Duke NICHOLAS INSTITUTE *for* ENERGY, ENVIRONMENT & SUSTAINABILITY

2023 Annual Trends in Plastics Policy: A Brief

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Summary

The 2022 update to the Plastics Policy Inventory, a searchable database of policies introduced by governments explicitly to address the plastics crisis, suggests that the 20-year global trend of increasing government responses to this crisis continues. Prior to 2022, the policy inventory had 571 policies. With 41 new international, national, and subnational policies introduced by governments in 2022, as well as 282 additional policies found from the previous period of 2000 through 2021, the inventory has now expanded to include 894 policies. Upward revisions to the data from 2020 and 2021 suggest that the "pandemic pause" hypothesized in 2022 (Karasik et al. 2022) did not materialize, and governments continue to introduce policies to reduce plastic pollution. In recent years, the scope of national policies has broadened to more frequently include a range of single-use plastic (SUP) types rather than only plastic bags. Similar gaps remain as compared to the previous annual update, as microplastics and marine sources remain relatively unaddressed by these policies and economic instruments are a minority of policy instruments used.

To date, the effectiveness of these policies (how well they are working to achieve stated or unstated goals) has been relatively understudied (Diana et al. 2022). For this reason, an effectiveness study library has been developed and added to the inventory as a searchable and public database of published literature with measures of plastics policy effectiveness. The library includes 117 studies published between 2000 and mid-2022. Since the period (2000–2020) summarized in a previous review by Diana et al. (2022), the number of studies has increased, though the majority still largely focus on policies targeting plastic bags. Research increasingly considers more dimensions of policy impact (social, economic, ecological) and identifies unintended consequences, but rarely uses causal inference methods to attribute effects to policies. While still a relatively nascent field of research dominated by plastic bag policies, more and more indicators can be identified (potentially supporting

global monitoring). However, models of global plastic flows and leakage are likely to depend upon significant assumptions to estimate the effect of current and future policies.

Although relatively underused in the policies analyzed from the inventory, scholars in the effectiveness studies reviewed frequently recommended greater governmental use of economic instruments (e.g., taxes, fees, levies) and information instruments (e.g., awareness campaigns to communicate other instruments to the public, education initiatives, etc.).

Looking toward the future, the Plastics Policy Inventory, which now includes updated data on policy and policy effectiveness, can not only provide a basis for tracking and assessing government responses to the plastic pollution problem, but also for monitoring compliance with a pending global agreement on plastics, which is being negotiated at the time of this writing.

INTRODUCTION

The Need for a Global Monitoring Platform for Plastics Policies. Over the past two decades, scientific evidence has confirmed that the production, consumption, disposal, and mismanagement of plastic has deleterious effects on social, ecological, and economic systems globally. Despite the benefits that plastics provide in the short term, there is growing consensus that the accelerated rate of plastic production and its associated harms and risks pose larger, long-term threats that are distributed unequally among social systems, creating or exacerbating environmental injustices across the world (Karasik et al. 2023; Landrigan et al. 2023). The fragmented solutions that comprise a business-as-usual response to the plastic crisis will not meaningfully reduce plastic entering the environment (Lau et al. 2020). Without significant and systemic changes to how we produce and consume plastic and manage post-consumer waste, the volume of plastic production is expected to increase threefold by 2060, according to OECD's Global Plastics Outlook (OECD 2022).

Plastic inputs, products, and waste circulate between and across jurisdictional boundaries. The transboundary nature of plastic, therefore, requires a global, coordinated response. Since 2000, governing bodies across the world have addressed plastic through the design and implementation of public policies and programs (Diana et al. 2022). More recently, global policymaking fora, including the UN Environment Assembly, World Trade Organization, and Basel, Rotterdam, and Stockholm Conventions are engaging in ongoing dialogue and international agreements to address plastic pollution. As part of this global effort, the UN Environment Assembly has called for global monitoring of the status and efforts to address plastic pollution (UNEA 2019), including policies introduced by governments (treaties, laws, regulations, and government strategies).

The Plastics Policy Inventory. With the increased momentum to address plastic, including the process to develop a legally binding treaty by 2024, governments and other stakeholders may seek to assess the baseline of policy responses, understand the rapidly changing policy landscape, and replicate approaches used in similar contexts. The Plastics Policy Inventory, housed within the Nicholas Institute for Energy, Environment & Sustainability at Duke University, is a tool designed to monitor and assess the evolution of the plastics policy landscape and support governments

in the design of new policy responses (potentially in seeking to comply with a new international treaty). The inventory, a searchable and updated online database, includes hundreds of public policy documents introduced by governments to address plastic pollution on the national, subnational, and international levels. This public inventory aims to help policymakers, scholars, practitioners, and other stakeholders engaged in the plastics policy process.

Additions to the Inventory in 2022. To ensure that the information remains up-to-date and relevant, the inventory is updated annually. In addition to updating the inventory, policy design characteristics are assessed, as well as trends and gaps as the policy landscape evolves. This brief is intended to capture the outcomes of the 2022 update and assessment.

Prior to 2022, the policy inventory had 571 policies. With the 41 new international, national, and subnational policies introduced by governments in 2022, as well as 282 additional policies found from the previous period of 2000 through 2021, the inventory now has expanded to include 894 policies. While the inventory organizes these policies for quick reference and tracking, to date, little information has been available about their effectiveness (e.g., how well the policy is working toward achieving relevant socioeconomic or ecological objectives). For this reason, an effectiveness study library has been developed and added in 2022 as a searchable and public database of published literature with measures of plastics policy effectiveness. This library was developed and published in an effort to update the state of knowledge regarding the effectiveness of plastics policies. Reviewing 117 documents published between 2000 and mid-2022, data for quantitative and qualitative measures of policy effectiveness were extracted and assessed, as well as information describing unintended consequences, enabling conditions, and policy recommendations (see the Methods section for further details).

Organization of this Brief. To best present the results of the analysis of the 2022 update to the Plastics Policy Inventory and some key conclusions, this brief summarizes

(1) trends and gaps in the global policy landscape from 2000 to 2022, with a focus on national-level policies and

(2) the state of published knowledge on the effectiveness of existing policies in achieving plastic reduction goals.

RESULTS—POLICY ANALYSIS

The analysis of the updated and expanded Plastics Policy Inventory focused on trends and gaps in national-level government responses to the plastics crisis based on a qualitative assessment of policy design characteristics. With the 2022 additions, there are now 514 national-level policy documents from more than 150 countries in the inventory, though not all of these could be assessed by the researchers because they were not published or credibly translated into English. From this sample of the global plastics policy landscape, 272 national-level policy documents from more than 100 countries were reviewed to identify the types of plastic targeted, the life cycle stages targeted, and the policy instruments used. Given the ad hoc nature of data collection for the inventory, as well as language constraints, the results of this analysis should be considered as indicative of the trends and gaps in the national policy landscape, but not as globally comprehensive.

Trends in National Policy Responses to Plastic Pollution

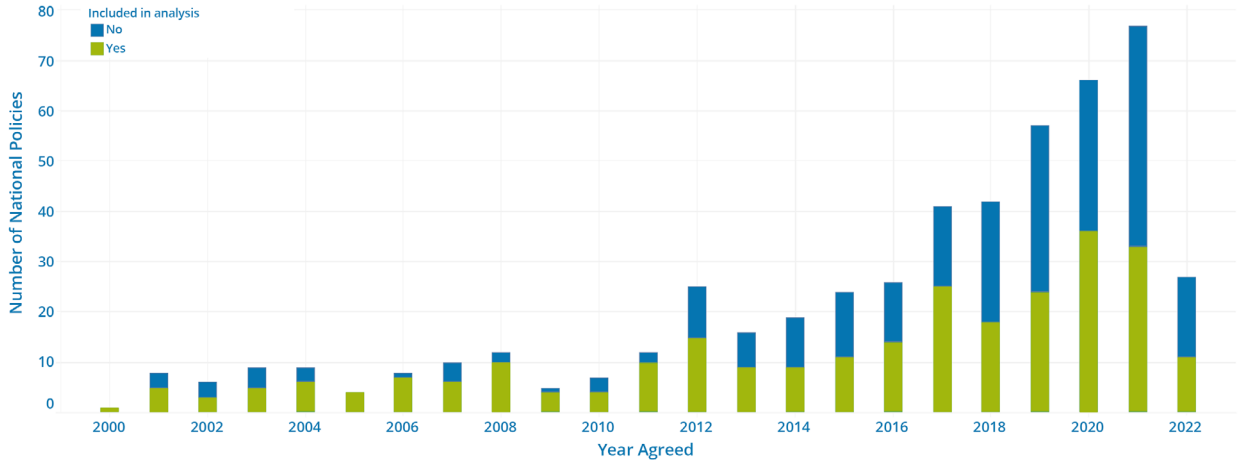
Total Number of National Policies Introduced

The total number of national policies introduced (e.g., agreed, enacted, amended, or published) to address plastic pollution has steadily increased from the year 2000 (Figure 1). The 2022 annual brief hypothesized that a drop in the number of policies introduced in 2020 and 2021 could either be the result of COVID-19 or because of the lag between when policies are passed and when they are publicly available as policy documents in legal databases or referenced in publications (Karasik et al. 2022). With the additional information available in 2022, the number of national policies passed in 2020 and 2021 now shows an increase in the rate of policies passed, suggesting that, overall, governments did not pause in response to the pandemic. The drop in the number of policies from 2022 is therefore likely a reflection of the lag between policy enactment and its public availability. This suggests that more data on the number of policies passed in 2022 will become available in 2023 and the number of policies passed in 2022 may be revised upward.

