the same source estimates that the total cost of managing plastic waste to governments (that is, collection, sorting, and safe disposal) would be an average US$33.5 billion per year between 2021 and 2040.

Plastics are also associated with other development issues throughout their production, consumption, and end-of-life phase:

- **Pollution at extraction, production, and conversion stage:** The oil and gas extraction and petrochemical industries producing plastics are an important source of industrial air pollution, wastewater effluents, and land contamination. Industrial processes that convert virgin plastics to useful materials and products are also a major source of air pollution, releasing toxic chemicals and greenhouse gases (European IPPC Bureau 2007).
- **Tourism and infrastructure:** Plastic litter on the beaches, on land, and in the waters deter visitors, and hence revenues of communities and countries depending on tourism. Plastic products in the waterways also impose a major cost on the water supply and wastewater infrastructure by clogging sewers and water intakes (Abt Associates Inc. 2019; APEC 2020; Jang et al. 2014; Krelling, Williams, and Turra 2017; Qiang et al. 2020).
- **Increase in carbon emissions:** One growing risk of plastic pollution is related to climate change. Plastic industry accounts for about 6 percent of global oil consumption and is expected to reach 20 percent by 2050. There is growing scientific evidence that plastics have begun to alter global carbon cycling (Hermabessiere et al. 2017; UNEP 2021) and that GHG emissions from the production, conversion, transport, recycling, incineration, and dumping of plastics could account for between 10 and 20 percent of the Paris Agreement's total allowable emissions in 2040 to limit warming to 1.5 degrees Celsius (CIEL 2019; UNEP 2021). Research is increasingly suggesting that plastic degrades naturally in the air under ultraviolet radiation and emits methane (Royer et al. 2018). Alternatives to plastic products also have a significant carbon footprint, especially if they are used just once. Glass or metal packaging are also carbon intensive to produce and are heavier than plastic packaging, hence their transport also requires more fuel. Their burden on climate change is lower than plastics only when reused dozens if not hundreds of times and if they do not travel too far.
- **Environmental damage due to plastic degradation:** Plastic degradation itself is a source of environmental degradation with the release of those chemicals into the environment in addition to smaller particles of plastics. Some plastic types take thousands—even tens of thousands—of years to degrade, depending on the type of resin, their combination, and the additives that make the final products. The breaking down of plastics releases microplastics as well as multiple toxic,

bioaccumulative, long-lived chemicals, including dioxins, polycyclic aromatic hydrocarbons, polychlorinated biphenyls, and heavy metals such as lead and cadmium (Zimmermann et al. 2019). Although plastics offer many advantages in farming (for example, plastic covers that extend the growing season, drip irrigation tubes that help save water), their use and disposal have raised concerns over soil fertility (by disrupting soil and aquatic microbes) and food safety (when land and sea animals eat microplastics and then enter the food chain). This is a growing concern in East Asia, where the World Bank is looking into the use of plastics in agriculture (Cassou, Jaffee, and Ru 2018).

- **Microplastics** are defined as "any synthetic solid particle or polymeric matrix, with regular or irregular shape and with size ranging from 1 µm to 5 mm, of either primary or secondary manufacturing origin, which are insoluble in water" (Frias and Nash 2019).[1] Microplastics penetrate all planetary systems, including the oceans, the air, and all living organisms. Studies have detected microplastics in 80 percent of global freshwater sources, 81 percent of municipal tap water, and 93 percent of bottled water (Damania et al. 2019). In addition to the breaking down of plastic items in the ocean, industry (for example, the textile sector) and consumers (for example, tire erosion) are the primary sources of microplastics on land.

On the evolutionary scale, plastic is a brand-new substance in the environment, so there is still uncertainty about its long-term impacts on ecosystems and human health. When scientific investigation has found uncertain but plausible and possibly large risks, the precautionary principle[2] is a guiding rule in decision-making to protect the public from exposure to potentially great and irreversible harm (Gollier and Treich 2003; Rio Declaration 1992). The precautionary principle has become an underlying decision-making rationale for multiple international environmental agreements, including several conventions on waste, chemicals, biodiversity, and climate (COMEST 2005; EU 2016; Pinto-Bazurco 2020). The need for precautionary measures to reduce the most toxic and longest-lived plastics entering the economy is particularly urgent, because downstream plastic-related pollution can quickly lead to irreversible harm, and large contingent liabilities for later cleanup and management are already costly.

Marine litter and plastic pollution have attracted much attention and many commitments by governments and private companies alike since 2015. Commitments range from enacting policy instruments to setting corporate targets for recycled plastic content or reducing the use of virgin plastics.[3] The amendment to the Basel Convention in 2019 confirmed political momentum for a new global agreement on plastic pollution. The adoption of a resolution to establish an intergovernmental negotiating committee at the fifth United Nations Environment Assembly to create a legally binding global instrument to end plastic pollution in the world's oceans, rivers, and landscape is a reflection of and driver for increased awareness and action on the issue and is backed up by the private sector. More than 70 companies representing all sectors along the plastic value chain signed The Business Case for a UN Treaty on Plastic Pollution, led by the Ellen McArthur Foundation, and its manifesto.[4] Despite corporate commitments, incentives in most markets encourage firms and households to increase plastic pollution. Without an enabling regulatory environment, corporate commitments will remain unmet and will not translate into investments and behavioral change.

Drivers of Plastic Pollution: Multiple Market and Policy Failures

The flow of plastic into the environment, rivers, and oceans is getting worse as production and demand for plastic increase globally. Managing plastic pollution therefore requires rethinking the whole value chain, from production of virgin plastics, through conversion and manufacturing of products, to solid waste management and the end of their lifetime in the environment. The key bottlenecks in the plastic value chain include the following:

- **Incentives to increase plastic consumption:** Upstream in the value chain, plastic production and consumption increase at an exponential rate, which overloads a downstream waste management system. Worldwide, plastic use has increased 20-fold in the past 50 years and continues to grow (Pew Charitable Trusts and SYSTEMIQ 2020). If recent trends continue, waste generation in low-income countries is expected to triple between 2016 and 2050, while urban growth will increase pressure on solid waste management systems, further blocking sewers and drainage systems and exacerbating leakage into the environment (Kaza et al. 2018). The amount of plastic entering the oceans annually could nearly triple, from 11 million metric tons in 2016 to 29 million metric tons by 2040[5] (Pew Charitable Trusts and SYSTEMIQ 2020).
- **Too few options and no incentives to reuse or substitute plastic:** Consumers could be nudged to change their choices of products. Reusing, as a consumer choice, remains a small niche, and repair and remanufacture are nascent and require a change in product design and consumer habits. The use of unnecessary and harmful plastics, especially multilayer and single-use plastic packaging, is the most pressing problem (Ministerial Statement 2021; UNEP 2018). Without fundamental redesign and innovation, about 30 percent of plastic packaging could not be reused or recycled at a cost that firms and consumers would be willing to pay (Ellen MacArthur Foundation 2017).
- **Too little and too costly recycling:** Recycling markets have existed for many years but have remained small and limited to the relatively few most valuable plastic products. Only about 10 percent of plastic produced between 1950 and 2015 has been recycled globally (UNEP 2021), and of this, only 10 percent is recycled more than

once (converted back to the same products and recycled again, that is, in closed-loop recycling) (Geyer, Jambeck, and Law 2017). The remaining 90 percent is either incinerated or disposed of in landfills, dumps, or the environment. The Chinese National Sword Policy, introduced in 2018, banned the import of most plastic waste on the basis of contamination grounds and has disrupted global trade of plastic waste, having a domino effect in many countries either exporting or importing plastic waste. At the same time, oil prices have been low between 2014 and 2020, which has made virgin plastic even cheaper compared with recycled plastics. The strong rebound of oil prices in 2021 and 2022 could be short-lived, requiring policy incentives to create and improve recycling markets.

- **Insufficient solid waste management:** The circular solutions still rely on the capacity of the downstream waste management systems. The bedrock for any value creation in the plastic value chain is to channel all waste through formalized collection systems. As long as waste dumping into the environment is the cheapest waste management option for economic actors, any sustainable and circular waste management measures will be difficult to implement and enforce. Expanding waste collection services and sorting capacities in low- and middle-income countries, providing support to the informal sector, and building facilities as an intermediate solution to dispose of sorted waste materials that cannot be recycled economically must be applied together with circular strategies focused on waste prevention and reduction (World Bank 2021a). Once dumping is prevented, safe disposal and recycling are next-level foundational prerequisites for a transition up the waste hierarchy[6] and toward a circular economy (EU 1975; World Bank 2021a).

Governments are trying different entry points to regulate plastic pollution. Most efforts so far have focused on the downstream part of the plastic life cycle, such as improving solid waste management systems, when plastic waste has already become postconsumer waste. Without incentives to reduce plastics at the source or to design products for upstream reuse, recycling, and repair, the waste collection and landfilling infrastructure becomes overloaded even in advanced countries. Waste management is costly, and the availability of investment and operational finance is arguably the single most critical factor in determining the sustainability of municipal waste services. Although revenues from recycled materials and energy tariffs can provide funds for operational costs, they are typically far smaller than the full costs associated with operating waste management systems (World Bank 2021a). For example, many countries subsidize sorting and recycling of waste, but plastic products, especially packaging, are becoming increasingly difficult and costly to separate and recycle, being made of multiple materials, layers, and additives that make downstream separation for recycling purposes prohibitively costly.

Policies like bans or fees on some of the most problematic plastic items have been introduced relatively recently, often in an ad hoc manner, without trying to create comprehensive circular markets. These interventions are usually fragmented and may shift the problem from one place to another. Banning specific products, such as disposable thin-film bags, without ensuring affordable access to environmentally friendly alternatives often pushes consumers to use even more problematic substitutes, with an even larger environmental footprint.

At each stage of the plastic life cycle, government efforts are hindered by lack of capacity. This is true all along the value chain (for example, upstream to enforce bans or restrict single-use plastics or downstream to improve solid waste management). Creating the right institutional structures is essential to an integrated solid waste management system and to deliver basic services (World Bank 2021a). This report promotes a comprehensive approach for plastic management in line with the World Bank Group approach to addressing marine litter and plastic pollution (see box 1.1), focusing on aforementioned policy and markets failures, but it does not delve into institutional aspects and capacity building, because other publications cover these issues (see World Bank 2021a).

BOX 1.1 The World Bank Group Approach to Addressing Marine Litter and Plastic Pollution

The World Bank Group approach is comprehensive and adapted to country context, and it revolves around three broad sets of solutions: (a) stopping leakages in the short term by improving integrated solid waste management and water management; (b) transitioning to circular economy schemes over the longer term to design out waste; reducing, reusing, and recycling plastics; capturing value instead of losing it to the environment; reducing waste and creating sustainable markets; and (c) as a last resort, restoring ecosystems through beach cleanup campaigns or gear retrieval, with a focus on labor creation and livelihood support. This approach requires new policies, behavior change by consumers and industry, investments, and innovation.

The total cost of this approach—covering the full life cycle of plastic—is not well understood, which hampers country decision-making to identify and sequence interventions tailored to their context and needs. Governments play a limited role in implementing plastic pollution management measures but play a critical role in creating incentives for firms and households to invest in and drive the transition to a circular economy. The private sector is diverse, with different motivations, and can contribute through increased financing of physical recycling infrastructure and through developing, producing, and using new products, alternatives to plastics, or more easily recyclable plastics.

Source: World Bank.

The Hidden Costs of Plastic

Reducing plastic pollution requires multiple policy instruments to correct multiple market and policy failures throughout the entire plastic life cycle. Markets fail to include external costs of damages in the market prices of plastic products. Most common policy failures are different forms of subsidies that encourage the use of polluting plastic products.

External costs of plastics are present not only in the production phase but also in the postconsumption phase when plastic products become waste. This is different from more traditional pollution problems, such as GHG emissions, where external cost is generated mainly in production and emissions of combustion processes represent a single entry point for regulations or pricing. Steel and aluminum products, for example, cause little damage to the environment once they are produced (although paints and coatings are often harmful) because they are mostly recovered and recycled. Plastic products create environmental damage when they are produced and when they are dumped or disposed of, so corrective policies must target upstream and downstream externalities. Failure to reflect the true costs of plastics from their production trickles down throughout the plastic value chain as follows:

- Producers of virgin plastics often fail to pay the full cost of GHG emissions and local air pollution associated with the extraction and processing of oil and gas and the production of virgin plastics. In addition, several countries add policy distortion by subsidizing the oil and gas feedstock to the petrochemical industry (Ollero et al. 2019). These market and policy failures hide the true costs of virgin plastic, making it look cheap for firms further down in the value chain.
- Plastic converters and manufacturers buy virgin plastics below their true cost to society. Their products are therefore unfairly cost competitive with products made from recycled plastic, which is associated with much lower GHG emissions but much higher market costs of labor and materials. Furthermore, converters and manufacturers emit additional unpriced GHG emissions and locally harmful air and water pollutants from their plants. They also add multiple chemical substances to virgin plastics to increase their functionality and make them more attractive to consumer goods companies and retail traders. These additives increase the downstream environmental harm that these products cause when they are processed or disposed of. They also make sorting and recycling more costly and make recycled material less valuable on the market.
- Consumer goods companies, brand owners, and retailers buy plastic materials that, in the absence of environmental regulations, are artificially cheap because they do not include pollution costs. Retail prices do not inform consumers about the downstream environmental costs of waste. Firms at this stage often add

external cost by designing products and packaging that are disposable after a single use and consist of many layers and materials. This customization increases products' visual attractiveness, differentiates brands, and improves functionality to consumers while dramatically increasing the cost of waste management systems, especially recycling. In the absence of upstream product fees or extended producer responsibility mechanisms, all these inflated waste management system costs must be covered by public budgets—that is, households as taxpayers.

- When all these environmental costs go unpriced, consumers have incentives to choose disposable plastic products (most of them single use) that are most environmentally harmful and most difficult to recycle, because somebody else is paying the associated external costs. Households have no incentives to minimize waste, to search and pay more for environmentally friendly alternatives, or to bear transaction costs of reusing plastic products and sorting plastic waste at home for recycling. Without social and cultural norms or regulations, households would dump plastic waste directly into the environment or burn it rather than trying to dispose of it through a managed collection system.
- If free dumping is possible, households and businesses are less inclined to pay for the services of waste collectors and sorters, who on the other hand face increasing costs as upstream market and policy failures exponentially increase the volumes of plastic waste. The cost of sorting also rises with the increased variety of materials and larger share of multimaterial, flexible plastic products that have low value for recyclers. In addition, formal collection and sorting companies face unfair competition from informal sorters who underpay their workers, put them in unsafe working environments, and pick the most valuable plastic products (for example, polyethylene terephthalate bottles) from the waste stream, leaving less valuable plastic to formal firms that face higher labor costs. All this squeezes the profit margins of collectors and sorters, making it hard for them to cover basic costs. Unless governments can afford to step up public funding, the level and quality of waste collection, sorting, and landfilling services will crumble.
- Recyclers' profits are also compressed. Recyclers, like collectors and sorters, create much lower environmental externalities than virgin plastic producers but face higher internal costs for labor, capital, and materials. Despite a higher demand from consumers and private companies' willingness to meet their commitments, there is still volatility in the prices of recycled products.
- At the end of the plastic value chain, landfill operators must compete with the costs of illegal dumping. Their clients may be willing to pay for waste removal but not necessarily to maintain strict sanitary conditions of waste, because those who dispose of waste live far from landfills and do not pay for the costs of odor, methane and dust emissions, or toxic leakage to groundwater.

This discussion shows how many links in the plastic value chains are financially broken. The market and policy distortions create a vicious cycle of high costs and low willingness to pay for sustainable plastic management measures, resulting in the entrenched linear, throwaway model of the plastic value chain. Theoretically, there is a considerable amount of valuable material in waste streams, but this material is currently not recoverable on commercial terms; therefore, it is not an asset but a liability.

Several consumer goods companies have committed to increasing the recycled content of their products or decreasing the use of virgin material, but the demand for recycled content has not yet led to market creation at scale. These companies are developing new products and marketing strategies under pressure from consumers or existing and anticipated regulations in a handful of countries. Much stronger regulatory and consumer behavior changes are needed to increase consumers' and companies' willingness to pay for recycled content or to switch from colorful, multimaterial, single-use plastic products to more sustainable substitutes.

So far, in only a few market niches are customers willing to pay more for reusable, alternative, or easy-to-recycle and easy-to-repair products made from simpler, less-colorful monomaterials that can be recycled multiple times into the same product (for example, bottle to bottle). In some sectors such as food, COVID-19 has even led to a surge in single-use plastics (see box 1.2). Increasing volumes of private investment have recently

BOX 1.2 Impacts of COVID-19 on Plastic Pollution

The COVID-19 pandemic has accelerated plastic pollution, with the surge in single-use plastic in the food industry and for protective equipment. The handling of COVID-19 cases has added even more pressure to existing and often inadequate waste management systems. It has revealed some of the key drivers of the plastic pollution problem, in particular recycling markets that have been upended by both low oil prices (which made virgin plastic cheaper) and reduced demand for recycled materials because of hygiene concerns. Waste pickers, who were already vulnerable, are even more in harm's way than before, losing their livelihoods and being exposed to the virus in their work. In the first months after March 2020, the implementation of plastic pollution policies and regulations stalled in some countries and cities, including short-term "quick-win" instruments, such as (a) delays or temporary lifting of bans on single-use plastics or (b) delays on the reuse of refillable containers. Building back greener, in a more resilient and inclusive way, provides a new impetus to drive policy changes that create a sustainable future and raise the demand from countries to address plastic pollution, as reflected in the ongoing international dialogues.

Source: World Bank.

been observed in solid waste management and recycling, albeit mainly in countries that have started to create enabling conditions for market creation, which level the playing field between virgin and recycled or reusable plastics. In most jurisdictions, incentives for market-based investments and financing are lacking, preventing the circular economy from being a viable, self-sustaining business model that could challenge the current linear throwaway economic paradigm.

Notes

1. This definition is consistent with the ones used by the UN Environment Programme, GESAMP, and various environmental agencies across regions.
2. The manifesto is online at https://www.iau-hesd.net/sites/default/files/documents/rio_e.pdf. It states: "Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation." Full overview of its application by Gollier and Treich 2003.
3. Examples of commitments announced at the Our Ocean conference in previous years can be found at https://ourocean2022.pw/commitments/.
4. The manifesto can be found at https://www.plasticpollutiontreaty.org/.
5. Estimates range from 9 million to 14 million metric tons per year in 2016 to 23 million to 37 million metric tons per year in 2040.
6. The concept of waste hierarchy was first introduced in the European Union waste framework directive and has been widely used as a framework for engagement in the solid waste management sector, including at the World Bank. It defines a preferred order of waste management practice, subject to technical feasibility, affordability, and financial sustainability constraints: prevention, (preparing for) reuse, recycling, recovery, and, as the least preferred option, disposal (which includes landfilling and incineration without energy recovery).

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2

Managing Plastic Pollution

Introduction

Plastic pollution is easily visible to everyone, but the information needed to understand and solve the problem is not readily available to the public. Plastic pollution management is a relatively new field, and knowledge and practices are still emerging. Few methodologies, decision-support tools, and guidelines are available. The complexity and multidimensional nature of the problem itself, the short history of policy interventions, and the challenge of combining solutions typical of solid waste management with those closer to pollution control and industrial product policy compound the uncertainty of how best to manage the plastic challenge.

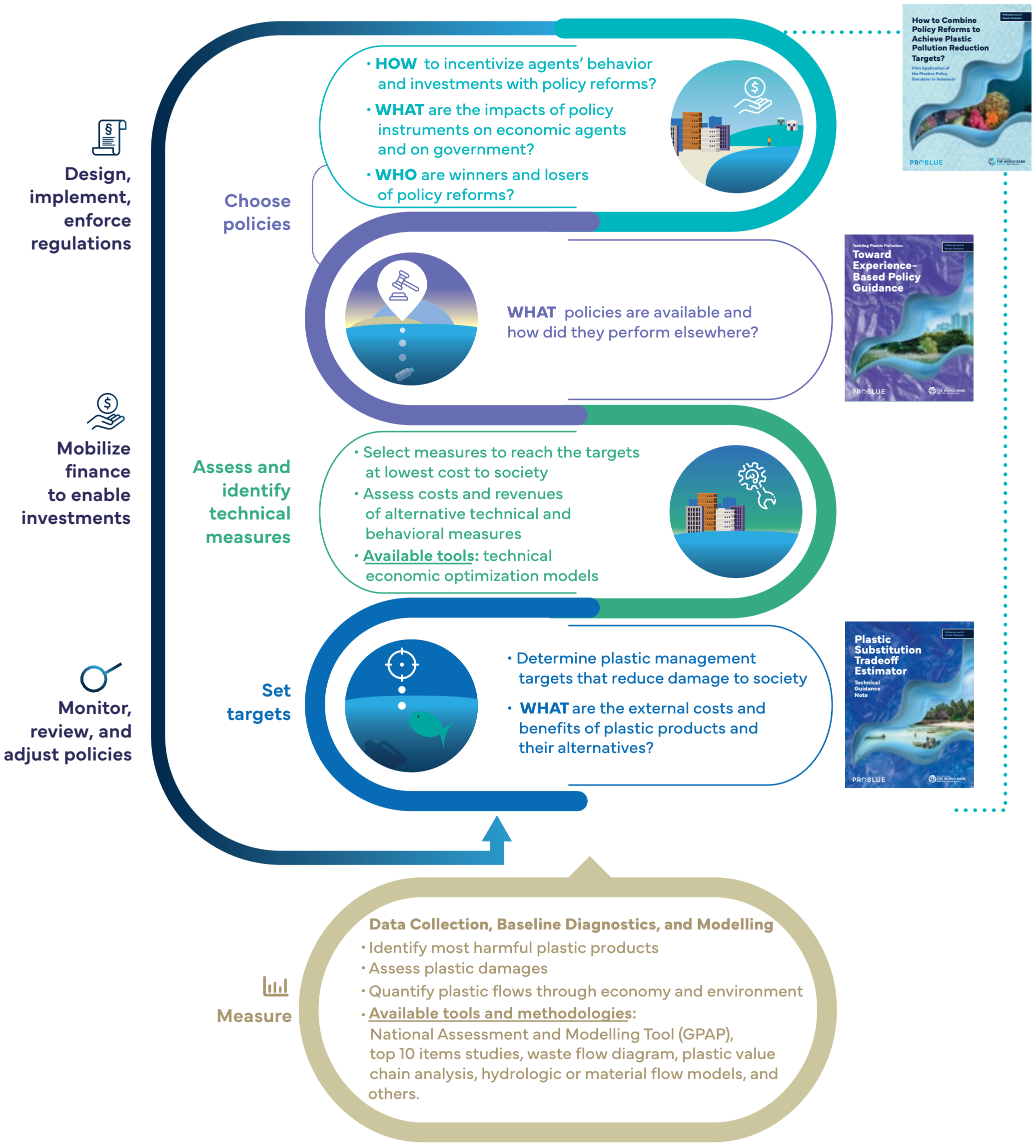
Effective plastic pollution management efforts usually follow a set of key steps and use a menu of available decision-support tools (figure 2.1). This algorithm represents the building blocks for the formulation of national action plans to address plastic pollution and country strategies to prevent plastic pollution, consisting of targets, technical measures, and policy instruments.

Data Collection, Baseline Diagnostics, and Modeling

Data scarcity is the first bottleneck that many countries face when starting to strategize for managing plastic pollution. Key questions that need to be answered concern the amount, types, and sources of virgin or recycled plastics being imported and produced and their flow from manufacturing to consumption, to waste management systems, and to eventual disposal or leakage into the environment. Approaching the plastics life cycle in such a comprehensive way not only helps shed light on the current system but also allows for an estimation of future plastic pollution trends. The following is an overview of existing methodologies and available tools to support such an assessment (more details are provided in appendix A):

- First, understanding the magnitude of the plastic pollution problem with material flow analysis from upstream to downstream the value chain—complementing plastic waste accumulation diagnostics and identifying the most common type of plastic waste found in those (see box 2.1 for an example of the latter).
- Second, understanding consumer preferences—what product features and qualities are particularly important for consumers. This step is useful later in the plastic management process to consider alternative designs and substitutes for the most environmentally problematic plastic products and materials, and to design policies that can alter behaviors.
- Third, estimating the postconsumption fate of plastic products in the waste management system. Beyond typical waste characterization and data on waste streams collected, transported, and disposed of, collecting data on volumes of

FIGURE 2.1 Building Blocks of Plastic Pollution Management



- **HOW** to incentivize agents' behavior and investments with policy reforms?
- **WHAT** are the impacts of policy instruments on economic agents and on government?
- **WHO** are winners and losers of policy reforms?

WHAT policies are available and how did they perform elsewhere?

- Select measures to reach the targets at lowest cost to society
- Assess costs and revenues of alternative technical and behavioral measures
- **Available tools:** technical economic optimization models

- Determine plastic management targets that reduce damage to society
- **WHAT** are the external costs and benefits of plastic products and their alternatives?

Data Collection, Baseline Diagnostics, and Modelling
- Identify most harmful plastic products
- Assess plastic damages
- Quantify plastic flows through economy and environment
- **Available tools and methodologies:** National Assessment and Modelling Tool (GPAP), top 10 items studies, waste flow diagram, plastic value chain analysis, hydrologic or material flow models, and others.

Source: World Bank.
Note: GPAP = Global Plastic Action Partnership.

plastic according to weight and product and how they are handled allows for (a) an estimation in turn of the commercial viability of individual activities in the waste management system and (b) an understanding of where the broken links are in the downstream plastic value chain, their origins, and therefore possible means of addressing them through policies.

- Last, mapping the stakeholders involved in the plastic life cycle, to identify all economic actors, their role and possible influence, how they may be affected by plastic pollution, and the possible avenues to address it.

The basic diagnostics of how plastic flows through the economy and environment enables the consequences of inaction to be predicted. Plastic pollution baseline studies should estimate how plastic pollution would increase under different assumptions about population growth and future per capita consumption of plastic. Using material flow assessment tools allows spatial simulation of the additional burden on waste management systems if no action is taken.

