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PLASTIC POLICIES IN CHINA

Country Profile

Acknowledgements

This Country Profile on plastic policies in China was prepared on behalf of the EU SWITCH-Asia Policy Support Component (PSC) by Dr Per-Olof Busch and Ms Maro Luisa Schulte under the supervision of Ms Cosima Stahr and Dr Zinaida Fadeeva, Team Leader, SWITCH-Asia Policy Support Component.

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Abbreviations

CZWA	China Zero Waste Alliance
EPR	Extended Producer Responsibility Scheme
FYP	Five-Year-Plan
MoEE	Ministry of Ecology and Environment
MSW	Municipal solid waste
NDRC	National Development and Reform Commission
NPC	National People's Congress
OECD	Organisation for Economic Cooperation and Development

1. Context

Estimates suggest that China generates over 55,697,000 tonnes of plastic waste annually, leading to nearly 39.4 kg per capita (Figure 1). This is almost 8 kg more more than the global average (31.9 kg) and almost twice the average countries that are covered by the SWITCH-Asia programme (20.1 kg) (EA 2024). Of the generated plastic waste, a total of 13,974,000 tonnes, or 25%, are mismanaged. Per capita, this is 9.9 kg, which is around 3 kg less than the global average of 12.5 kg per capita and the average of 12.2 kg per capita in countries where the SWITCH-Asia programme is active.

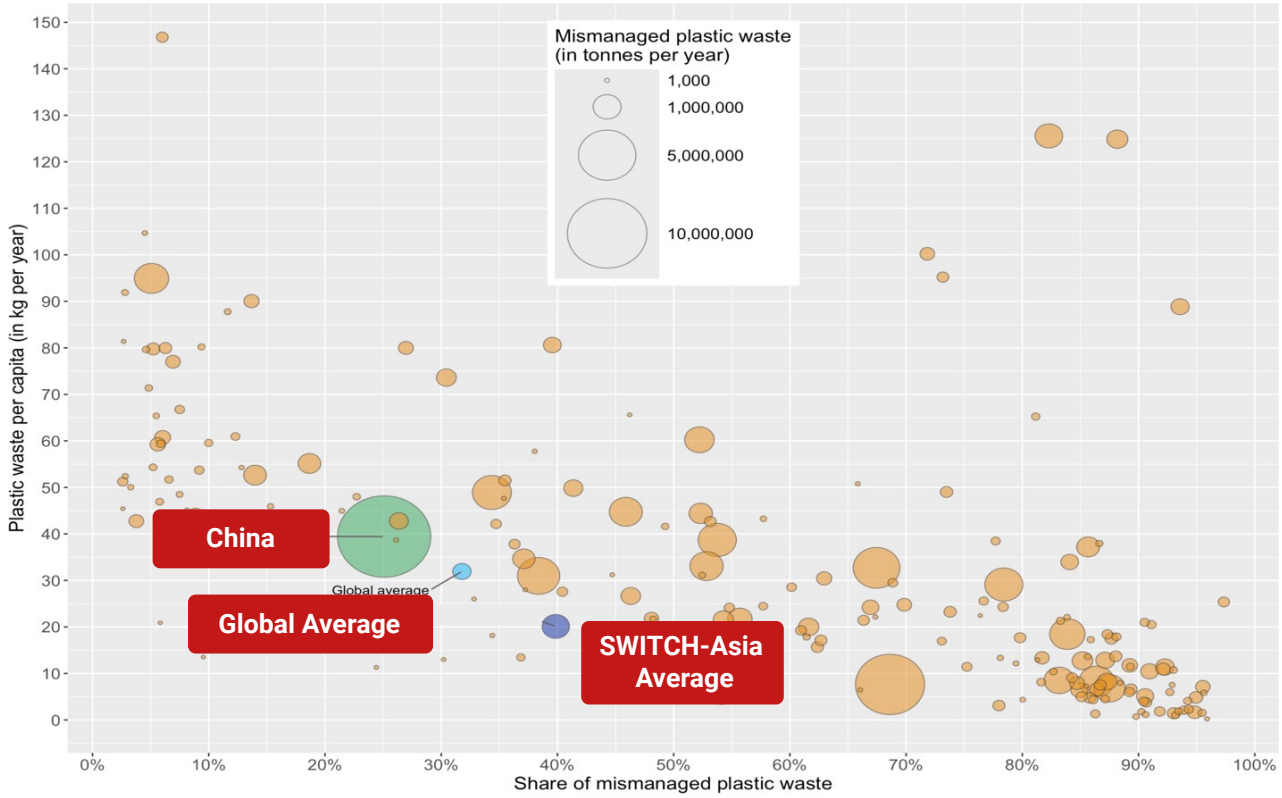

Figure 1. Plastic waste in China in 2023
Source: Earth Action 2024 data, authors' calculations

China's plastic industry is a cornerstone of the country's economic landscape, exhibiting remarkable growth and playing a pivotal role in various sectors. The expansion of China's plastic market was driven by several factors, including rapid urbanisation, increasing domestic consumption, and the growing demand for plastic products across various end-use industries. The packaging sector remains a significant consumer of plastics in China, along with other important end-use markets such as automotive, electronics, construction, and agriculture (OMR 2022).

Rank of China in global comparison (out of 192, 192 being the highest in pollution/mismanagement)	
Plastic waste in metric tonnes	**192**
Plastic waste per capita (kg/year)	**129**
Mismanaged plastic waste in metric tonnes	**192**
Mismanaged plastic waste per capita (kg/year)	**101**
Share of mismanaged plastic waste	**46**

The market size of China's plastic industry was estimated at USD 73.5 billion in 2021 (MMR 2022). Between 2014 and 2023, China's share of global plastic materials production grew from 26 percent to 33 percent (Statista 2021 and 2024). In 2023, China produced almost 138 million tonnes plastic or 98 kg per capita (Plastics Europe 2024) This massive production capacity not only caters to domestic demand. According to estimates of the Organisation for Economic Cooperation and Development, OECD, China consumed 107 million tonnes, i.e. 76 kg per capita, or 21 percent of global plastic consumption (OECD 2024). The production also serves international markets, making China a key player in the global plastic supply chain (see below).

The market structure of China's plastic industry is characterised by a mix of large state-owned enterprises, multinational corporations, and a vast number of small and medium-sized enterprises (SMEs). This diverse landscape has led to a highly competitive market. The industry's Herfindahl-Hirschman Index (HHI) was estimated at 929 in 2023, decreasing from 1030 in 2017, indicating a trend towards increased competition (6WResearch 2022).

Looking ahead, China's plastic industry is expected to continue its growth trajectory, with projections indicating that the plastic market will reach USD 98.5 billion by 2029, representing a compound annual growth rate (CAGR) of 3.7% during this period (MMR 2023). This robust growth underscores the industry's significance in China's economic development and is attributed to increasing demand from various end-use industries such as packaging, automotive, construction, consumer goods, and electronics (6WResearch 2022). The plastics packing market in China, for example, is projected to grow at a CAGR of 4.3% during the forecast period of 2019-2029 (Mordor Intelligence 2023).

Plastic-related trade data corroborates the important role of the plastic industry for the global plastic economy in general and China's economy in particular. Overall, in 2022, China's trade volume of plastic-related products and goods amounted to USD 445.6 billion, according to UNCTAD data. This is more than 7.1% of China's overall trade volume in products and 15.6% of the global trade volume, the highest share in global plastic trade followed by the US (with 10.4%) and Germany (with 7.1%). It is a net exporter of plastic-related products and goods with an overall positive trade balance of USD 179.4 billion in 2022 (Figure 2), which is by far the highest positive trade balance in global comparison. With imports worth over USD 133 billion in 2022, China is nevertheless also the second most-important global import market behind the US.