Types of Policy Instruments Used by National Governments to Address Plastic Pollution

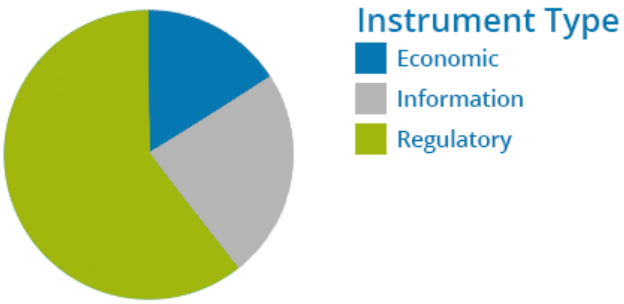
Policy instruments refer to the tools that governments use in their policies to address plastic. Of the types of policy instruments used by national governments, countries have most frequently used regulatory instruments such as bans (243 national policy documents, or 89% of national policy documents included in the analysis), followed by information-based instruments such as education and outreach (94 national policy documents, or 34% of national policy documents included in the analysis). Countries have least frequently used economic instruments such as fees or subsidies (65 national policy documents, or 24% of national policy documents included in the analysis) (Figure 2). Policies often use more than one type of instrument, which is why the percentages add up to more than 100%. These proportions have not meaningfully changed from the previous year, though the percentage of all national policy documents using economic

Figure 1. National policies in the Plastics Policy Inventory (2000–2022)



Note: Characteristics of policy design in policies coded as "included in analysis" were assessed using the qualitative analysis software NVivo. The remainder were not included in the analysis because the researchers do not speak the languages they were written in.

Figure 2. Types of instruments used in national policies (2000–2022)



instruments, which are already the least-used compared to regulatory and information-based instruments, declined three percentage points from 2021 to 2022.

The overall national policy approach to addressing the plastics crisis is comprised of all of the national policies and programs on plastic, as countries may employ multiple and varied instruments to achieve plastic reduction outcomes. In some cases, one national policy document will combine different types of instruments—for example, by banning a certain type of SUP and initiating a corresponding outreach campaign to inform the public. Other times, a national response to the plastics crisis is comprised of multiple policy documents using varied instruments over multiple years. Figure 3 maps which countries included in the analysis are using economic, information, and regulatory instruments in and across their national policies. Consistent with last year's findings, across all regions, regulatory instruments are more frequently used than economic and information-based instruments by countries with analyzed policy documents. While many of the countries included in the analysis use a combination of regulatory, economic, and information-based instruments (e.g., China, Australia, South Africa), some only use a single instrument or instrument type.

Types of Plastic Targeted by National Policies

The majority of national plastics policies target land-based sources of macroplastics, such as plastic bags, other SUPs, and plastic waste (Figure 4). In recent years, national policies have more frequently expanded beyond targeting plastic bags to target additional SUPs (such that national policies targeting plastic bags comprise a smaller proportion of the plastic types covered). Further analysis of the macroplastics category will be required to quantitatively identify the frequency of each type of SUP targeted in national policies. Based on a qualitative review of the coded text, however, the following SUPs are currently targeted: plastic drink stirrers, plastic cotton buds, plastic cutlery, plastic lids, polyvinyl chloride food trays, expanded polystyrene (e.g., Styrofoam), sticks attached to balloons, pizza lid supports, lollipop sticks, kebab sticks, and beverage containers.

Alternatively, there have been relatively few countries targeting microplastics (e.g., from tire abrasion) or marine sources of plastic pollution, despite their contribution to overall plastic pollution. This is consistent with findings by Karasik et al. (2020, 2022). Tire abrasion in particular remains an unregulated source of microplastic pollution that is projected to grow

Figure 3. Use of policy instruments by analyzed countries (2000–2022)

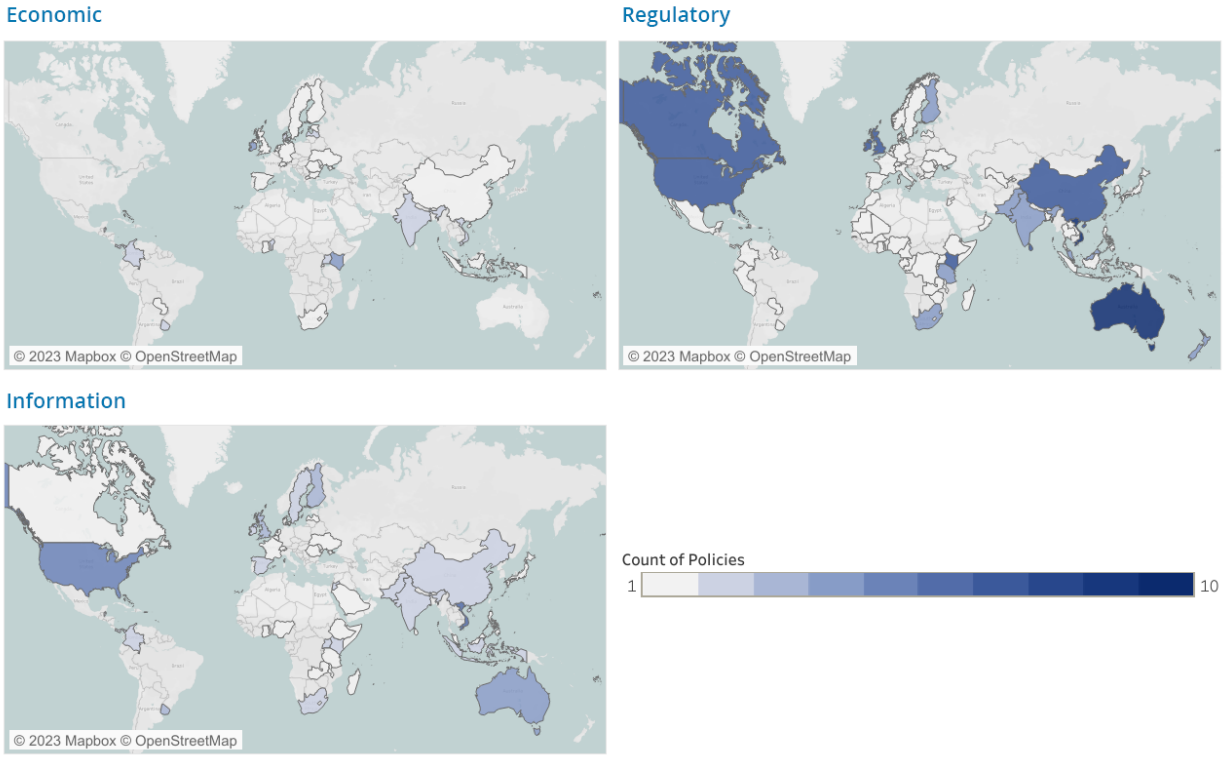
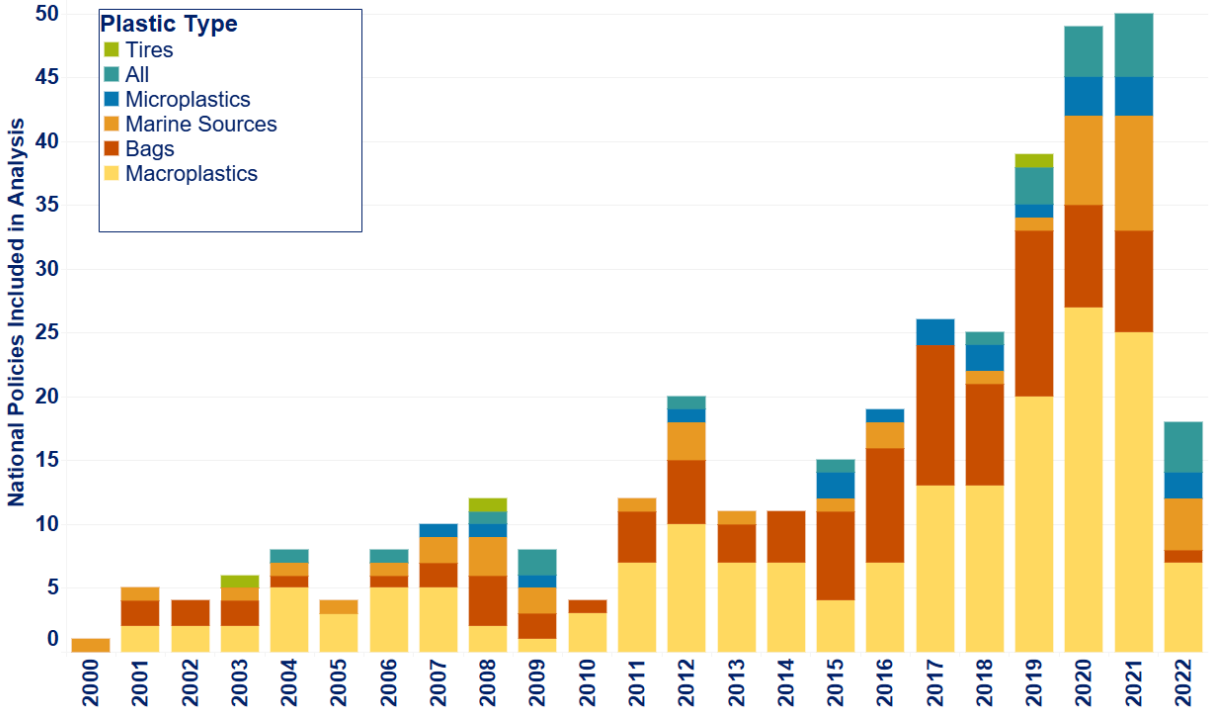


Figure 4. National policy documents targeting each plastic type



(Lau et al. 2020; OECD 2022). Policies that regulate solid waste management and port reception facilities may have an impact on the release of these pollutants into aquatic systems (Schmaltz et al. 2020; Lauer 2019), but these policies are not included in the analysis or the inventory if they do not explicitly target plastic pollution.