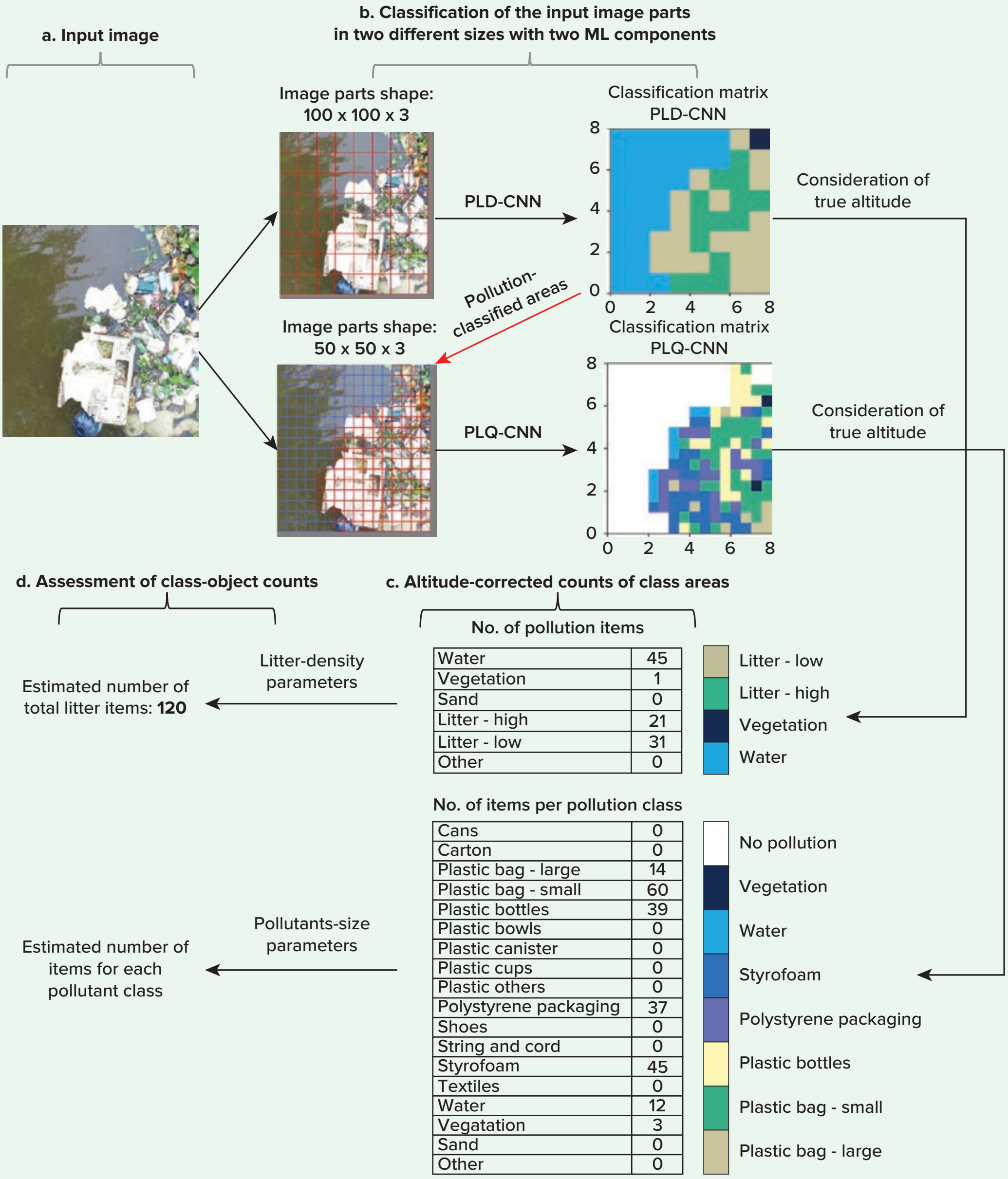
BOX 2.1 Identifying the 10 Plastic Products Most Commonly Found in the Environment Using Drones and Artificial Intelligence in Cambodia and Myanmar

The methodology used in Cambodia and Myanmar was based on the European Union strategy that informed the development of the European Commission's Directive on Reduction of the Impact of Certain Plastic Products on the Environment (commonly referred to as the Single-Use Plastics Directive). The 10 plastic products most commonly found in the environment were identified; various policy options to address leakage of those 10 plastics were assessed; and the applicability of those options was considered in terms of factors such as pragmatism, affordability, and availability of alternatives. Two surveys were initiated between October 2019 and April 2020. The first focused on field sampling following international marine plastics survey guidelines. The second involved a highly innovative approach of remote sensing and automated detection, quantification, and classification of plastics using a machine-learning process (figure B2.1.1). Drones were used to collect images of rivers, beaches, and urban canals at different height levels, which were automatically analyzed to show pollution hot spots, waste area coverage, and volume of plastics, and, most importantly, to classify the most common types of plastics found in and along the waterways being studied. This information can be used as the basis for targeted measures against specific plastic types or in specific areas.

(continued)

BOX 2.1 *continued*

FIGURE B2.1.1 Steps in Remote Sensing Survey to Detect and Tally Plastic Products



No. of pollution items

Water	45
Vegetation	1
Sand	0
Litter - high	21
Litter - low	31
Other	0

No. of items per pollution class

Cans	0
Carton	0
Plastic bag - large	14
Plastic bag - small	60
Plastic bottles	39
Plastic bowls	0
Plastic canister	0
Plastic cups	0
Plastic others	0
Polystyrene packaging	37
Shoes	0
String and cord	0
Styrofoam	45
Textiles	0
Water	12
Vegatation	3
Sand	0
Other	0

Source: Adapted from Wolf et al. 2020.
Note: CNN = convolutional neural networks; ML = machine learning; PLD = plastic litter detector; PLQ = plastic litter quantifier.

Source: World Bank.

Setting Targets

Setting targets is the second building block of plastic pollution management. Once a baseline is established, policy makers and other stakeholders are better equipped to discuss specific targets related to plastics. Whether these targets concern (a) a reduction of consumption of plastics upstream the value chain, (b) a phasing out of specific plastic items, or (c) better management of plastic waste, they help define necessary policy measures and enable monitoring and progress. They can be revised over time. Setting targets is not a one-time, static exercise. Targets must be reviewed and adjusted as new information and technical measures become available and people's preferences change over time.

Most countries begin target setting from the end of the plastic life cycle, since following the waste hierarchy (figure 2.2) helps adjust priorities from downstream waste management to upstream prevention. The concept of the *waste hierarchy*, introduced to frame the European Union approach to waste (see box 2.2), assigns priority to reducing consumption of products that will become harmful waste later, then sequentially reusing, recycling, and recovering. At the end of the waste hierarchy, safe disposal at a landfill is seen as a last resort for waste that cannot be managed using the circularity measures. Examples of targets and considerations regarding their design include the following:

- Targets for reduction of marine litter—for example, reducing plastic litter by 50 percent by 2025 and 75 percent by 2030 in Vietnam, or by 70 percent by 2025 in Indonesia.

FIGURE 2.2 European Union Waste Hierarchy

Source: EU 2018.

BOX 2.2 EU Plastic-Related Regulations: Evolution of Target Setting

The past 30 years of European Union (EU) legislation provide a lesson in the evolution of setting targets to reduce plastic pollution. The current plastics strategy[a] was adopted in 2018 and is now part of the EU circular economy action plan[b] adopted in 2020. It builds on previous legislation that focused on solid waste management but proved insufficient to stem the flow of plastic to the environment. The updated framework covers the whole value chain; it includes measures upstream of the life cycle and complements the previous downstream-focused framework.

Until recently, plastic pollution was regulated in the framework of waste management regulations that were established in the early 1990s by the Urban Waste Management Directive and Landfill Directive. In 1994, the Packaging and Packaging Waste Directive called on member states to look upstream and prioritize prevention, reuse, and recovery of packaging before it becomes waste. A growing realization of the high costs of waste management systems triggered the evolution of targets to include separate collection of packaging waste in the 2008 Waste Directive. The evolution further led to adoption of the Waste Framework Directive in 2018, which consolidated scattered waste legislation and called for a more system-wide approach to waste, formally integrating the waste hierarchy into the EU legal system (EU 2018), introducing the “polluter pays” principle and extended producer responsibility, and setting new separate collection targets.

The plastic strategy builds on previous legislation and targets set in the previous three decades, and it informs the development of the European Commission’s Directive on Reduction of the Impact of Certain Plastic Products on the Environment (commonly referred to as the Single-Use Plastics Directive). One objective (protect the environment and human health by reducing marine litter, greenhouse gas emissions, and dependence on imported fossil fuels) and the main ways to achieve it have focused specific targets on particular items found on beaches (for example, restrictions on use of beverage containers or bans on select single-use plastic items when available and affordable alternatives exist) and on increasing recycling. Targets include reaching 77 percent separate collection for plastic bottles by 2025, increasing to 90 percent by 2029, incorporating 25 percent of recycled plastic in polyethylene terephthalate beverage bottles from 2025, and including 30 percent of all plastic beverage bottles by 2030.

Source: World Bank.

a. The current strategy can be found at https://ec.europa.eu/environment/strategy/plastics-strategy_en?msclkid=734f618daa0d11ec8f284b9d5e4397ac.

b. The EU circular economy plan can be found at https://ec.europa.eu/environment/strategy/circular-economy-action-plan_en?msclkid=f976fab1aa0d11ecadcdc9d41353a617.

- Targets can be specific to solid waste management and include rates of collection, recycling, incineration, and organized landfilling of waste that the society wants to reach by a specific date; for example, increasing the handling rate of waste to 70 percent in Indonesia.
- Targets for reduction of waste at the source can be generic, such as reducing waste at the source by 30 percent in Indonesia, or can be more specific to a category of products (for example, collecting 100 percent of abandoned, lost, or discarded fishing gear and eliminating single-use plastics and nonbiodegradable plastic bags from coastal tourist attractions by 2030 in Vietnam; or reducing the use of targeted single-use plastics by 90 percent from 2020/21 to 2026 in Bangladesh). The European Union, and to some extent Japan and South Korea, include targets for extending the longevity of plastic products through redesign to make them reusable and ready to repair.
- Targets are also sometimes set for restricting waste imports, such as the Chinese National Sword Policy launched in 2017 by the government of China.

Any target setting needs to reflect baseline levels and keep affordability criteria in mind to be realistic and achievable. Moving up the waste hierarchy and introducing policies for greater circularity is expensive, as experienced by countries with advanced waste management systems, since it requires investments in improved infrastructure and results in higher operational costs for collection, sorting, and waste treatment. Costs for solid waste management in the highest-performing countries in Europe can go up to US$350/ton for waste treated. The user fees that need to be raised to cover these costs stay typically below the commonly used benchmark for assessing affordability of 1 to 1.5 percent of disposable income. Costs in low-income countries, on the other hand, often exceed that threshold, although the waste management systems are much more basic (collection, partial recycling, disposal). Moving up the hierarchy from landfilling to preventing waste requires alignment of incentives of economic actors operating upstream in the value chain, such as producers, converters, consumer goods companies, and consumers, with those operating in the downstream, waste management segments of the value chain. This concept is explained further in chapter 4.

Several decision-support tools are used to inform target setting. Some economic tools are designed to estimate the *cost of inaction*—in other words, the *benefits of action* to reduce plastic pollution, considering that benefits come from avoided costs. Some of these benefits are monetized using valuation techniques based on market prices or—in the absence of markets—“shadow prices” derived from hypothetical people’s willingness to pay. The benefits of reducing plastic pollution can be compared with the costs of doing it, using cost-benefit analysis. Not all benefits of reducing plastic pollution can be monetized: assessment of avoided harm can be quantitative without putting a price tag on it, such as net impact on jobs, premature deaths of animals and humans due to ingestion, or exposure to toxic pollution from burning of plastic waste. Many other impacts may only be qualitatively represented. The costs of reducing plastic pollution include additional investment, operations, and maintenance costs and may differ in geographic areas depending on availability, costs of alternative options, and local cost of capital. The costs of managing plastic pollution are lower in countries that import most single-use plastic products and can easily manufacture alternatives domestically. Some solutions, such as recycling, require economies of scale, benefit from preexisting waste management infrastructure, and may be more expensive for small countries, especially island states. In such contexts, measures to avoid certain plastics altogether may be a cheaper approach. In any case, available measures to reduce plastic pollution should be identified and their costs estimated in a specific country context to inform target setting.

One particularly difficult debate has been about comparing external costs of single-use plastic products and their multiuse plastic and nonplastic alternatives. Alternatives to plastic products may have negative environmental impacts, so the environmental costs of plastics should always be compared with substitutes in each country context. There are no established methodologies to transparently compare external costs of single-use plastic products and their multiuse plastic and nonplastic alternatives. The Plastic Substitution Tradeoff Estimator (presented in chapter 3) was developed to fill this gap.

Decision-support tools for setting plastic pollution management targets inform but do not replace the political process of choosing what society wants to achieve and when. In democratic societies, target setting is a dynamic bargaining process between different social and interest groups, during which social impacts and cultural norms play important roles. The transition from a linear to a circular model creates winners and losers in related value chains, which will influence the political economy of target setting. Availability of alternatives, infrastructure, or simply entrenched habits determine how feasible a switch from single-use plastic to more sustainable alternatives will be. Creation of these enabling conditions must be integrated into the process of setting ambitious but achievable targets.

Identifying Available Technical and Behavioral Measures

Once targets have been developed, stakeholders in the public and private sectors can select which technical measures and behavioral actions could be applied to reach the targets, how to sequence them, how effective they can be, and what costs and revenues can be expected by applying them. At this stage, techno-economic models can be applied to identify the combination of technical and behavioral measures that have a potential to reach the targets at the least cost to society (Gao et al. 2020; Pew Charitable Trusts and SYSTEMIQ 2020). It is recommended that governments assess the aggregate effectiveness potential of various measures and choose measures that are most cost-effective for society.

Assessing possible technical measures in a given context should build the foundations for the development of road maps and national action plans with specific policy instruments. Many countries are developing their knowledge base by assessing technical measures in parallel with conducting baseline studies and diagnostics. In Bangladesh, a technology assessment has complemented baseline studies and stakeholder consultations to inform a multisectoral strategic road map. As a result, one strategic orientation of the action plan is the use of resource-efficient technologies based on alternative materials and safe chemicals. In Cambodia, a plastics road map has been developed based on preliminary assessment of possible alternative products to plastic items identified in the waste streams or in accumulation areas.

Technical measures are available all along the plastic value chain, from measures to improve solid waste management (indispensable for recycling and recovery of products) to measures that help transition to a more circular economy, including reduction (rethinking the source, redesign), reuse, repairing, and remanufacturing. Upstream technical and behavioral measures prevent and reduce use of single-use plastic and packaging products to create less waste downstream. Product design can be altered to increase longevity, reusability, repairability, and recyclability in the midstream part of the plastic life cycle. Downstream measures such as recycling and recovery rely on effective collection and upgrading of existing solid waste infrastructure—to manage waste and plastic items that cannot be kept in circulation in the economy through recycling, repair, or reuse. Improving solid waste management in many countries is necessary to avoid leakages to the environment (World Bank 2021). Important, though least cost-effective, is a set of measures to clean up and restore ecosystems. Such measures could include developing small businesses to provide livelihoods for poor communities and for women in particular, and they should consider in the long term what to do with the plastic litter collected either in relation to solid waste management systems or by developing a value chain (for example, recycle, reuse).

There is broad consensus that innovations are needed at different stages of the plastic life cycle, from upstream design of materials—plastics and alternatives to single-use products—to creation of new supply chain models for reuse and for post-consumer materials and material substitutes to the downstream part of the life cycle. Innovations are needed at various stages of the life cycle to address broken links and can be driven by standards and policies.

Choosing Policy Instruments

Targets reflect where the society wants to be in future. Technical and behavioral measures discussed thus far provide information about the potential to meet these targets. This potential becomes reality only if economic actors—including firms and households—are willing to implement these measures. As discussed earlier, in the absence of government interventions to correct market and policy failures, economic actors tend to follow linear and polluting business models. Policy instruments are needed to encourage them to willingly undertake technical and behavioral measures that achieve society's targets. Well-selected and -designed policy instruments—especially economic ones—provide incentives for firms and households to innovate and search for new, previously unknown technical and behavioral measures to reach the targets.

The goal of plastics policy reforms should be the creation of effective, commercially self-sustaining markets for the prevention and substitution of the most environmentally harmful plastic materials and products, and for the sustainable waste management activities, such as waste collection, sorting, recycling, material recovery, and safe disposal of what cannot be circulated within the economy. Self-sustaining markets mean that firms and households find it in their own interest to change their consumption and production behaviors and adopt existing circular products and business models (or invent new ones). Building the capacity of relevant institutions and managing social and distributional issues and political economy challenges should always be integrated into policy reforms.

The choice of policy instruments is usually guided by the following criteria:

- Environmental effectiveness (changes in plastic flows through the economy and in plastic pollution attributed to policy reform)
- Economic impact on a country and financial impacts on economic actors (winners and losers)
- Social impact on vulnerable households
- Acceptability and political economy of reforms
- Scalability; replicability; sustainable market creation; positive spillovers to the rest of the economy, such as jobs, skills, and innovation
- Institutional and administrative feasibility
- Ancillary impacts, such as health, safety, air pollution, GHG emissions, and others

There are far fewer decision-support tools to inform the choice of policy instruments than to inform the previous steps in the plastic pollution management process. Chapter 4 offers a closer look at existing practices with regard to use of policy instruments in isolation and combined. It also introduces a new formal decision-support tool for ex ante assessment of the multidimensional impact of plastics policy instruments.

Implementation, Enforcement, Monitoring, and Evaluation

Eventually, multiple stakeholders must agree on detailed design of policy instruments and enact regulations, followed by implementation, enforcement, monitoring, periodic evaluation, and revision. Although policy regulations create incentives for economic agents to invest and change behavior, access to finance and other complementary measures are necessary to enable agents to respond to policy incentives. Ex post analyses of plastics policy performance are limited. An analysis from 10 countries and states has been conducted in this regard, and its main findings are summarized in chapter 4.

Access to finance is a necessary enabling condition for the implementation and enforcement of policy instruments. Financing does not make economic actors willing to invest in plastic management options or change behavior; policy instruments create incentives for economic agents, whereas financing just enables them to respond to policy incentives. The important distinction between subsidies (policy instruments) and financing (enabling conditions) is discussed in chapter 4.

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3

Setting Targets Based on the True Cost of Plastics and Alternatives

Techniques Used to Support Target Setting

This chapter presents a new model, the Plastic Substitution Tradeoff Estimator, developed to inform decision-making by national stakeholders in setting policy goals and targets with respect to substituting alternative materials for major plastic consumer products.

Lack of understanding of the societal cost of plastics often leads to confusion about the desired outcomes of the plastic management policy. The social burden that plastic products cause throughout their life cycle is significant, but potential substitutes also have social and environmental costs. As bans and restrictions on the use of certain single-use plastic items have been enacted, various stakeholders have raised challenges and highlighted the tradeoffs of substituting other products for plastic items. There are tradeoffs throughout the life cycle of products, and they are difficult to quantify, let alone monetize, often resulting in policies and stakeholders focusing on only a fraction of them. Data are scarce, methodologies for estimating the value of societal and environmental damages are untried, and governments lack the tools to determine whether proposed targets' benefits are higher than their costs. Qualitative and quantitative assessments, including monetary valuation techniques, throughout the life cycle can help overcome these uncertainties and determine whether it would be desirable to replace single-use plastic products with reusable plastic products, bioplastics, or alternatives made from other materials.

Targets sometimes imply greater consumption of alternative materials deemed less harmful to society and the environment that can be substituted for plastics. When alternatives exist, their costs and environmental footprints are similarly not well quantified, and there are no methodologies to compare them with those of equivalent plastic products. This equivalency must be function-based because a one-to-one, weight-based comparison is not justifiable. For example, polyethylene terephthalate bottles weigh less than glass bottles and fulfill the same function. The Estimator helps bridge this knowledge gap by allowing users to estimate the value and distribution of external damages caused by plastic products and compare them with those of their substitutes throughout their respective life cycles. Tradeoffs will always exist, and the Estimator helps to inform targets for reduction and substitution.

The Plastic Substitution Tradeoff Estimator

The Plastic Substitution Tradeoff Estimator is the first model to reduce uncertainty and increase transparency of decision-making regarding some of the tradeoffs of plastic substitution, therefore informing the decision-making process for policy makers. It combines monetary valuation techniques with nonmonetary, quantitative, and qualitative assessment of the multiple environmental footprints of the top plastic consumer goods found in marine litter and their typical alternatives.

The Estimator is an innovative model that estimates the external costs of 10 plastic products and their alternatives throughout their life cycle: fishing nets, beverage bottles, cups and food containers, shopping bags, disposable utensils, food wrappers, sachets, beverage cartons, clothing, and diapers. It can be applied in any country to identify what substitution materials, or what combination thereof, would perform best while examining tradeoffs between plastics and alternatives to help establish targets for reduction and substitution. It can provide decision-makers with answers to critical policy questions such as "What is the external cost and effect of banning a certain plastic product?" and "What is the impact of substituting different materials for a single-use plastic product?" Because the Estimator accounts for the entire product life cycle, it can ascertain which life cycle stage results in the largest external costs and therefore propose interventions that should be prioritized along the life cycle.

The methodological framework applied in the Estimator is an external cost analysis, which consists of two steps: quantification of effects according to life cycle assessment (LCA), complemented by literature review and valuation of effects (figure 3.1).

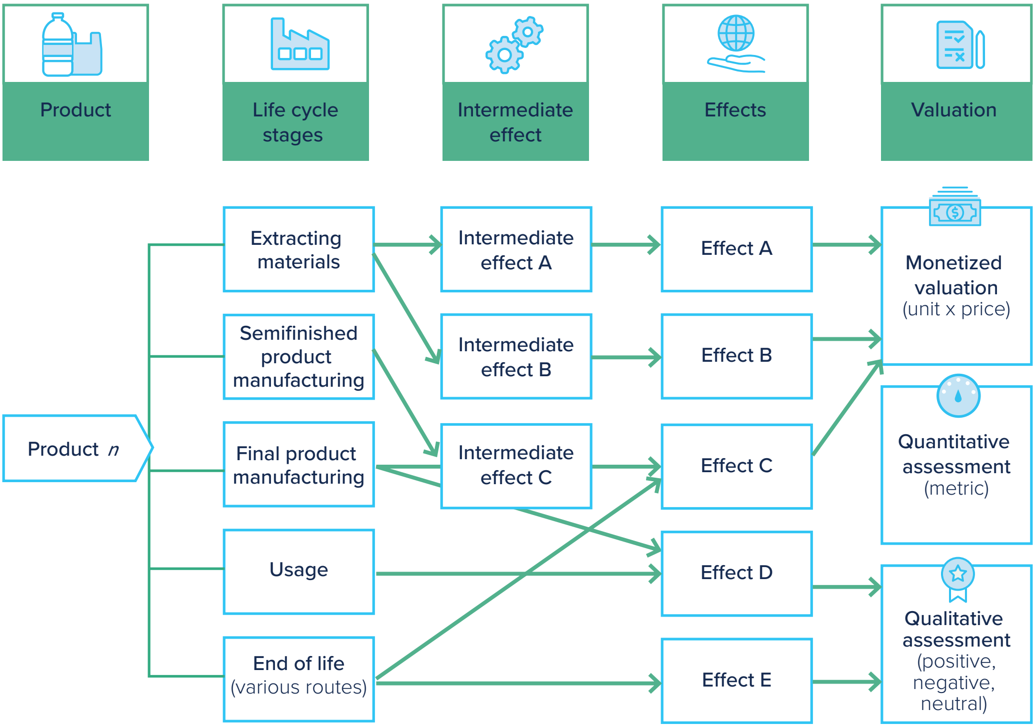
Each life cycle stage is associated with various effects, leading to externalities and occasionally benefits. All 30 relevant effects included in the Estimator (table 3.1) have been assessed using LCA complemented by a literature review because LCA data are unavailable for litter. The literature review was conducted to determine, define, quantify, and assess external costs and, where applicable, benefits that the LCA does not address.

Once quantified, the effects for which data are available are monetized using environmental prices and literature review. The monetized costs are then complemented with relevant quantitative and qualitative cost-and-benefit indicators (table 3.1). The outputs of the Estimator are then organized around monetary valuation, quantitative assessment, and qualitative assessment (figure 3.2). This approach provides users and decision-makers with a holistic comparison of the costs and benefits of plastics and their alternatives. More details on the assumptions and principles followed to develop the model are provided in appendix A.

The Estimator can also be used to assess hypothetical scenarios of, for example, anticipated or desired consumption and waste management trends of plastic products. The what-if scenarios can help explain the external costs of intended outcomes of plastics policies.

A model is always a simplification of reality and is developed based on the best available science at the time of its development. The Estimator cannot assess the effectiveness of regulatory schemes and policies, the affordability of products, or

FIGURE 3.1 Overview of Cause-and-Effect Tree for Valuation of External Effects of Plastic Products



Source: Adapted from World Bank 2022.

TABLE 3.1 Effects Included in the Estimator and the Assessment Method Used

Main activities and sectors	**Effect/environmental impact category (LCA only)**^{a}	**Assessment method used in the Estimator**
Effects identified using LCA		
Combustion of fossil fuels, fertilizer use, land use, incineration	1. Global warming potential, climate change	Monetization of LCA impacts via environmental prices
Combustion of fossil fuels, manure use, incineration	2. Particulate matter formation	Monetization of LCA impacts via environmental prices
Combustion of fossil fuels, direct volatile organic compound emissions	3. Photochemical ozone formation	Monetization of LCA impacts via environmental prices

(continued)

TABLE 3.1 *continued*

Main activities and sectors	**Effect/environmental impact category (LCA only)[a]**	**Assessment method used in the Estimator**
Combustion of fossil fuels, manure use, incineration	4. Acidification	Monetization of LCA impacts via environmental prices
Fertilizer use, manure use, incineration	5. Eutrophication of fresh water	Quantitative assessment
Land use	6. Land use: soil quality	Quantitative assessment
Risk of improper use or disposal of chemicals, incineration	7. Ecotoxicity in fresh water	Quantitative assessment
Risk of improper use or disposal of chemicals, incineration	8a. Human toxicity—carcinogenic effects	Quantitative assessment
	8b. Human toxicity—noncarcinogenic effects	Quantitative assessment
Water use	9. Water use	Quantitative assessment
Effects identified using literature review		
Packaging design and choice	10. Environmental cost of decrease in shelf life of perishable goods	Qualitative assessment
	11. Replacement cost of perished goods	Qualitative assessment
	12. Damage to or loss of packed goods due to inadequacy of packaging material	Qualitative assessment
	13. Replacement cost of damaged or lost packed goods due to inadequacy of packaging material	Qualitative assessment
Use	14. Clothing (synthetic textiles): environmental damage of primary microplastics	Qualitative assessment
	15. Diapers: opportunity cost of time spent washing diapers	Qualitative assessment
Littering (prevention) and cleanup	16. (Beach) cleanup costs	Qualitative assessment
	17. Cost of eradication programs targeting invasive species	Qualitative assessment

(continued)

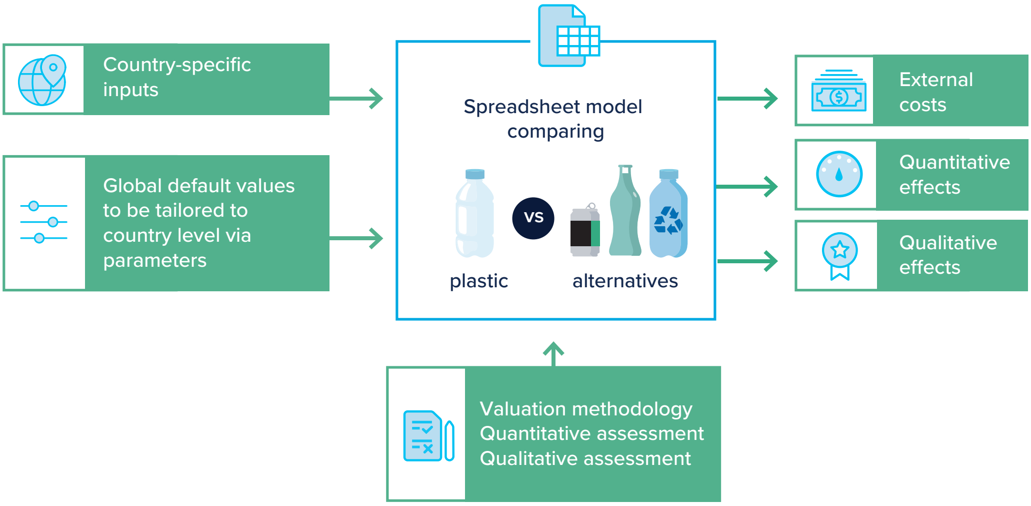
TABLE 3.1 *continued*

Main activities and sectors	Effect/environmental impact category (LCA only)[a]	Assessment method used in the Estimator
Marine ecosystem service delivery	18. Decrease in provision of marine ecosystem service delivery	Monetization via literature review
	19. Decrease in biodiversity and alteration of ecosystem due to spread of invasive species	Qualitative assessment
	20. Environmental damage from secondary microplastics	Qualitative assessment
Urban livability	21. Risk of floods caused by clogged drains	Qualitative assessment
	22. Risk of spread of disease caused by clogged drains	Qualitative assessment
Tourism	23. Loss of income from tourism due to litter	Monetization via literature review
Fisheries and aquaculture	24. Decrease in revenue associated with fish stock affected by invasive species	Qualitative assessment
	25. Decrease in revenue due to ghost fishing	Qualitative assessment
	26. Loss of value of sales from certain types of seafood due to perceived health risks of microplastics	Monetization via literature review
	27. Cost of repairing fishing vessels	Qualitative assessment
	28. Cost of cleaning, repairing, or replacing abandoned, lost, or discarded fishing gear	Monetization via literature review
Coastal agriculture	29. Costs associated with private land cleanup, clearing ditches, and repairs and animal entanglement, incurred by farmers	Qualitative assessment
Commercial shipping	30. Cost of repair and replacement of equipment and rescue operations of vessels	Monetization via literature review

Source: Adapted from World Bank 2022.

a. LCA uses the nomenclature “environmental impact category” in classifying the environmental effects throughout a product’s life cycle.