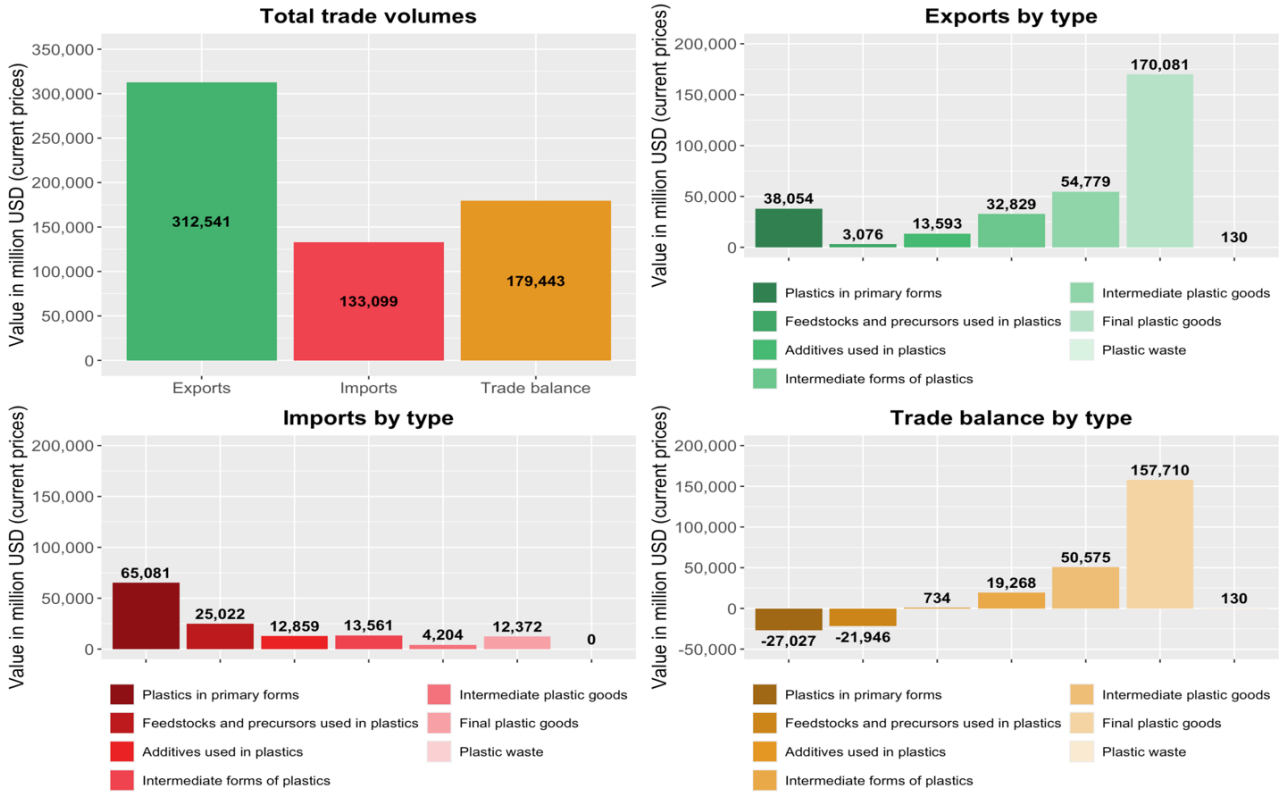

Figure 2. Plastic-related trade in China in 2022
Source: UNCTAD data

Overall, its exports amount to 22.3% of all exports worldwide, making China by far the largest exporter of plastic-related products and goods, again followed by the US (with 8.8%) and Germany (with 7.6%). China mainly exported intermediate and final manufactured plastic goods (together worth USD 224.9 billion), which together amount to almost 72% of its total plastic exports. These two product categories are also those where China features the greatest positive trade balance (USD 208.3 billion altogether). The five most important target countries of Chinese exports of plastic-related products and goods are the US (13.9% of all exports), Viet Nam (4.8%), Japan (3.8%), Germany (3.2%) and India (2.7%), according to UNCTAD data.

2. Policy landscape

2.1. Overview

As the world's largest producer and consumer of plastic products, China's policy decisions have far-reaching implications for global plastic pollution control efforts. Its policies to reduce plastic pollution have evolved significantly over the past two decades. Since 2016, the policy efforts to address plastic pollution increasingly gained momentum with plastic pollution featuring prominently in several Five Year Plans (FYP) and related strategies, action and implementation plans, directives, notices, regulations or other official documents. From early targeted interventions in the late 1990s to the landmark "National Sword Policy" of 2017 (SCGO 2017a) and the ambitious Plastic Pollution Control Action Plan of 2020 (NDRC and MEE 2021), China has progressively strengthened and expanded its regulatory framework.

The cornerstone of China's approach lies in its comprehensive regulatory framework, which employs four distinct yet complementary types of policy instruments: command-and-control measures, market-based mechanisms, information-based tools, and voluntary initiatives. Command-and-control measures form the backbone of China's regulatory response to plastic pollution. These include prohibitions and bans on environmentally harmful plastic products, mandatory standards for production and manufacturing, and performance targets for waste management. Complementing these regulatory mandates, China has implemented a diverse array of market-based measures that create economic incentives for sustainable practices. These include plastic bag charges to discourage consumption, deposit-refund schemes to encourage the return and recycling of plastic packaging, tax incentives and subsidies to support sustainable alternatives, and green procurement policies to create market demand for environmentally friendly products. The Extended Producer Responsibility (EPR) system, formally established in 2016, represents one of China's most significant market-based approaches, extending manufacturers' responsibilities beyond production to include the entire lifecycle of their products. Information-based instruments constitute another critical component of China's strategy, facilitating informed decision-making and behavioural change among stakeholders. These include reporting and monitoring systems to collect data on plastic production, use, and disposal; standards, certifications, and labelling requirements to guide consumer choices; information disclosure obligations to enhance transparency; and public education campaigns to raise awareness about plastic pollution and waste management.

In addition, China's comprehensive approach to reduce plastic pollution spans the entire lifecycle of plastic products from production and manufacturing over consumption to disposal. The regulatory framework span across all sectors and encompasses measures targeting the retail sector, catering industry, hospitality sector, express delivery services, agricultural practices, and marine environments.

Table 1 gives an overview of the most relevant policy outputs that aim at preventing plastic pollution.

Table 1. Overview of relevant key policy approaches to prevent plastic pollution.

Source: Authors' work

Year of adoption	Title
1983 amended in 2017 and 2023	Marine Environmental Protection Law
1989 amended in 2014	Environmental Protection Law
1996 amended in 2004, 2013, 2015, 2016 and 2020	Law on Prevention and Control of Environmental Pollution by Soild Waste
2001	Urgent Notice[1] on the Immediate Cessation of Production of Disposable Styrofoam Tableware
2008	Opinions[2] on Strengthening the Management of Plastic Packaging Waste in Key Transportation Lines, River Basins, and Tourist Attractions
2002 amended in 2012	Cleaner Production Promotion Law
2005	Opinions on Speeding up the Development of Circular Economy
2007	Notice on Restricting the Production, Sale, and Use of Plastic Shopping Bags
2007 amended in 2016	Administrative Measures for the Recovery of Renewable Resources
2008	Administrative Measures for the Paid Use of Plastic Bags at Commodity Retailing Places
2008	Announcement on Including Ultra-thin Plastic Shopping Bags in the Catalogue of Industries to be Eliminated
2009 updated in 2018 and 2020	Circular Economy Protection Law
2011	Opinions on Establishing a Complete and Advanced Recycling System for Waste and Used Commodities
2012	Regulations on Pollution Prevention and Control in Waste Plastic Processing and Utilisation
2013	Circular Economy Development Strategy and Near-Term Action Plan
2013	Notice on Deepening the Implementation of Restrictions on the Production, Sale, and Use of Plastic Shopping Bags
2015	13th Five-Year Plan for Economic and Social Development of the People's Republic of China 2016 – 2020

1 Notices play an important role as formal policy instruments and serve as important regulatory mechanisms.
2 Opinions serve as important strategic documents that establish and guide policy direction, coordinate efforts across different sectors, and lay the groundwork for more specific regulations.

Year of adoption	Title
2015	Medium- and Long-Term Plan for the Construction of a Renewable Resources Recycling System (2015–2020)
2015	Ecological Environment Protection Plan
2016	Implementation Plan for the Extended Producer Responsibility System
2017	Agricultural Film Recovery Action Plan
2017	Implementation Plan for Prohibiting the Entry of Foreign Garbage and Promoting the Reform of the Solid Waste Import Management System (National Sword Policy)
2017	Implementation Plan for the Domestic Waste Classification System
2017	Guiding Opinions on Accelerating the Development of the Renewable Resources Industry
2019	Implementation Plan for the Reform of the Waste Sorting System
2020	14th Five-Year Plan for Economic and Social Development of the People's Republic of China 2021 – 2025
2020	14th Five-Year Plan for Marine Ecological Environment Protection
2020	Law on the Prevention and Control of Environment Pollution Caused by Solid Wastes
2020	Opinion on Further Strengthening Plastic Pollution Control
2020	Opinions on Further Promoting the Classification of Domestic Waste
2020	Notice on the Phased Prohibition of the Production, Sale, and Use of Certain Plastic Products
2020	Notice on Solidly Promoting Plastic Pollution Control Work
2020	Notice on Accelerating the Green Transition of Express Packaging
2020	Circular on Further Strengthening the Control of Plastic Pollution in the Business Sector
2020	Announcement on Measures for the Reporting of the Use and Recovery of Disposable Plastic Products in the Commercial Sector (for Trial Implementation)
2020	Agricultural Film Management Measures
2020	New Restrictions on Plastics
2021	14th Five-Year Plan for Circular Economy Development
2022	14th Five-Year Plan for Urban Domestic Waste Classification and Treatment Facilities Development
2021	Plastic Pollution Control Action Plan
2021	Guidelines for assessing easy-to-collect & easy-to-recycle design of plastic products
2021	Environmental Protection Control Standards for Solid Waste That Can Be Used as Raw Materials—Waste Plastics
2021	Technical Specification for Pollution Control of Waste Plastics

Year of adoption	Title
2021	Administrative Measures for Mail and Express Packaging
2023	Action Plan for Further Promoting the Green Transformation of Express Packaging
2024	Opinions on Accelerating the Construction of a Waste Recycling System

While China's plastic pollution control framework is primarily driven by top-down government policies, it operates through a multi-tiered governance system where provincial and municipal governments serve as crucial implementation agents, often developing innovative pilot programmes and localised legislative measures that complement and enhance national directives (Chen et al. 2024; see also the following subsections for more details). For example, the Implementation Plan for the Household Waste Classification System mandated waste sorting in key cities, including municipalities, provincial capitals, and planned cities, establishing a four-category waste classification system that serves as the foundation for municipal plastic waste management. This top-down approach has been reinforced by China's Zero Waste City pilot programme, which identified 16 cities in 2019 and expanded to 134 cities by 2022, specifically targeting plastic waste reduction through improved municipal waste management systems. At the municipal level, cities have developed pioneering initiatives that often serve as testing grounds for national policy expansion. Shanghai exemplifies this approach through its recyclable courier packaging pilot project and separate recycling pilot project for plastic recyclables, which municipal authorities are implementing as potential models for nationwide adoption (CMS 2024; Shanghai International Services 2024). The city's legislative body passed regulations in March 2024 requiring e-commerce, express delivery, and online food industries to develop comprehensive packaging recycling plans, demonstrating how municipal legislation can advance national packaging waste reduction goals. Similarly, the 14th Five-Year Plan for Urban Domestic Waste Classification and Treatment Facilities Development specifically targets municipal infrastructure development (see the following subsections for more detail). Provincial governments have also played essential roles in adapting national policies to local contexts, particularly regarding infrastructure development and enforcement mechanisms. The Plastic Pollution Control Action Plan's phased implementation approach required different timelines for key provinces and cities versus nationwide rollout, recognising regional variations in administrative capacity and infrastructure readiness (see the following subsections for more detail). This tiered approach allows provincial authorities to develop context-specific implementation strategies whilst maintaining alignment with national objectives, creating a dynamic policy ecosystem where local innovations can inform broader national policy development.