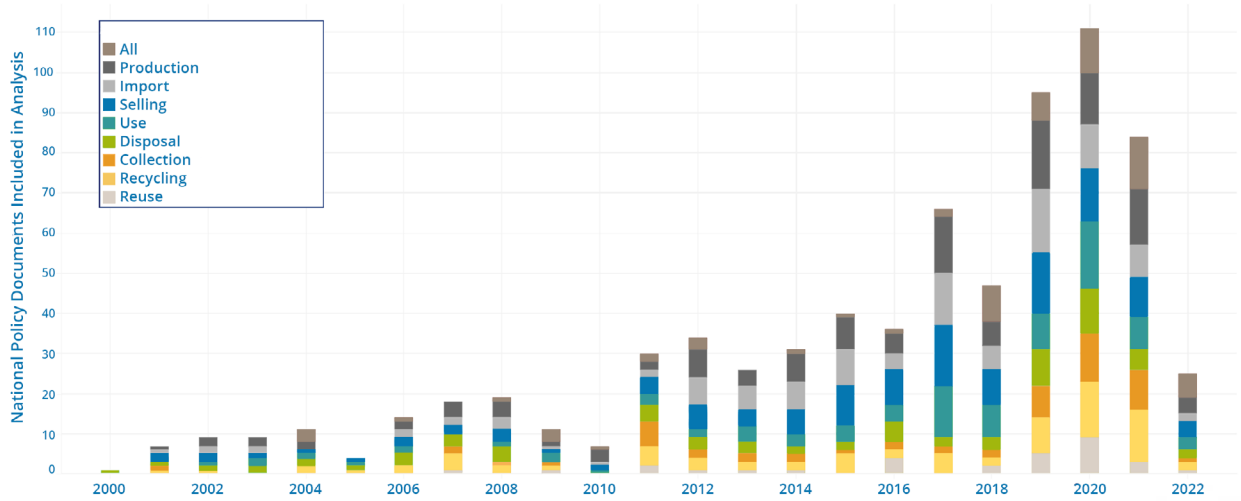
Stages of the Life Cycle of Plastic Pollutants Targeted by National Policies

Consistent with previous findings, there are no notable trends in the life cycle stages of plastic targeted by national policies. Likewise, there remain very few instruments targeting reuse. While the number of policies targeting the production and consumption stages of the life cycle outnumbers the number of policies targeting the management of postconsumption plastic waste (Figure 5), this should not be taken as an indicator of comprehensive upstream measures advocated for by various stakeholder groups (Simon et al. 2021; Brander et al. 2022; Almroth et al. 2022). Instead, it is indicative that the majority of policy documents are fees or bans on the manufacture, import, selling, and use stages of specific and often narrowly defined product types, most often plastic bags, SUPs, and microbeads. Upstream measures not widely used in the policy landscape include postconsumer recycled content minimums, procurement policies, and virgin production caps. While previous analyses (Karasik et al. 2020, 2022) of the inventory did not include the export stage, initial review shows that policies are starting to target export of plastics (Box 1).

Concentrations and Gaps in Policy Approaches

Within the many policy documents assessed, a wide diversity of instruments can be applied to many plastic types and life cycle stages in a given context. However, certain instruments, plastic types, and life cycle stages are included in national policies at much higher frequencies than others. Tables 1 and 2 demonstrate which combinations of instruments and plastic types or life cycle stages are most frequently targeted and which are not. Bans or prohibitions on bags and macroplastics at the production, import, and consumption stages are most commonly used, followed by plans or commitments for future action, research and data collection, and

Figure 5. National policy documents targeting each life cycle stage



Box 1. Policies Targeting Export of Plastics

A small but growing number of national policy documents include instruments and provisions intended to target the export of plastic. Some, such as Australia's 2021 Recycling and Waste Reduction (Export–Waste Plastic) Rules, prohibit the export of plastic waste without a waste plastic export license and requires exporters to provide the minister an export declaration for exported plastic waste (Ley 2021). Others, such as New Zealand's Imports and Exports (Restrictions) Prohibition Order, are existing export prohibition laws that have been updated to ensure plastic waste now classified as hazardous waste under the Basel Convention is prohibited from export (Elias 2021). Samoa's Waste (Plastic Bag) Regulation of 2018 prohibits the import, manufacture, and export of plastic bags and straws (Crawley 2018).

rules to guide responsible handling of plastic waste for macroplastic across the whole life cycle. Microplastics are least commonly addressed. Policy instruments not often used include postleakage capture, subsidies, and tax breaks. Policies most infrequently target reuse, followed by recycling.

RESULTS—EFFECTIVENESS REVIEW

Descriptive Data Update

Taking the literature from 2000–2020 assessed by Diana et al. (2022), an additional 52 publications from that time frame were added and reviewed, resulting in a library with 117 publications that include data on effectiveness of plastics policies. Data extracted from publications in this library included quantitative and qualitative outcomes of policy, as well as unintended consequences, enabling conditions, and recommendations. Effectiveness data were extracted for 103 specific policy documents in the inventory. Effectiveness data were also extracted from effectiveness literature even for policy documents that are not in the inventory and the research team was not able to find. The following sections summarize the qualitative data and quantitative data assessed separately. For the former, policy effectiveness and unintended consequences were summarized across policy types. For the latter, metrics used to measure policy effectiveness were characterized, with 193 individual points of quantitative data on policy effectiveness extracted from 73 studies. Some of the studies found were primary sources of data, while others were secondary. Secondary data sources were reviewed for duplicates and removed to avoid double counting. In addition, summaries based on quantitative and qualitative data were written for policies with extended producer responsibility (EPR) and solid waste management provisions. Social outcomes of policy, namely policy perception, were also summarized. Lastly, summaries of known policy effectiveness for national and subnational policies in China and Indonesia were written, as multiple policies from both countries have been assessed and published within the effectiveness library.

The number of studies published with some measure of the effectiveness of plastics policies has grown in recent years, following the trend in national policies (Figure 6), though with a significant lag time on average (Karasik et al. 2020). Most of these studies have focused on plastic bag policies, though a small number have focused on other policy types in recent years (e.g., information instruments or EPR schemes).

Table 1. Number of national policy documents coding various combinations of plastic types and policy instruments in national policies

Policy Instrument Category	Policy Instrument Type	Bags	Tires	Marine Sources	Macroplastics	Microplastics	All
Regulatory—Affirmative	Develop new, or improve existing process or product	15	0	11	48	1	8
	Plan, commitment	15	2	23	63	12	21
	Post-leakage plastic capture	0	0	5	2	0	0
	Responsible handling of plastic	14	1	3	40	1	1
Regulatory—Prohibitive	Ban plastic	63	0	1	70	6	1
	Irresponsible handling of plastic	6	0	15	18	2	0
	Limit plastic	6	0	0	17	0	1
Economic—Disincentive	Disincentive (fee, tax, levy, duty)	31	0	2	20	0	3
Economic—Incentive	Cash for return	3	0	0	19	0	1
	Subsidy	0	0	1	6	0	0
	Tax break	2	0	0	3	0	1
Information	Education or outreach	13	0	9	25	1	6
	Labels or placards	23	0	3	21	0	1
	Research, data collection, data reporting or record-keeping	12	0	15	45	4	5

Note: Colors generated by Nvivo as a heat map. Colors correspond to the following number of documents:
0 = dark orange
1-10 = light orange
11-20 = yellow
21-30 = green
31-40 = light teal
40+ = dark teal

Table 2. Number of national policy documents coding various combinations of life cycle stages and policy instruments in national policies

Policy Instrument Category	Policy Instrument Type	All	Production	Import	Selling	Use	Disposal	Collection	Recycling	Reuse
Regulatory—Affirmative	Develop new, or improve existing process or product	15	24	13	22	17	14	22	26	10
	Plan, commitment	43	21	10	11	25	29	30	42	22
	Post-leakage plastic capture	1	1	0	0	0	2	4	2	2
	Responsible handling of plastic	1	16	12	13	9	23	21	25	7
Regulatory—Prohibitive	Ban plastic	6	77	72	88	50	5	1	5	2
	Irresponsible handling of plastic	1	5	4	6	5	31	3	4	2
	Limit plastic	1	9	17	7	7	2	2	2	2
Economic—Disincentive	Disincentive (fee, tax, levy, duty)	6	11	15	26	10	5	3	1	0
Economic—Incentive	Cash for return	1	8	4	9	4	6	13	10	4
	Subsidy	1	1	2	2	1	3	3	4	2
	Tax break	2	1	2	1	1	1	0	0	0
Information	Education or outreach	23	5	4	6	10	9	9	11	8
	Labels or placards	4	20	9	16	6	5	3	7	4
	Research, data collection, data reporting or record keeping	23	18	14	16	12	20	16	22	8