FIGURE 3.2 **Plastic Substitution Tradeoff Estimator: Inputs and Outputs**

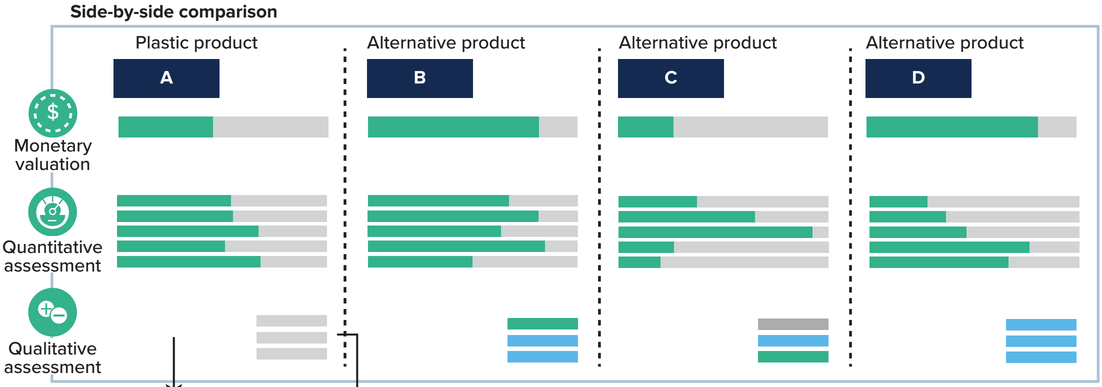


Source: Adapted from World Bank 2022.

their acceptability by users because it focuses on the impact of substitution; cannot assess the financial implications of product substitution (for example, those arising from price differences) because the model is built to estimate only external costs and, where relevant, benefits; and cannot provide results at a level of certainty that matches a model custom built for a specific country because it is a universal model. Data scarcity is a limiting factor—in particular acquiring data on the product level. Considering how challenging data collection can be, the Estimator offers default values that can be used when no local data exist. For example, the Estimator uses a life cycle inventory data set and other default values obtained from the literature review to fill gaps in local data. Users at different levels can overwrite default values when data are available; the more granular the inputs are, the more specific the outcomes become. Guidance notes have been developed to help users and can help define data collection needs in any country.

The outputs from the Estimator (figure 3.3) are presented in three types of comparisons: side-by-side product comparison, scenario comparison, and aggregate comparison. The side-by-side comparison compares the key outputs of one plastic product with those of its alternatives, assuming that each of the alternative materials is completely substituted for the plastic product. The scenario comparison allows the user to specify a target percentage of consumption for each product serving the same function (product type) and to determine the external costs of substitution with

FIGURE 3.3 Example Pilot of the Plastic Substitution Tradeoff Estimator: Shopping Bags in Mozambique



Product: Shopping Bag	**Single-use LDPE**	
Key Parameters		
Product weight	10	g / product
Product use	1	times
Consumption	0.77	kg / capita / year
Waste generated	0.77	kg / capita / year
Costs, Quantitative, and Qualitative Effects	Detailed Outputs	
Monetary Valuation		
Climate change	6.87	US$ mln. / year
Photochemical ozone formation	0.26	US$ mln. / year
Particulate matter	0.30	US$ mln. / year
Acidification	0.11	US$ mln. / year
Provision of marine ecosystem services	4.13	US$ mln. / year
Tourism	0.00	US$ mln. / year
Total costs	11.67	US$ mln. / year
Quantitative Assessment		
Climate change	91,578,022	kg CO_2 eq / year
Photochemical ozone formation	336,288	kg NMVOC eq / year
Particulate matter	4	disease incidence / year
Human toxicity, total	1	CTUh / year
Acidification	349,697	mol H+ eq / year
Eutrophication, freshwater	2,421	kg P eq / year
Ecotoxicity, freshwater	1,289,617,372	CTUe / year
Land use	327,315,252	Pt / year
Water use	55,755,540	m^3 depriv. / year

Alternative 2:	**Jute**	
Key Parameters		
Product weight	150	g / product
Product use	100	times
Consumption	0.12	kg / capita / year
Waste generated	0.12	kg / capita / year
Costs, Quantitative, and Qualitative Effects		
Monetary Valuation		
Climate change	1.74	US$ mln. / year
Photochemical ozone formation	0.06	US$ mln. / year
Particulate matter	0.17	US$ mln. / year
Acidification	0.06	US$ mln. / year
Provision of marine ecosystem services	0.14	US$ mln. / year
Tourism	0.00	US$ mln. / year
Total costs	2.18	US$ mln. / year
Quantitative Assessment		
Climate change	23,165,281	kg CO_2 eq / year
Photochemical ozone formation	74,977	kg NMVOC eq / year
Particulate matter	2	disease incidence / year
Human toxicity, total	1	CTUh / year
Acidification	196,322	mol H+ eq / year
Eutrophication, freshwater	18,981	kg P eq / year
Ecotoxicity, freshwater	1,115,067,349	CTUe / year
Land use	422,880,101	Pt / year
Water use	66,531,659	m^3 depriv. / year

(continued)

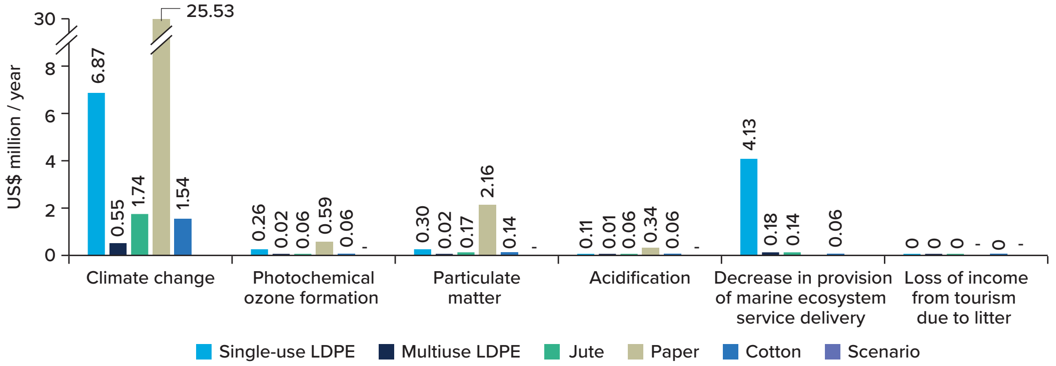
FIGURE 3.3 *continued*

Qualitative Assessment (relative to the base case)

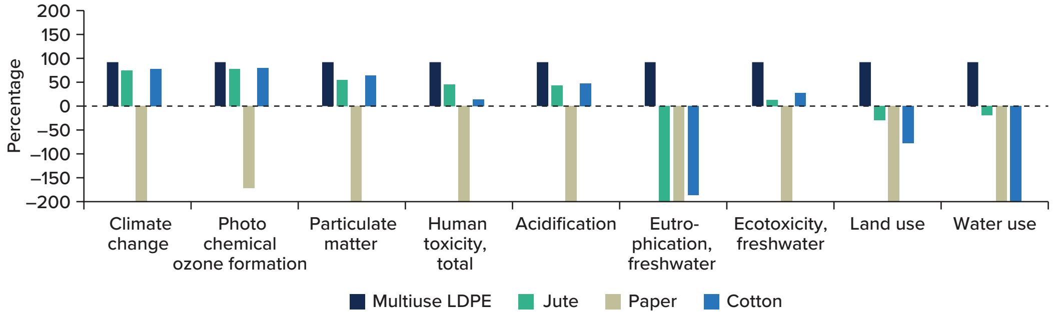
** Please visit the Guidance worksheet and the users' manual for additional information.*

Environmental cost of decrease in shelf-life of perishable goods	🟥
Replacement cost of perished goods	🟥
Damages to / loss of a packed good due to inadequacy of the packaging material	🟩
Replacement cost of damaged / lost packed good due to inadequacy of the packaging material	🟩
Diapers: Opportunity cost of time spent washing diapers	
Clothing: Environmental damage of primary microplastics	
(Coastal) Clean-up costs	🟩
Cost of eradication programs targeting IAS	🟩
Decrease in biodiversity / ecosystem due to spread of IAS	🟩
Environmental damage of secondary microplastics	🟩
Increased risk of floods caused by clogged drains	🟩
Increased risk in spread of disease caused by clogged drains	🟩
Decrease in revenue associated with fish stock impacted by IAS	🟩
Decrease in revenue associated with fish stock due to ghost fishing	
Cost of cleaning, repairing, or replacing ALDFG	🟩
Costs associated with private land clean-up, clearing ditches, and repairs, as well as animal entanglement incurred by farmers	🟩

Monetary Valuation



Quantitative Assessment (% change from the single-use LDPE shopping bag)



*Over 200% is not reflected in the graph. Please refer to the Output tab for values 200% and above.

**Positive percentages represent a decrease in value compared to the base case (that is, an improvement); negative percentages represent an increase from the baseline (that is, worsening).

Source: Adapted from World Bank 2022.

Note: ALDFG = abandoned, lost, discarded fishing gear; CO_2 = carbon dioxide; CTUe = comparative toxic unit ecotoxicity; CTUh = Comparative Toxic Unit for human; mol H+ eq = equivalent molar concentration of the hydrogen ion; g = gram; IAS = invasive alien species; kg = kilogram; LDPE = low-density polyethylene; mln = million; NMVOV = non-methane volatile organic compounds; P eq = phosphate equivalent; Pt = points; m^3 depriv. = cubic meters deprived.

a combination of materials. The aggregate comparison compares cumulative external costs of several plastic products (all or some of the 10 included in the Estimator) with those of alternatives.

Lessons from Implementing the Estimator

The Estimator was piloted in five countries: Bangladesh, Mozambique, Nigeria, St. Lucia, and Vietnam. These countries represent diverse settings and geographies to help contextualize possible country contexts relevant to plastic management, including production and consumption profiles (for example, importer or exporter of raw materials and products), income level (prioritizing low- and middle-income countries), and region (to account for behavioral and cultural differences that can affect consumption and disposal patterns); an island state was also included (relevant from a transport and trade perspective).

Although the Estimator is country specific and therefore does not provide global estimates, its application in the five pilot countries has enabled the identification of trends and tradeoffs that policy makers might consider.

Greenhouse gas emissions account for most of the monetized costs of all products.

For most products (plastics and alternatives), the monetized effects related to greenhouse gas (GHG) emissions are larger than the other monetized effects, accounting for approximately 70 to 90 percent of the monetized costs of all the products because, in almost all life cycle stages, fossil fuels are burned or electricity is used. Although these emissions occur along the whole life cycle, not just in the upstream life cycle stages, the upstream life cycle stages sometimes dominate in single-use items. This is also linked to the disposal options modeled; the GHG emissions from open-air burning and landfilling are higher than those from recycling.

Design changes can reduce external costs of plastic products while maintaining their functionality.

Decreasing the weight of a product while maintaining its functionality will decrease its quantified and monetized effects. All external costs of products are calculated on a weight basis, given that the weight of a product influences the effects of upstream and downstream life cycle stages, including the impact of product transportation. The heavier a product is, the higher the GHG emission footprints are during transport.

However, there are tradeoffs for the substitution of plastic products when considering GHG emission footprints during transport. The Estimator shows that the alternative that will perform better (in this case, generate fewer GHG emissions) will depend not only on the weight of the product but also on two other variables that users should consider: the number of times the product is used and the distance from production to sales. For example, in one country in Africa, GHG emissions from transportation of glass bottles are lower than those from transportation of single-use plastic bottles if the former are (re)used more than 13 times. If used only once, glass bottles could still generate fewer GHG emissions from transportation if the distance from production to sale is less than 8 percent of that of its plastic alternative. Local sourcing can therefore help reduce the external costs of alternatives, and the Estimator provides users with metrics to understand these thresholds.

Reusable and refillable alternative products perform better than single-use items if they are reused multiple times.

Multiuse alternatives have significantly lower total external costs than single-use plastic products. For some products, the costs are as much as 99 percent lower than those of the single-use plastic product.

The number of times reusable or refillable items are used can determine whether they perform better or worse than their single-use alternatives. For example, in a country in East Asia, cotton bags perform better (in terms of monetized effects) than single-use plastic bags only after being used more than 20 times. Similarly, glass containers perform better than multimaterial beverage cartons after being used 12 times. In the Caribbean, all disposable utensils (wood, polypropylene, and biopolypropylene) perform worse than the metal alternative if the metal utensils are used more than 15 times. In one country in Africa, the reusable polypropylene alternative for cups and food containers has lower external effects than its single-use expanded polystyrene, paper, or biodegradable polylactic acid alternatives only if used six times or more. The Estimator allows users to adjust the number of times a certain product is used over its lifetime and to (re)run the model as many times as needed to understand how the external costs and quantified effects respond to such changes. These metrics provide relevant quantitative information to inform discussions on alternatives and consumption patterns. It is clear that consumer behavior can play a significant role in reducing the external costs of products and that shifting to reusable alternatives should be accompanied by efforts to promote behavior change.

The choice of certain alternatives can increase employment, particularly when the alternative is manufactured domestically and replaces imports.

A substitute product that contains recycled content or is designed to be recyclable can be a source of direct employment from recycling and associated sorting and collection activities. Moreover, the literature review conducted for the Estimator found that for both plastics and alternatives, the employment intensity of the production phase tends to be lower than in recycling activities, suggesting that countries could gain by focusing on recycling rather than maintaining employment in the more upstream stage of the life cycle.

Using alternatives can involve tradeoffs that increase domestic employment at all stages of the product life cycle (for example, substituting a domestically manufactured alternative for an imported product). The reverse is also true: for example, substituting an imported alternative for a domestically manufactured product can reduce local employment. In the long term, using alternatives that have less of an impact on tourism and fishing is likely to increase employment in those sectors.

Loss of income from coastal tourism can account for more than half of the costs of littering in small island developing states.

In most country cases, the costs of GHG emissions accounted for most of the external costs. When the model was applied in a small island developing state, the external costs of littering accounted for 45 to 95 percent of the total external costs for 8 of the 10 plastic products. In this case, the external cost of littering was a larger factor because of the loss of income from tourism. In the Estimator, this loss is calculated based on beachgoers' willingness to pay for removal of plastic litter that has washed ashore. For example, when decreasing the number of tourist beach days by 10 percent in St. Lucia, the loss of income from tourism due to litter decreases by 20 percent to 50 percent per product.

Understanding and considering all tradeoffs is essential for the choice of substitutes. Alternative products may have indirect impacts, such as increasing land and water use, and could displace the plastic problem to another development issue.

In one country in the Caribbean, the decrease in provision of marine ecosystem services accounts for 27 to 38 percent of the total monetized external costs of plastic fishing nets: when left in the sea or swept away, fishing nets made of synthetic fibers do not degrade, and they retain functionality for a long period of time, leading to "ghost fishing." This leads to a loss of fishery resources, although there are other tradeoffs when using cotton and hemp alternatives. For example, cotton and hemp performed worse in terms of land (effects on soil quality) and water use, given the soil and water requirements for production. Those effects, although not monetized, are included as part of the quantitative assessment in the Estimator and can become a relevant tradeoff for consideration in countries with water scarcity, limited agricultural land, or conflicts over land use. The Estimator also includes qualitative assessments of effects that are relevant for alternatives but that cannot be currently monetized or quantified, such as the opportunity cost of time spent washing reusable diapers (box 3.1).

BOX 3.1 Maintaining a Gender Lens in Policy Design and Target Setting

Although the burden of certain effects may disproportionately fall on women, it is not possible to monetize these effects because of knowledge gaps and lack of data in life cycle analysis databases. For example, diapers and their environmental impact have become widely discussed in recent years. Multiuse products have lower external costs, and as could be expected, monetized external costs of natural fiber-based diapers are lower than those of single-use diapers, which indicates that substitution of these products is favorable. Nevertheless, women are the primary caregivers in many countries, so it is reasonable to assume that the task of washing reusable diapers falls disproportionately on them, but no study on the opportunity cost of time spent washing diapers (especially in countries where washing machines are not widely used or accessible) was found. Although some social effects cannot be monetized using the Plastic Substitution Tradeoff Estimator, they are still relevant for comparing alternatives, and the Estimator includes them as part of the qualitative assessment until further studies are conducted that will enable this effect to be quantified.

Source: World Bank.

Reference

World Bank. 2022 (forthcoming). *Plastic Substitution Tradeoff Estimator: Technical Guidance Note*. Washington, DC: World Bank.

4

Choosing Plastics Policy Instruments

Lessons Learned from Existing Policy Instruments

Many countries have implemented policies to manage plastic pollution, yet there is little evidence of how effective these policies are. Consumption of plastics was initially greatest in the Organisation for Economic Co-operation and Development (OECD) countries, so these countries have the longest experience in addressing the negative consequences of plastic pollution. For decades, plastics policies were considered part of solid waste management, and solutions were sought in the downstream part of the plastic life cycle—after plastic products were consumed and became waste—but extension toward upstream policy interventions (waste prevention at the design and production stages) has been evident.

Lower-income countries have been implementing plastic management policies more recently, often in a more fragmented manner (Alpizar et al. 2020). For example, in 2002, Bangladesh became the first developing country to ban single-use plastic bags after plastic items were found to clog drainage systems during floods. The range of policy instruments can be grouped into regulatory, economic, and informative measures (table 4.1). Direct regulations are the most commonly used policy instruments, having been implemented 3.5 times more often than economic instruments and 3 times more often than information instruments (Karasik et al. 2020).

Several plastic pollution reduction policies are aimed specifically at plastic packaging and packaging waste. Many countries operate deposit-refund schemes that encourage the return of plastic containers for reuse and recycling (for example, Australia, Canada, Chile, countries in the European Union, Mexico, Turkey, United Kingdom, United States) (UNEP 2020, 2021; Watkins et al. 2019). Most of the policies focus on specific plastic products such as bans or taxes on lightweight plastic bags. Bans and product restrictions were found to be effective where affordable alternatives were available and strong enforcement mechanisms existed (Hasson, Leiman, and Visser 2007). Some countries successfully used bans to reduce the consumption of plastic bags and food packaging (for example, Bulgaria, Fiji, Rwanda [see box 4.1], and Tanzania). In Italy, a ban on plastic bags stimulated an increase in the production of biodegradable and compostable bags.

None of the countries analyzed in the case studies rely on a single policy instrument to reduce plastic waste. All of them, like the OECD countries, use a mix of plastics policy instruments. A policy mix can be made more effective by implementing complementary policy instruments simultaneously. For example, appropriate collection and recycling systems are required together with raising awareness and incentivizing people and firms to separate waste at the source. Otherwise, people and firms lose motivation when they see that their segregated waste is mixed again by collectors. Where affordable alternative products are lacking, complementary policies should address the

TABLE 4.1 Types of Policy Instruments to Manage Plastic Pollution

Type of policy instruments	Description	Examples
Regulatory	Mandate product standards, performance levels, or technologies to be used and restrictions on production or consumption of specific plastic products. They are as stringent as their enforcement (level of sanction for noncompliance weighted by probability of its imposition).	Bans, prohibitions, standards, input thresholds, or limits
Economic	Provide price incentives to firms and consumers to change behavior, use resources more efficiently, and reduce the negative environmental impacts, but do not force firms and consumers to change behavior if it is too costly. This flexibility of economic instruments allows affected stakeholders to meet the policy targets at the lowest overall cost (static efficiency). Economic instruments also provide dynamic efficiency because even after changing behavior, polluters still pay for any remaining environmental footprint and hence have an incentive to seek innovative, low-cost ways to further reduce it.	Taxes and fees, subsidies, extended producer responsibility, and deposit-refund schemes
Informative, behavioral	Facilitate information exchange and behavioral nudges along the plastics value chain and influence stakeholder (usually consumer) behavior to prevent and manage waste.	Awareness-raising campaigns, consumer education, environmental labeling, behavioral nudges

Source: World Bank 2022b.

identification of alternatives to the product being banned or taxed. In Bangladesh, the absence of cost-effective alternatives to synthetic polymer bags was cited as hindering the effectiveness of the 2002 ban on plastic bags (Uddin et al. 2019). Even though the Bangladeshi government implemented the Jute Packaging Act (2010) to provide a market for local jute-based alternatives to plastic packaging, the jute-bag alternatives were expensive, costing the equivalent of 100–200 polyethylene bags, making the policy less effective. Conversely, after the plastic ban was introduced in Rwanda, the government provided subsidies for manufacturers of alternative materials and products.

BOX 4.1 Implementation of the 2008 Plastic Bag Ban in Rwanda

The 2008 plastic bag ban in Rwanda was designed to address plastic bag pollution by prohibiting the manufacture, use, importation, and sale of polyethylene bags.

Before implementation

There was a three-year transition period before the ban was introduced to build awareness and support among residents and businesses. This transition period adequately prepared residents and businesses for the proposed ban. Previously implemented environmental laws such as the 2005 Law on the Protection, Conservation and Promotion of the Environment and the 2007 Umuganda Law provided a legal framework for a structured waste management system and established environmentally conscious behaviors among Rwandese.

During implementation

Awareness-raising campaigns continued after the introduction of the ban, including educational interventions aimed at teaching children to avoid using plastic bags and to appreciate the environment (de Freytas-Tamura 2017).

There has been strong enforcement of the ban by the judicial police, customs authorities, the Rwanda Environment Management Authority, the Rwanda Bureau of Standards, security bodies, and local authorities. These authorities conduct regular checks, spontaneous shop inspections, and closures and fines for offending businesses. Moreover, the unique approach of making passenger announcements on arriving aircraft that no polyethylene bags are to be taken off the plane and into the country also played a significant role in ensuring enforcement of the ban (Dundas, Lacharny, and Bertsch 2013).

The government supported businesses by providing subsidies for manufacturers of alternative products and allowing exemptions in specific situations. For instance, Rwandese exporters of fruits and vegetables were exempted from the ban because there were no suitable alternative packaging products. The ability to secure well-defined, well-controlled exemptions has helped limit the impact on businesses and avoid noncompliance (Rwanda, Ministry of Trade and Industry 2011).

Barriers to implementation

Smuggling of plastic bags into Rwanda from nearby countries such as the Democratic Republic of Congo undermines the plastic bag ban.

Even though many business owners agree with the ban, the lack of suitable and affordable plastic alternatives causes them to continue selling products in plastic packaging, risking prosecution (de Freytas-Tamura 2017).

Source: World Bank 2022b.

As a result of these subsidies, small businesses offering alternatives, including paper bags, textile bags, and bags made of hemp, papyrus, bamboo, or banana peel, have emerged across Rwanda. In addition, the government organized awareness-raising campaigns to instill new behaviors and attitudes in Rwandese. The interaction of complementary policies and the use of different types of policy measures are more effective than using a single policy in reducing plastic pollution and promoting a circular economy.

Many existing plastics policies have applied restrictions and conditions on individual or combinations of polymer and specific product types (for example, polyethylene bags in Bangladesh, polyethylene terephthalate bottles in the European Union, and polystyrene food and drink containers in St. Lucia and the European Union) (Ocean Conservancy 2019; Pew Charitable Trusts and SYSTEMIQ 2020; UN 2018). The focus on a narrow set of plastic products and types has a moderate effect on plastic pollution reduction since other plastics remain in the economy. For instance, the levy on plastic bags in Fiji applied only to single-use polyethylene bags with handles, the type of bags usually provided for packing groceries at supermarkets. Other bags, such as plastic gift bags from duty-free stores and major shopping centers, were not covered, nor were bags distributed from vendors without a point-of-sale system, such as small dairy shops or market vendors (UN 2018). Similarly, in Bulgaria, the fee covered only a narrow range of plastic bags (15–25 microns) and excluded some of the most commonly used shopping bags (25–50 microns). When exemptions are made, there should be measures to mitigate the use of the exempt items (for example, specific collection). The European Union has implemented policies to target the top 10 plastic items in rivers or beaches, which appears to be an effective way of significantly reducing plastic pollution in the short term, promoting innovation, and developing new businesses that rely on the substitutes for those items. Similar approaches are being followed in Cambodia, the Caribbean, Kenya, and the Philippines.

Extended producer responsibility (EPR) mechanisms have been applied in many OECD countries since the 1990s (OECD 2001). They link the upstream and downstream segments of the plastic value chain by making producers at least partly responsible for financing and organization of products' reuse, collection, recycling, material recovery, and disposal. This is intended to provide incentives for producers and retailers to prevent waste at the source and promote product design that supports public materials management goals (OECD 2016). EPR mechanisms can also be used to mobilize financing for the creation of efficient collection schemes, to reduce disposal, and to increase recycling. In many cases, EPR schemes shift part of the responsibility for financing a portion of the plastic waste management system away from municipalities to the producers and consumers and therefore reduce the burden on public budgets. Such schemes also increase the cost efficiency of collection and recycling processes

(World Bank 2021). EPR applications in Europe and the Republic of Korea have reduced disposal rates, increased recycling rates, and lowered waste management costs by financing public budgets and encouraging producers to optimize efficiency (Watkins et al. 2017). Users of EPR mechanisms in the case study countries found that extending EPR to all producers and importers to avoid free riding, clearly allocating responsibilities across EPR stakeholders, and specifying the steps the private sector is expected to follow increase its effectiveness. Using EPR schemes to incentivize more sustainable design requires careful fee modulation. A review of EPR schemes (OECD 2021) has shown little evidence that collective EPR schemes with basic fee modulation (based on weight averages per material or product type) instigate better product design. An upgraded or more ambitious EPR scheme with advanced fee modulation stresses that fees should be set more specifically on criteria related to the environmental impact, instead of the weight, of the plastic products. This means that more environmentally friendly aspects like recyclability are taken into account, and eco-design improvements upstream are encouraged.