Likewise, civil society organisations, environmental NGOs, and community-level initiatives play increasingly important complementary roles in implementation and advocacy (see the following subsections for more detail). For example, the China Zero Waste Alliance (CZWA), established in 2011, exemplifies this trend as a nationwide coalition of over sixty environmental NGOs engaged in policy advocacy, capacity building, and grassroots mobilisation around waste-related matters (Lu and Steinhardt 2020; BreakFreeFromPlastic 2022). CZWA focuses on building NGO partner capacity and increasing political will to combat plastic pollution whilst participating in China's legislative processes, demonstrating how environmental organisations navigate the complex political landscape to influence policy development. At the municipal and community levels, grassroots organisations have emerged as crucial actors in waste management implementation, with community-based collection systems and smart recycling stations being deployed in residential areas to improve plastic waste sorting and recycling rates (see the following subsections for more detail). The government's policy framework explicitly recognises the importance of public engagement, with multiple policies emphasising education campaigns, community clean-up efforts, and the role of social organisations and volunteers in environmental protection activities.

2.2. Command-and-Control Measures

China has implemented a comprehensive framework of command-and-control measures to address plastic pollution across the entire lifecycle of plastic products. These regulatory instruments span production, manufacturing, consumption, waste management, and trade. This section provides an overview on the range of prohibitions, bans, standards, and targets that form the backbone of China's regulatory response to plastic pollution, drawing on multiple policy documents issued between 1998 and 2025.

Production and Manufacturing

Prohibitions and Bans on Production: China has progressively introduced strict prohibitions on the production of environmentally harmful plastic products. A cornerstone of this approach is the ban on ultra-thin plastic bags with a thickness of less than 0.025 mm, which was initially established in the 2008 Notice of the General Office of the State Council on Restricting the Production, Sale and Use of Plastic Shopping Bags (SCGO 2007). The Notice on Deepening the Implementation of Restricting the Production, Sale and Use of Plastic Shopping Bags (SCGO 2013a) reinforced and expanded this ban five. It called for strengthened law enforcement and comprehensive inspections, particularly targeting the production and sale of ultra-thin plastic bags, and encouraged local governments to develop detailed implementation rules or local regulations, potentially exploring the feasibility of a complete ban on plastic bags in some areas. This prohibition was reinforced in subsequent policies, including the Plastic Pollution Control Action Plan (2020), which explicitly bans the production of these ultra-thin bags as part of its key measures to reduce plastic production and usage (NDRC and MEE 2021).

Likewise, the Plastic Pollution Control Action Plan (2020) prohibits the production of ultra-thin agricultural mulch with a thickness of less than 0.01 mm (NDRC and MEE 2021). This measure specifically targets the agricultural sector, where plastic film residues have been a significant source of soil pollution. The ban aims to address what is colloquially known as "white pollution" in rural areas, as outlined in both the Plastic Pollution Control Action Plan (NDRC and MEE 2021) and the Agricultural Film Recovery Action Plan (2017) (MOA 2017).

The production of products containing plastic microbeads, particularly in daily chemical products, has been prohibited since 2020 under multiple policies. The Opinion on Further Strengthening Plastic Pollution Control (2020) (NDRC and MoEE 2020) explicitly bans the production of daily chemical products containing plastic microbeads. This prohibition targets microplastics that can easily enter waterways and pose significant environmental risks due to their small size and persistence.

A longstanding prohibition in China's plastic control regime is the ban on production of disposable foam plastic tableware. This measure dates back to the Ban on Production and Use of Plastic Tableware (2001), which mandated "the immediate cessation of production of disposable foam plastic tableware" for all production enterprises, including domestic and foreign-invested companies (SETC 2001). This prohibition was reinforced in the Opinion on Further Strengthening Plastic Pollution Control (2020), which explicitly banned the production of foam plastic tableware by 2020 (NDRC and MoEE 2020).

The Notice on Resolutely Eliminating the Circulation of "Too Thin" Plastic Products (2020) further strengthened these production bans by targeting what it terms "too thin" plastic products, specifically ultra-thin plastic shopping bags and ultra-thin polyethylene agricultural films (#). This notice, issued by the All-China Federation of Supply and Marketing Cooperatives, emphasizes the importance of preventing these products from entering distribution channels.

Mandatory Standards for Production: China has established mandatory standards for plastic product design and manufacturing to reduce environmental impacts. The Plastic Pollution Control Action Plan (2020) promotes mandatory green design standards for plastic products, including "optimization of product structure, reduction of material complexity and enhancement of recyclability." (NDRC and MEE 2021) These standards aim to improve the environmental performance of plastic products throughout their lifecycle.

The Administrative Measures for Mail and Express Packaging (SAMR 2021) set standards for packaging materials, including limits on lead, mercury, cadmium, chromium, and benzene solvent residues. While not exclusively focused on plastics, these standards ensure that packaging materials, including plastics, meet environmental and safety requirements.

The General guidelines for the evaluation of plastic products' easy-to-collect & easy-to-recycle design (2021) (Chen 2021) establishes evaluation indicators for plastic products' design to improve collection and recycling rates.

The Technical specifications of recycled plastics for household electrical appliances (Liu 2024) outlines necessary standards for incorporating recycled plastics into household appliances and describes the methods for calculating the percentage of recycled plastics used, as well as the requirements for quality control and labelling.

Consumption

China has implemented a series of prohibitions and bans targeting the consumption of plastic products, particularly single-use items. One of China's earliest bans was established in the Opinions on Strengthening the Management of Plastic-packed Waste in Key Traffic Lines, Watersheds and Tourist Attractions (NDRC 1998). This policy prohibited the use of non-degradable disposable foam plastic tableware in railway stations, passenger trains, and vessels operating in inland waterways like the Yangtze River and Taihu Lake, targeting areas where plastic waste was particularly problematic for the environment.

Another longstanding prohibition in China is the ban on production of disposable foam plastic tableware. This measure dates back to the Ban on Production and Use of Plastic Tableware (2001), which mandated "the immediate cessation of production of disposable foam plastic tableware" for all production enterprises, including domestic and foreign-invested companies (SETC 2001).

The Opinion on Further Strengthening Plastic Pollution Control reinforced some of the earlier measures and more generally established a comprehensive framework for phasing out other single-use plastic products in different sectors (NDRC and MoEE 2020). In the catering industry, the policy banned plastic straws in the catering industry nationwide and plastic tableware in key cities. In the retail sector, it banned the sale of non-degradable plastic bags in key cities and subsequently in other areas in 2025. In the hospitality sector, the policy required star-rated hotels to eliminate these items by 2022, while all other hotels and home-stay businesses must comply by 2025. In the express delivery sector, the policy banned the use of plastic packaging bags and woven bags in key provinces and cities by 2022, with nationwide implementation by 2025.

Waste Management

Mandatory Process Standards: China has established numerous mandatory process standards for plastic waste management. Already in 1998, China adopted the Opinions on Strengthening the Management of Plastic-packed Waste in Key Traffic Lines, Watersheds and Tourist Attractions (NDRC 1998). This policy required ships to have garbage management plans and adequate waste storage facilities, ensuring that waste is collected and disposed of properly. This early policy recognized the importance of preventing plastic waste from entering waterways.

More recently, the Implementation Plan for the Household Waste Classification System (SCGO 2017b) mandated waste sorting in key cities, including municipalities, provincial capitals, and planned cities (NDRC and MoHURD 2017). This policy established a four-category waste classification system, dividing waste into recyclable waste (which includes most plastic items), hazardous waste, kitchen waste, and other waste. This classification system is essential for separating plastics from other waste streams, making recycling more efficient.

The Technical Specification for Waste Plastic Pollution Control (2021) established comprehensive standards for managing plastic waste throughout its lifecycle (MEE 2021a). It mandated separate storage sites for

different types of plastic waste, with specific measures such as rainproofing and anti-leakage systems to prevent environmental contamination. The specification also prohibited open-air burning of plastic waste and processing by-products, addressing a significant source of air pollution and toxic emissions from improper plastic waste disposal. A key aspect of the Technical Specification for Waste Plastic Pollution Control is the requirement to establish plastic waste management records. This measure enables better tracking of materials from source to final destination, improving transparency and accountability in the plastic waste management system. This policy was preceded by the Regulations on Pollution Prevention and Control Management for Waste Plastic Processing and Utilisation, which already in 2012 set forth several key prohibitions and requirements for plastic waste processing (MEE et al. 2012). They strictly forbid plastic waste processing in residential areas and the production of ultra-thin plastic shopping bags and ultra-thin plastic bags from plastic waste. The use of plastic waste for producing food-grade plastic bags is also prohibited. The policy mandates that only entities with proper hazardous waste management licenses can engage in the recycling of hazardous plastic waste, such as plastic packaging contaminated by dangerous chemicals or pesticides, and discarded single-use medical plastic products.

Finally, the Plastic Pollution Control Action Plan (2020) also calls for improving standards for recycled plastics and recycling technologies (NDRC and MEE 2021). This measure aims to enhance the quality and performance of recycled plastics, making them more competitive with virgin materials and thereby increasing the demand for recycled content.