Note: Colors generated by Nvivo as a heat map. Colors correspond to the following number of documents:
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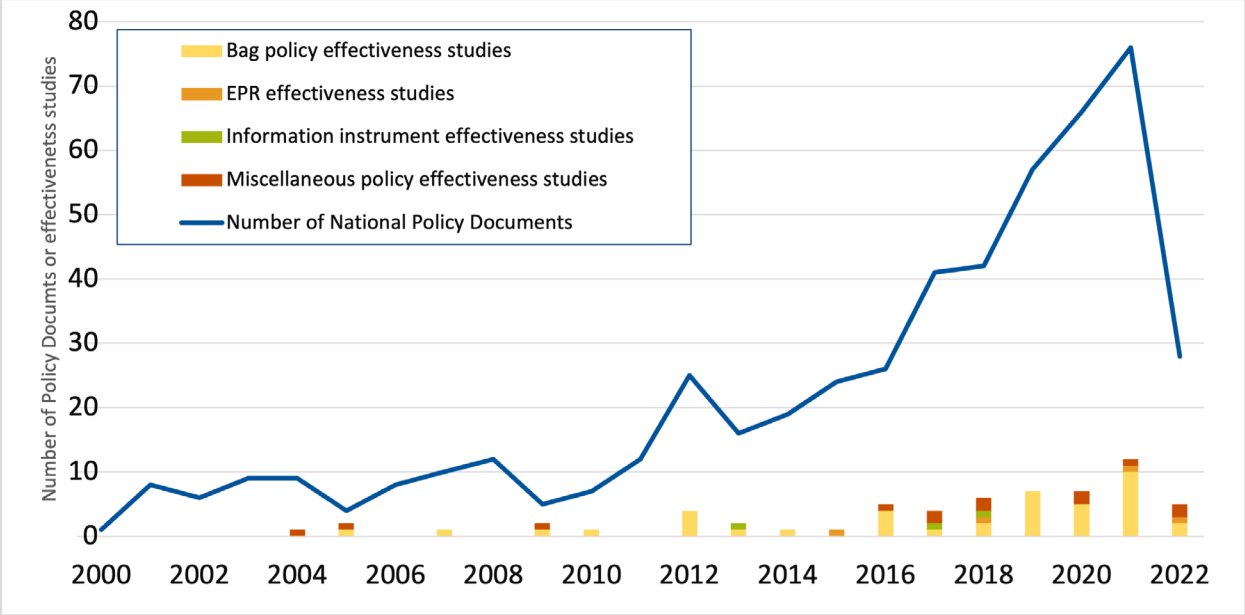
Figure 6. Trends in national policies in the inventory compared to effectiveness studies



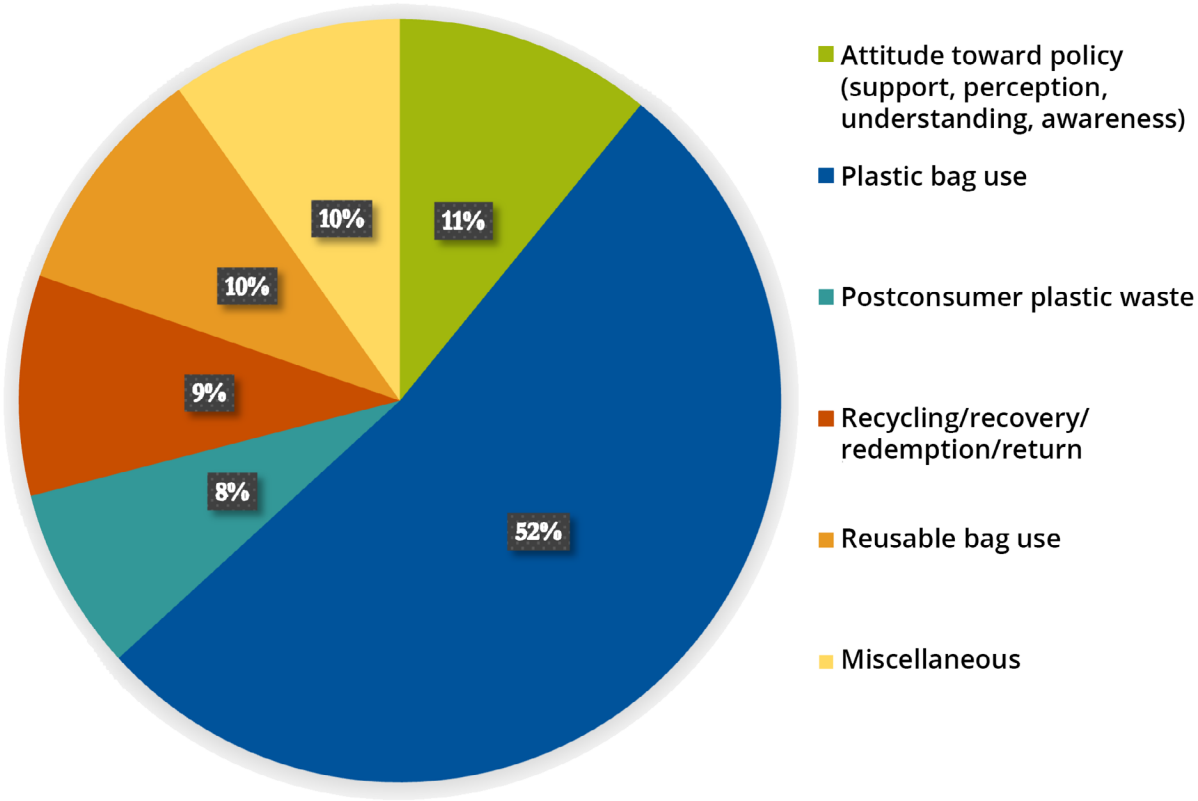
Types of Plastics Policy Effectiveness Data Found

There are several metrics used to measure policy effectiveness found in the literature. From the 193 individual effectiveness data measures in the literature reviewed, more than half report on change in plastic bag use metrics (Figure 7). Additional metrics include attitude toward the policy, postconsumer plastic waste, recycling and recovery rates, and reusable bag use. The attitude metrics include support, perception, understanding, or overall awareness of the policy instrument. The plastic bag use metric category includes frequency or volume of bag use (e.g., while shopping in stores and overall household consumption). The postconsumer plastic waste metric category includes litter (e.g., plastic bags in stormwater drains) and overall plastic waste production (e.g., amount of plastic discarded in landfills). The recycling metric category includes recycling, recovery, redemption, or return (e.g., rates or volumes) of recyclable materials. The reusable bag use metric category includes reusable bag use (frequency or volume). Other metrics that do not fit into any of these categories and are infrequently cited in the effectiveness literature were placed in a miscellaneous category. Metrics in this category include the number of plastic bottles avoided, income generated by plastic bag fees, and plastic disposable tableware use. These metrics may be underused in current assessments of policy effectiveness and can be challenging to characterize.

Update on the Effectiveness of Plastic Bag Bans

The following figures represent the percent change in plastic bag use measured in effectiveness studies on national or subnational plastic bag policies (e.g., bans, fees, or a combination). In Figure 8, the values appear as reported by the study and policy instrument. Generally, all percentage changes are negative, indicating a decrease in plastic bag use. However, a study of the Government of Romania's national bag policy, in which an increase in plastic bags of 122% was verified between 2009 and 2010 (27 million bags to 60 million bags) (Martinho et al. 2017),

Figure 7. Types of plastics policy effectiveness data measured



was considered an outlier and removed. In Figure 9, plastic bag use changes are annualized to compare the effects of a policy in a controlled time frame. This dataset represents the results of a subset of evaluated policies, as most studies in the sample did not include sufficient information about the evaluation period to enable the annualization of every reported value. As observed, there is high variability in the reported values, though all experience a decrease in plastic bag use rates. Even in the same country, different methodologies from multiple effectiveness studies have led to varied findings regarding the change in plastic bag use. For instance, the measured effect of a tax on plastic use in England varies from –21% to –96%. Although variability is high, results on the effect of fees on plastic bag use might indicate the most consistent reduction rates among the policy instruments.