Further lessons learned from the country case studies can be grouped according to policy stage (see World Bank 2022b).

- **Participatory design:** Early identification and engagement of stakeholders in policy dialogue, including their participation in selection and design of policy instruments, increases the chance of buy-in and support for the policy. For instance, all plastics policies in Rwanda were developed ensuring multistakeholder engagement, and as a result, they generated support for the government and the policies. Furthermore, aligning expectations and setting a clearly defined process that details the roles and responsibilities of key stakeholders is important. In the state of Kerala in India, when the plastic waste management rules were introduced in 2016, stakeholders further suggested detailing the roles and responsibilities of authorities, citizens, and businesses, as well as the timeline toward waste management objectives (for example, segregation, collection, recycling).
- **Communication during implementation:** Evidence shows that clear and consistent communication is a key aspect of policy implementation, and effective programs raise awareness using a variety of media to help reach a wider audience. For instance, the Clean Kerala campaign used a mixture of media, such as murals, local meetings, handbooks, and internet-based visuals, to emphasize the importance of separating waste and avoiding littering. In Tanzania, the government ran a successful social and traditional media campaign to promote the 2019 plastic bag ban. According to stakeholders, the campaign was credited with driving a green movement across Tanzania. These findings are consistent with a study (Kaza et al. 2018) that concludes that education campaigns are a key aspect of raising awareness and that effective

programs distribute content using basic and advanced technology such as radio, television, and mobile phone applications. Uncoordinated awareness campaigns have led to confusion among households and businesses with limited understanding of the policies (for example, in Bulgaria and Fiji), highlighting the need for policy clarity and communication across stakeholder groups.

- **Enforcement:** It is necessary to build enforcement mechanisms and capacity for detection of noncompliance. Aside from detection, enforcement requires acting when noncompliance occurs (for example, using penalties, fines, or social pressure). In Tanzania, the threat of a fine and potential jail time proved to be an effective deterrent for retailers and the public. Members of the public and sellers were fined particularly in the early stages after the ban was instituted. In Fiji, the Department of Environment reported near full compliance from businesses during inspections on the first day of the ban on thin plastic shopping bags. The Fiji Revenue and Customs Service stated that the heavy fines imposed for flouting the ban provided a good deterrent. Conversely in St. Lucia, although enforcement procedures are included in the plastics policies and upper limits for fines are defined, minimum amounts are not stipulated, so minimal fines might be imposed. According to stakeholders, the maximum amount of the fines is not high enough to have a dissuasive effect.
- **Monitoring:** Tracking progress and reporting on the results of policy implementation provide transparency and invoke greater accountability of the implementing agency. Nonetheless, most case study countries reported a lack of data and challenges with monitoring policy progress, and countries often did not plan for measurement or reporting of the use, manufacture, import, or export of plastic bags for targets related to these products. In Bulgaria, the government reports national waste recycling data, including plastic bag use and collected fees, such as revenues accrued from the plastic bag tax, but environmental groups and the European Commission have questioned the quality of published data (Friends of the Earth Europe 2018). In Bangladesh, data such as the quantity of polyethylene bags produced and sold, which are needed to determine whether the 2002 ban on plastic bags is successful, were unavailable.
- **Evaluation and revision:** Ex post evaluation of policy performance is essential for policies to be adjusted over time to increase their effectiveness and adapt to new challenges and circumstances. Evaluation helps learn what is and is not working and what change is attributable to a policy (Gertler et al. 2016). Although few countries have a formal evaluation process in place, some conducted informal policy assessments, including examining whether targets were met and adjusting policies. Policies in Bangladesh were found to have varying levels of success. Some were not deemed successful, and others, such as the Jute Packaging Act, were deemed

partially successful but were expensive. The assessment also detected apparent growth in the recycling industry, including jobs. Evaluation should lead to policy revisions in response to the implementation experience. Rwanda's plastic bag ban led to illegal imports of bags. In response, Rwanda implemented border checks, fines, and punishments for noncompliance. Furthermore, Rwanda altered its plastic packaging ban to allow fruit and vegetable exporters to apply for an exemption to import preferred plastic packaging for their produce. Tanzania introduced standards to close a loophole in its single-use packaging ban. Some manufacturers, retailers, and consumers had bypassed the ban by increasing the use of exempt packaging such as bread packaging. In Bulgaria, informal waste pickers scavenge recyclables in urban settlements and landfills and sell them, which reduces the revenue that the government receives from selling these materials. The government responded by outlawing waste picking, but the practice remains prevalent because of staff shortages in enforcement agencies. Regulators are considering closing buy-back centers so that informal collectors and waste pickers do not have anywhere to sell recyclables and to increase collection efficiency.

A Whole-System Approach to Plastic Management: Applying the Plastics Policy Simulator in Indonesia

Why Simulate Plastics Policy Impacts?

Governments set targets for society, while it is the individual firms and households that make millions of decentralized decisions every day that jointly determine whether government targets are achieved. All governments can do is create incentives and enabling conditions to influence these decisions toward implementation of the agreed technical and behavioral measures. Before laws are passed or public money is spent, it is difficult for policy makers to know how economic actors will react to various policy instruments and what the costs, revenues, and other impacts of these policies will be. A trial-and-error approach to policy implementation is risky because the economic and political costs of errors in the real world may be high. Therefore, models can be used to simulate the impacts of the decisions that various stakeholders consider and to reduce the risk of mistakes.

Financial models to simulate the impacts of plastics policies on economic actors have not been available until now. Several qualitative policy options and road maps exist, and some quantitative ex ante policy impact assessments are emerging (Common Seas 2019a, 2019b; European Commission 2018b). However, the existing models do not systematically quantify the multiple impacts of applying multiple policy instruments and the interactions between them. To fill this gap, the World Bank developed the concept of the Plastics Policy Simulator (PPS), a simulation model to estimate the impacts of various policy instruments on economic actors operating in the entire plastic value chain. The PPS model was then implemented in Indonesia in collaboration with SYSTEMIQ to support policy makers and other government, industry, and civil society stakeholders in search of mutually agreeable policy solutions. The PPS helps policy makers navigate public consultations about highly complex, sometimes controversial policy interventions before they are implemented.

The PPS builds on detailed plastic volume flow data and technology costs developed for the Breaking the Plastic Wave study (Pew Charitable Trusts and SYSTEMIQ 2020), which optimized the combination of technical measures to address plastic pollution from the perspective of a social planner. The PPS takes this system-modeling approach to the next level by adding a financial and behavioral module, which uses market data to simulate the impacts of upstream and downstream policy interventions on private decisions of economic agents. As such, it is designed to support policy dialogue between stakeholders who may initially disagree on how to solve the plastic pollution problem. The PPS is built to support more effective and transparent policy making, align the self-interests of firms and households, and create commercially viable markets for collective action to reduce plastic pollution.

In this section, we discuss the results of alternative plastics policy scenarios for Indonesia, while the next section and appendix C explore methodological issues, including PPS model architecture and functions. Detailed technical model documentation and a user's manual are available upon request.

Making Policy Coherence Tangible and Measurable

Even when policies comprehensively cover upstream and downstream parts of the plastic value chain, they will not be effective unless they send coherent signals to economic actors. Policy coherence is important even if policy coverage is not comprehensive. Any two policy instruments can be incoherent. For example, subsidies to fishing vessels and plastic fishing gear on the one hand, and subsidies to beach and ocean cleanup on the other, is an example of incoherent policies, which cancel each other's effects and lead to a waste of public funds.

Policy coherence is about fostering synergies across the value chain, managing tradeoffs between policies, and aligning the objectives of critical actors. Quantifying synergies and tradeoffs between policy instruments is an important step toward identifying a coherent mix of instruments that effectively achieves desired policy goals by aligning the self-interests of households and businesses. It also helps make social goals more affordable for people and government budgets. The PPS was developed to identify such coherent plastics policy mixes with the best possible quantitative evidence.

In the following section, we show how it was applied in Indonesia. It is important to note that quantifying the impacts of policy mixes with the PPS informs but is not a substitute for the complex decision-making process that involves value judgments and political bargaining to win broad support across society.

Simulating Plastic Management Policies in Indonesia

The Indonesian government set three national solid waste management targets by 2025: reduce marine plastic debris by 70 percent, reduce waste at the source by 30 percent, and increase the safe collection and disposal rate to 70 percent. To operationalize the first of these targets, the government has published a comprehensive Plan of Action on Marine Plastic Debris, enshrined in Presidential Decree 83/2018. Furthermore, several ministries have initiated policy action in their own fields of competence. For example, the Ministry of Environment and Forestry has issued regulation No. 75/2019 (MR 75/2019) requiring waste reduction and recyclability targets from businesses, the Ministry of Finance has drafted a concept for a plastic bag excise tax, and the Ministry of Home Affairs has drafted regulations to make it easier for local governments to raise waste fees from households, while the Coordinating Ministry for Maritime Affairs and Investment has initiated refuse-derived fuel plant and river cleanup initiatives. In February 2020, the parliament of Indonesia also proposed an excise on a variety of plastic products beyond the initial excise plan on carrier bags (Diela 2020). In addition, dozens of nongovernmental initiatives to reduce plastic waste pollution have emerged across the country as partnerships among local municipalities, business leaders, and environmental groups. The proposed regulatory initiatives and public investments are discussed extensively within the country, but their combined effects and mutual interactions are hard to understand for parties engaged in the consultations. Without a better assessment of the impacts of their actions and who the potential winners and losers may be, policy makers—not just in Indonesia—hesitate to implement ambitious policy changes.

In Indonesia, the PPS model was first used to simulate the impacts of individual policy initiatives proposed by different ministries, business groups, and civil society. Second, the joint impact of a mix of policy instruments was simulated. All scenarios quantify synergies and tradeoffs across several impact variables—environmental, social, fiscal, and financial. The impacts of alternative policy proposals were compared with the impacts of maintaining policies already implemented in the country.

The key finding from the PPS application in Indonesia is that it is possible to encourage Indonesian firms and households to reduce plastic pollution in alignment with the government targets, but only by integrating multiple upstream and downstream policy interventions. The PPS simulations also identified where to begin comprehensive policy reform and how to gradually unlock market conditions for plastic circularity and pollution management.

First, the PPS simulated the impacts of individual policy initiatives proposed by different ministries, business groups, and civil society. Second, it simulated the integrated policy reform (IPR) scenario combining 12 policy instruments applied upstream and downstream in the plastic value chain. Among others, the IPR scenario includes upstream excise taxes on packaging with low recycled content, EPR fees, bans on selected products, and upstream product design standards. Among downstream interventions, the IPR scenario includes subsidized reuse of certain packaging, a deposit-refund system for beverage bottles, additional public financing for formal collection and landfilling in periurban and remote locations, and higher household waste management fees. Complementary "softer" policies include information campaigns, behavioral nudges, mandatory labeling, and improved waste management governance. Unlike scenarios focused on individual policy instruments, an adequate mix of policy instruments targeting all segments of the value chain could trigger systemic changes in the Indonesian plastic management system, which are necessary to achieve government targets. A full list and short description of assumptions for each instrument can be found in table 4.2.

The mandatory EPR mechanism was simulated as a fee levied on consumer good companies with revenues earmarked to an extrabudgetary packaging recovery organization (PRO) managed by industry itself under government supervision. The PRO uses the funds collected to increase earnings of collection and sorting services. In this way, the EPR fees serve the dual objective of encouraging less plastic waste generation upstream, increasing demand for recycled plastic, and mobilizing revenue to finance the downstream waste management system. One difference between the EPR fee and plastic excise taxes is that the revenue of the former is channeled through an extrabudgetary private fund managed by industry, while taxes are channeled through the government budget.

The PPS users can choose between immediate and delayed implementation (table 4.2). In reality, political and social processes can take more time, and some of the instruments in this mix may turn out to be unfeasible for nonfinancial and nontechnical reasons, which are not captured by the PPS. Implementation hurdles, especially in countries with lower income and weaker institutions, may take longer to overcome than assumed in the PPS, which—as with any model—is a simplified representation of reality. The model also estimates the administrative costs of implementing and enforcing policies for the governments, as well as firms' and households' transaction costs of compliance with policies.

TABLE 4.2 Package of Policy Reforms Assumed in the Integrated Policy Reform Scenario, Indonesia

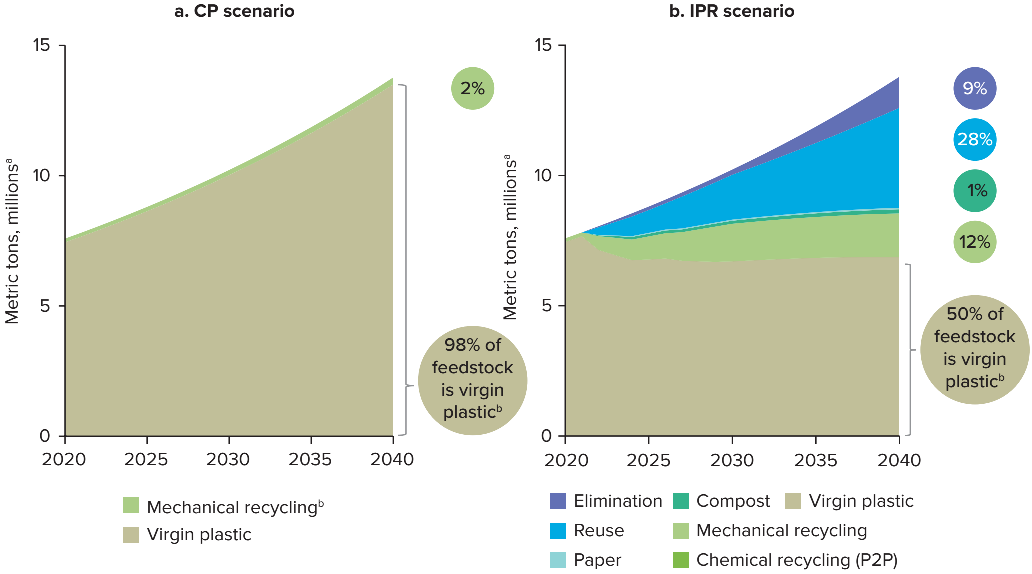
	Policy instruments applied	
Timeline **Policy objectives**	**Now**	**In 5 years**
A Slow the growth of plastic use and waste generation	• **Impose product bans** on bags, disposable utensils, takeaway food containers, and beverage cups and lids	• **Subsidize reuse systems** for bottles and rigids at US$95/metric ton
B Fund waste management and recycling at scale	• **Enable household fees:** applied as indirect fees in megacities and medium-sized cities; direct in periurban areas • **Mandatory modulated extended producer responsibility:** US$70/metric ton for bottles, US$130/metric ton for rigids and monoflexibles, and US$150/metric ton for multimaterials • **Public financing of formal collection:** expand by 500,000 metric tons in periurban and remote archetypes • **Public financing of sanitary landfill:** expand by 500,000 metric tons in periurban and remote archetypes	• **Enable household fees:** applied as direct in remote archetype
C Create market demand for recycled plastic	• **Virgin plastic excise tax on all packaging:** at ≈US$70/metric ton • **Consumer education campaigns** (downstream) • **Enforce mandatory design requirements** on all materials except multilayers	• **Establish mandatory deposit return schemes** on all beverage bottles • **Enforce plastic labeling**
D Strengthen institutional capacity and governance	**n.a.**	• **Improve governance**

Source: Adapted from World Bank 2022a.
Note: n.a. = not applicable; no policy instrument was applied.

Impacts on Plastic Use, Circularity, and Leakage to the Environment

In the ***current policies (CP) scenario,*** plastic municipal waste generation in Indonesia would increase by 82 percent—from 7.9 million tons (Mt) in 2020 to about 13 Mt in 2040 (figure 4.1a). The expected volume of mismanaged plastic waste (see figure 4.2) significantly increases to 2040 because of the combined effect of growth in total plastic use and the absence of incentives to increase the rate of collection, recycling, and landfilling of waste. The downstream plastic waste management system would

FIGURE 4.1 **Use of Virgin Plastics in Indonesia**



Source: Adapted from World Bank 2022a.

Note: CP = current policies; IPR = integrated policy reform; P2P = plastic to plastic.

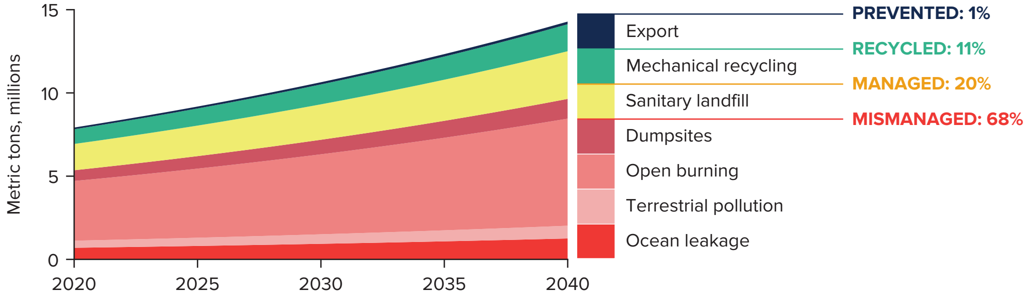
a. The volume illustrated in the chart is plastic waste generated. This is different from plastic consumption in that plastic waste is heavier, because it contains humidity or contamination. Plastic waste is "counted" in the year it becomes waste, not the year it is first consumed.

b. Mechanical recycling includes both open-loop and closed-loop mechanical recycling. Open-loop recycling has a very small impact on reducing the total volume of the virgin plastics generated as a feedstock.

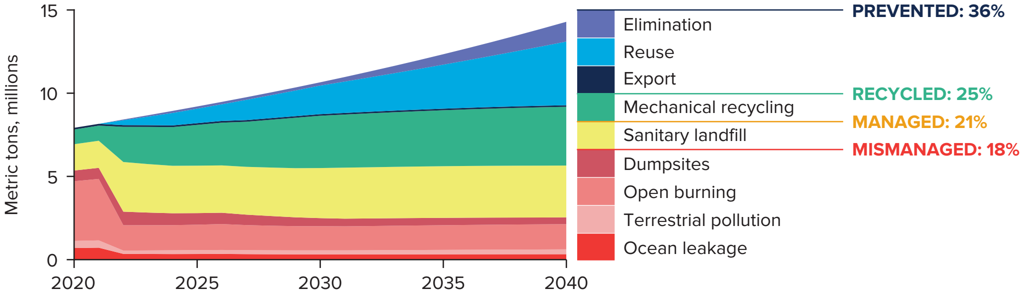
be more overloaded than today. By 2040, nearly 70 percent of Indonesia's plastic waste would pollute the environment, either by being dumped on land, flowing to the ocean, or being burned in the open air. In absolute terms, this will be a major increase from 5.4 Mt in 2020 to 9.6 Mt in 2040. In the CP scenario, plastic leakage into the ocean would roughly double annually to 1.3 Mt in 2040, compared with 0.7 Mt per year today. A small rate of recycling (11 percent, the same as today) would remain commercially viable, mainly in large cities. Recycling would continue to be limited to plastic products collected by informal waste pickers. As little as 2 percent of plastics would be sourced from recycled feedstock, the same as today.

FIGURE 4.2 **Impacts of Policy Reforms on Plastic Final Destination in the System, Indonesia**

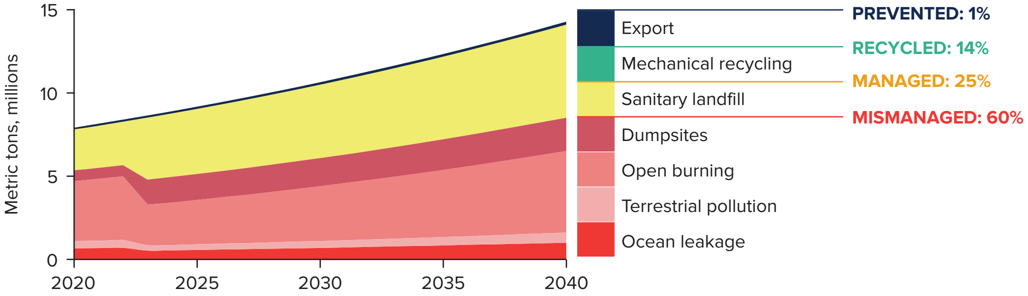
a. CP scenario



b. IPR scenario



c. SCS scenario



Source: Adapted from World Bank 2022a.
Note: CP = current policies; IPR = integrated policy reform; SCS = subsidies for collection and sorting.

The integrated policy reform (IPR) scenario combines upstream policy interventions that align incentives of firms and consumers for plastic circularity. Applying the IPR scenario has multiple synergistic impacts on reducing plastic pollution in Indonesia. First, upstream excise product taxes, product bans, EPR fees, and policies to change consumer behavior would reduce the volume of virgin plastic feedstock used in final plastic goods in Indonesia from 98 percent in the current policies scenario to 50 percent by 2040 (figure 4.1b). This would prevent almost half of virgin plastic from entering the waste management system, relieving it from overload and creating willingness to pay for the plastic reuse and substitute businesses as well as for recycled plastic feedstock.

Coherent upstream and downstream policies in the IPR scenario reduce the volume of total mismanaged waste (sum of that discarded at open dump sites, in the environment, openly burned, and leaked to oceans) from 68 percent of total waste by 2040 in the CP scenario (figure 4.2a) to 18 percent in the IPR scenario (figure 4.2b). A circularity rate (a sum of plastic volume that is avoided, reused, and recycled) could grow from 12 percent to 62 percent. All the Indonesian government targets could be achieved by 2040—marine pollution would be reduced by 74 percent, plastic waste would be reduced by 37 percent, and safe handling rates (circulated, composted, and safely disposed plastic waste) would exceed 80 percent.

In the increasing subsidies for collection and sorting (SCS) scenario, in figure 4.2c—the traditional way of solving the waste management problems—could increase the formal collection rate from 24 percent in 2020 to around 80 percent of total plastic waste generated in 2040, exceeding one government target of the collection rate reaching 70 percent. The PPS estimates that extra financing of Rp 3 trillion (US$200 million) per year for formal collection of plastic waste would allow an increase of the volume of plastic waste collected from 4.3 Mt per year in 2040 in the CP scenario to 10.4 Mt per year in 2040 in the SCS scenario (a portion of additional collection cost of total waste allocated to plastic waste on a tonnage basis). However, just spending more public funds in the solid waste management system would not achieve the core government target of reducing marine plastic debris by 70 percent from 2017 to 2025. In this scenario, the environmental leakage would increase with respect to 2020, although it would be 22 percent lower by 2040 compared with the CP scenario. The volume of plastic pollution would drop more initially but accelerate later in the absence of upstream incentives to change production and consumption patterns. The PPS allocates additional volumes of collected plastic waste to sorting and landfilling in the same proportions as in the CP scenario, also increasing its costs and claims on public funds (see discussion of fiscal impacts that follows).

Results of other selected single-policy scenarios are discussed in appendix C.

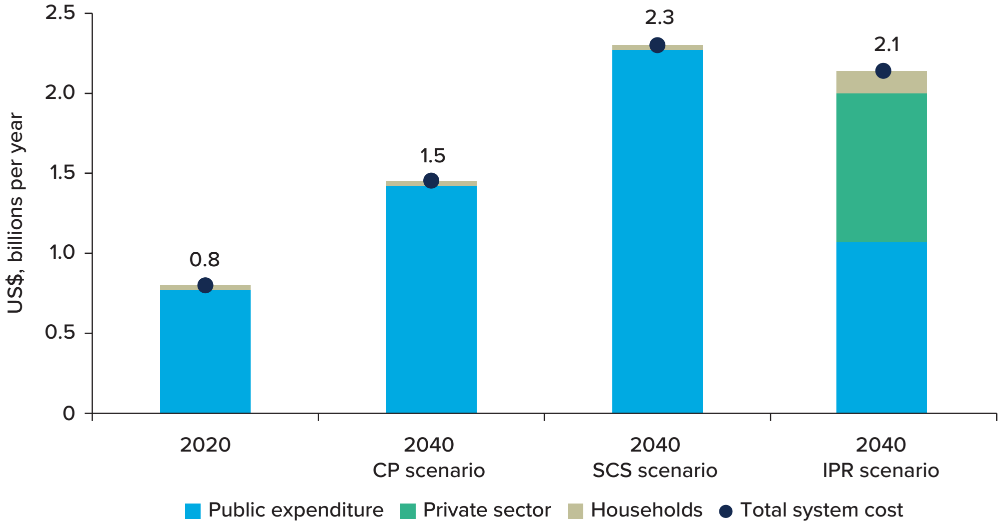
Total Financial Cost of the Solid Waste Management System and Who Pays

The continuation of the CP scenario would almost double the solid waste management cost (figure 4.3) while increasing plastic pollution by nearly 75 percent (figure 4.2a).

In the SCS scenario, the traditional way of solving the problem by public financing of downstream waste management systems (collection, sorting, and landfilling) would almost triple the solid waste management costs (to US$2.3 billion per year in 2040) and put an enormous strain on public budgets, while still not reversing the trends of increasing plastic pollution (figure 4.2c). The comprehensive mix of upstream and downstream plastic management policies in the IPR scenario would reduce plastic pollution by 70 percent below 2020 levels at a total system cost (US$2.1 billion per year), which is lower than in the SCS scenario because upstream product taxes, standards, and bans in the IPR scenario would reduce the volumes of plastic waste that the solid waste management system must handle.

Without reforming the current regulatory framework in the CP and SCS scenarios, all the market failures described in chapter 1 of this report (see the section called

FIGURE 4.3 **Total Plastic Waste Management System Cost and Financing Sources under Different Policy Scenarios in Indonesia**



Source: Adapted from World Bank 2022a.

Note: 2020 price level. CP = current policies; IPR = integrated policy reforms; SCS = subsidies for collection and sorting.

"The Hidden Costs of Plastic") would deprive the firms operating in the Indonesian plastic value chain from commercially viable opportunities to engage in circular economic activities and reduction of plastic pollution. Lack of private investments and financing would significantly increase the burden on already stretched public budgets. Insufficient revenues to cover increased costs of collection and sorting of plastic waste would be the main bottlenecks in the plastic value chain. Firms operating these services would have to deal with much larger volumes of waste while receiving limited revenues from users and polluters (households) and no revenues from upstream producers who are responsible for introducing plastic products into the economy.