Performance Targets for Waste Management: China has established numerous performance targets for plastic waste management, particularly in the Plastic Pollution Control Action Plan (2020) (NDRC and MEE 2021).

For household waste, this plan set a target to establish a system for the classification, disposal, collection, transportation, and treatment of household waste in cities at and above the prefecture level by 2025. This comprehensive approach aims to create an integrated waste management system that can effectively handle plastic waste. The plan also set a target to expand waste incineration and treatment capacity to about 800,000 tonnes per day in urban areas by 2025. This significant expansion of infrastructure aims to reduce the direct landfilling of plastic waste, which is another target of the plan. The 14th Five-Year Plan for Urban Domestic Waste Classification and Treatment Facilities Development (2022) reinforces this target, stating that by the end of the plan period, the incineration capacity is expected to reach 800,000 tonnes per day, accounting for 65% of urban waste treatment (NDRC and MoHURD 2022).

For agricultural plastics, the Plastic Pollution Control Action Plan set a target to increase the recovery rate of agricultural film to 85% by 2025 and to reduce the growth of mulch residue to zero (MEE and NDRC 2021). These targets address the significant environmental challenges posed by plastic film residues in farmlands, which have been a persistent issue in China's agricultural regions. The Agricultural Film Recovery Action Plan (2017) had previously set a target for a recycling rate of over 80% in demonstration areas, with a particular focus on the north-western regions and crops like cotton, corn, and potatoes (MOA 2017).

For plastic waste already in the environment, the Plastic Pollution Control Action Plan also established a target to clear open-air plastic garbage in key waters, tourist attractions, and rural areas by 2025 (MEE and NDRC 2021). This measure directly addresses visible plastic pollution in environmentally sensitive and touristically important areas. The 14th Five-Year Plan for Marine Ecological Environment Protection (MEE 2020a) reinforces this target for marine environments, calling for implementing specialized clean-up operations in key areas such as bays, estuaries, and shorelines, with the goal of establishing long-term mechanisms for marine plastic waste management in coastal cities and counties, ensuring that key coastal areas remain free of visible plastic waste.

In the express delivery sector, the Plastic Pollution Control Action Plan set a target to use 10 million recycled express packaging by 2025 (MEE and NDRC 2021). This target promotes the circular economy concept in a rapidly growing sector that generates significant packaging waste. The Action Plan for Deeply Promoting the Green Transformation of Express Packaging (NDRC 2023) further supports this target by promoting recyclable packaging and establishing recovery points for recyclable express packaging.

The Opinions of the General Office of the State Council on Accelerating the Construction of a Waste Recycling System (SCGO 2024) set a broader target for the annual utilization of major renewable resources, including plastic waste, to reach 450 million tonnes by 2025.

Trade

Prohibitions and Bans on Trade: China has implemented significant trade restrictions on plastic waste as part of its broader strategy to control plastic pollution. The internationally best known measure is certainly the Implementation Plan for Reforming the Management System of Solid Waste Imports to Ban Foreign Garbage from Entering China (SCGO 2017a), also known as the National Sword Policy or Green Fence. The policy established a comprehensive ban on the import of plastic waste and marked a significant shift in global plastic waste trade patterns, as China had previously been the world's largest importer of plastic waste.

The plan set out a phased approach, with the goal of completely halting the import of solid wastes that can be replaced by domestic resources by the end of 2019. This included banning the import of plastic waste from household sources, unsorted paper waste, and textile waste by the end of 2017. The plan also raised the threshold for solid waste imports by revising and tightening the Environmental Protection Control Standards for Imported Solid Wastes as Raw Materials (MEE 2021b). This measure increased the quality requirements for any plastic waste that could still be imported, reducing the potential environmental impact. To ensure its effective implementation and enforcement, the plan furthermore limited the number of ports allowed for solid waste imports, creating designated entry points where inspection and enforcement could take place. This measure helped prevent the illegal entry of banned plastic waste through unauthorized ports. Moreover, the plan increased oversight of the entities permitted to import plastic waste, by expanding the licensing system for solid waste imports.

Before this ban, the Regulations on the Prevention and Control of Pollution from the Processing and Utilization of Waste Plastics (MEE 2012) already prohibited the import of unwashed used plastic waste and the transfer of imported plastic waste to entities or individuals not specified on the import license. These measures aimed to prevent environmental contamination from imported plastic waste and ensure that only qualified entities handle these materials.

2.3. Market-based Measures

China has implemented a diverse array of market-based measures to address plastic pollution across the entire lifecycle of plastic products. These economic instruments target various stages including production, manufacturing, consumption, waste management, and trade. This section describes the market-based approaches embedded within China's policy framework, highlighting how economic incentives and disincentives are being deployed to combat plastic pollution while promoting sustainable alternatives and circular economy principles.

Waste management

China's **Extended Producer Responsibility system** represents one of the country's most significant market-based approaches to addressing plastic pollution. Formally established in 2016 (SCGO 2016), this system extends manufacturers' responsibilities beyond production to include the entire lifecycle of their products, including disposal and recycling. The EPR system assigns a decisive role to the market while offering planning and policy support through the government.

For plastic packaging specifically, the EPR framework outlines several market-based mechanisms, including operational or financial EPR systems. Producers can fulfil their recycling responsibilities through various methods, namely independent recycling, joint recycling initiatives, entrusted recycling to professional enterprises, or paying relevant funds to subsidize professional recycling enterprises. This flexibility allows market participants to determine the most cost-effective approach for their specific circumstances.

To support implementation, the policy includes several financial instruments, namely enhanced credit evaluation systems, a green finance system to support enterprises in meeting their EPR obligations, and financial incentives for compliant companies. These economic tools create market advantages for companies that successfully implement EPR requirements while imposing indirect costs on those that fail to comply.

The 14th Five-Year Plan for the National Economic and Social Development (SCGO 2021) further expanded the EPR approach, calling for its expansion and specifically urging the reduction, standardization, and recycling of express delivery packaging.

In addition, China has implemented several other market-oriented approaches to waste management that impact plastic pollution.

In 2015, the Medium and Long-term Plan for the Construction of Renewable Resource Recovery System (2015-2020) (MOFCOM 2015) outlines incentives for private companies to invest in recycling infrastructure and technologies, including tax benefits and financial subsidies. These economic instruments help offset the costs of establishing and operating recycling facilities, making recycling more financially viable.

The 14th Five-Year Plan for Urban Domestic Waste Classification and Treatment Facilities Development (NDRC and MOHURD 2022) advocates for financial incentives, improved regulatory frameworks, and public engagement to drive participation and compliance in waste management systems. The plan promotes market orientation as a guiding principle and encourages the development of waste-to-energy incentives through support for expanding incineration facilities and reducing landfill disposal.

Consumption

Plastic Bag Charges and Consumption Fees: One of China's earliest and most recognizable market-based measures is the mandatory charge for plastic shopping bags. Implemented through the Administrative Measures for the Paid Use of Plastic Bags at Commodity Retailing Places (MOFCOM, NDRC and SAIC 2008), this policy prohibits retailers from providing free plastic bags or selling them below cost and requires separate listing of plastic bag purchases on sales receipts. This market-based approach directly internalizes some of the environmental costs of plastic bags into their price, creating a financial disincentive for consumers. The policy includes significant economic penalties for non-compliance, with fines for non-compliance ranging from 5,000 to 20,000 yuan, depending on the violation. These financial penalties create a strong market incentive for retailers to implement the charging system properly.

Building on this foundation, subsequent policies have encouraged retailers to develop additional market-based incentives. The Notice on Further Strengthening Plastic Pollution Control in the Commercial Sector (MOFCOM 2020a) requests to incentivize the use of eco-friendly bags through reward systems. These reward systems represent a positive economic incentive complementing the disincentive of the bag charge.

Deposit-Refund Schemes: Several Chinese policies promote the use of deposit-refund schemes and other financial incentives to encourage the return and recycling of plastic packaging.

With regard to express delivery, the Action Plan for Deeply Promoting the Green Transformation of Express Packaging (NDRC 2023) requests the establishment of incentive mechanisms such as points rewards, green credit, deposit systems, and commitment systems to encourage consumers to return recyclable packaging voluntarily. The policy encourages express companies to offer free reusable boxes or provide preferential rates to promote packaging recycling and reuse, creating economic advantages for both consumers and businesses that participate in sustainable packaging practices.

With regard to households, the Opinions on Further Promoting the Work of Household Waste Sorting (MoHURD 2020) similarly suggest implementing measures such as deposits and trade-in programmes to enhance the recovery and disposal of product packaging. Likewise, the Implementation Plan for the Household Waste Classification System (SCGO 2017b) promotes the exploration of green account systems for residents, offering exchangeable points as rewards for correct waste sorting.

These schemes provide tangible economic benefits for environmentally responsible behavior and hence cen motivate people to properly dispose of plastic waste by providing.

Financial support: tax Incentives and subsidies

China employs various tax incentives and financial subsidies to promote sustainable practices throughout the plastic value chain and in different sectors.

The Notice on Accelerating the Green Transformation of Express Packaging (SCGO 2020) advocates for financial incentives to drive participation and compliance in sustainable packaging initiatives. It specifically mentions the government's commitment to providing financial support, green credit policies, and tax incentives to companies engaged in producing and using green packaging solutions."

The Opinions on Accelerating the Establishment of a Green Production and Consumption Legal and Policy System (NDRC 2020a) similarly calls for financial incentives and tax benefits for cleaner production initiatives and waste recycling, creating economic advantages for businesses that adopt environmentally friendly practices.