Additional Types of Plastics Policies with Effectiveness Studies

EPR

Several recent effectiveness studies have evaluated the performance of EPR schemes for plastic bottles and packaging. Data from an EPR policy in British Columbia, Canada, for example, demonstrated that the annual recovery volume and rate for packaging increased significantly from 2014 to 2018 after the policy was implemented in 2011, from 116,457 to 183,983 tonnes (52% to 80%), respectively, and remained high. The authors also compared municipal data on recovery volume and rate to packaging pollution counted during beach cleanups from Surfrider Vancouver and The Great Canadian Shore Clean Up during the same time. Using this method, which relied

Figure 8. Percent change in plastic bag use after policy introduction

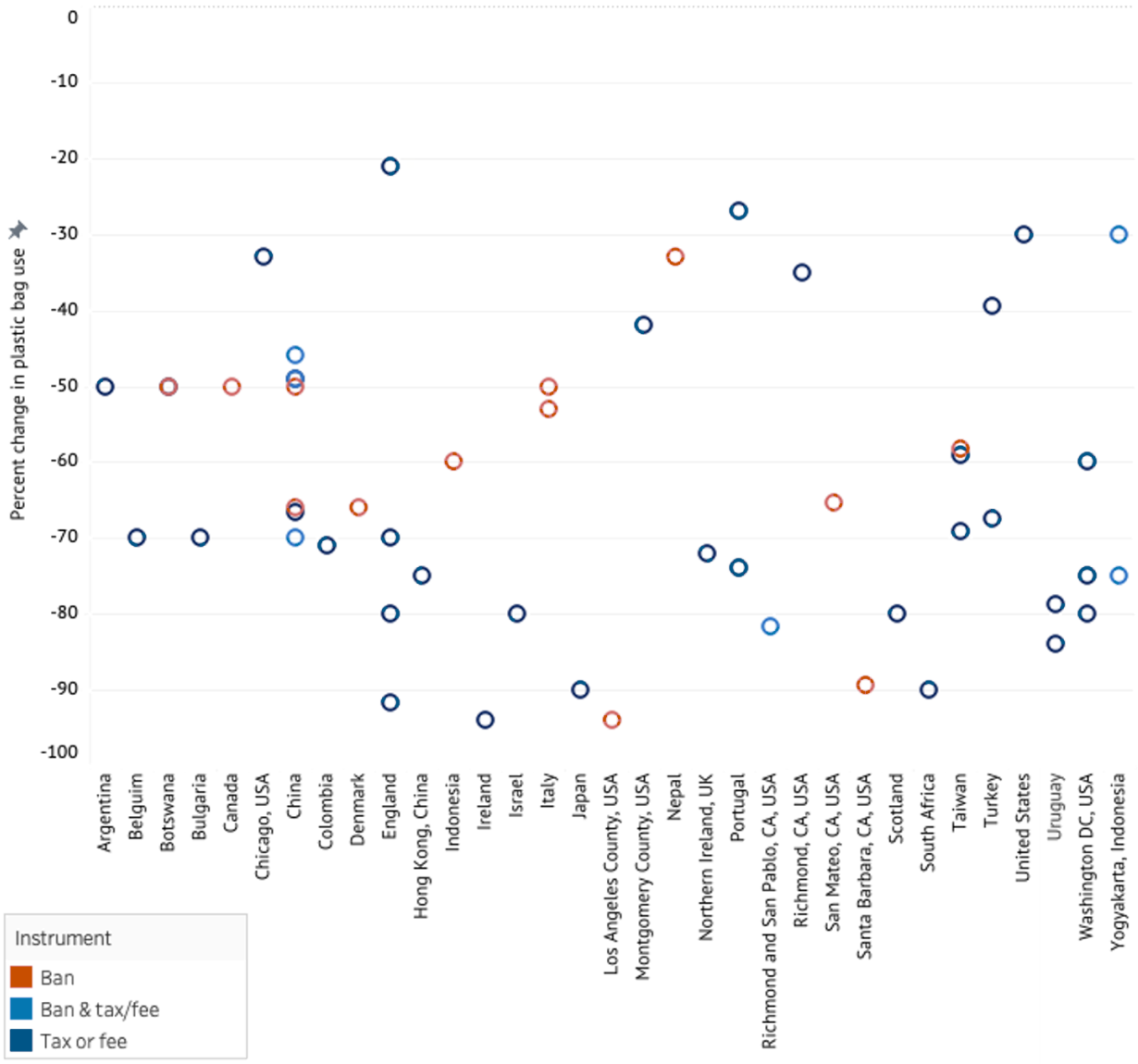
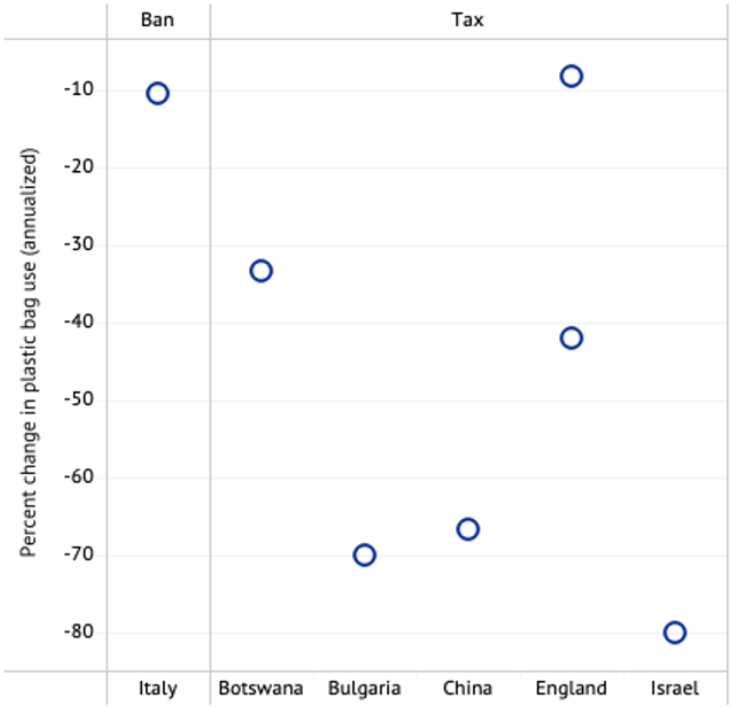


Figure 9. Annualized percent change in plastic bag use after policy introduction



on citizen science data, the researchers found that the quantity of packaging pollution did not decrease over time. The researchers suggest that an increase in material recovery may not be an indicator of a change in pollution levels and raise questions about EPR's effectiveness in reducing plastic pollution in the environment (Harris et al. 2021).

In the Netherlands, Calisto Friant et al. (2022) found that the overall recycling rate of 57% achieved in 2019, attributed to the government's EPR policies for packaging, surpassed the policy goal of 49%. However, the researchers noted that plastic waste exports are not incorporated in recovery and recycling rate estimates, so the actual recycling figure may be lower. The authors also noted that the recycling rates differ across municipalities because of the design of the EPR program. In the implementation of this policy, each municipality was allocated a proportion of the funding collected through the EPR. This allocation is based on the volume of collected waste and each municipality coordinates its solid waste management system differently. One drawback of such a system is that municipalities with lower or poorer waste separation practices subsequently receive less money to cover improved waste management costs. Therefore, the burden of covering costs required to meet recycling targets may fall disproportionately on local ratepayers in municipalities with relatively less efficient waste collection (Calisto Friant et al. 2022).

Taiwan's EPR scheme, coupled with its solid waste management program, led to a resource recovery rate of 55.23%. This rate includes papers, cans, plastics, kitchen waste, and bulk waste and does not clarify the composition of plastic (Wu 2022).

Finally, an industry-led EPR policy in South Africa reported an increase in polyethylene terephthalate recycling from 2% to 55% from 2000 to 2020 and the creation of 52,600 jobs (Deme et al. 2022).

Solid Waste Management and Recycling, Including Incineration Tax

Several studies aimed to measure the effects of solid waste management efforts to control plastic. De Weerdt et al. (2022) examined the effect of a Flemish incineration tax on industrial plastic waste. The study tested the effect of an increase in the tax rate (7 euros per ton in 2007 and a 50% rate increase after the second quarter in 2015), finding a negative and significant effect on waste generation, meaning that an increase in the tax rate was credited with incentivizing reductions in volume of plastic waste generated by industry. The study concludes that "an incineration tax is only effective in minimizing industrial plastic waste generation if the tax rate increases. In other words, our empirical findings indicate that a decreasing incineration tax rate does not affect industrial plastic waste generation" (De Weerdt et al. 2022).

Other solid waste management policies or action plans with effectiveness studies seek to increase recycling rates. In measures of the effectiveness of Taiwan's efforts to increase recycling, Taiwan's Environmental Protection Agency found increased rates of recycling that were largely unaffected by the COVID-19 pandemic (Tsai 2022). Similarly, Chen et al. (2021) reported that recycling rates (47%) in Kuala Lumpur, Putrajaya, and Selangor exceeded the goals set for 2020 in the Government of Malaysia's Eleventh Plan and ratifying Act 672. The study also notes that only 6 of 13 states and 2 of 3 federal territories have ratified relevant policies required to increase recycling rates.

Support for and Perception of Plastics Policies

Several effectiveness studies measured social outcomes associated with plastics policies, notably public support for or perception of specific implemented plastics policies. Consistent with the overall trend of effectiveness studies, this subset looks primarily at bag policies. Several studies showed high levels of support for plastic bag bans and plastic bag taxes: 8.2/10 mean support for a plastic bag ban in South Australia (Sharp et al. 2010), 95% agreement with a plastic bag ban in Chile (Abril Ortiz et al. 2020), 91.27% of survey respondents with higher secondary education supporting a plastic bag ban in Pakistan (Jehangir et al. 2022), and 70% of survey respondents agreeing with the introduction of a plastic bag tax in Wales (Frater and Lee 2020). To a lesser extent, other studies evaluated the public perception of implemented policy instruments. For example, one study surveyed individuals on the perceived effects of a bag fee implemented in Portugal (Luís et al. 2020), where a majority of survey participants "agreed" and "totally agreed" that the fee "encouraged people to reuse bags for shopping" and "increased state revenues." Conversely, another study evaluated the Mauritian population's perceived success or failure of a bag ban (Foolmaun et al. 2021), finding that only 23% of questionnaire respondents believed the bag ban was successful while 65% of respondents believed the ban failed to prohibit the usage of plastic bags. For those that indicated the ban was a failure, many believed the failure was due to a lack of enforcement (Foolmaun et al. 2021). Public support and awareness of policies is an important indicator of policy effectiveness that should not be overlooked, as many plastics policies affect individual consumption behavior, and buy-in for plastics policies can encourage governments to act ambitiously toward achieving plastic reduction goals.