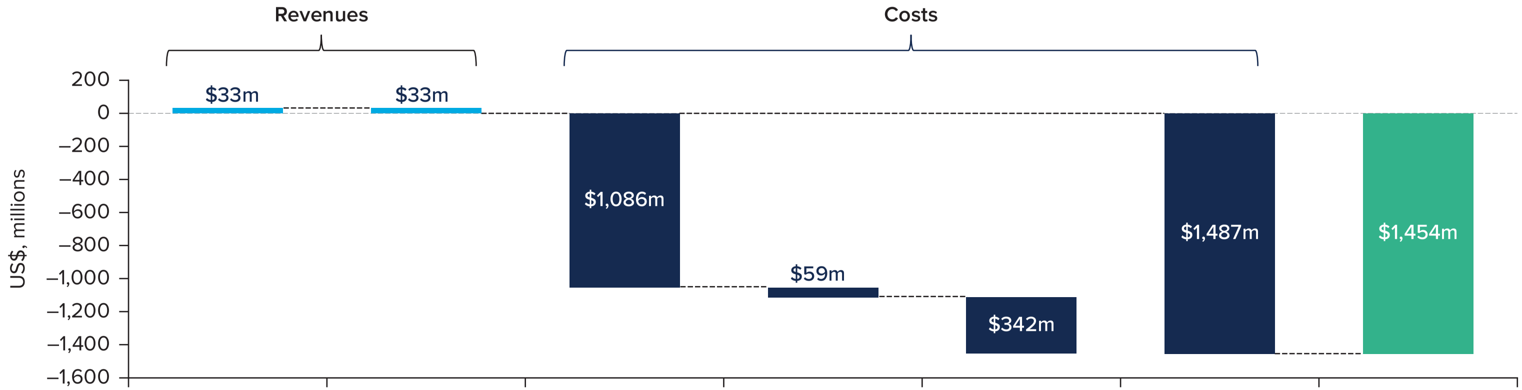
The IPR scenario delivers ambitious plastic management goals at additional cost compared with doing nothing (CP scenario), but at lower cost than traditional subsidies for collection and sorting (SCS scenario). The IPR scenario unlocks financing by the private sector by aligning incentives of upstream firms and households with downstream sorting and recycling businesses (figure 4.3). Most of this financing would come through voluntary, profit-seeking investments, although some funds would be channeled from the private sector through mandatory transfers, such as the EPR fees and product taxes.

Fiscal Impacts

Today, the formal waste management services in Indonesia, such as collection and landfilling, are financed and operated by government-controlled entities. Therefore, in the PPS model, financing for formal waste is drawn from subnational budgets.[1] The public sector can partly recover or reduce its expenditures on waste management in policy scenarios by raising households' waste management fees, sometimes called "retribution" fees, and by introducing a mandatory EPR fee, which is collected from brands and retailers and transferred through extrabudgetary channels to formal waste collection and sorting operations. Another, indirect, way for the government to reduce the net fiscal burden is to levy taxes on plastic products upstream and generate additional revenue, which may or may not be allocated to finance the improvement of waste management services.

In the CP scenario, the volume of plastic waste continues to increase and private investors have no incentives to invest in the waste management activities. Therefore, the local governments must pick up the bill, boosting public expenditure by 87 percent in real terms—from Rp 11 trillion (US$800 million) in 2020 to Rp 21 trillion (US$1.49 billion) by 2040—just to maintain the same rates of formal collection, sorting, and sanitary landfilling as in 2020 (figure 4.4). Formal waste collection represents the largest fiscal liability, amounting to about US$1.1 billion per year. The waste management fees paid by households are assumed to remain low, because raising tariffs would be difficult amid worsening plastic pollution. In the CP scenario, local governments recoup

FIGURE 4.4 Fiscal Liabilities of Doing Nothing: Annual Net Fiscal Impact of CP Scenario, National and Subnational Governments, Indonesia, 2040



	Household fees	Total revenue	Public financing to formal collection	Public financing to formal sorting	Public financing to landfilling	Total cost	Net fiscal impact under CP scenario
Key data and assumptions	Depending on archetype[a] • Fees of US$0.14–2.08/hh/month • Compliance 15–55%	Includes household fees only	• Annualized CAPEX of US$6/t input • Annual OPEX of US$24/t input • Formal collection rate of ≈32%[b]	• Annualized CAPEX of US$17/t input • Annual OPEX of US$8/t input • Landfills only in megacities and medium-sized cities			

Source: Adapted from World Bank 2022a.

Note: Includes all municipal solid waste management costs. CAPEX = capital expenditure; CP = current policies; hh = household; m = million; OPEX = operating expenditure; t = ton.

a. Based on actual data points from all archetypes with remote extrapolated.

b. GPAP and WEF 2020.

only US$33 million from plastic users, leaving the general government with a net fiscal deficit on the waste management system amounting to almost US$1.5 billion in 2040 in 2020 prices. Current policies would therefore mean greater public spending for worse environmental and service outcomes.

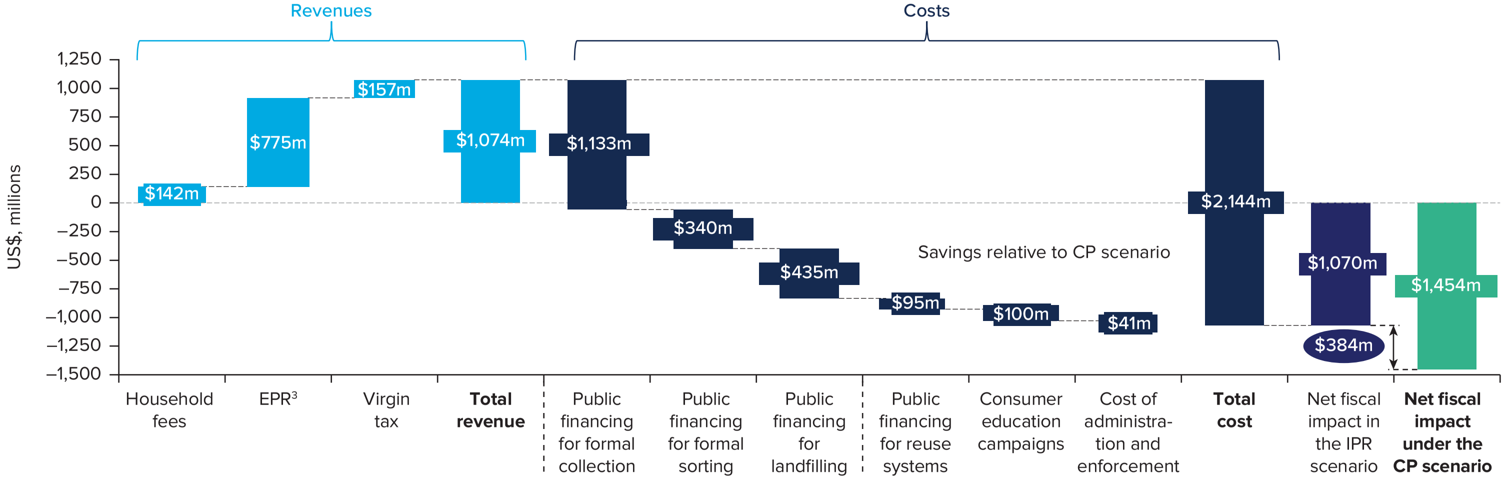
The SCS scenario of just increasing public funding of downstream solid waste management (figure 4.2c) could meet only one government target of a 70 percent collection rate, but at high system cost and fiscal burden (figure 4.3). Additional public expenditure of Rp 3 trillion (US$200 million) per year would be needed to lift the collection rate to around 80 percent. This would imply an increase of public financing of landfills (Rp 8.1 trillion or US$560 million) and sorting (Rp 1 trillion or US$75 million) to accommodate a larger volume of plastic waste collected. The total incremental fiscal expenditure on the top of the current policies (CP) scenario would be US$835 million, bringing the overall solid waste management system cost and fiscal liabilities to US$2.3 billion per year in 2040, compared with US$800 million in 2020.

The IPR scenario demonstrates the synergies of applying a coherent policy mix that includes downstream and upstream fiscal instruments (figure 4.5). The IPR scenario would achieve much better environmental and waste management service outcomes at relatively low fiscal cost. The total system cost increases from over US$800 million in 2020 to US$2.14 billion, but the net public spending on plastic waste management would increase to US$1.1 billion annually in 2040 compared with around US$1.5 billion in 2040 in the CP scenario, and to over US$2.3 billion in the SCS scenario (figure 4.3). The difference in net fiscal burden of Rp 6 trillion (almost US$400 million) in 2040 against the CP scenario (and by US$1.2 billion against SCS) can be mainly attributed to lower system cost, higher private investments, and higher government revenue. The capital and operational expenditures of collection, sorting, and landfilling companies are lower in the IPR scenario (compared with CP and SCS scenarios), because less plastic waste is generated due to the incentive effect of upstream policies. The waste management companies also collect a larger share of revenues through the EPR fees (US$775 million per year) and from recyclers. The government also mobilizes additional revenues from household fees (US$142 million per year) and virgin plastic excise taxes (US$157 million per year). Higher EPR fees allow the application of lower virgin tax rates than in the virgin plastic tax scenario (see appendix C) and achieve the same incentive effect. In conclusion, the IPR scenario achieves environmental targets and improves the level of waste management services at affordable costs to the budget and households.

Financial Impact on Firms

The fiscal results previously discussed show that the IPR scenario puts a lower burden on public budgets compared with CP and SCS scenarios. Then the question arises—who pays for the higher system costs of achieving the government targets? As a

FIGURE 4.5 How Government Can Achieve More with Less: Annual Net Fiscal Impact of IPR Scenario, National and Subnational Governments, Indonesia, 2040



	Household fees	EPR³	Virgin tax	Public financing for formal collection	Public financing for formal sorting	Public financing for landfilling	Public financing for reuse systems	Consumer education campaigns	Cost of administration and enforcement
Key assumptions	• US$2/hh per month[a] compliance 90% (megacities and medium-sized cities), 60% periurban and remote[b]	• US$70/t for bottles • US$130/t rigid and monoflex • US$150/t multi	• ≈US$70/t	• Increase by 3.5 Mt due to EPR funding[c] and improved (level 3) governance • Costs same as CP scenario • Extra 500 kt expansion	• Extra 500 kt expansion		• Bottles and rigids US$95/t subsidy[b]	• US$25m per arche type	• Varies per policy

Source: Adapted from World Bank 2022a.

Note: Includes all municipal solid waste management costs. CP = current policies; EPR = extended producer responsibility; IPR = integrated policy reform; kt = kiloton; m = million; t = ton.

a. In line with government regulation Permen Dagri 3/2021.

b. Policy implemented after five years.

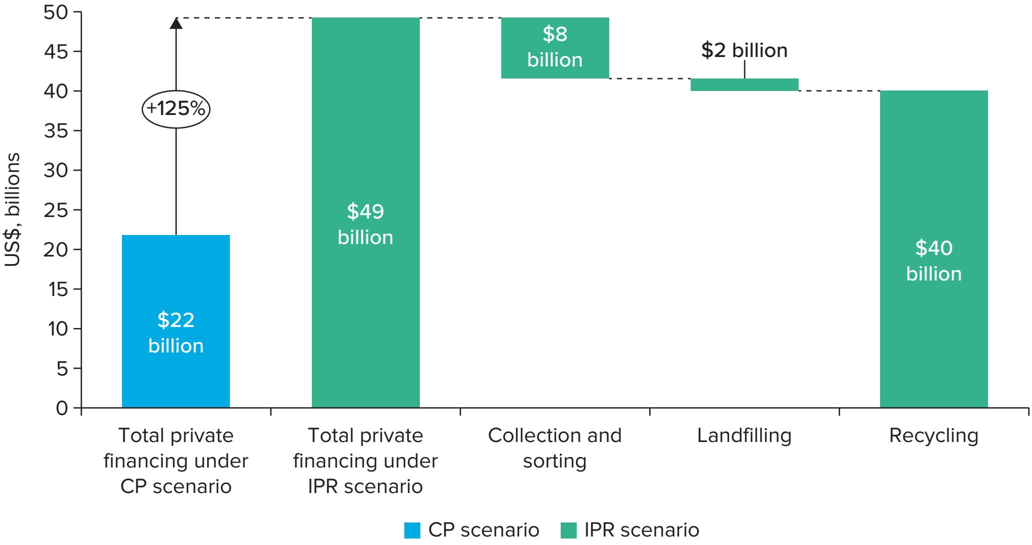
c. EPR is not a revenue to government; it finances collection and sorting directly through packaging recovery organization. It is displayed in this chart becuase it offsets a portion of government spending.

financial model, the PPS calculates the distribution of costs and financing among key economic actors active in the plastic value chain, including the governments, households, and 10 types of firms.

The IPRs would create enabling market conditions to leverage US$50 billion in profit-driven private financing into sustainable waste management services, of which US$40 billion would go to recycling alone (figure 4.6). Recycling firms scale up their activity and attract commercial investments because upstream policy packages generate a sustainable flow of revenue to recycling businesses. In the IPR scenario, the upstream plastic converters are willing to pay more for recycled content of their products because they face bans and design standards for plastic products, as well as virgin plastic tax and EPR fees paid by their clients (brands and retailers). In addition, the funds collected through EPR fees and household waste fees increase revenues of sorting and recycling firms, allowing them to secure significant investments in business expansion.

The integrated policy incentives in the IPR scenario would also increase profit margins of producers of alternative materials, brands and retailers, waste collectors,

FIGURE 4.6 **Private Financing in IPR Scenario, for Plastic Waste Only, Indonesia, 2020–40**



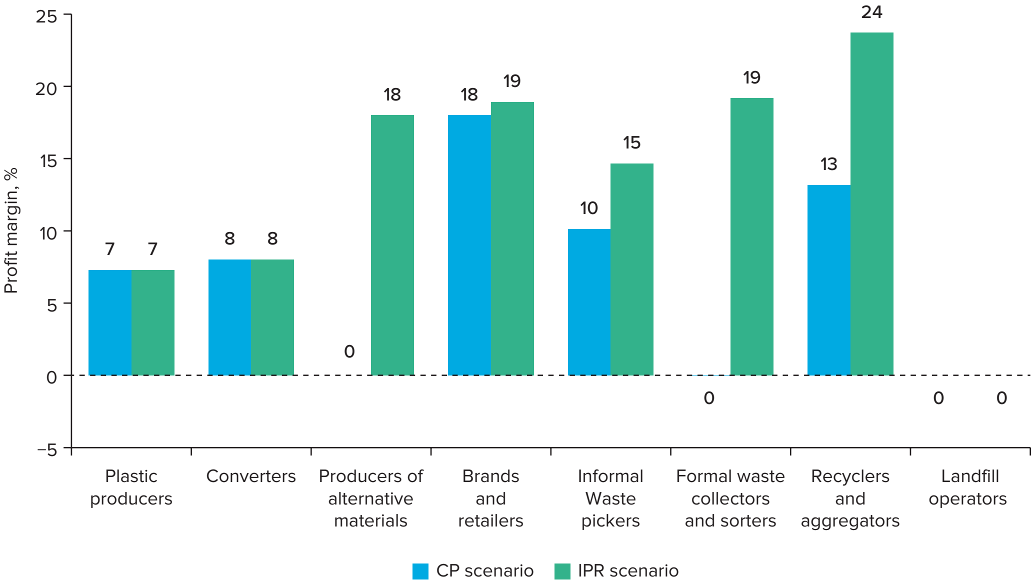
Source: Adapted from World Bank 2022a.
Note: CAPEX = capital expenditure; CP = current policies; IPR = integrated policy reform; OPEX = operating expenditure.

sorters, recyclers, and aggregators (figure 4.7). At the same time, the aggregate impact on the profit margins of plastic producers and converters would be negligible.

The uneven impact on profit margins of different types of firms would be associated with the shifts in the shares of different firms in the total plastic profit pool in Indonesia. A plastic profit pool can be defined as the total profits earned in an industry at all points along the plastic value chain. Figure 4.8 illustrates that while the shares of plastic producers, converters, consumer goods companies, and retailers in the total plastic profit pool decrease, new profit centers would be created around design, new materials, and downstream businesses—mainly recyclers, waste management aggregators, and waste pickers and collectors.

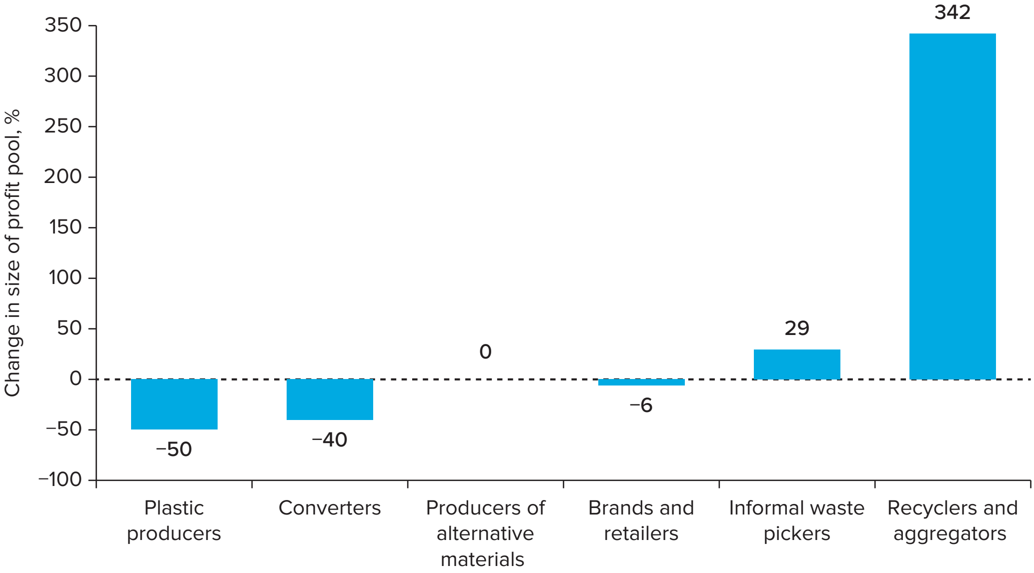
Although IPR could achieve multiple government targets related to plastic pollution management and attract significant private finance, it would not be easy to implement, given the scale and complexity of reforms. Improving governance and strengthening administrative capacity to implement and enforce all these policy instruments will take more time, especially as many of them have few precursors even in the most advanced countries. The expected changes in consumer habits could be longer than expected, and political momentum for reforms could take more time and

FIGURE 4.7 **Economic Actors' Profit Margins, Indonesia, 2040**



Source: Adapted from World Bank 2022a.
Note: CPS = current policies scenario; IPR = integrated policy reform.

FIGURE 4.8 Change in Profit Pool among Firms in the Plastic Value Chain in the IPR Scenario, Indonesia, 2040



Source: Adapted from World Bank 2022a.
Note: Total profit pools show total net profit per agent to all volume. This excludes agents that are subsidized to cost recovery in the current policies. IPR = integrated policy reform.

effort to develop. Some additional business risks or bureaucratic hurdles could delay expected commercial investments. For all these reasons not represented in the PPS, the Indonesian government's ambition to achieve its targets by 2025 may be a challenge. The implementation and enforcement of many policies that are assumed in the PPS to be effective immediately could take more time than simulated with PPS. The user can delay their application in the PPS by five years, effectively delaying achievement of some of the government targets. The core message of the IPR scenario is that a comprehensive mix of complementary policy instruments has a potential to achieve the government target, even though it will be challenging to implement comprehensively in the time frame expected by the government of Indonesia.

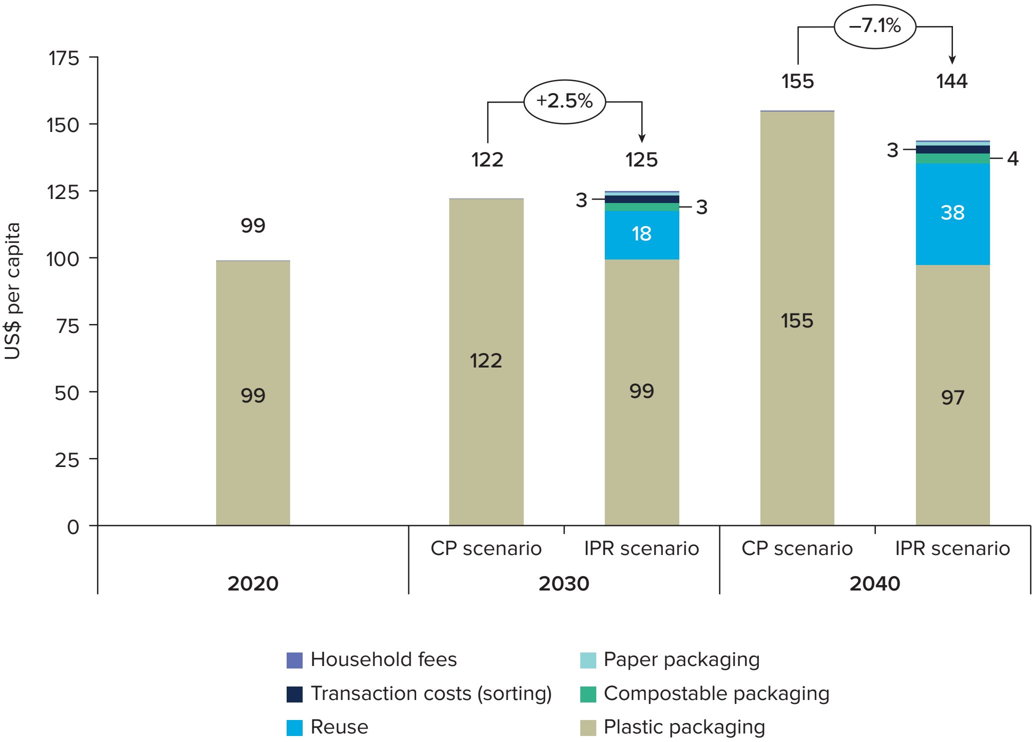
Impact on Households

Higher profits of green businesses and lower net fiscal spending than in the CP scenario would not need to come at the expense of an increased burden on households (see also Ashenmiller 2011). For each scenario and each geographical archetype, the

PPS calculates average household expenditure on "plastic utility" (that is, the expenditures that households incur on plastic products and their substitutes—for example, on paper and compostable packaging),[2] plus expenditure on reusing plastic products, sorting plastic waste at home, and on the plastic-related portion of waste management fees paid by households. The PPS also calculates the share of household plastic utility expenditure in total household expenditures to estimate whether plastics policy reforms will leave households with either more or less expenditures available for other goods and services (disposable income).

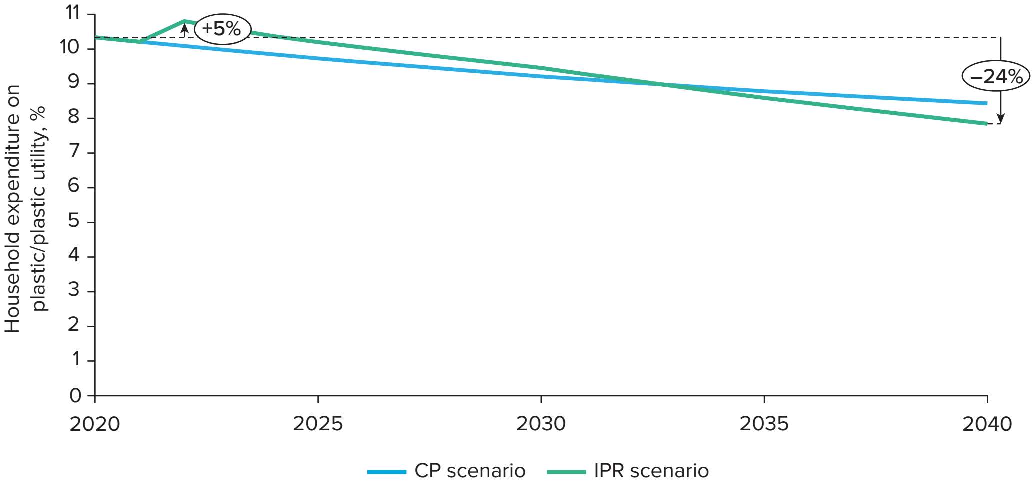
In Indonesia's PPS simulations, the IPR scenario initially increases household expenditures on plastic utility both per capita (figure 4.9) and as a percentage of total household expenditure (figure 4.10). This is because upstream taxes and fees are passed through to the prices of plastic products, increasing households' expenditure on new plastic products. Product bans and a virgin plastic tax reduce consumption of such

FIGURE 4.9 **Household Expenditures on Plastic Utility, Indonesia**



Source: Adapted from World Bank 2022a.
Note: CP = current policies; IPR = integrated policy reform.

FIGURE 4.10 Household Expenditures on Plastic Utility as a Share of Total Household Expenditures, Indonesia



Source: Adapted from World Bank 2022a.
Note: CP = current policies; IPR = integrated policy reform.

products, however, leading to lower total spending on plastic packaging. Lower household spending on new plastic products is partly offset by the increase of the cost of reusing plastic products, higher expenditures on compostable and paper packaging, and higher transaction costs of sorting waste. The household waste fees attributed to plastics are also higher in the IPR scenario than in the CP scenario, as they cover a portion of increased cost of collection, sorting, and landfilling. Nonetheless, they account for an insignificant portion of the total cost of plastic utility. For these reasons, the total household expenditures on plastic utility in the IPR scenario are higher than in 2020.

The temporary increased household expenditure on plastic utility per capita by 2030 could be more than compensated for vulnerable households by using fiscal savings and additional government tax revenue in the IPR scenario. After 2030, however, household plastic utility expenditures per capita and as a share of total household expenditure grow more slowly in the IPR scenario than in the CP scenario.

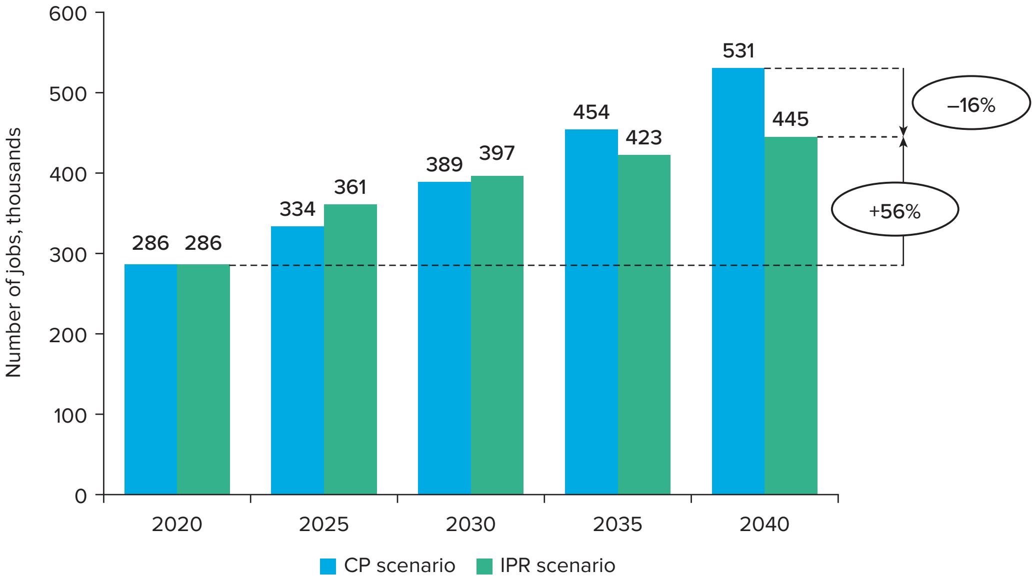
Potential social hardship of plastic waste management is additionally mitigated by the expectation that under both scenarios, the burden of plastic utility costs as a share of total household spending decreases, since total household expenditures are expected to grow faster than expenditures on plastic utility (figure 4.10).