For the agricultural sector, policies promote subsidies for high-standard agricultural films to replace ultra-thin films that cause pollution, as mentioned in the implementation documents related to the plan for eliminating harmful plastic products. These subsidies help offset the higher costs of more environmentally friendly agricultural films, making them more competitive in the market.

Finally, the Plastic Pollution Control Action Plan includes provisions to support biodegradable plastics industry expansion and improve quality and reduce costs of alternatives through market interventions (MEE and NDRC 2021). The 14th Five-Year Plan for Circular Economy Development (NDRC 2021b) also includes economic support mechanisms for the biodegradable plastics industry. This includes research and development funding to help make these alternatives more cost-competitive with conventional plastics. The Ban on Production and Use of Plastic Tableware (NDRC 2001) was accompanied by efforts to ensure the production and supply of alternative products that meet national standards for biodegradable tableware. This included market support measures to ensure that alternatives were available and economically viable when the ban on conventional products was implemented.

Green Procurement and Market Creation

Several policies promote green procurement practices that create market demand for sustainable alternatives to conventional plastics. The Opinions on Accelerating the Establishment of a Green Production and Consumption Legal and Policy System (NDRC 2020a) aims to expand green product consumption by improving green product certification and labelling systems. This creates market recognition and potential price premiums for environmentally friendly products.

The Notice on Promoting Green Development of E-commerce Enterprises (MOFCOM 2021) encourages e-commerce platforms to establish incentive mechanisms to guide consumers towards purchasing green goods, using green packaging, and participating in packaging recycling. It also supports e-commerce platforms in expanding the sale of energy-saving, environmentally friendly, and green products and encourages the creation of dedicated green product sales areas and the promotion of green brands.

2.4. Information-based instruments

China has implemented a comprehensive suite of information-based measures to address plastic pollution across the entire value chain. These measures are embedded within various policies and regulations that target different sectors and stages of the plastic lifecycle. Information-based instruments include reporting and monitoring systems, standards and certification schemes, labelling requirements, information disclosure obligations, public education campaigns, and capacity development initiatives.

Reporting and Monitoring Systems

China has established several reporting and monitoring systems to collect data on plastic production, use, and disposal. One of the most significant is the Measures for Reporting the Use and Recycling of Disposable Plastic Products in the Commercial Field introduced in 2020 (MOFCOM 2020). This policy requires retail establishments, e-commerce platform companies, and takeaway businesses to report their use and recycling of disposable plastic products to the authorities. The reporting system covers non-degradable plastic shopping bags, roll bags, plastic packaging bags, non-degradable disposable plastic lunch boxes, plastic cutlery, and plastic straws. Companies must report through a unified national system on a semi-annual basis. The Ministry of Commerce oversees this nationwide reporting work, while local authorities at or above the county level supervise reporting in their respective regions. The reported information serves as a reference for government support policies, and non-compliance may result in legal consequences.

The Plastic Pollution Control Action Plan of 2020 further reinforces the importance of monitoring and reporting by mandating the development of systems to track the use and recycling of disposable plastic products (MEE and NDRC 2021). This plan also emphasizes strengthening monitoring and enforcement of national regulations in the recycling industry, ensuring that plastic waste is properly managed throughout its lifecycle. Additionally, the plan calls for establishing monitoring systems specifically for marine plastic waste and microplastics.

Information on marine plastic pollution also receives special attention in the 14th Five-Year Plan for Marine Ecological Environment Protection, which outlines requirements for conducting monitoring and surveys of marine plastic waste and microplastics (MEE 2020a). This plan encourages research on monitoring methods related to marine plastic pollution, with the goal of ensuring that key coastal areas remain free of visible plastic waste.

The Administrative Measures for Mail and Express Packaging (SAMR 2021) grant postal administration departments the authority to require enterprises to report on their use of single-use plastic products in packaging. This monitoring mechanism helps track progress and enforce regulations related to plastic use in the express delivery sector, which has become a significant source of plastic waste due to the rapid growth of e-commerce.

Standards, Certifications, and Labelling

China has developed an extensive framework of standards, certifications, and labelling systems to guide the production, use, and disposal of plastic products.

The 14th Five-Year Plan for Circular Economy Development and the Plastic Pollution Control Action Plan both emphasize the development of standards, certifications, and labelling for biodegradable plastics (NDRC 2021b; MEE and NDRC 2021). These standards serve to differentiate truly biodegradable products from conventional plastics and prevent greenwashing by manufacturers.

The Opinions on Accelerating the Establishment of a Green Production and Consumption Legal and Policy System (NDRC 2020a) calls for establishing a grading quality control and labelling system for recycled resources, promoting recycled products and raw materials. This approach aims to increase consumer confidence in recycled plastic products and create market demand for such items. Similarly, the Opinions of the General Office of the State Council on Accelerating the Construction of a Waste Recycling System aims to establish a certification system for recycled materials (SCGO 2024).

For express delivery packaging, the Action Plan for Deeply Promoting the Green Transformation of Express Packaging (NDRC 2023) promotes green product certification and encourages packaging manufacturers to participate in certification processes. Express delivery companies are encouraged to establish qualified supplier systems for packaging products and gradually increase the procurement and use of products from these suppliers. This certification system helps identify environmentally friendly packaging options and drives market transformation toward more sustainable alternatives.

The Implementation Plan for the Household Waste Classification System (SCGO 2017b) calls for establishing a waste classification labelling system for product packaging, helping consumers identify and properly dispose of plastic items. This labelling system complements the broader waste classification efforts and contributes to reducing plastic pollution by improving sorting and recycling rates.

Information Disclosure Requirements

Information disclosure requirements form another important category of information-based measures in China's approach to plastic pollution.

The Extended Producer Responsibility (EPR) policy requires producers to disclose information about product quality, safety, durability, energy efficiency, and toxic or hazardous substance content to the public (SCGO 2016). Manufacturers must also provide additional targeted information to waste recycling and resource utilization entities. This transparency enables consumers to make informed choices and facilitates proper end-of-life management of plastic products.

The Action Plan for Deeply Promoting the Green Transformation of Express Packaging (NDRC 2023) includes provisions for establishing a system to expose typical cases of violations regarding express packaging regulations. The plan mandates random inspections of express delivery packaging with public disclosure of results. This "name and shame" approach creates reputational incentives for companies to comply with regulations and adopt more sustainable packaging practices.

Information Platforms and Systems

China has invested in developing information platforms and systems to facilitate plastic waste management and recycling.

The Implementation Plan for the Household Waste Classification System (SCGO 2017b) promotes the establishment of information platforms for recycling, providing details on recyclable materials, transaction prices, and collection methods. These platforms connect consumers with recyclers, improving the efficiency of plastic recycling by creating a more transparent and accessible market for recyclable materials.

The Opinions on Accelerating the Construction of a Waste Recycling System encourages the development of "Internet + recycling" models to make waste collection more efficient and accessible (SCGO 2024). This approach leverages digital technologies to optimize collection and transportation routes, reducing the environmental footprint of recycling operations while increasing their effectiveness.

The Medium and Long-term Plan for the Construction of Renewable Resource Recovery System (2015-2020) (MOFCOM 2015) emphasizes the importance of upgrading sorting and processing facilities through the integration of information systems to optimize the logistics of recycling operations. By enhancing the technological capabilities of recycling centers, China aims to increase the recovery rate of plastics and other recyclable materials, thereby reducing the volume of waste sent to landfills.

The 14th Five-Year Plan for Urban Domestic Waste Classification and Treatment Facilities Development (2022) calls for the integration of technology to optimize collection and transportation routes and prevent the mixing of classified waste. This technological integration improves the efficiency of waste management systems and ensures that sorted plastic waste remains separated, facilitating more effective recycling and reducing the likelihood of plastic pollution.

Public Education and Awareness Campaigns

Public education and awareness campaigns constitute a significant portion of China's information-based measures to address plastic pollution. Multiple policies emphasize the importance of raising public awareness about plastic pollution, waste sorting, and recycling.

The Opinions on Further Promoting the Work of Household Waste Sorting (MoHURD 2020) calls for extensive publicity, education, and training to raise awareness and encourage active participation in waste

classification. This public engagement is crucial for the success of plastic pollution reduction efforts, as it can lead to more responsible consumption and disposal of plastic items.

The Action Plan for Deeply Promoting the Green Transformation of Express Packaging (NDRC 2023) emphasizes the importance of public education and awareness, calling for the use of various media channels to publicize laws, regulations, and standards related to express packaging. Industry associations are encouraged to play a self-regulatory role by issuing industry self-discipline conventions and signing self-discipline commitment letters for green transformation of express packaging.

The Medium and Long-term Plan for the Construction of Renewable Resource Recovery System (2015-2020) (MOFCOM 2015) calls for nationwide campaigns to raise awareness about the importance of recycling and the environmental impact of plastic waste. The plan emphasizes the need to change public perceptions of waste, promoting the idea that recycled materials are valuable resources rather than mere garbage. Educational programs are designed to inform citizens about proper waste segregation practices, thereby increasing the quality and quantity of materials available for recycling.

The Plastic Pollution Control Action Plan includes provisions for implementing education and awareness campaigns about disposable plastic products, targeting both consumers and businesses (MEE and NDRC 2021). The plan also emphasizes educating tourists on responsible waste disposal in tourist areas and organizing community clean-up efforts in rural areas.

The Notice on Solidly Promoting Plastic Pollution Control (MEE 2020b) stresses the importance of public awareness and engagement through publicity and guidance initiatives. Similarly, the Opinions on Strengthening the Management of Plastic-packed Waste in Key Traffic Lines, Watersheds and Tourist Attractions (NDRC 1998) underscores the importance of public education and awareness, calling for widespread dissemination of information about the dangers of plastic waste pollution and the importance of waste management using various media platforms.