Country-Level Reviews of Effectiveness

Indonesia Subnational Policy Reviews

Our effectiveness review included evaluations for six Indonesian local governments that have adopted policies to tackle plastic bags.

Despite efforts to implement policies to tackle plastic pollution in several cities, outcomes have been mixed. For instance, plastic bag bans have led to a reduction of between 40% and 80% in plastic bag usage in Jakarta, and in Balikpapan, these policies have reduced the waste produced from 40 to 2 tons per day (Tarigan 2021). The impact has been similar in Bogor, where the plastic bag ban policy has led to a 62.5% reduction in plastic bag usage (Nurulhaq 2019). In Banjarmasin, a ban measure has been estimated to prevent the monthly use of 52 million plastic bags (Garcia et al. 2019). Padang, on the other hand, imposed a fee on bags, but according to Yorenza and Yusran (2020), may have failed to achieve its intended purpose because the bag's price was relatively low. Semarang faced a similar outcome, as one study concluded that the bag fee was insufficient to motivate consumers to change their behavior (Muslihun et al. 2020). Additionally, lack of public awareness has resulted in ineffective policies. For example, people who shop in traditional Semarang markets are unaware of the fee policy and do not participate in it (Muslihun et al. 2020). In Bogor, some consumers are unaware that the funds generated from selling plastic bags are used for corporate social responsibility activities (Nurulhaq 2019).

According to the effectiveness studies, the success of these policies depends on the enforcement mechanisms and the specific type of policy implemented. For instance, the presidential regulation on marine plastic debris lacks clarity on law enforcement officials, mechanisms, and sanctions for polluters. Fee mechanisms intended to disincentive plastic bag use have also proved ineffective in some cities, resulting from limited knowledge of the mechanism or too small fees to encourage behavior change.

China's National Policy Reviews

Three different types of national policies in China have been evaluated for their effectiveness. One study evaluating the impact of a plastic carrier bag fee found a reduction of nearly 44% in plastic bag usage, which is consistent with other studies (Wang and Li 2021). However, the fee only applied to certain types of plastic bags, which affected the overall policy's effectiveness. For instance, supermarkets offering expensive biodegradable plastic carrier bags had almost 40 times higher usage of free inner plastic bags, which are often used for packaging produce, than those offering cheap nonbiodegradable plastic carrier bags (i.e., the cost of the biodegradable bag caused consumers to increase their use of free inner bags) (Wang and Li 2021). Also, the average usage of plastic carrier bags was lower (26.8%) than that of free inner plastic bags (81.8%), indicating excessive usage of free inner plastic bags. As a result, the pricing policy had a boomerang effect as it increased the usage of free inner plastic packaging bags, offsetting the decrease in plastic carrier bag usage. Finally, the assessment revealed that more than 90% of consumers do not reuse old plastic bags, with an average reuse rate ranging from 2.5% to 9.3% (Wang and Li 2021).

In 2021, China implemented stricter regulations to combat the use of plastic carrier bags by instituting a ban and superseding the fee. A study on this new ban showed reduced charged carrier bag usage by 46% and increased the usage of old plastic and reusable bags by 117%

and 36%, respectively (Wang et al. 2021). Despite this progress, the issue of inner plastic bags remained problematic. Although the usage of inner bags decreased by over 50% in grocery markets, there was a 2.7% increase in non-grocery markets (Wang et al. 2021). To address this issue, the assessment recommended that incentives be provided to businesses or consumers to encourage compliance with policies and to improve product packaging. Demand for free inner bags is elastic, meaning people naturally reduce their usage if products are packaged differently. The research concluded that stricter measures do not always determine people's usage of bag type.

Lastly, China's plastic waste import ban resulted in a 23.2% increase in plastic waste landfilled in the US (Vedantam et al. 2022). Kumamaru et al. (2021) found that China's plastic waste import ban led to a decrease in the price of plastic waste in Japan (43,000 to 19,702 yen/ton), and an increase in the price of plastic waste in China (from 43,000 to 208,959 yen/ton). These findings suggest a surplus for plastic waste buyers in Japan who are now able to purchase more plastic waste.

Unintended Consequences and Risks Cited in the Literature Reviewed

In some cases reviewed, introducing bag policies has produced unintended consequences. These included an increase in the use of bag alternatives that may harm or reduce the policy's net benefit or socioeconomic negative impacts to certain communities affected by the policy.

One of the most commonly cited unintended consequences of bag policies was an increase in alternative bag purchase and use, potentially counteracting the policy's goal. In 71 local government ordinances in the US, researchers have found a significant increase in paper bag consumption. This effect decreases where inexpensive reusable bags are available (Wagner 2017). In China, introducing a plastic bag tax led supermarkets to provide biodegradable plastic carrier bags, which were not taxed. The use of this type of bag was almost 40 times as high as that of supermarkets providing only nonbiodegradable plastic carrier bags, even though the cost of biodegradable bags for supermarkets is higher. As a result, rather than decreasing, the overall usage of plastic bags increased (Wang and Li 2021). In Portugal and Richmond, CA, a tax on plastic bags led consumers to buy garbage bags (Luís et al. 2020; Taylor and Villas-Boas 2019), with an increase in the consumption of garbage bags of almost 12% in Portugal (Martinho et al. 2017) and up to 129% in California (Huang et al. 2022). This is consistent with findings in Australia, where the reductions achieved by the plastic bag ban were primarily offset by increases in the consumption of other bags, and the net effect of the ban on plastic consumption over the period was relatively low (Macintosh et al. 2020).

Some studies found that people started using bags not regulated by the policy (Taylor and Villas-Boas 2016). In a bag policy in Chicago, for example, people began using slightly thicker bags not covered by the plastic ban (Homonoff et al. 2022). This unintended consequence can be attributed, in part, to political or capacity challenges related to effectively including multiple types of plastics or plastic thicknesses in policies (Wagner 2017). There is also evidence of consumers stocking up on or demanding free bags in anticipation of the implementation of bag policies (Cabrera et al. 2021).

Other unintended consequences disproportionately affect specific sectors, which can exacerbate inequalities, job losses, protests, and illegal trade. In Rwanda, Kenya, and Uganda, plastic bag bans were reported to have detrimentally affected manufacturers and exacerbated inequalities for informal sector workers and rural farmers who use plastic bags to transport goods cheaply (Behuria 2021). In some cases, such as in Antigua and Barbuda, an illegal market to trade plastic emerged (Clayton et al. 2021; El Mekaoui et al. 2021; Da Costa et al. 2020). Where a black market for bags exists, vendors participating in informal markets experience pressure to procure plastic bags to maintain their client base, which takes a toll on their revenue and leaves them open to persecution and heavy fines by authorities. For informal sector workers and rural farmers, a ban on plastic bags is also a threat to already narrow profit margins, as people in these professions often use these bags as a cheap means of transportation for goods (Zulganef et al. 2019). In another example of unintended consequences, in Indonesia, people started buying plastic bags to protest against government regulations (Zulganef et al. 2019).

The ban on plastic bags in New York and Portugal has been correlated with increased contamination and decreased waste separation in waste streams (Meert et al. 2021; Luís et al. 2020). These outcomes may increase waste management costs for municipalities. Other economic unintended consequences were assessed. In Ireland, for example, a study found a loss of 26 jobs in one plastic manufacturing firm that went out of business, potentially as a result of the ban (Convery et al. 2007), and in China, the ban on ultrathin bags caused some wholesalers to close down. For instance, Suiping Huaqiang Plastic in China, which had employed 20,000 people and produced 250,000 tons of bags annually, closed after the policy's introduction (O'Loughlin 2010).

DISCUSSION

State of Plastics Policy Landscape: Continuation of Long-Term Trend

The 2022 update to the Plastics Policy Inventory provides evidence that the long-term trend of growth in the number of government responses to plastic pollution continues. Upward revisions to the data from 2020 and 2021 suggest that the "pandemic pause" hypothesized in 2022 (Karasik et al. 2022) did not materialize, and governments continue to introduce policies to address plastic (with more than 70 national policies introduced in 2021). In recent years, the scope of national policies has perhaps broadened to more frequently include additional kinds of SUPs rather than just plastic bags. Similar gaps documented in previous policy assessment remain as well, as microplastics and marine sources remain relatively unaddressed by these policies and economic instruments remain a minority of tools used.