Impact on Direct Jobs

Employment (formal and informal) in the plastic value chain could increase from 290,000 jobs in 2020 to about 400,000 by 2030 in the IPR scenario, more quickly than in the CP scenario (figure 4.11). After 2030, however, total jobs in the IPR scenario grow more slowly than under the CP scenario. In the latter, more low-skilled jobs are needed to collect and landfill a much larger volume of waste in the absence of upstream incentives to reduce plastic consumption. In the IPR scenario, fewer but better (more productive and skilled) jobs are created in the knowledge- and technology-intensive parts of the value chain (product design, recycling, system aggregation).

Interestingly, in the single policy scenario of product bans, the employment loss by 2040 is estimated at 12,000 jobs with narrow coverage of banned products and 72,000 jobs are lost with extended product coverage of the bans. Some of these jobs would be shed abroad since Indonesia imports approximately 40 percent of plastics as resins or finished products. These losses could be partly or even fully offset by the estimated increase of profits and jobs among producers of substitute materials and products, many of which could be domestic and substitute plastic imports. Therefore, the net impact on the domestic labor market could be positive, but the

FIGURE 4.11 **Direct Jobs in the Plastic Value Chain, Indonesia**



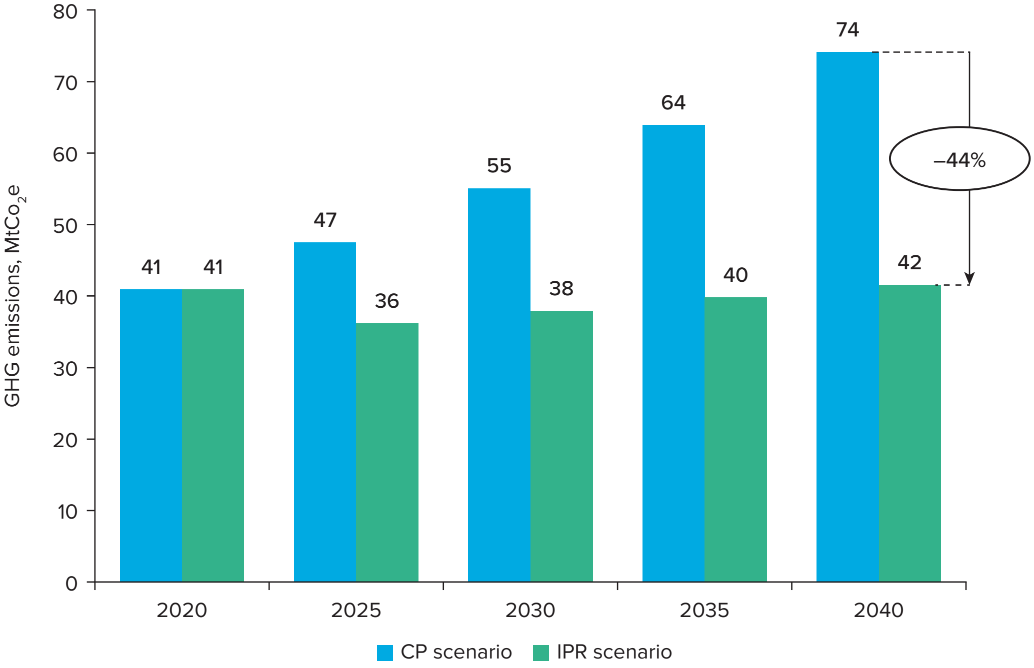
Source: Adapted from World Bank 2022a.
Note: CP = current policies; IPR = integrated policy reform.

detailed and more realistic assessment of opportunities for a transition to more, better, and greener jobs in the plastic value chain in Indonesia requires targeted analysis with economywide, multisectoral models.

Impact on Greenhouse Gas Emissions

In the CP scenario, greenhouse gas (GHG) emissions continue to grow from 41 million tons of carbon dioxide equivalent (MtCO_2e) in 2020 to 74 MtCO_2e by 2040. This growth is predominantly driven by an increase in plastic waste generation, which drives emissions along the entire value chain, 70 percent of which is due to the production of virgin plastics and their conversion to materials and products, and 25 percent from open burning. The remaining 5 percent of CO_2 emissions originates in small quantities from other parts of the plastic value chain. The IPR scenario would maintain GHG emissions from the plastic value chain close to 2020 levels of 41–42 MtCO_2e, as opposed to 74 MtCO_2e in the current policies scenario (figure 4.12).

FIGURE 4.12 **Direct GHG Emissions in CP and IPR Scenarios, Indonesia**



Source: Adapted from World Bank 2022a.
Note: GHG = greenhouse gas; CP = current policies; IPR = integrated policy reform; MtCO_2e = millions of tons of carbon dioxide equivalent.

The IPR scenario presents an opportunity to put Indonesia's plastic management system on a commercially sustainable path and deliver on government targets while creating new growth and employment opportunities without creating major burdens on government and household budgets. The next section provides essential information on the architecture and methodology of the PPS model, through which these results and insights were obtained.

The Plastics Policy Simulator: Architecture and Methodology

The PPS is a techno-financial model to help governments navigate public consultations about highly complex, sometimes controversial policy interventions to manage plastic pollution and increase its circularity. The PPS builds on and extends the model developed for the Breaking the Plastic Wave study (Pew Charitable Trusts and SYSTEMIQ 2020). The original model was built to find the most feasible and the least costly technical measures to address plastic pollution from a social planner's viewpoint rather than from the perspective of economic actors operating in the plastic value chain. For the needs of the Pathways out of Plastic Pollution model, it was thoroughly redesigned to simulate the expected impacts of alternative combinations of plastics policy instruments from the point of view of these economic actors (firms, households, and governments) in the marketplace (hence the name of the model, Plastics Policy Simulator). It is a universal model that can be applied in any country at the national or subnational level, and it does not replace detailed policy design.

Key Functions and Outputs of the PPS

Comparing alternative policy reform scenarios helps to understand their environmental and social impacts, the financial impact on different actors in the plastic value chain, and the fiscal impact on government budgets. The PPS identifies potential winners and losers of alternative policy reforms, informing policy makers about the potential political tensions with their implementation. In particular, it helps stakeholders negotiate agreeable policy action plans by quantifying ex ante the impacts of alternative mixes of specific policy instruments on the following:

- Distribution of the major revenue gaps, and hence the key bottlenecks in the plastic value chain
- Incentives for firms and households to change plastic flows through the economy and environment: volumes and types of plastic and plastic products that are reduced, reused, collected, recycled, landfilled, incinerated, burned on the ground, imported, and dumped into the environment
- Commercial viability of firms' investments and operations of sustainable plastic management measures

- Households' consumption choices and waste management behavior
- Distribution of costs, revenues, and profit margins between formal and informal firms in different segments of the plastic value chain (Who would pay, who would gain?)
- Government budgets—fiscal revenues and expenditures at national and subnational level
- Households' expenditures on plastic products, their substitutes, and waste management fees
- GHG emissions in the plastic value chain
- Direct employment in formal and informal firms in the plastic value chain

Architecture of the PPS

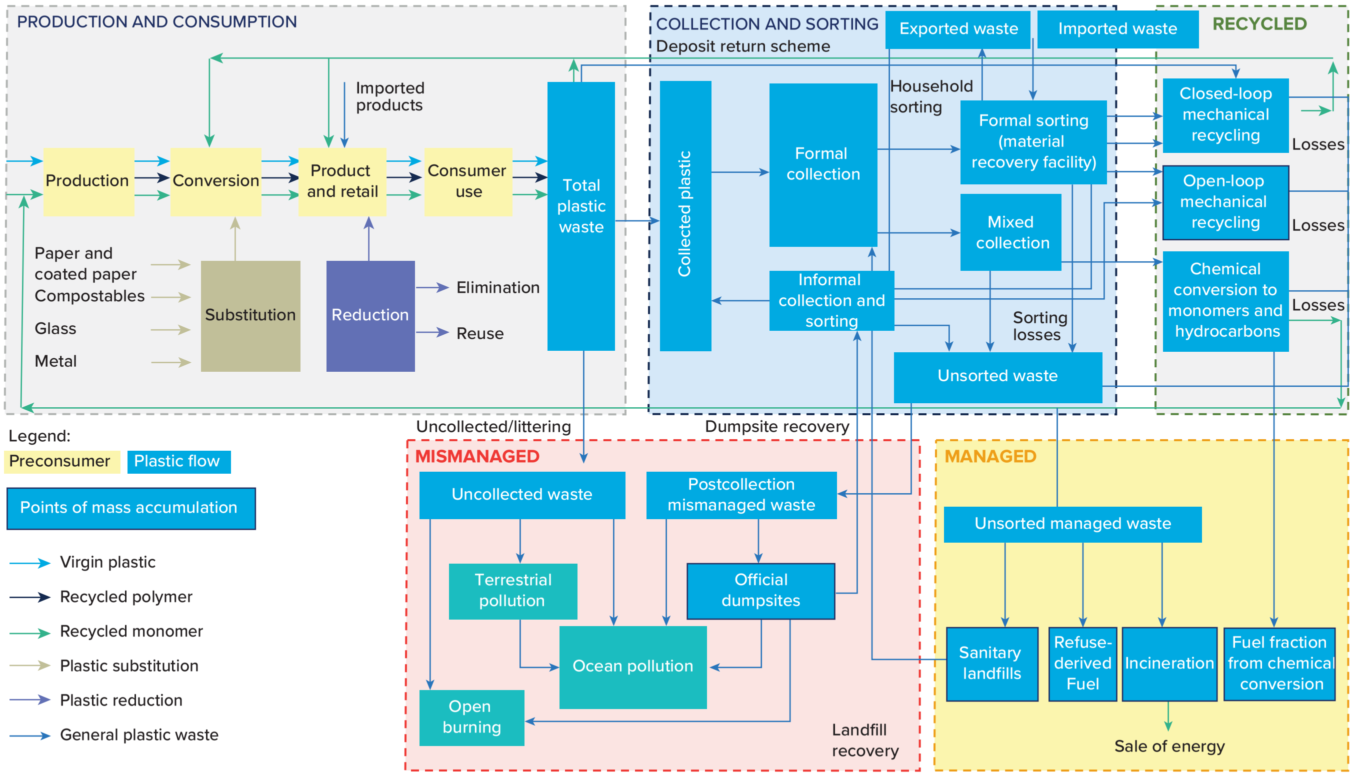
The architecture of the PPS defines the key actors operating in the plastic value chain and how they are interlinked through plastic product and financial flows.

The PPS Takes a Whole-System Approach to the Plastic Life Cycle.

The effective, cost-effective, and socially and politically implementable solutions to plastic pollution require a whole-system approach along the entire plastic value chain. Therefore, the PPS is based on a national plastic system map covering multiple actors interacting in upstream and downstream segments of the value chain (figure 4.13). It encompasses all important stocks and flows of plastic products through the economy and environment, starting from production and importation of virgin plastics, their conversion to materials and products, and imports of such products. Then, the plastic value chain system map traces how plastic products flow to the firms that use them (for example, as packaging) and then to retail traders who sell final consumer goods to households. Households are represented in their role as consumers who make cost-minimizing choices about whether and what products to buy and whether to reuse plastic products instead of buying new ones. Households are also actors who decide whether to transfer their waste to formal collection systems or throw it out in the environment; whether to sort waste at a source or bring used plastic products to deposit refund systems.

Once plastic products enter the downstream waste management system, different types of firms come into play—those who collect (formal and informal), sort, recycle, or otherwise recover materials from plastic waste, and eventually those who operate sanitary landfills, incinerate waste with heat recovery, or convert waste to liquid or gaseous fuels. Finally, the value chain map captures waste that leaks from the managed systems to the environment, where it is either burned in the open or becomes terrestrial and ocean pollution.

FIGURE 4.13 Universally Applicable National Plastic System Map



Source: Adapted from World Bank 2022a.

Note: Boxes represent mass aggregation points in the model; arrows represent mass flows. "Mixed collection" is plastic collected for disposal or recovery rather than recycling. "Losses" refers to plastic losses during processing (for example, sorting or recycling), typically because of inability to process certain plastic products or types. The corresponding financial flows are not shown in this figure.

Five Categories of Plastics Flow through the System.

Each policy instrument in the PPS can be applied to 20 individual plastic product types or to one of their five aggregated categories (figure 4.14). Plastic categories are distinguished mainly according to the difficulty and cost of sorting and recycling—from the easiest (for example, plastic bottles, rigid monomaterial plastic products) to the most difficult (for example, flexible or multimaterial products, cigarette butts). Within each category, plastic products are divided into types that are the most common components of plastic litter. Excluded from the PPS scope are medical waste; hazardous waste; electronics; textiles; furniture; agricultural waste; fishing gear; microplastics; and automotive, construction, and other industrial waste that does not typically enter the municipal solid waste stream in significant quantities.

Twelve Economic Actors Operate in the Plastic Value Chain.

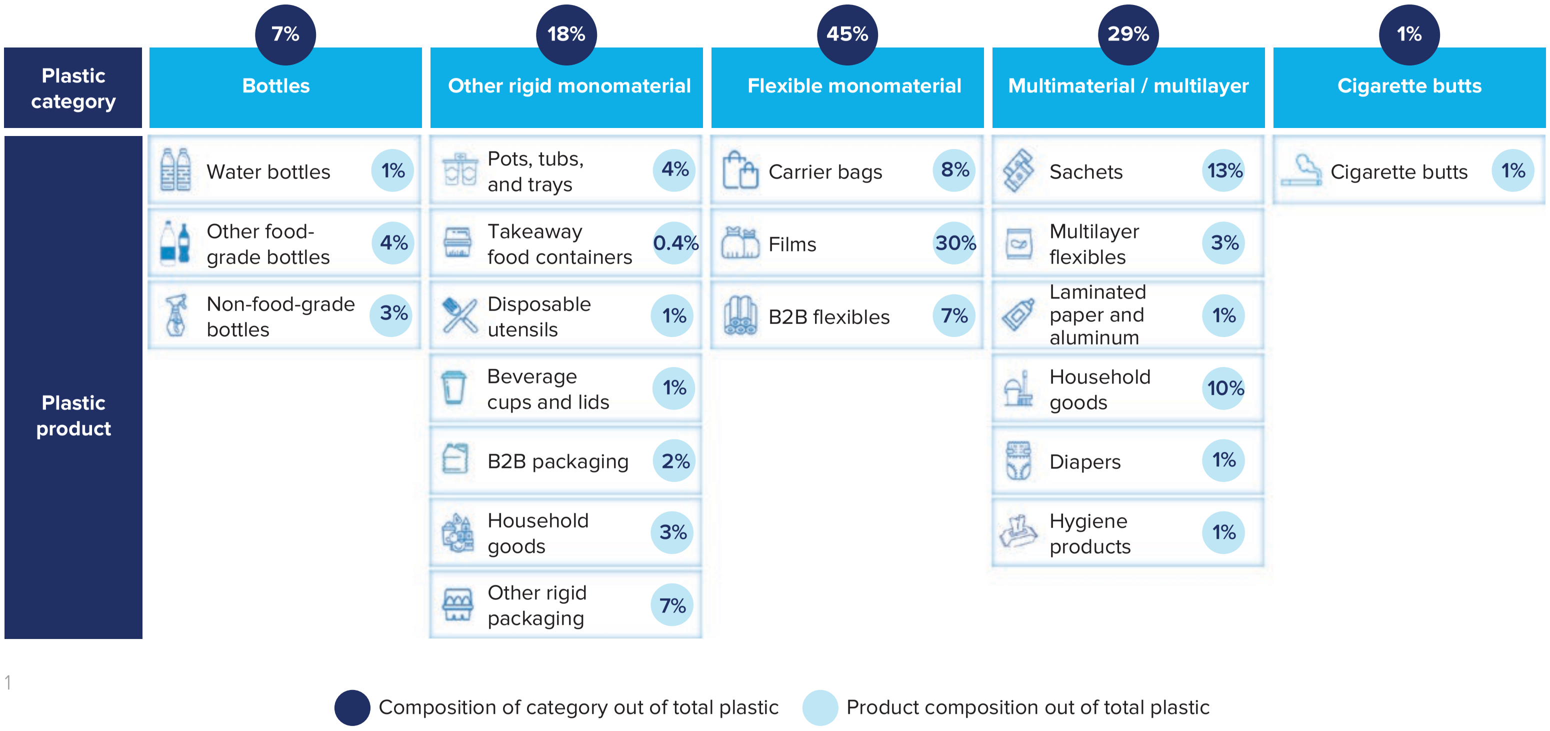
The PPS model details how 12 economic actors operate and interact along the plastic value chain. The actors include governments, households, and 10 types of firms (see figure 4.15). The model calculates the fiscal and financial impacts for each actor type under each policy scenario for each year between 2021 and 2040. The model does not distinguish between private and public firms engaged in the plastic value chain; it assumes that they all behave in a commercially rational way under the market incentives that policies create.

Economic Actors Choose the Scale of Multiple Technical and Behavioral Plastic Management Options.

Economic actors choose whether they invest in and use plastic management options available. The model contains data on volumes of plastics and plastic products that go through each segment of the systems, as well as the annual capital expenditures, operational expenditures of all plastic management options, and transaction costs, in addition to market prices and revenues after taxes and subsidies. Policy instruments change these variables and hence the costs, revenues, and profit margins for each group of economic actors, changing their investment, sale, and purchase decisions and hence plastic flows through the system.

The PPS traces how money flows in the opposite direction from plastics. Expenditures of some actors are revenues of others, including the government. Firms accumulate capital through investments only if the investments are commercially viable under a specific policy scenario—that is, when rates of return on these investments are higher than their hurdle rates (the minimum rate of return on a project or investment required by a manager or investor). For example, when the government subsidizes waste sorting and material recovery facilities, volumes of sorted plastic products increase if the subsidy makes sorters' internal rate of return greater than

FIGURE 4.14 Scope of Plastic Products and Product Categories Represented in the Plastics Policy Simulator Model

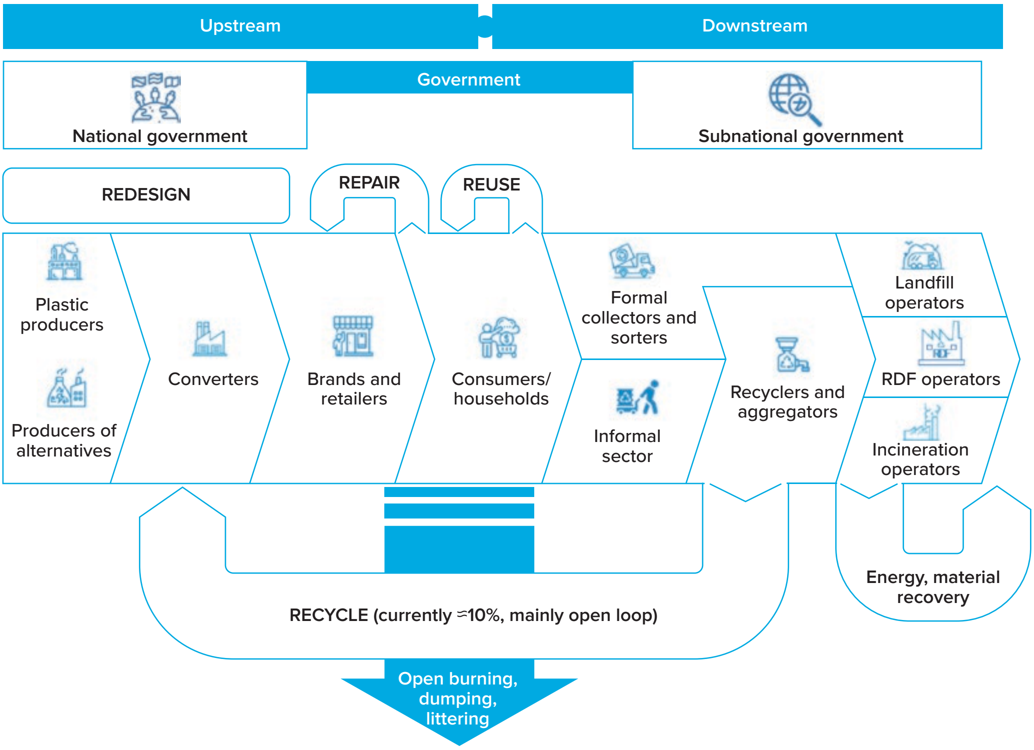


Plastic category	Bottles 7%		Other rigid monomaterial 18%		Flexible monomaterial 45%		Multimaterial / multilayer 29%		Cigarette butts 1%	
Plastic product	Water bottles	1%	Pots, tubs, and trays	4%	Carrier bags	8%	Sachets	13%	Cigarette butts	1%
	Other food-grade bottles	4%	Takeaway food containers	0.4%	Films	30%	Multilayer flexibles	3%		
	Non-food-grade bottles	3%	Disposable utensils	1%	B2B flexibles	7%	Laminated paper and aluminum	1%		
			Beverage cups and lids	1%			Household goods	10%		
			B2B packaging	2%			Diapers	1%		
			Household goods	3%			Hygiene products	1%		
			Other rigid packaging	7%						

Source: Adapted from World Bank 2022a.

Note: Percentages for single plastic products are rounded and therefore do not total 100 percent. B2B = business-to-business.

FIGURE 4.15 **Key Economic Actors Operating in the Plastic Value Chain and Circularity Pathways**



Source: Adapted from World Bank 2022a.
Note: RDF = refuse-derived fuel.

their hurdle rate. This leads to a corresponding increase in mechanical recycling volumes (again, only if recycling operations are profitable under a given policy scenario). Households minimize private costs when making product purchase, use, and waste management decisions.

Twenty-Four Plastic Management Policy Instruments Are Available to Manage the System.

The PPS simulates the effect of 24 plastic management policy instruments grouped into five categories: taxes and fees, public financing, bans and standards, behavioral change, and governance (table 4.3). Each instrument influences the flows of plastic through different segments of the system by affecting private financial costs and revenues, and hence profitability of different plastic management options represented

TABLE 4.3 List of Policy Instruments from Which Plastics Policy Simulator Users Can Select

Category	Policy instruments for system reform
Taxes and fees	Mandatory modulated extended producer responsibility fees Virgin plastic excise tax on all packaging Plastic excise tax on all packaging Plastic excise tax on individual products Carbon tax Deposit return schemes Landfill tax Household fees
Public financing	Alternative materials Reuse systems Formal collection Informal collection Sorting facilities and operations Mechanical recycling Chemical recycling Landfill facilities and operations Incinerators Refuse-derived fuel
Bans and standards	Plastic labeling Product restrictions / bans Mandatory product design requirements Target reduction in plastic waste imports
Behavioral change	Consumer education campaigns
Governance	Improvements in governance system

Source: Adapted from World Bank 2022a.
Note: The plastics policy simulator model was designed to offer a wide range of options available to policy makers and does not reflect the World Bank Group's support of one option versus another.

in the technical core of the model. Application of policy instruments is not costless. For governments, the model incorporates administrative costs of implementing and enforcing policy instruments. The PPS also includes transaction costs of compliance with some policy instruments by economic agents represented in the system. For example, in Indonesia, stakeholders indicated that about 4 percent of the total value of subsidies that formal waste collectors receive from the government is spent on application for funds and reporting how they were spent.

Policy instruments can be applied individually or combined in many configurations, or packages. Combining policy interventions is a common practice in many countries and is a good practice, because—as discussed earlier—multiple market and policy failures throughout the plastic life cycle compound plastic pollution. Many perverse incentives overlap, requiring multiple policy instruments to correct them.

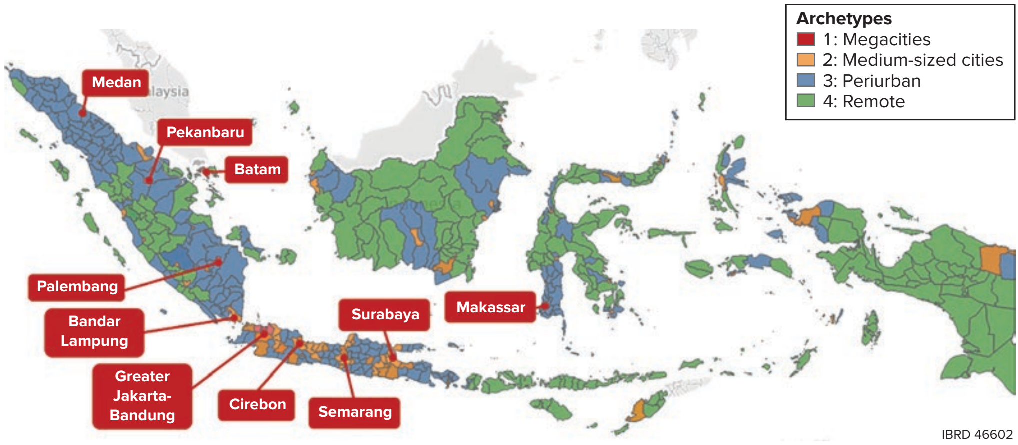
Policy instruments naturally interfere and interact with one another. Some combinations of policy instruments produce incoherent, conflicting incentives and lead to policy failures. For example, subsidies for oil and gas used by the petrochemical industry favor the use of virgin plastics by making them unfairly competitive compared with recycled plastics or nonplastic alternatives. In the presence of fossil fuel subsidies, the EPR fees may not provide expected incentives to change consumer choices and increase sorting and recycling. Examples of synergies among policy instruments are also common. Investment subsides for collection and sorting of waste and taxes on virgin plastic packaging, together with behavioral nudges for consumers to choose alternatives, encourage product design for recycling, decrease downstream costs of recyclers, and allow recyclers to increase volumes through commercially viable investments.

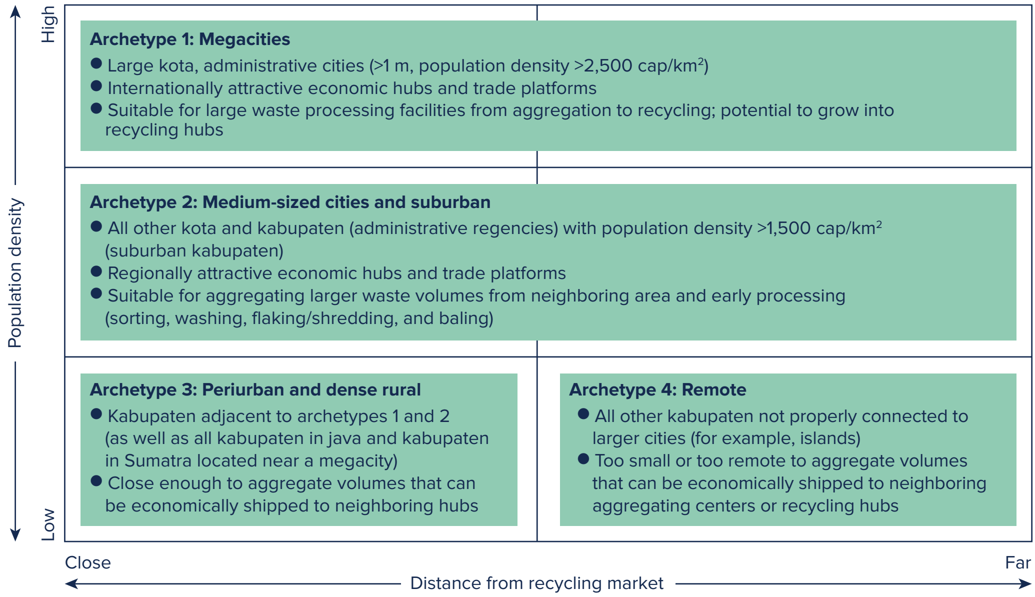
Geographical archetypes account for country-specific differences within the plastic value chain. The PPS model is divided into different geographic archetypes to account for the fact that different locations have different characteristics—for example, quantities and patterns of consumption of plastic products, waste composition, costs of collection and sorting, prices, plastic litter, infrastructure, proximity to recycling, and population density—and require customized solutions. Map 4.1 provides an example of how archetypes were broken down in Indonesia, where the model is split into four different geographic archetypes—megacities, medium-sized city and suburban, periurban and dense rural area, and remote area. All model calculations are conducted separately according to geographic archetype and then aggregated to the national level. This means that archetypes can be defined flexibly (the archetype definition could be different in each country), and the number of archetypes could be different for each country.