The 14th Five-Year Plan for Marine Ecological Environment Protection emphasizes increasing public awareness about marine environmental protection and encourages the participation of social organizations and volunteers in various marine eco-protection activities, which can include efforts to reduce plastic pollution (MEE 2020a).

Capacity Development and Knowledge Sharing

Capacity development and knowledge sharing initiatives form another category of information-based measures in China's approach to plastic pollution. Multiple policies promote collaboration for knowledge sharing among industry stakeholders.

The Extended Producer Responsibility (EPR) policy encourages industry-wide collaboration to achieve EPR goals and the formation of alliances between manufacturers, bottling companies, and recycling companies (SCGO 2016).

The Guiding Opinions on Accelerating the Development of the Renewable Resources Industry (MIIT et al. 2017) calls for strengthening the position of enterprises as the main body of technological innovation and encourages increased investment in research and development. It promotes close collaboration between enterprises, universities, and research institutes to tackle key common technologies, including those related to plastic recycling.

The Strategy and Near-term Action Plan for Circular Economy Development (SCGO 2013b) emphasizes the development and application of new technologies for resource recycling and utilization, which could include innovations in plastic recycling and alternatives to plastic. The plan also stresses the importance of incorporating circular economy concepts into education and training systems and conducting various publicity activities to promote waste recycling.

The 14th Five-Year Plan for Marine Ecological Environment Protection supports research on mechanisms and prevention technologies related to plastic pollution, as well as research on control technologies for marine plastic waste (MEE 2020a). This research contributes to the knowledge base needed to effectively address plastic pollution in marine environments.

Economic Incentive Information

Information about economic incentives also plays a role in China's approach to plastic pollution.

The Implementation Plan for the Household Waste Classification System (SCGO 2017b) encourages the exploration of "green account" systems for residents, offering exchangeable points as rewards for correct waste sorting. This information about potential rewards motivates individuals to properly dispose of plastic waste and other materials.

The Action Plan for Deeply Promoting the Green Transformation of Express Packaging (NDRC 2023) suggests implementing incentive mechanisms such as points rewards, green credit, deposit systems, and commitment systems to encourage consumers to return recyclable packaging voluntarily. Information about these incentives helps drive behavioural change among consumers and increases participation in recycling programs.

The Opinions of the General Office of the State Council on Accelerating the Construction of a Waste Recycling System mentions exploring subsidies for recycling low-value recyclables, including low-value waste plastics (SCGO 2024). Information about these subsidies can encourage recycling businesses to collect and process materials that might otherwise be economically unattractive, thereby reducing plastic pollution.

2.5. Outlook

Currently, China is developing an Ecological and Environmental Code (NPC 2025) that will integrate many existing environmental laws, including some of those that address plastic pollution, namely the Environmental Protection Law, the Marine Environmental Protection Law and the Law on the Prevention and Control of Environmental Pollution by Solid Wastes. The draft code aims to strengthen enforcement and create a more coherent legal framework for environmental protection. This comprehensive code comprises 1,188 articles structured into five chapters covering general provisions, pollution prevention and control, ecological protection, green and low-carbon development, and legal liability. The code consolidates and replaces ten existing environmental laws and addresses critical gaps in China's regulatory framework, particularly in emerging areas such as climate change, biodiversity, and new pollutants. Once enacted, this will become China's second formal statutory code after the Civil Code.

The code does establish only a few standalone plastic-specific measures but addresses plastic pollution through comprehensive, integrated approaches in areas related to plastic pollution. In its solid waste management framework, the Code establishes provisions that directly target plastic waste through mandatory waste classification and recycling systems and requirements for waste reduction at source and circular utilization principles, creating a foundation for reducing plastic waste generation and promoting recovery and reuse. The code also mandates packaging controls, including restrictions on excessive packaging practices and requirements for packaging material reduction and sustainable alternatives. The Code strengthens extended producer responsibility mechanisms, requiring manufacturers to manage packaging waste throughout product lifecycles, which is particularly relevant for plastic packaging producers. Marine plastic pollution is addressed through comprehensive marine environmental protection measures, including controls on land-based pollution sources affecting marine environments and requirements for marine waste management and prevention. The Code's chemical substance management provisions also apply to plastic additives and microplastics through new chemical substance registration requirements and risk assessment systems for chemical substances in products. The most important standalone plastic-specific measure is certainly Article 991 of the Draft Code that prohibits and restricts the manufacture, sale and use of single-use, non-biodegradable plastic bags and other disposable plastic products.

3. Good practices in the private sector

While government policies and regulations provide the framework for addressing plastic pollution, the private sector plays a crucial role in implementing innovative solutions across the entire plastic lifecycle. This section explores exemplary initiatives by Chinese companies and communities that demonstrate good practices in reducing plastic pollution at each stage of the plastic lifecycle. These are just a few illustrations from the vast array of initiatives thus reflecting their diversity.

3.1. Production Stage: Innovations in Sustainable Polymer Development

At the production stage, several Chinese companies are pioneering innovations to reduce the environmental impact of plastic production through the development of alternative materials and more efficient production processes.

Biodegradable and Bio-based Polymer Development: Sinopec, China's largest petrochemical company, has made significant investments in green polymer development. The company has established dedicated research facilities focused on developing biodegradable plastics and bio-based polymers that can replace conventional petroleum-based plastics.[3] These alternative materials are designed to degrade naturally in the environment, reducing long-term pollution. Sinopec's biodegradable plastics portfolio includes polylactic acid (PLA) and polybutylene adipate terephthalate (PBAT), which are increasingly being used in packaging applications (Sinopec 2022, 2020).

Similarly, Kingfa Sci & Tech has emerged as a leader in biodegradable polymer innovation. The company has developed a range of fully biodegradable polymers specifically designed for agricultural applications, such as mulch films that naturally decompose in soil after use, addressing the significant environmental challenge posed by agricultural plastic waste. Kingfa's biodegradable materials are also being used in food packaging, shopping bags, and other single-use items that are typically difficult to recycle (Kingfa 2024).

Circular Feedstock Integration: PetroChina has implemented a Circular Feedstock Program that integrates recycled materials into polymer production. This initiative reduces reliance on virgin fossil resources by incorporating post-consumer plastic waste as feedstock for new polymer production. The company has invested in advanced chemical recycling technologies that can break down plastic waste into its molecular components, which can then be used to produce new plastics with properties equivalent to those made from virgin materials. This approach creates a closed-loop system that reduces both waste and the need for new fossil resource extraction (PetroChina 2023).[4]

Resource Efficiency Optimization: Sinochem has focused on resource efficiency optimization in polymer production. The company has implemented advanced process technologies that significantly reduce resource consumption and waste generation during production. These technologies include catalytic systems that improve conversion efficiency, reducing the energy required for polymerization processes. Sinochem has also implemented comprehensive water recycling systems in its production facilities, minimizing water consumption and wastewater discharge. By optimizing resource use, Sinochem has reduced the environmental footprint of plastic production while also achieving cost savings (Sinochem 2024).

3 It should be noted that the environmental claims surrounding bio-based, biodegradable and compostable alternatives are under increasing scrutiny worldwide. Bio-based plastics can mean plastics from renewable sources (e.g. corn starch), or plastic that biodegrades either in the environment or in special composting facilities. Only plastics that biodegrade in the natural environment are considered to reduce plastic pollution effectively. The efficacy of biodegradable and compostable plastics often hinges on very specific conditions, which may not always be achievable in real-world conditions.

4 Chemical recycling converts plastic waste into monomers or chemicals via chemical reactions, breaking polymer chains into building blocks for new products. It is however contested for several reasons. First, and unlike mechanical recycling, it requires high energy inputs, often from fossil fuels, leading to significant greenhouse gas emissions. Second, processes like pyrolysis yield low recycled material, with some outputs used as fuel, further reducing plastic recovery. Fourth, environmental and health risks, especially in developing countries with lax regulations, raise concerns (Quicker 2023). Fifth, economic viability at scale remains unclear (Paddison 2024).

Advanced Monitoring and Emission Control: Several major polymer producers in China have implemented advanced monitoring and emission control systems to reduce environmental impacts during production. These systems use real-time monitoring of air and water emissions, allowing for immediate adjustments to production processes when necessary. Some facilities have installed zero-liquid discharge systems that eliminate wastewater discharge entirely, while others have implemented carbon capture technologies to reduce greenhouse gas emissions associated with plastic production

Mycelium-Based Materials: Chinese companies are increasingly exploring mycelium (mushroom root) technology for packaging applications . While companies like Ecovative have pioneered this globally, Chinese firms are developing localised production using agricultural waste from rice hulls and wheat straw . These materials can be grown in moulds within 5-7 days and are completely home-compostable, offering a revolutionary alternative to polystyrene packaging .

Seaweed-Derived Polymers: Several Chinese biotechnology companies are developing seaweed-based packaging films that dissolve in water, addressing the challenge of single-use packaging in e-commerce . These materials utilise abundant marine resources and create packaging that can safely dissolve without environmental harm.

Circular System Innovations:

Closed-Loop Industrial Symbiosis: Some Chinese chemical parks are implementing industrial symbiosis models where plastic waste from one company becomes feedstock for another, creating zero-waste industrial ecosystems. These systems eliminate the concept of waste by ensuring every material output becomes an input elsewhere in the system.

Digital-Physical Integration: Companies are developing "Internet + Circular Economy" platforms that use AI and IoT sensors to track materials throughout their lifecycle, enabling real-time optimisation of circular flows and automatic redirection of materials to their highest-value applications.