A More Comprehensive Assessment of Policy Effects

Diana et al. (2022) found a relatively small number of studies on the effectiveness of plastics policies through 2020. Since then, the number of studies has increased, though still primarily focused on policies targeting plastic bags. Research increasingly considers more policy impact dimensions (social, economic, ecological) and identifies unintended consequences, but rarely uses causal inference methods to attribute effects to policies. While still a relatively nascent field of research dominated by plastic bag policies, more and more indicators can be identified (potentially

supporting global monitoring). However, models of global plastic flows and leakage are likely to depend upon significant assumptions to estimate the effects of current and future policies.

Policy Recommendations Emerging from the Literature on Policy Effectiveness

In terms of policies targeting plastic bags, many studies recommended the increased use of economic instruments—for example, raising taxes, fees, or levies on bags (Zulganef et al. 2019; O'Brien and Thondhlana et al. 2019; He 2012; Dang et al. 2021; Sobaya et al. 2018). Additionally, some scholars recommended introducing higher environmental protection taxes specifically for plastic items that are nondegradable (Dang et al. 2021) or steadily increasing tax rates on incineration (De Weerdt et al. 2022) to discourage the generation of nonrecyclable waste and promote recycling. Other recommendations included increasing the scope of types of bags that are banned or subject to a fee, including paper bags, thicker bags, or biodegradable bags (Taylor and Villas-Boas 2016). In other instances, phasing in and subsidizing biodegradable bags was offered as a recommendation (Orset et al. 2017; Foolmaun et al. 2021).

Across recommendations for different material types, including alternatives, authors suggested the coupled use of information instruments, including disclosure mechanisms and labels, to allow consumers to more easily distinguish and differentiate between product types and assess their relative costs and benefits (Macintosh et al. 2020; Orset et al. 2017). To enhance monitoring and increase compliance, Foolmaun et al. (2021) suggest enforcement agencies conduct surprise checks in manufacturing industries, businesses, and customs to further suppress plastic bag production and consumption.

A commonly mentioned category of policy recommendation is better and more regular monitoring and data collection. These include plastic bag standards that include all potential chemical additives used in and emitted during production (Macintosh et al. 2020); recycling processes, trends, and rates; microplastic concentrations in the natural environment; and volumes of plastic waste imported and exported (Dang et al. 2020; Xanthos and Walker 2017). Likewise, a significant portion of recommendations regarding implementing and enforcing plastics policies focuses on how they are communicated to the public. The literature emphasizes that consumers and businesses must be informed about policy changes and how they may affect them (Nurulhaq 2019; Meert et al. 2021; Omondi and Asari 2021). Higher awareness among the public about the necessity of reducing their plastic consumption may also have further positive trickle-down effects, including increasing interest in recycling at home and participating in cleanup activities (Genon et al. 2022).

METHODS

Policy Document Collection

Global Environmental Policy Database Search

The 2022 update was completed using slightly adapted methods to those outlined by Karasik et al. (2020) and Diana et al. (2022). While the researchers previously relied on ECOLEX and Informea as the principal legal databases for review, this year and likely moving forward the team will rely on FAOLEX and the Global Regulations database.

Using FAOLEX, the researcher input each search term outlined in Box 2.

Box 2. Search terms used in FAOLEX

Search terms are separated by a dash (-). Each term was input into FAOLEX one at a time.

Plastic - Marine Debris - Marine Litter - Microplastic - Microfiber - Nurdle* - Nylon - Tyre/ Tire – Cigarette Waste - Shopping Bag - Styrofoam - Synthetic Disposable - Polyethylene - Polymethyl methacrylate - Polypropylene - Polystyrene - Polyvinyl chloride - Beach clean-up - Coast* clean-up - River clean-up

To avoid duplicating past research efforts by Karasik et al. (2020), the researcher limited the search to policies passed or amended in 2021 and 2022. The results (i.e., public policy documents) of these searches were quickly screened (e.g., title, summary, search for key terms) for inclusion and combined into one list (stored in an Excel spreadsheet). If the title or short description provided by the online source (e.g., FAOLEX) clearly indicated that the document was not relevant (e.g., a policy for sterilizing plastic gloves for surgery) and lacked key search terms, it was not added to the database. Policies not written in English were similarly screened; keywords were translated into the language of the policy document using Google Translate and then searched for in the document. Once found, the paragraph in which the keywords appeared were translated using Google Translate and reviewed. If those translated paragraphs provided clarity that the policy document intended to address plastic pollution, they were retained for inclusion, though they could not be qualitatively analyzed using NVivo.

Duplicate policy documents were not added to the database. Instead, each of the remaining documents received a unique identification number and was retained in the internal database.

As a first targeted step to help correct the English language bias of the inventory, search terms in Box 2 were translated into French and searched in FAOLEX (Box 3). The search terms were translated from English into French by a French speaking research assistant familiar with the inventory. The online French-English dictionary Linguee was used to verify the accuracy of translated terms, as this resource offers examples of uses of said terms. Policy documents from EUR-Lex were also consulted to confirm that translated terms were used in relevant official directives in French. Translated terms were input into FAOLEX from the years 2000–2022. The terms used are considered the most accurate translation found for the terms used in English. Words that remain the same translated into French have been omitted, as searches would not yield anything new.

Nurdle was not included in this list as a French equivalent does not seem to exist. *Nylon* remains the same translated into French, so was also not included. *Microplastiques* and *Micro-plastiques*, as well as *Microfibres* and *Micro-fibres* are interchangeable spellings of terms both used in policy documents. Both versions were input into FAOLEX. Each new policy document found was given a unique identification number and retained in the internal database.

Box 3. French search terms

- Plastique (English: Plastic)
- Débris marins (English: Marine debris)
- Déchets marins (English: Marine litter)
- Microplastiques/Micro-plastiques (English: Microplastic)
- Microfibres/Micro-fibres (English: Microfiber)
- Pneumatiques (English: Tyre/tire)
- Déchets de cigarette (English: Cigarette waste)
- Sac à provisions (English: Shopping bag)
- Styromousse (English: Styrofoam)
- Synthétiques jetables (English: Synthetic disposable)
- Polyéthylène (English: Polyethylene)
- Polyméthacrylate de méthyle (English: Polymethyl methacrylate)
- Polypropylène (English: Polypropylene)
- Polystyrène (English: Polystyrene)
- Chlorure de polyvinyle (English: Polyvinyl chloride)
- Nettoyage des plages (English: Beach clean-up)
- Nettoyage du littoral (English: Coast clean-up)
- Nettoyage des rivières (English: River clean-up)

Assessment of Trends in Plastics Policies

Every new policy document added that was written in English was qualitatively analyzed by one researcher using the qualitative data analysis software, NVivo, to identify and characterize each of the policy instruments within the policy document. Using a codebook (Table 3), each instrument was coded by which plastic type(s) it targeted, which stage(s) of the life cycle it targeted, and which policy instrument(s) it used. In all cases, more than one plastic type, stage of the life cycle, and instrument type could be coded for each individual policy instrument within a policy. For example, a ban and information campaign on manufacturing and importing plastic bags and expanded polystyrene containers would be identified for encompassing multiple dimensions. This step served as an additional screening step because policy documents could be considered outside of the scope of this analysis upon further review (e.g., they were too broad).

Total Policies in Inventory

A total of 894 public policies introduced since January 2000 have been identified and included in the inventory (as compared to 291 reported by Karasik et al. 2020 and 571 by Karasik et al. 2023), of which 514 are national government laws or regulations (Table 4). Of these 894 policy

Table 3. Policy design elements included in the analysis

Dimension	Code	Subcode (If Any)
Type of instrument	Regulatory—affirmative	Develop new, or improve existing process or product
		Plan/commitment
		Postleakage plastic capture
		Responsible handling of plastic
	Regulatory—prohibitive	Ban plastic
		Irresponsible handling of plastic
		Limit plastic
	Economic	Disincentive (fee, tax, levy, duty)
		Incentive: Cash for return
		Incentive: Subsidy
		Incentive: Tax break
	Information	Education or outreach
		Label or placards
		Research, data collection, data reporting or record-keeping
Type of plastic pollutants targeted	Macroplastics from land-based activities, excluding plastic bags	
	Plastic bags	
	Microplastics from land-based activities, excluding tire abrasion	
	Microplastics from tire abrasion	
	Plastic pollutants from maritime activities	
	All* plastic pollution	
Stage of the life cycle of the plastic targeted	Production	
	Import	
	Selling	
	Use	
	Disposal	
	Collection	
	Recycling	
	Reuse	
	All*	

* Note: All refers to broad and unspecified references to plastic, rather than comprehensive and targeted approaches for plastic (e.g., "conduct an outreach program about plastic").

Table 4. Policy document totals

Jusrisdictional Level	Included in Trend Analysis	Not Included in Analysis	Total
International	35	1	36
Regional	60	0	60
National	272	242	514
Subnational	206	78	284
Totals	573	321	894

documents, 573 have been analyzed using NVivo, and 272 national policy documents (Figures 10 and 11) are included here in the summary of trends. The remaining 321 policy documents have not yet been translated into English for qualitative analysis.

Effectiveness Literature Review

Literature Review

The methodology for the effectiveness assessment repeated the methods used for the effectiveness reviews from Diana et al. (2022) and Karasik et al. (2020). In the former publications, three search strings (Box 4) were developed and input into Web of Science, Google Scholar, and Hein Online (legal literature) search engines. The search engines were filtered from January 2019 to June 2022. The abstract and title of the results were subsequently screened for inclusion. A search string was considered exhausted when either all title and abstracts were reviewed if the search string yielded under 200 results, when 100 results in a row were not relevant, or when 10% of the results (or in the case of Google Scholar, 1000 results) were reviewed.