The PPS Is a Dynamic Simulation Reflecting Current Knowledge and Its Limitations.

In the PPS, the use of materials and technologies is limited by their availability and market valuation at the time of simulations. Thus, the PPS must be updated as innovation advances and more affordable solutions are brought to market. In addition, several factors such as health and hygiene impacts, accessibility, safety, and availability of feedstocks are incorporated qualitatively into the model. Although the PPS identifies effective and implementable policy packages, it does not substitute for a detailed design and impact assessment of specific policy instruments. The PPS is not a macroeconomic model, although it can be linked to input-output tables, fiscal frameworks, or macroeconomic models. Likewise, it is not designed to conduct detailed social distributional analysis, because the financial results for households are not broken down according to income group. The PPS results can be used as input to microsimulation models that can calculate the policy impacts on income and poverty.

MAP 4.1 Archetypes as Modeled in the Plastics Policy Simulator Application in Indonesia





Archetype 1: Megacities

- Large kota, administrative cities (>1 m, population density >2,500 cap/km^2)
- Internationally attractive economic hubs and trade platforms
- Suitable for large waste processing facilities from aggregation to recycling; potential to grow into recycling hubs

Archetype 2: Medium-sized cities and suburban

- All other kota and kabupaten (administrative regencies) with population density >1,500 cap/km^2 (suburban kabupaten)
- Regionally attractive economic hubs and trade platforms
- Suitable for aggregating larger waste volumes from neighboring area and early processing (sorting, washing, flaking/shredding, and baling)

Archetype 3: Periurban and dense rural

- Kabupaten adjacent to archetypes 1 and 2 (as well as all kabupaten in java and kabupaten in Sumatra located near a megacity)
- Close enough to aggregate volumes that can be economically shipped to neighboring hubs

Archetype 4: Remote

- All other kabupaten not properly connected to larger cities (for example, islands)
- Too small or too remote to aggregate volumes that can be economically shipped to neighboring aggregating centers or recycling hubs

Source: Adapted from World Bank 2022a.

Note: cap = capita; km^2 = square kilometers; m = million.

Notes

1. The PPS calculates only direct fiscal effects of policy instruments, including changes to government revenues collected from and expenditures provided to affected firms and households. Direct effects do not include the tax interaction effects (for example, higher excise taxes would also increase value added tax revenues but may decrease income tax revenues). Nor do they include economywide and general equilibrium effects on government fiscal position. The PPS can provide inputs to economic and fiscal models that capture these economywide effects but lack the sectoral and technology granularity of the PPS.

2. We call these costs “plastic utility” because they include not just costs related to plastics, but also the costs of alternative products and materials (mainly packaging) that deliver the same functions (utility) to households as plastic products they replaced. Note that the solid waste management system cost financed from the general budget is not counted here as part of a household’s utility, despite the fact that additional budget expenditures are financed by increasing payroll taxes paid by households.

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5

Conclusions

Plastic pollution is a development challenge, resulting from multiple market and policy failures along the entire value chain. Market prices do not accurately account for the cost of plastic pollution. This report proposes evidence of analyses and tools to identify and address market and policy failures that cause plastic pollution. It demonstrates how coherent policy reforms can prevent plastic pollution in a way that also creates value for households and firms participating in the plastic economy, while avoiding additional fiscal burden.

Under the forthcoming legally binding instrument to end plastic pollution, countries may need to develop action plans to manage plastic pollution. The report presents the building blocks of a dynamic process to manage plastic pollution that can help countries develop such plans. Managing plastic pollution requires combining traditional solid waste management solutions with those closer to pollution control, including upstream industrial and product policies, that cut across various sectors. The policy mix to solve the plastic problem combines planning, pricing, and regulations along the entire value chain—both upstream and downstream.

Available decision-supporting tools for policy makers do not cover the whole plastic value chain. Neither do they simulate the potential impacts of comprehensive policy reforms on environmental, social, economic, financial, and commercial aspects of market creation for sustainable plastic management, including winners and losers and resulting impacts on public budgets. The analysis in this report helps countries identify and choose among the many plastic alternatives and policy instruments that are available to prevent plastic pollution, determine how to set up targets and how to reach those targets, and determine what the effects of the policies on economic actors could be. Results and lessons from this report provide concrete examples of what a comprehensive approach means in practice. To achieve this, two new models to inform policy makers are available to countries—namely, the Plastic Substitution Tradeoff Estimator and the Plastics Policy Simulator (PPS):

- **The Plastic Substitution Tradeoff Estimator:** Despite increasing media attention, plastic pollution awareness remains relatively low. The systemic scale of environmental, social, and economic risks was identified just a few years ago. But breaking from reliance on plastic products is not straightforward. Alternative materials and products are not free from environmental and social risks either. The legitimate question—if not plastics, then what?—is often clouded by biases, incomplete and unverified information, and vested interests. The Plastic Substitution Tradeoff Estimator, developed by the World Bank with Rebel Group and CE Delft, helps stakeholders transparently compare the comprehensive, environmental footprints of plastic products with available alternatives along the whole life cycle and in a specific country context. Results can be used to choose targets and help calibrate pollution prices or product standards to life-cycle external costs of plastic products, leveling the playing field with their sustainable substitutes. The Estimator does not make or optimize choices for public or private stakeholders, but rather allows stakeholders to make informed choices for themselves.

- **The Plastics Policy Simulator:** In the absence of an extensive track record, the impacts of plastics policy choices are difficult to predict. Before laws are passed or public money is spent, it is difficult for policy makers to know how economic actors will react to various policy instruments and what the costs, revenues, and other impacts of these policies will be. A trial-and-error approach to policy implementation is risky because the economic and political costs of errors in policy interventions may be high. With support from SYSTEMIQ, the World Bank developed the Plastics Policy Simulator model, which helps simulate the impacts of policies on plastic flows through the economy and the environment. It estimates financial, social, and fiscal impacts on firms, households, and the government, identifying policy mixes that align the self-interests of firms and households along the plastic value chain for environmentally sustainable material and product management. The Plastics Policy Simulator supports policy makers and other government, industry, and civil society stakeholders in navigating public consultations about highly complex, sometimes controversial, policy interventions.

As with any other decision-support tool, these models inform but provide no substitute for the consultative, institutional, and legal process of detailed design, implementation, and enforcement of policy instruments.

Introducing more circular measures upstream provides opportunities to create viable markets along the plastic value chain and to prevent the most problematic plastic products from entering the economy in the first place. Upstream policy incentives are essential to change the behavior of producers and users of plastic materials and products to make midstream interventions (such as reuse and repair) and downstream waste management and cleanup efforts technically feasible and commercially viable. Upstream policy interventions can prevent the most problematic plastic products from entering the economy, thereby minimizing waste volumes in the long term and reducing costs for waste management. Furthermore, upstream policy interventions have the potential to make product substitution, reuse, repair, and recycling commercially viable. They can incentivize more sustainable materials, products, and business models. Product standards and fiscal incentives to design products for greater durability and easier repairability and recyclability increase demand and profit margins of circular activities. Upstream instruments can also be designed to provide revenues to improve solid waste management systems—for example, to ensure sustainable cost recovery of waste collection and sorting. This in turn can attract commercially driven private investments, induce innovation, and create productive jobs in circular plastic economic activities, such as sorting, closed-loop recycling, and material recovery while mitigating climate change.

A comprehensive mix of coherent policy instruments is most effective for avoiding plastic pollution and reducing mismanaged waste. Applying the PPS in Indonesia revealed that Indonesian firms and households could be incentivized to reduce plastic pollution and make profits on it by applying a coherent set of multiple upstream and downstream policy interventions. Compared to a fragmented approach that introduces individual policies in isolation, such an integrated policy reform package has better environmental and service outcomes, while also reducing net fiscal spending and, over time, household expenditure on plastic products, substitutes, and plastic waste management. Applying upstream taxes on plastic packaging in isolation could, in principle, significantly reduce plastic pollution by incentivizing the use of plastics alternatives or recycled plastics, but it would not be sufficient to meet government targets without synergies from improved downstream waste management policies. Applying the PPS in Indonesia also illustrated that the impacts of bans on single-use plastics are limited since bans cover only a fraction of total plastic waste.

Improving solid waste management is essential to a comprehensive approach. This includes three key steps: establishing waste collection services and ending illegal dumping to protect public health; improving waste treatment and disposal to provide environmental protection; and implementing systems and incentives to enable the transition to sustainable resource management. Improving solid waste management and moving up the waste hierarchy are expensive in the sense that they require investments in improved infrastructure and result in higher operational costs for collection and waste treatment, as observed in countries with advanced waste management systems. But focusing only on improving solid waste management does not lead to a reduction of plastic pollution in the long term, and more upstream measures present an opportunity to keep materials in the economy and avoid generating waste in the first place.

The sequencing of policy implementation is important. A comprehensive policy mix can only be developed gradually, especially in countries with weaker institutions and capacity. But adequate sequencing of policies is crucial. For example, landfill taxes implemented without enforcement of the littering ban or behavioral nudges can increase environmental pollution. Bans of the most harmful plastic products as a first step can produce quick and visible results that create buy-in from stakeholders for more comprehensive policy packages at a later stage. This positive demonstration and awareness-raising effect is, however, conditional on complementary policies that make alternatives available and affordable.

Phasing out single-use plastics requires considering alternatives and their availability. Substitution choices should be informed by their external costs and benefits compared with those of the plastic product they would replace. Availabilities of substitutes can evolve over time: phasing out single-use plastics can drive both innovation and development of new green businesses, and policy simulations show that incentives can contribute to creating markets for alternatives. Understanding the true costs of plastics and substitutes allows an examination of tradeoffs between different products—for example, those related to greenhouse gas emissions, other environmental impacts, and jobs. It is possible to minimize costs of damages by improving product design and selecting more sustainable alternatives. Improving design can lead to a reduction of external costs of plastic products while maintaining their functionality.

Circular solutions can have positive impacts on climate and jobs. Applying the PPS in Indonesia suggests that a circular policy package would likely lead to higher direct job growth in the short to medium term compared with business as usual. In the long term, direct job growth would be slower but would result in shifts in the labor market—from low-skilled jobs in waste collection to more productive and skilled jobs in the knowledge- and technology-intensive parts of the value chain (product design, recycling, and system aggregation). The impact of an integrated reform package on climate change mitigation could be similarly positive and keep direct greenhouse gas emissions at current levels, compared with an increase of almost 80 percent under business as usual, where plastic waste generation increases exponentially and drives higher emissions along the entire value chain. When looking at alternatives to single-use plastics, the choice of certain alternatives can increase employment, in particular when the alternative is manufactured domestically and replaces imports. A country-specific focus is important in this respect. For example, whether plastics and alternatives are produced locally or are imported determines the local impact on labor, trade, upstream pollution, and carbon footprint.

The private sector plays a key role in shifting to a circular economy. Not every sector or firm gains equally from introducing policies against plastic pollution, and various policies have a different distribution of impacts. Some companies operating upstream in the plastic value chain (plastic producers, converters, some consumer goods companies, and retailers) may experience a decrease in revenues and profit margins because of circular measures. Waste management companies, recycling businesses, and waste pickers in the informal sector, on the other hand, could profit from circular policies that move profit centers to the downstream part of the value chain. New concentrations of value and profit could also be created around design, new materials, and delivery models. Tailoring policy interventions to manage political economy issues and bringing economic actors together to participate in solutions are therefore crucial conditions for policy success.

As countries strive to achieve green, resilient, inclusive development, this report brings new evidence and new models to support efforts to reduce plastic pollution. The Pathways out of Plastic Pollution toolkit shows that coherent policies are effective to reduce plastic pollution, by unlocking value in the plastic value chain.

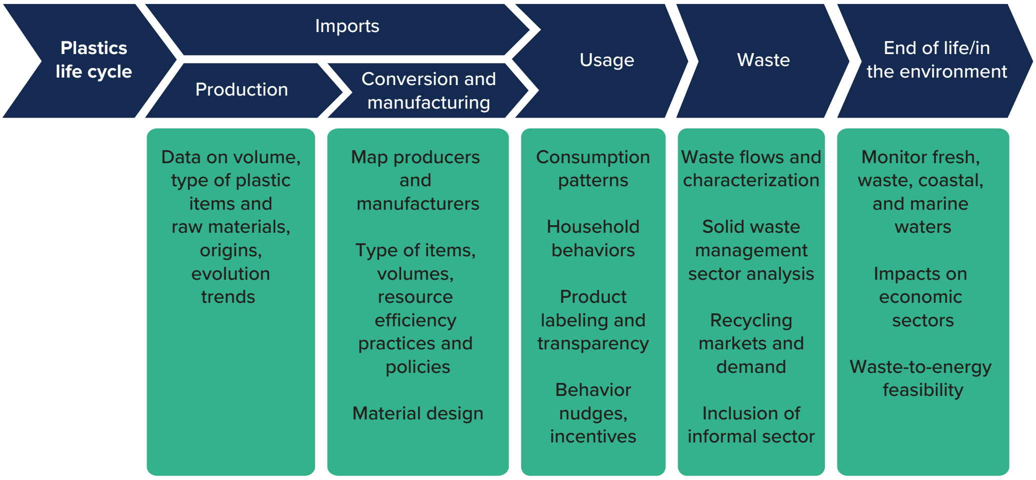
Appendix

Collecting Data: Examples of Methodologies and Tools

This appendix presents an overview of existing methodologies and available tools. Figure A.1 shows typical steps in and examples of a comprehensive country-level assessment along the plastic life cycle. Box A.1 provides examples of available methodologies for the assessment and quantification of plastic material flows and plastic pollution.

- First, understanding material flows from upstream to downstream in the value chain complements the diagnostics of accumulation of plastic waste areas and the most common type of plastic waste found in those areas. This analysis is essential for governments to fully comprehend the magnitude of the plastic problem.
    - Material flow analysis should include analysis of sources, volumes, and distribution channels of plastic materials and products flowing between economic actors upstream in the value chain—from producers and importers of virgin plastics through converters, product designers, and manufacturers to retail trade and final consumers.
    - Analysis of financial flows are also useful to understand the economic value of the upstream plastic economy, including investments, costs, revenues, profit margins, tax payments, and jobs in each link of the upstream value chain. Imports are also an essential set of data as they will help to understand the economic landscape linked to production, conversion, and manufacturing of plastic products.

FIGURE A.1 **Examples of a Comprehensive National Country-Level Diagnostic throughout the Plastics Life Cycle**



Source: World Bank.

BOX A.1 Examples of Available Methodologies

In many developing countries, it is not possible to readily access all the data and information discussed in this report. That is why several methodologies for the assessment and quantification of plastic material flows and plastic pollution have been developed and piloted and guidelines are being published to support countries in their data collection efforts. Among others, notable publications come from the following sources:

- The Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) program on marine litter and plastic pollution includes development of tools and methodologies, as well as regional and national programs in countries (for example, GIZ 2020).
- The United Nations Environment Programme (UNEP) has published a series of reports on marine litter and plastic pollution, the most recent of which (UNEP 2021) has a chapter on monitoring methods, indicators, standards, and programs.
- The Joint Group of Experts on Scientific Aspects of Marine Environmental Protection (GESAMP) has published reports and guidelines related to marine litter (http://www.gesamp.org/publications).

Initiatives such as the Global Plastic Action Partnership (GPAP) provide toolkits and methodologies for countries, as well as for nongovernmental organizations and research centers (https://globalplasticaction.org/). One of GPAP's toolkits is the National Analysis and Modelling tool that allows countries to assess their plastic pollution situation and develop actions to transition to a circular plastics economy. It is designed to guide national platforms through the data input and analytics process in order to generate evidence-based scenarios for actions that consider environmental, economic, and social impacts.

Financed in part by PROBLUE, the World Bank carried out analytical work, including diagnostics and assessments, in more than 50 countries between 2019 and 2021. Through such support, teams in East Asia and the Pacific region have developed a toolkit on plastics monitoring methodologies that can help governments, local authorities, nongovernmental organizations, and stakeholders assess which methods are best suited to meeting their needs based on users' requirements. Published reports and methodologies can be found at https://www.worldbank.org/en/topic/how-the-world-bank-group-is-addressing-marine-plastic-pollution#1.

Source: World Bank.

  - Hydrological and transport flow models that simulate the spatial and temporal flows of plastic waste throughout the environment help to define a baseline against which countries could measure the progress made against plastic pollution (World Bank 2021). Such analyses help identify sources and types of plastic waste that are most responsible for downstream environmental, health, and economic harm, including pollution hot spots on beaches and in oceans.
  - There are not yet approved and widely used methodologies for this baseline analysis, although GESAMP provides useful guidance (GESAMP 2019). Some methodologies aim to identify accumulation areas, floating litter on rivers, the top 10 or top 20 plastic items within the debris, and the fraction of those items within the volume of waste. From these diagnostics, it is then possible to derive measures that could target the most problematic items. This type of methodology was pioneered in the European Union, where the European Commission commissioned a study that used litter data from research projects, monitoring programs, and cleanups of European beaches to identify the 10 most common single-use plastic items found on beaches (Addamo, Laroche, and Hanke 2018). This study underpinned legislative action to ban these items in the EU common market. In the past three years, the World Bank Group has supported similar studies of plastic leakage to the environment in Cambodia, the Caribbean, Indonesia, Kenya, and the Philippines and aimed to identify the 10 most common plastic items found in river and coastal areas, using satellite imagery, drones and remote sensing, and artificial intelligence. Such analytics have enabled governments to focus limited capacity on implementing upstream regulations targeting the sources of the items contributing the most to pollution hot spots.
- Second, consumption patterns of plastic products need to be understood by analyzing retail trade data and household and consumer surveys. The questions are: who buys what and why? Understanding consumer preferences—what product features and qualities are particularly important for consumers—is useful later in the plastic management process to consider alternative designs and substitutes for the most environmentally problematic plastic products and materials, and to design policies that can alter behaviors.
- Third, the postconsumption fate of plastic products in the waste management system needs to be estimated. This includes data on volumes of plastic according to weight and product that is collected in different human settlements (through formal and informal channels), sorted at a source or in specialized material recovery facilities, recycled using mechanical and chemical means (through open- and closed-loop systems), or incinerated with or without energy recovery. Then it is important to know the volumes that are transported to formal sanitary landfills and those that are burned in the open, disposed of in unsanitary dumpsites, or just dumped. Information on the commercial viability of individual activities in the waste management system helps assess where the broken links are in the downstream plastic value chain, their origins, and therefore possible means of addressing them through policies.

- Lastly, all the data collection should be accompanied with a mapping of the stakeholders involved in the plastic life cycle, to identify all economic actors, their role and possible influence, and how they may be affected by plastic pollution and the possible avenues to address it.

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Appendix

The Plastic Substitution Tradeoff Estimator: Overview

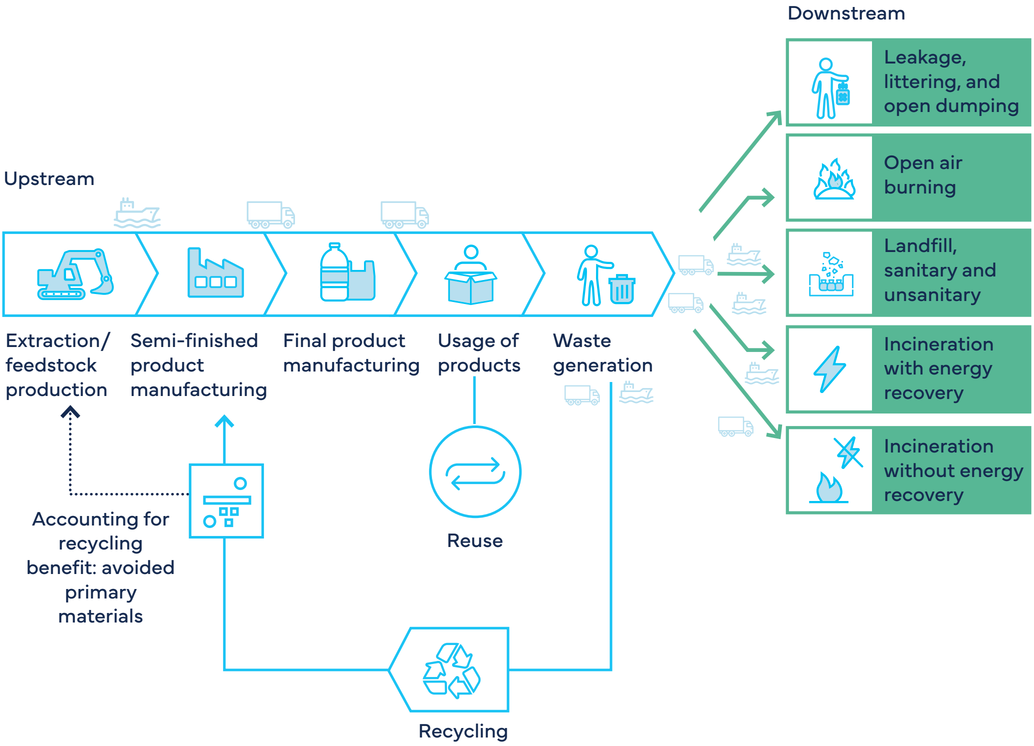
How Does the Plastic Substitution Tradeoff Estimator Work?

The scope and methodology of the Plastic Substitution Tradeoff Estimator deals with various aspects:

- **Ten plastic products in scope:** Ten plastic products were included in the Estimator, primarily based on their occurrence in marine litter. These products are (a) fishing nets, (b) beverage bottles, (c) beverage cups and food containers, (d) shopping bags, (e) disposable utensils, (f) food wrappers, (g) sachets, (h) beverage cartons, (i) clothing, and (j) diapers.

  For each of these products, up to four alternative products have been selected that are readily available in the (global) market.
- **Product system:** The product system covers the entire life cycle of a plastic product or an alternative material, from the sourcing of primary materials to end-of-life stages (figure B.1).

FIGURE B.1 **Overview of the Life Cycle Stages Covered in the Plastic Substitution Tradeoff Estimator**



Source: Adapted from World Bank 2022.

- **Geographical coverage:** The Estimator is a universal model with default values that can be tailored to country-specific context using various parameters. The final unit of analysis is at the country level.
- **Consumption-based perspective:** Calculating the external costs and effects associated with products throughout their life cycles can be performed from two different perspectives. While the *production-based perspective* implies that a producer (for example, a country or a company) is responsible for all externalities associated with a product, regardless of where a product is used, the *consumption-based perspective* shifts the responsibility of all impacts associated with a product, arising from both upstream and downstream stages of the life cycle, to the consumer. Given that the Estimator is used in a country setting, the methodology adopts a consumption-based perspective, which facilitates policy discussions about reduction of plastic littering, environmental conservation, waste treatment options, sustainable consumption, and production.
- **Function-based comparison:** The function of a product needs to be articulated to allow for a meaningful comparison. For example, PET bottles require less weight to fulfill the same function compared with glass bottles, so a one-to-one weight-based comparison of plastics and their alternatives is not justifiable. The Estimator uses a functional unit to provide a basis for comparison based on an equal function to be performed by the plastic products and the alternative products.
- **Technology coverage:** The general global average industry practices of production processes and waste treatment options are used in the Estimator. The extent to which a waste treatment or disposal technology (recycling, incineration, and landfilling) is used in a certain country can be entered by the user to reflect the current situation in the model application country and can be adjusted to calculate what-if scenarios. Additional innovations in technology (for example, chemical recycling of plastics) are not in the scope.
- **Quantitative and qualitative outputs:** Where possible, the Estimator valuates the external effects monetarily, expressed in US dollars. In addition, quantitative and qualitative assessment methods are used to complement monetary valuation and provide a holistic comparison of the costs and benefits of plastic and their alternatives. A number of effects pertaining to usage and littering stages of a product's life cycle can be neither monetized nor quantified because of data gaps. Nonetheless, there is evidence that these effects do occur. Therefore, to facilitate a holistic comparison of the costs and benefits of plastics and their alternatives, a qualitative assessment method has been devised specifically for the Estimator. The assessment of the alternatives involves assigning a direction (positive, neutral, or negative) to the alternatives in comparison with the plastic product. The overview of all pertinent effects identified and quantified, together with the valuation methodology used, are presented in Table 3.1. For the life cycle assessment (LCA), the Estimator uses life-cycle inventory (LCI) data sets (Ecoinvent) as a baseline since they contain peer-reviewed LCI data sets on production of

raw materials and intermediates, production processes, energy carriers, transportation means, and end-of-life waste treatment routes; is furnished annually with data by sectoral organizations; and allows for efficient updating. Because of the global scope of the Estimator, global LCI data were used, noting that the actual impact of production in any one country can differ from the global average. For example, in the Estimator, users can customize the transportation distance from production to sales location, although not the transportation distance of raw materials from extraction to production. Monetization of effects quantified by LCA was accomplished by using "environmental prices," which reflect the social (marginal) costs of emissions and environmental damage. Although many of the environmental impacts can be monetized, the scientific community has not reached a consensus or devised a methodology to monetize all impacts and effects. Whether monetization of the environmental impact category applicable to the external effects of plastics was possible was determined by two factors: (a) the robustness of the assessment method for the environmental impact category, and (b) the existence of an environmental price for the impact category or the possibility of establishing such a price. Given that the Estimator needs to yield results with minimal user input and should be tailored based on detailed user input, environmental prices are determined on three levels: global, regional, and national. In setting the environmental prices, a three-step benefit transfer has been applied.

- **Uncertainty of the information and data gaps:** The output of the Estimator can be tailored to the country context by inserting country-specific input data, which may require research. However, given that this is a universal model, the Estimator cannot provide results at a level of certainty that matches a model custom-built for a specific country. Therefore, outcomes of the Estimator should be regarded as an estimation.

Reference

World Bank. 2022 (forthcoming). *Plastic Substitution Tradeoff Estimator: Technical Guidance Note.* Washington, DC: World Bank.

Appendix

C

Plastics Policy Simulator: Policy Package Comparison

Additional Scenarios in the Plastics Policy Simulator

This annex presents results of more scenarios that were run to reflect a broad range of policy reforms proposed by different stakeholders in Indonesia.