3.2. Manufacturing Stage: Sustainable Product Design and Material Use

Packaging Redesign and Material Reduction: Mengniu Dairy, one of China's largest dairy companies, has implemented a comprehensive packaging redesign initiative that has resulted in significant plastic reduction. The company has optimized the design of its yogurt containers and milk bottles to reduce plastic content by approximately 15% while maintaining product integrity and shelf life. This has been achieved through wall-thinning technologies and structural design improvements that allow for less material use without compromising package performance. Mengniu has also transitioned many of its products from rigid plastic packaging to flexible packaging formats that use less plastic overall (Mengniu 2024).

Huawei has implemented a Green Packaging Design initiative for its electronics products. The company has redesigned its packaging to be modular, reducing plastic use by 17% across its product lines. The new packaging designs also improve recyclability by using fewer mixed materials and eliminating difficult-to-recycle components such as plastic laminates. Huawei has also reduced the overall size of its packaging, which not only decreases material use but also improves transportation efficiency, reducing the carbon footprint of product distribution (Huawei 2024).

Incorporation of Recycled Content: Haier Group, a leading home appliance manufacturer, has made significant progress in recycled content integration. The company has developed technologies to incorporate post-consumer recycled plastics in appliance manufacturing, with targets to increase recycled content by 30% by 2027. Haier has established partnerships with plastic recyclers to secure a stable supply of high-quality recycled materials and has invested in processing technologies that can improve the properties of recycled plastics to meet the performance requirements of appliance components. The company has successfully incorporated recycled plastics into non-visible internal components and is working to expand their use to external parts as well (Haier 2024).

BYD Auto, one of China's largest electric vehicle manufacturers, has implemented a Sustainable Materials Program that focuses on replacing virgin plastics with bio-based and recycled alternatives in automotive components. The company has developed proprietary technologies to improve the performance of recycled plastics for automotive applications and has established targets for increasing the percentage of sustainable materials used in its vehicles. BYD has also implemented design-for-disassembly principles that make it easier to recover and recycle plastic components at the end of a vehicle's life (BYD 2024).

3.3. Consumption Stage: Reducing Single-Use Plastics and Promoting Reuse

E-commerce and Delivery Packaging Innovations: Alibaba, China's largest e-commerce company, has implemented a Green Logistics Initiative that focuses on reducing plastic packaging waste. The company has developed an algorithm-based system that optimizes packaging size based on product dimensions, reducing unnecessary plastic use. Alibaba has also introduced reusable packaging options and provides incentives for consumers who choose plastic-free delivery options. Alibaba's Cainiao logistics network has pioneered a number of initiatives: it established over 80.000 package recycling points across China where consumers can return packaging materials for reuse or recycling; it developed industry standards for green packaging that have been adopted by thousands of merchants on Alibaba's platforms; it developed an AI-powered system that optimizes packaging for each shipment, reducing unnecessary materials by up to 40%; and it replaced traditional plastic shipping labels with electronic alternatives, eliminating millions of plastic-coated labels (Alibaba 2024, 2023; Cainiao 2024).

JD.com, another major e-commerce platform, has launched the Green Stream Initiative, which has led to significant reductions in disposable packaging and the overall amount of packaging needed. It has implemented packaging-free options for certain product categories, where items are delivered in their original manufacturer packaging without additional plastic wrapping. In addition, the company has introduced reusable delivery boxes that can be used up to 50 times before recycling, substantially reducing single-use plastic packaging waste. Finally, it has designed innovative boxes that do not require plastic tape for sealing, eliminating a significant source of non-recyclable plastic waste (JD.com 2023, 2022, 2021, 2020).

Food Delivery Waste Reduction: Meituan, China's largest food delivery platform, has implemented a Plastic Reduction Program that gives customers the option to opt out of receiving disposable cutlery when ordering food delivery. The company incentivizes this choice through its rewards program, offering points that can be redeemed for discounts on future orders. Meituan has also partnered with restaurants to promote the use of biodegradable packaging alternatives and has established a rating system that highlights restaurants with sustainable packaging practices. The company reports that over 90% of its users have opted out of disposable cutlery at least once, demonstrating the program's success in changing consumer behaviour (Meituan 2023).

Consumer Education and Engagement: Many Chinese companies have recognized the importance of consumer education in reducing plastic pollution. They have implemented awareness campaigns that inform consumers about the environmental impacts of plastic waste and provide practical guidance on reducing plastic consumption. These campaigns use social media, in-store displays, and product packaging to communicate sustainability messages. Some companies have created interactive mobile applications that allow consumers to track their personal "plastic footprint" and suggest ways to reduce it, turning sustainable consumption into an engaging experience (Zhang et al. 2022).

3.4. Waste Management and End-of-Life Stage: Improving Collection, Sorting, and Recycling

Advanced Sorting and Recycling Technologies: ALBA Group China, a leading environmental services company, has implemented advanced sorting technology that significantly improves plastic waste separation and increases recycling rates. The company has deployed AI-powered sorting systems that can identify and separate different types of plastics with high accuracy, even when they are contaminated or mixed with other materials. These systems use optical sensors, machine learning algorithms, and robotic

sorting arms to automate the separation process, making recycling more efficient and economically viable. ALBA Group's facilities can process mixed plastic waste streams and produce high-quality recycled materials that meet the specifications required for manufacturing applications (ALBA Group 2023).

Community-Based Collection Systems: China Resources, a state-owned conglomerate with significant investments in waste management, has established a recycling network that focuses on improving plastic waste collection at the community level. The company has installed smart recycling stations in residential communities that provide incentives for residents to properly sort and recycle plastic waste. These stations use digital technology to track recycling behaviour and reward participants with points that can be exchanged for goods or services. The system has significantly increased plastic recycling rates in participating communities and has helped to educate residents about proper waste sorting practices (China Resources 2023).

Product Take-Back Programs: TCL Technology, a major electronics manufacturer, has implemented a comprehensive Take-Back Program to ensure proper recycling of plastic components in electronic products. The company offers incentives for consumers to return end-of-life products to designated collection points and has established partnerships with specialized recyclers who can recover and process the various materials contained in electronic devices. TCL has also invested in technologies that can separate and recycle the different types of plastics used in electronics, which often contain flame retardants and other additives that make recycling challenging. The company uses some of the recovered plastics in the production of new devices, creating a closed-loop system (TCL 2023).

Plastic Waste Valorisation: Innovative companies in China are developing technologies to transform plastic waste into valuable products beyond recycled plastics. These include processes that convert plastic waste into construction materials. For example, some companies have developed technologies to transform mixed plastic waste into durable construction materials like plastic lumber and paving tiles, which can replace wood and concrete in certain applications (Liu and Liu, 2023).

4. Challenges

With annual total plastic waste generation reaching approximately 60 million tonnes and an amount of mismanaged plastic waste of roughly 14 million tonnes (EA 2024), the scale of China's plastic pollution problem is unparalleled globally (Liu and Liu 2023). The country's rapid economic growth, expanding middle class, booming e-commerce sector, and position as the "factory of the world" have all contributed to its massive plastic footprint.

As result, China faces considerable and complex array of challenges, spanning production, consumption, governance, waste management, data collection, economic factors, and consumer behavior. While the country has made significant strides in developing policies and initiatives to address plastic pollution, these challenges highlight the need for a more comprehensive, integrated approach.

Effectively addressing plastic pollution in China will require strengthening policy implementation and enforcement, improving coordination across different levels of government, enhancing waste management infrastructure (particularly in rural areas), developing better data collection and monitoring systems, investing in recycling technologies, aligning economic incentives with environmental goals, and fostering greater public awareness and engagement.

Production and Consumption Challenges

China's position as the global leader in plastic production creates fundamental challenges for pollution control efforts. With roughly 138 million tonnes in 2023, the country produces more than 30% of the world's plastics (see Context), with production continuing to grow at an alarming rate. Projections indicate that by 2040, China's plastic product output could reach 340 million tonnes, more than tripling compared to 2017 levels (Wang et al. 2024).

The consumption patterns in China further complicate pollution control efforts. The rapid rise of e-commerce, food delivery, and express delivery services has led to significant growth in plastic packaging waste. Between 2008 and 2016, the number of plastic bags consumed by China's express delivery industry alone increased over four-fold from 8.2 billion to over 34.7 billion (Liu & Liu 2023). The COVID-19 pandemic exacerbated this trend, significantly increasing plastic consumption through accelerated online food delivery and online shopping development (Lai 2023).

Additionally, China's consumption of single-use plastics remains high despite various restriction policies. The relatively low cost of plastic bags means shoppers are not deterred from paying for them despite bans on free bags. In 2020, China consumed at least one-fifth of the world's plastics, with single-use items comprising a significant portion of this consumption (Lai 2023).

Governance and Implementation Challenges

China's complex governance structure presents significant challenges for implementing effective plastic pollution control measures. The country operates with a five-level legal and policy system (constitution-level, laws, administrative regulations, ministry regulations, and local government regulations), creating coordination challenges across different levels of government and between various agencies responsible for environmental protection (Liu & Liu 2023).

Policy implementation and enforcement remain particularly challenging. Although the Chinese government has initiated multiple regulatory measures, the issue of plastic waste pollution remains considerable, and the relevant legal and regulatory system presents a complex situation with limited enforcement efficacy (Wang et al. 2024). Local governments often prioritize economic growth over environmental protection, leading to inconsistent enforcement of plastic pollution regulations. The "New Restrictions on Plastic" and relevant policies do not clearly define the responsibilities among government, businesses, and consumers, which further impedes policy effectiveness (Liu & Liu 2023).

Regional implementation disparities also pose significant challenges. There are stark differences in policy implementation across China, with varying levels of enforcement and compliance between different provinces and municipalities (Igini 2024). In developed regions, waste management systems are more advanced, while in underdeveloped regions, waste is still often dumped without treatment. These disparities create an uneven landscape for plastic pollution control, with some regions making significant progress while others lag behind.