Researchers compiled a library of published literature about plastics policies only from August 1, 2019, to June 2022. The reviewer attempted to determine if each of the published studies fell into one of the following four categories:

- **Effectiveness studies (original/primary data).** Added if the study reported data from other studies on the effectiveness of the policies.
- **Effectiveness reviews and meta-analyses.** Added if the study evaluated a policy outcome directly.
- **Policy recommendations and enabling conditions.** Added if the study included information or evaluated the conditions that lead to effectiveness data and what the researchers recommend.
- **Not relevant.**

Figure 10. All national policies in inventory

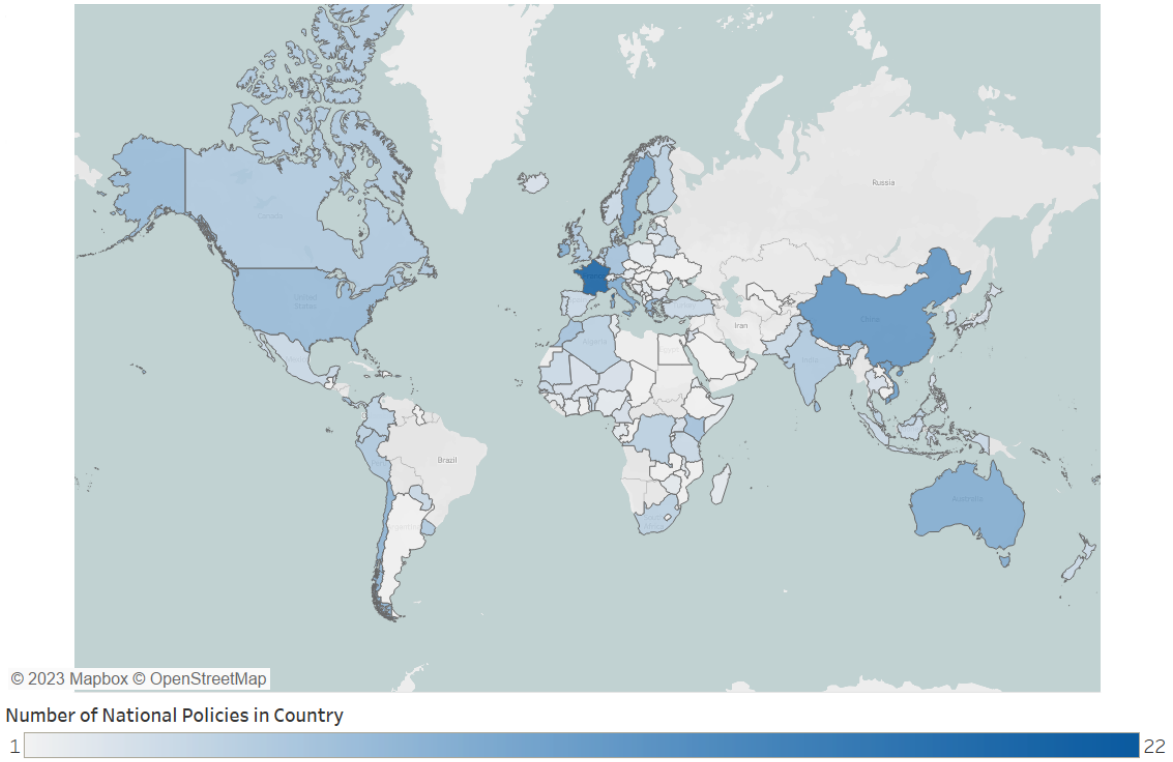
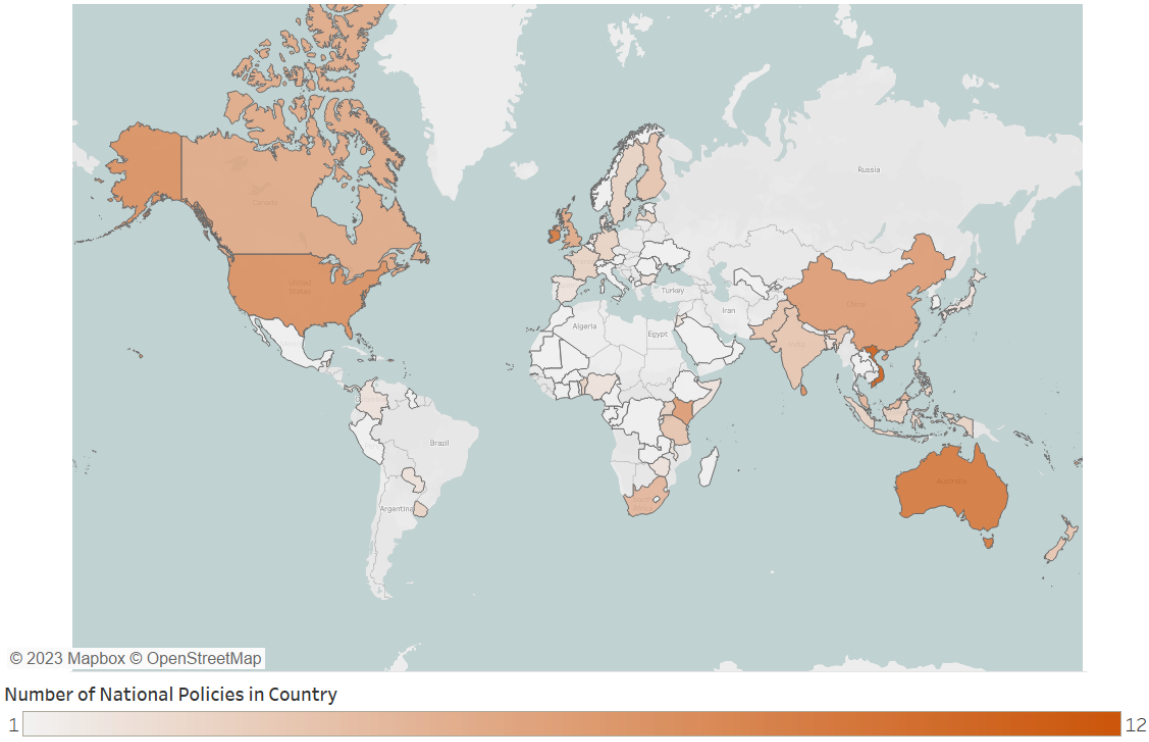


Figure 11. National policies included in analysis



Box 4. Search strings

1. ("Marine debris" OR "Marine litter" OR Microplastic OR Microfiber OR Plastic NOT Surge* NOT elast*) AND (Policy OR Govern* OR Institution OR Law OR Regulat* OR Legal OR Intervention OR Infrastructure OR Coastal city OR Mega-city OR Municip* OR Subsidy OR subsidize OR Subsidies OR Ban OR bans OR banned OR Tax OR taxes OR taxed OR Fee OR Fees)

2. (Nylon OR "Shopping bag" OR Styrofoam OR "Synthetic disposable" OR "Tire" OR "Tyre" OR "Cigarette waste" OR "Beach clean-up" OR "Coast* clean-up" OR "River clean-up") AND (Policy OR Govern* OR Institution OR Law OR Regulat* OR Legal OR Intervention OR Infrastructure OR Coastal city OR Mega-city OR Municip* OR Subsidy OR subsidize OR Subsidies OR Ban OR bans OR banned OR Tax OR taxes OR taxed OR Fee OR Fees)

3. (Polyethylene OR Polymethyl methacrylate OR Polypropylene OR Polystyrene OR Polyvinyl chloride OR Recyclate OR Polymer OR Bioplastic OR Oxodegradable) AND (Policy OR Govern* OR Institution OR Law OR Regulat* OR Legal OR Intervention OR Infrastructure OR Coastal city OR Mega-city OR Municip* OR Subsidy OR subsidize OR Subsidies OR Ban OR bans OR banned OR Tax OR taxes OR taxed OR Fee OR Fees)

Once classified, the team extracted data from all of the publications categorized as "effectiveness studies" or "effectiveness reviews and meta-analyses" and extracted and classified data according to the following categories:

- **Policy document.** Refers to the original name of the policy
- **Key words.** Terms such as SUP, bags, bottles, EPR, microplastics, and packaging
- **Quantitative outcomes observed.** (As reported in the study from which data was extracted)
- **Qualitative.** (As reported in the study from which data was extracted)
- **Unintended consequences.** Conclusions referring to policy outcomes not predicted by policymakers
- **Enabling conditions.** Conditions referring to contextual circumstances that allow the policy to have an effect
- **Recommendations.** Made by study authors to enhance or improve the policy landscape in the discussion or conclusion of the study.

After extracting data, the researchers looked to see if the policy documents mentioned in the effectiveness publications were in the inventory database. If not, the original policy documents were searched for using Google, the Global Regulations Database, and the Library of Congress' country page, which includes links to legislative databases and gazettes for each country. Similarly, the researchers looked at the countries or cities' government websites and local news, spending not more than 30 minutes trying to find a referenced policy document that was not in the Plastics Policy Inventory. Policy documents in languages other than English were screened using Google Translate. Finally, each policy document that was found was given a unique identification number and retained in the internal database.

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