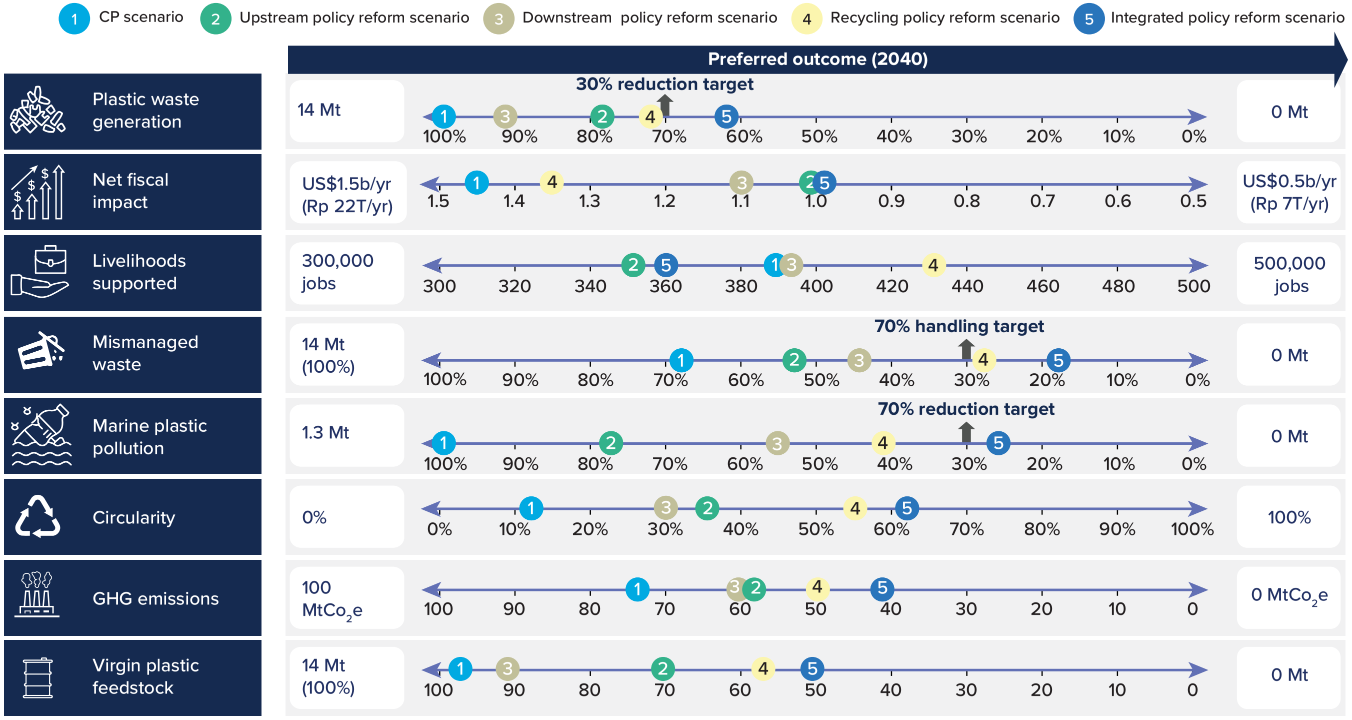
Figure C.1 aims to illustrate that only the integrated policy reform (IPR) scenario achieves all targets set by the government of Indonesia: a 30 percent reduction of plastic at source, a reduction of mismanaged waste to achieve a 70 percent handling rate, and a 70 percent reduction of plastic pollution in the ocean compared with current policies levels. Other scenarios have more limited impacts (see figure C.2; tables C.1 and C.2 provide a comparison of policy packages modeled).

Upstream Policy Reform

The upstream policy reform scenario focuses on policy objective A: slowing the growth of plastic use and waste generation. This is simulated through enacting product bans, subsidizing reuse systems, applying an excise tax on packaging made from virgin plastic, and conducting upstream consumer campaigns. While this policy package is estimated to reduce plastic waste by 21 percent and the use of virgin feedstock by 30 percent by 2040, 52 percent of waste remains mismanaged, and ocean pollution is reduced by only 22 percent by 2040. Importantly, this scenario reduces the government net fiscal cost by approximately Rp 7.3 trillion/US$0.5 billion per year given that there is less plastic waste to collect and there are more sources of revenue for the government. Under this scenario, the PPS estimates that plastic producers and converters will reduce their profit pools by an estimated 30 percent and 20 percent respectively, while recyclers' profit pool could increase by 190 percent due to the increased demand for recycled content. Yet plastic producers and converters can mitigate this loss by entering new value pools such as recycling or using recycled content at scale.

- **A virgin plastic packaging tax (VPT)** (figure C.2a) scenario simulates the impacts of upstream taxes levied on plastic packaging with high (more than 70 percent) virgin content. The tax rate for most plastic products is US$280 per ton and US$420 per ton for multilayer and multimaterial packaging. Such upstream fiscal incentives could significantly reduce the volume of plastic entering the downstream waste management system as some consumers, facing higher prices of virgin plastics, would switch to nonplastic alternatives and choose to reuse plastic products. Upstream taxes on virgin plastic products also encourage plastic users to switch from virgin to recycled plastic and increase demand and prices and profits of recyclers who increase their investments and recycling rate. This upstream effect could prevent major growth in the volume of plastic waste. The VPT scenario could reduce plastic waste generation by 31 percent versus current policies (CP) scenario in 2040 and raise Rp 18 trillion (US$1.3 billion) per year of revenue to the state budget. This would reduce plastic pollution to the environment by an estimated 35 percent—halfway through to the government target, but still not necessarily lower than current levels. The excise tax on packaging made from plastic has a greater impact on heavy consumers of plastic and less so on light ones.

FIGURE C.1 Comparison of Scenarios across Key System Indicators, Indonesia, 2040

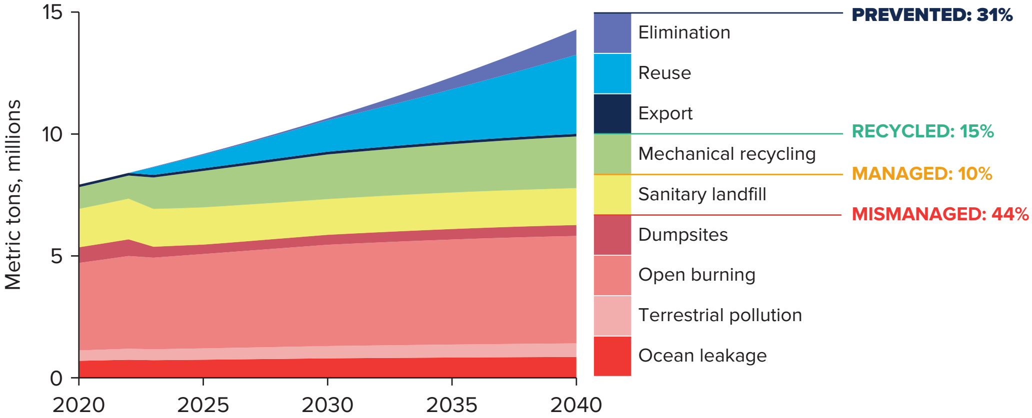


Source: Adapted from World Bank 2022.

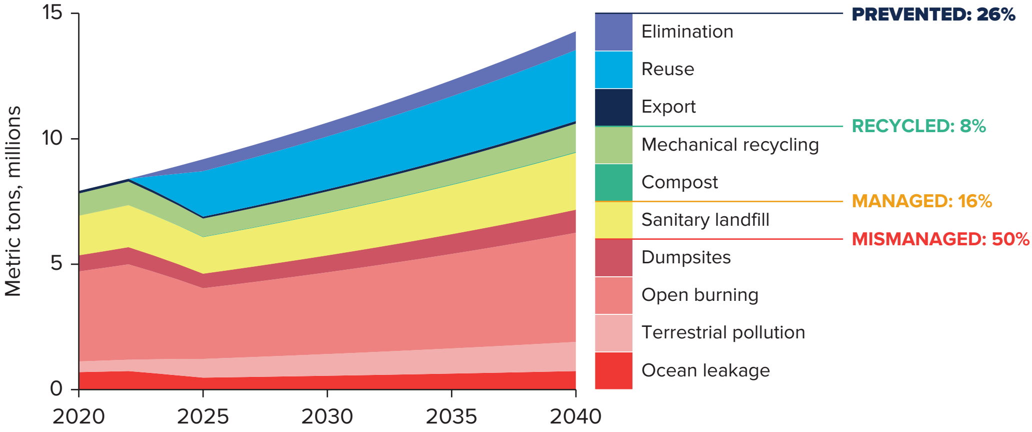
Notes: The scale indicates the preferred outcome on the right. While the current policies scenario has the highest number of livelihoods supported, these mostly stem from production outside of Indonesia. The other scenarios see a growth of livelihoods in local industries (for example, collection, sorting, and recycling). "Circularity" is calculated as the share of open- and closed-loop recycling (including the share of substitutes recycled), reusing, substituting other materials, and eliminating the use as a percentage of the total plastic utility demand. b = billion; CP = current policies; Rp = rupiah; Mt = million tons; $MtCO_2e$ = million tons of carbon dioxide equivalent; T = trillion.

FIGURE C.2 Plastic Waste by Destination in Selected Single-Policy Scenarios, Indonesia

a. Virgin plastic packaging tax



b. Extended coverage of product bans



Source: Adapted from World Bank 2022.
Note: P2P = plastic to plastic; P2F = plastic to feedstock.

Virgin plastic producers and consumer good companies would see reduced profits because of this tax.

- **An alternative excise tax levied on all plastic packaging (with or without recycled content)**—also simulated by PPS—could raise even more revenue of Rp 29 trillion (US$2 billion) to government coffers because of a broader tax base. It would have a slightly lower impact on plastic pollution, however, because it is less effective in encouraging recycling than the tax targeted at virgin plastic content. The extra tax revenues are in addition to the fiscal savings that come from lower government expenditures in waste management systems due to reduced volumes of plastic waste.

- **The bans of certain plastic products** (figure C.2b), such as shopping bags, disposable utensils, beverage cups and lids, and takeaway containers (similar scope to the EU Single-Use Plastics Directive) would reduce plastic waste creation and downstream pollution. The simulated product coverage would be an extension to the whole country and to more products of limited bans already applied at the local (Banjarmasin, Bandung) and provincial (Jakarta, Bali) levels. If an enforcement effectiveness of a ban amounts to 70 percent, the PPS model estimates that plastic waste generation in 2040 could be reduced by 7 percent compared with the CP scenario. Plastic pollution to the environment could also be reduced by 7 percent below the CP scenario or by 660,000 tons per year in 2040. Impacts are limited compared with a plastic virgin tax because the subset of plastic products covered by a ban represents a smaller volume of total plastic waste. If product restrictions and bans are extended to a much wider scope of plastics products (also including water bottles under 200 milliliters, other beverage bottles, nonbeverage bottles, films, and sachets), the PPS calculates a much larger (41 percent) reduction in waste generation and related plastic pollution.

While the IPR scenario achieves the highest performance across almost all indicators, the CP scenario achieves the worst performance across almost all indicators. Hence, any of the policy packages modeled would be a considerable system improvement. And while the CP scenario appears to perform well on jobs, it is important to note that most of these jobs are either in virgin plastic production and hence are outside Indonesia, or in waste collection systems, hence are low-skilled and low-wage jobs. The scenarios support local and more productive jobs such as sorting, recycling, material recovery, and new product development.

Downstream policy reform: The downstream policy reform scenario focuses on the government policy objectives related to (a) financing an expansion in waste management and recycling, and (b) strengthening the institutional capacity and governance for waste management. This is simulated through mandatory extended producer responsibility, improving institutional governance (which includes an increase in public financing for collection, sorting, and landfill), and enabling household fees. The PPS estimates that this policy package can reduce ocean pollution by 44 percent by 2040 and bring the proportion of mismanaged waste down to 43 percent. This package also reduces the amount of plastic waste generated by 8 percent by 2040. However, as this scenario is largely focused on increasing collection and landfilling, the share of demand met by virgin plastic feedstock is only marginally reduced, with an estimated 3 percent of plastic demand fulfilled by recycled content by 2040. This package reduces government spending, estimated at almost Rp 3.6 trillion/US$250 million per year by 2040, mostly driven by increased extended producer responsibility (EPR) fees as well as a stronger governance system. Under this scenario, plastic producers and converters will reduce their profit pools by an estimated 8 percent, while waste pickers' profit pool will increase by 10 percent, and recyclers by 100 percent.

TABLE C.1 List of Policy Instruments Included in the Scenarios, Indonesia

SCENARIO	Policy instruments included now (incremental to CP scenario)	Policy instruments included in five years (incremental to CP scenario)
Upstream IPR scenario	• Product bans on bags, disposable utensils, takeaway food containers, and beverage cups and lids • Virgin plastic excise tax on all packaging at US$70/metric ton for bottles, rigids, and flexibles, and US$105/metric ton for multimaterials	• Subsidies of reuse systems for bottles and rigids at ≈US$140/metric ton • Consumer education campaigns (upstream)
Downstream IPR scenario	• Household fees: indirect in megacities and medium-sized cities; direct in periurban areas • Mandatory modulated EPR US$70/ton for bottles, US$130/ton for rigids and monoflexibles and US$150/ton for multimaterials	• Household fees: direct in remote areas • Improvement in governance (includes expansion of public financing into formal waste collection, formal sorting, and sanitary landfills)
Recycling IPR scenario	• Design requirements on bottles, rigids, and monoflexibles • Mandatory modulated EPR US$70/ton for bottles, US$130/ton for rigids and monoflexibles and US$150/ton for multimaterials • Consumer education campaigns (downstream) • Public financing of mechanical and chemical recycling at US$150/ton and $50/ton, respectively	• Virgin plastic excise tax on all packaging at US$70/ton for bottles, rigids, and flexibles, and US$105/ton for multimaterials • Mandatory DRS on all beverage bottles • Enforcement of plastic labeling
FULL-SYSTEM IPR SCENARIO	• Mandatory modulated EPR US$70/ton for bottles, US$130/ton for rigids and monoflexibles, and US$150/ton for multimaterials • Virgin plastic excise tax on all packaging at US$70/ton for bottles, rigids, and flexibles, and US$105/ton for multimaterials • Household fees: indirect in megacities and medium-sized cities; direct in periurban areas • Public financing of formal collection • Public financing of landfill facilities and operations • Enforcement of plastic labeling • Impose product bans on bags, disposable utensils, takeaway food containers, and beverage cups and lids • Design requirements on bottles, rigids, and monoflexibles • Consumer education campaigns (downstream)	• Mandatory DRS on all beverage bottles • Subsidies of reuse systems for bottles and rigids at ≈$140/metric ton • Improvement in governance (includes expanding public financing into formal waste collection, formal sorting, and sanitary landfills)

Source: Adapted from World Bank 2022.
Note: CP = current policies; DRS = deposit refund schemes; EPR = extended producer responsibility; IPR = integrated policy reform.

Recycling policy reform: The recycling policy reform scenario focuses on the Indonesia government policy objective related to increasing the market value of plastic waste. This is simulated through mandatory design requirements and labeling, EPR (which includes an increase in financing for collection and sorting), deposit return schemes, excise tax on all packaging made from virgin plastic, public financing of recycling facilities, and consumer

TABLE C.2 Result Comparison of Policy Packages Modeled, Indonesia

	2040 outputs					
SCENARIO	Plastic pollution in environment[a] (Mt)	Circularity[b] (%)	GHG Emissions ($MtCO_2e$)	Net fiscal impact[c] (US$, billions)	Employment[d] (thousands of jobs)	Virgin fossil plastic use (Mt)
CP scenario	9.6	12	74	1.5	390	13.5
Upstream IPR scenario	7.4	35	60	1.0	350	9.7
Downstream IPR scenario	6.1	30	61	1.1	390	12.4
Recycling IPR scenario	3.9	55	49	1.4	430	7.8
FULL-SYSTEM IPR SCENARIO	2.5	62	42	1.1	360	6.9

Source: Adapted from World Bank 2022.

Note: CP = current policies; GHG = greenhouse gas; IPR = integrated policy reform; Mt = million tons; $MtCO_2e$ = million tons carbon dioxide equivalent.

a. Defined as total plastic pollution in the ocean, in land (including dumpsites), and burned to the atmosphere.

b. Defined as the share of plastic utility that is either reduced, substituted by circular materials, or recycled mechanically or chemically, excluding plastic entering stock.

c. Defined as the total cost to national and subnational governments per year to run the plastic waste management system, including operating expenditures and capital expenditures.

d. Defined as direct domestic employment in the plastic sector across the entire value chain (including the informal sector).

education campaigns (to discourage littering and encourage separating waste). The PPS estimates that this policy package can reduce ocean pollution by 59 percent by 2040 and bring the proportion of mismanaged waste down to 27 percent. It does, however, cost the government 30 percent more than the system policy reform scenario, achieving an impact that is comparable but does not reach all three of the targets set by the Indonesian government. Recyclers and aggregators stand to gain the most as this policy package is expected to increase their profit pool by almost 600 percent, while plastic producers and converters will shrink in both size and profitability.

Integrated (full system) policy reform is discussed in detail in chapter 4.

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Appendix

D

Tackling Plastic Pollution: Toward Experience-Based Policy Guidance—Executive Summary

Plastic pollution threatens public health, local economies, and ecosystems (including the marine environment), and its environmental impact is growing at an alarming rate. According to a number of recent studies, the global production of plastics was over 438 million metric tons in 2017 and is expected to double between 2020 and 2040 and triple by 2050. The implementation of end-of-life solutions, such as recycling and safe disposal, to manage plastics is not keeping pace with production, resulting in an estimated 75 million to 199 million metric tons of plastics already in the ocean with up to 11 million additional tons entering the ocean each year. Exposure to chemicals and pathogens associated with plastics, microplastics, and the burning of plastics has direct impacts on human health and economies, and the environmental costs of marine plastic pollution are significant. Plastic pollution presents a serious threat to marine life through entanglement, starvation, and toxicological harm, and is understood to alter the global carbon cycle.

A comprehensive approach to addressing plastic pollution in the life cycle of plastics has been promoted by the World Bank Group and many other government agencies and international organizations. Technical and financial support through the World Bank Group's PROBLUE program for marine pollution control has focused on three main interventions: (a) *stopping the leakage*, a multisector approach from solid waste management to wastewater management; (b) *encouraging a circular economy*, including actions to reduce (rethinking the source), redesign, repair and remanufacture, reuse and recycle; (c) *restoring ecosystems* through necessary actions for ecosystem recovery. To be effective and sustainable, this approach needs to be supported by policy reforms—both fiscal and regulatory—that create incentives and generate financial resources to improve waste management systems, expedite the transition to a circular economy, and reduce plastics use.

Many countries, including developing countries, have begun to implement a range of public policies to manage plastic pollution. For example, more than 60 countries have applied bans, taxes, and levies to curb plastic waste and its impacts. Inventories of policies used to manage plastic pollution and studies have been developed to assess plastics policies and their effectiveness. Most policies currently being implemented focus on banning plastic bags and foamed plastic products, as well as on the prevention and management of plastic waste, the reduction of plastics production, or the incorporation of renewable or recycled content into plastics. However, little is known yet about the effectiveness of many of the plastics policies implemented by developing countries.

To address this gap, this report builds on a review of the existing literature and summarizes the findings from the ex post analysis of the effectiveness of plastics policies in 10 case study countries and states. The case studies were conducted in Bangladesh, Bulgaria, Fiji, the state of Kerala in India, Italy, Malaysia, Morocco, Rwanda, St. Lucia, and Tanzania. They were purposely selected to cover a wide range of diversity in geography, economies, plastics policies, and implementation experience.

The purpose of this report is to review experiences and lessons learned from the development and implementation of policies to manage plastic pollution and to provide evidence-based guidance for policy. The report is aimed at policy makers and stakeholders involved in the design, implementation, and evaluation of policies to manage plastic pollution.

Key entry points for policy interventions are in the management of solid waste and the reduction of plastics' impact across the value chain, including through circular economy and better governance and accountability. Global municipal waste is expected to increase by 73 percent (from 2.24 billion tons in 2020 to 3.88 billion tons by 2050). The "circular economy" is a system-wide approach that considers the entire value chain, focusing on reducing the use of nonrenewable materials, increasing recycling and the use of renewable and recycled materials, preventing pollution, and extending the lifespan of products, while regenerating natural systems. It considers the entire plastics life cycle: (a) *upstream* (extraction and production) policies to prevent upstream waste and pollution, including those that encourage manufacturers to reduce waste by environmentally friendly design and to build durability, repairability, reusability, and recyclability into products, use recycled and renewable materials, and reuse products; (b) *midstream* (including use) policies to keep existing products and materials in use for as long as possible and encourage waste prevention and recycling behavior; and (c) *downstream* policies to improve solid waste management systems, particularly regarding collection, and to facilitate reuse, recovery, and recycling of resources. Finally, better governance (for example, strategy, accountability, targets, and coordination) ensures the alignment of policies and reduces fraud and corruption.

A variety of policy instruments have been used for environmental management, solid waste management, and the control of plastic pollution. The range of instruments adopted in developing countries includes bans, standards, taxes, fees, and subsidies. They can be grouped into (a) command-and-control or regulatory measures and (b) market-based instruments or economic measures. The extended producer responsibility (EPR) measure provides a blended approach, offering both restrictions and financing mechanisms. In the 10 case study countries and states, all except for two (Bulgaria and Malaysia) incorporated policies banning or restricting plastics products, with all but three (Bangladesh, Malaysia, and Rwanda) having taxes, levies, or fees on plastics products. Three of the countries (Bulgaria, Italy, and St. Lucia) had existing EPRs, and five other countries and states (Bangladesh, Fiji, Kerala, Malaysia, and Morocco) were in the process of considering them. Kerala was the only case study focused on subnational responses, with product bans in place at both the national and subnational levels and with EPR under discussion nationally. Other policies that were reviewed focused on governance, behavioral change, public and private financing, and investment or encouraging voluntary action by industry.

Policy development needs to be well designed and technically sound to strengthen its robustness and impact. Policy development proceeds in stages—predesign, design, implementation, monitoring and evaluation, and revision. The report summarizes the experience and lessons learned in each stage of policy making and implementation in the case studies and provides evidence-based policy guidance.

The predesign stage is an opportunity for policy makers to set the agenda, define the problem, and decide how to address it. The cases studies and literature review indicate that many developing countries lack basic data and a good diagnosis of their solid waste management and plastic pollution problems and that they face weak institutional and financial capacity, low political commitment, and poor stakeholder participation. To address such gaps, the report highlights the following elements necessary for the predesign stage:

- Fully understand the development context, including local and cultural specificities.
- Conduct diagnostics on the plastics problem by collating and assessing available information and evidence through, among other things, litter surveys, data on plastics production, consumption, and impact studies.
- Identify, map, and consult with stakeholders from across the value chain to improve the evidence base.
- Assess institutional and waste management capacity to avoid shortfalls in design and implementation.
- Develop a national vision and political will and commitment.
- Explore financing and cost-recovery mechanisms.
- Consider cross-government engagement and international agreements.

The policy design stage is where targets are set, policy options/alternatives are assessed and selected, and the approaches are developed for funding, implementation, enforcement, monitoring, reporting, evaluation, and revision. The case studies highlighted the importance of setting targets and clarifying policies, an appropriate policy mix and sequencing, stakeholder engagement, policy impact assessment, financial arrangement, policy monitoring, and evaluation in the design of plastics policies. The following tasks are key at the design stage:

- Use data to set targets.
- Develop a policy mix by selecting a combination that encourages desired outcomes, discourages undesired ones, and ensures policy coherence.
- Consider timing and sequencing of policy implementation to ensure that the various policy instruments will work in tandem.
- Engage stakeholders to increase participation, transparency, and accountability in policy making.
- Conduct policy impact assessments to understand and plan for optimal response and effectiveness.
- Understand and specify how a policy will be funded, implemented, enforced, monitored, reported, evaluated, and revised.

The policy implementation to revision stages involves putting policies into effect, enforcing execution, monitoring, reporting, evaluating the results, and revising policies whenever necessary. The evaluations will inform policy revisions as needed. The case studies found that the mechanism for policy enforcement, monitoring, and evaluation is weak or largely missing in many developing countries. Key elements include the following:

- Implementation
- Enforcement
- Monitoring and reporting
- Policy evaluation and revision

Cross-cutting issues, ranging from institutional and waste management capacity, incentivizing private sector innovation, and integrating the informal sector, to addressing poverty and corruption, need to be well incorporated and addressed in policy development. The report also identifies the following cross-cutting findings from case studies and emphasizes that they are broadly applicable across all stages of policy making.

- Build institutional capacity. Policy implementation, particularly in decentralized governance models, requires national technical and financial support and oversight. All case studies of low-income countries cited shortcomings in institutional and financial capacity and expertise, typically due to a lack of funding.
- Improve solid waste management. An effective system for the management of solid waste with integral management of plastic waste is shown to provide the most effective means for managing plastics at end of life.
- Opportunities to strengthen and develop human capital were highlighted in case studies:
  - Provide work and empowerment opportunities for low-skilled workers.
  - Fill gaps in service provision. Most case study countries have an active informal sector, which is responsible for most of the waste collection, sorting, and bulking.
  - Improve working conditions and training for waste management workers. There were many examples in the case studies of inadequate health and safety practices and of poor wages and working conditions.
  - Engage and integrate the informal sector. The informal sector is seen as a competitor to the regulated sector and has shown a willingness to be "formalized" (for example, by cooperatives). Public-private models of informal sector inclusion exist.
- Private sector investment and innovation are necessary to grow recycling. The cost of making products from recycled materials may be higher than that of products made from virgin materials, resulting in a difficult viability for green businesses. There is a need for financial incentives (for example, subsidies) and disincentives (for example, taxes) to drive the incorporation of recycled content (for example, for technology, capacity building, and meeting environmental standards).
- Poverty and government corruption are linked to the mismanagement of plastic waste. Corruption is noted as a key barrier to policy effectiveness in some case study countries and must be addressed.

Overall, the report concludes that the effectiveness of policies to address plastic pollution can be substantially improved through careful design, implementation, and evaluation. Key elements include building institutional capacity, aiming for circularity, involving all relevant public and private stakeholders, and making adequate provisions for the monitoring, evaluation, and revision of policies. Fiscal and regulatory policies can be used to create incentives and generate financial resources that improve waste management systems.

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Where Is the Value in the Chain? Pathways out of Plastic Pollution aims to support policy makers in their efforts to address plastic pollution. By examining the economic and financial implications of plastic management, the report provides key recommendations on how to create a comprehensive approach to addressing plastic pollution and to help policy makers make informed decisions for plastic pollution management.

The report brings together new evidence from three analytical undertakings:

- *Tackling Plastic Pollution: Toward Experience-Based Policy Guidance*—A review of existing literature and a summary of findings from the ex post analysis of the effectiveness of plastics policies in 10 countries and states and an evidence-based policy guidance aimed at policy makers and stakeholders involved in design, implementation, and evaluation of policies to manage plastic pollution.
- *The Plastic Substitution Tradeoff Estimator* (the Estimator)—An innovative model that estimates the external costs of 10 plastic products and their alternatives along their entire life cycle, developed and piloted in five countries. The Estimator can be applied in any country to identify what substitution materials, or what combination of them, would perform best in a given scenario and to examine tradeoffs between plastics and alternatives to help establish targets for reduction and substitution.
- *The Plastic Policy Simulator* (PPS)—A country-level, data-driven model for policy analysis to better describe the impacts of different policy instruments and policy packages on individual economic agents and on the plastic value chain at large. The PPS has been developed as a universal model and piloted in Indonesia. Its objective is to support policy makers and others in government, industry, and civil society in search of policy solutions to stem the flow of plastics by bringing an evidence-based approach to policy.

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