Historical evidence suggests that maintaining policy effectiveness over time is challenging. The plastic shopping bag ban of 2008 was initially highly effective, achieving a two-thirds reduction in shopping bag use within five years. However, the use of plastic bags rebounded thereafter, demonstrating the difficulty in sustaining behavioural changes without continuous enforcement and public education (Lai 2023).

Recycling and Waste Management Challenges

China's recycling infrastructure and waste management systems face substantial challenges in handling the enormous volume of plastic waste generated. Despite being the world's largest plastic producer, China's plastic recycling rate remains low. Approximately 70% of plastic waste is managed through landfill, incineration, or haphazard discarding rather than proper recycling (Liu and Liu 2023). In 2020, of the 60 million tonnes of plastic waste generated, only 16 million tonnes were recycled, representing a recycling rate of approximately 26.7% (Lai 2023). This not only aggravates environmental pollution but also increases the severity of the plastic pollution issue. Of the 76.99 million tonnes of plastic products consumed in China in 2019, only about 14 million tonnes (18%) remained within the socio-economic system. Of the 63 million tonnes collected as waste, approximately 4.2 million tonnes (7%) leaked to the environment during collection, transportation, and disposal (Liu & Liu 2023).

The rural-urban divide in waste management infrastructure creates additional challenges. While urban areas have increasingly sophisticated waste collection and sorting systems, rural areas often lack basic waste management infrastructure (Igini, 2024). This disparity leads to significant plastic leakage into the environment from rural areas, particularly agricultural plastic waste such as mulch film, which has become a significant source of soil pollution in agricultural regions.

China's waste management system is further complicated by its dual structure—one system for municipal solid waste (MSW) and another for renewable resources—which creates coordination challenges and inefficiencies (Liu & Liu 2023). This bifurcated approach makes it difficult to implement comprehensive plastic waste management strategies that address the entire lifecycle of plastic products.

Data and Monitoring Challenges

Effective plastic pollution control is hampered by significant data and monitoring limitations. Data on the plastic supply chain are inadequate, with no official data released on the amounts of plastic waste generation by sector or plastic waste entering the environment through different channels (Liu & Liu 2023). This lack of comprehensive data makes it difficult to develop targeted interventions and measure progress accurately.

Statistical blind spots further complicate the picture. Current statistical data on municipal solid waste in China only includes quantities that have entered the environmental sanitation collection and transportation system but does not include unprocessed waste or waste that has entered the recycling system (Liu & Liu 2023). This creates significant data gaps, particularly regarding agricultural plastic waste and waste in rural areas.

Monitoring system limitations also pose challenges. Current policy focus is directed more on monitoring direct plastic litter and environmental impacts, while upstream (product and material-related) monitoring and downstream monitoring (waterways, waste, marine and coastal environment) lack sufficient integration (Liu & Liu 2023). Without comprehensive monitoring across the entire plastic lifecycle, it is difficult to identify leakage points and develop effective interventions.

Economic and Technological Challenges

Economic factors present significant barriers to reducing plastic pollution in China. The transition to plastic alternatives faces economic obstacles, as many sustainable alternatives remain more expensive than conventional plastics. The plastics industry is also a significant contributor to China's economy, employing millions of workers and generating substantial revenue. This creates resistance to policies that might restrict plastic production or use.

Technological limitations in plastic recycling capabilities, particularly for low-value plastics that are difficult and expensive to recycle, further complicate pollution control efforts. Many types of plastic waste, such as thin films, multi-layer packaging, and contaminated plastics, are technically challenging to recycle with current technologies. The quality of recycled plastic products is also a concern, as the definition of 'Reclaim' needs to be clarified, and the evaluation index of recyclability of plastic products is inconsistent and unclear (Liu & Liu 2023).

Conflicting policy objectives create additional challenges. For example, the 14th Five-Year Plan Plastic Pollution Control Action Plan proposes reducing landfill plastic waste while boosting incineration capabilities (MEE and NDRC 2021), which would nearly triple the carbon footprint and conflict with carbon neutrality targets (Liu & Liu 2023). These contradictions between environmental policies make it difficult to develop coherent strategies for plastic pollution control.

Consumer Behavior and Awareness Challenges

Changing consumer behaviour remains one of the most significant challenges in reducing plastic pollution in China. Studies have found that although most consumers are aware of plastic bans/restrictions, the purpose and importance of these policies are not well communicated, leading to limited compliance (Zhang et al., 2022). The convenience of plastic products, particularly in a fast-paced society with growing middle-class consumption, makes it difficult to shift consumer preferences toward more sustainable alternatives.

Inadequate incentives and penalties for plastic reduction behaviour further limit progress. Research has asserted that incentives and penalties are essential to raising public motivation in implementing plastic reduction behaviour, but these mechanisms are not sufficiently developed in China (Liu & Liu 2023). Without strong economic signals to guide consumer choices, behavioural change remains slow and inconsistent.

Many policies, while positive and effective in addressing specific aspects of plastic pollution, cannot address the root causes of the problem by changing current consumption patterns (Liu & Liu, 2023). A more fundamental shift in consumer culture and values is needed to achieve substantial reductions in plastic pollution, but such changes are difficult to implement through policy alone.

5. Way forward

The following recommendations on the way forward provide a framework for strengthening China's plastic pollution control efforts and address the just described key challenges. To this end, a comprehensive approach is needed that combines stronger governance, improved infrastructure, economic incentives, technological innovation and behavioural change. Here, China can build on its existing policy framework to create a more effective and sustainable system for plastic pollution control.

Strengthen Policy Integration and Coordination

To address the challenges of fragmented governance and policy implementation, China could consider establishing a dedicated national-level coordinating body for plastic pollution control. This body would be responsible for harmonizing policies across different government departments and levels, ensuring coherent implementation of plastic pollution control measures (Liu and Liu 2023). This approach would help resolve conflicts between different policy objectives, such as the tension between waste incineration expansion and carbon reduction goals. In a similar vein, China's approach to reduce plastic pollution might benefit from clarifying the distribution of responsibilities among stakeholders by establishing a more detailed accountability system that clearly defines the roles and responsibilities of government agencies, businesses, and consumers in plastic pollution control (Wang et al. 2024). This would help address the current lack of clarity that impedes policy effectiveness.

Enhance Monitoring and Data Collection Systems

To overcome data and monitoring limitations, it might help China to establish a comprehensive national plastic monitoring system that tracks plastic flows from production through consumption to disposal and environmental leakage (Liu Liu 2023). This system would ideally include standardized methodologies for data collection and reporting across all provinces and municipalities. In this context, monitoring plastic pollution in rural areas and agricultural settings deserves special attention, since this is currently a statistical blind spot. Here, targeted monitoring programs for agricultural film and other rural plastic waste sources would certainly help to better understand and address these pollution pathways (Liu and Liu 2023). To support monitoring and data collection, investments in advanced tracking technologies, such as digital watermarking and blockchain, can improve traceability throughout the plastic value chain and help identify leakage points and hold producers accountable for the end-of-life management of their products (Liu and Liu 2023).

Improve Waste Management Infrastructure and Systems

To create a more efficient and comprehensive approach to plastic waste management (Liu & Liu, 2023), an integration of the dual waste management systems (MSW and renewable resources) might be considered. This integration would reduce coordination challenges and improve overall system efficiency.

In addition, significant investment is needed to expand waste collection and recycling infrastructure in rural areas to close the rural-urban divide in waste management. This might include establishing community-based collection systems tailored to rural contexts and developing regional processing facilities that can serve multiple rural communities (Igini 2024; Ye 2023).

China might also want to prioritize the development of specialized recycling infrastructure for difficult-to-recycle plastics, such as multi-layer packaging, thin films, and contaminated plastics. This would help address the technological limitations that currently hinder recycling efforts for these materials (Liu and Liu 2023; Ye 2023).

Develop Economic Incentives and Market-Based Instruments

To overcome economic barriers to plastic pollution reduction, China could consider implementing a comprehensive Extended Producer Responsibility (EPR) system for plastic packaging that requires producers to take financial and operational responsibility for the end-of-life management of their products (Liu and Liu 2023). This would shift the economic burden of waste management from local governments to producers, creating incentives for more sustainable product design.

The government could also introduce a plastic pollution tax that applies to virgin plastic production, with revenues earmarked for recycling infrastructure development and environmental remediation. This would help internalize the environmental costs of plastic production and create economic incentives for recycling and alternative materials (Wang et al. 2024).

Additionally, it would certainly help if China established a quality certification system for recycled plastics to improve market confidence and increase demand for recycled materials. This system would help address quality concerns and create a more robust market for recycled plastics (Liu and Liu 2023).

Foster Technological Innovation and Research

To address technological limitations in plastic recycling and alternatives, increased investments in research and development for advanced recycling technologies are a good option (Liu and Liu 2023; Ye 2023). This would help overcome current technical barriers to recycling low-value plastics.

The establishment of innovation hubs and pilot projects could help to develop and test biodegradable and compostable alternatives to conventional plastics. Ideally, these initiatives would include comprehensive lifecycle assessments to ensure that alternatives offer genuine environmental benefits (Liu and Liu 2023; Ye 2023).

Finally, China might want to leverage its strengths in digital technology to develop smart waste management systems that use artificial intelligence, Internet of Things, and big data analytics to optimize collection routes, sorting processes, and recycling operations (Igini, 2024).

Change Consumer Behavior and Raise Awareness

Last but not least, to address challenges in consumer behavior and awareness, more effective public education campaigns are needed that clearly communicate the environmental impacts of plastic pollution and the importance of reduction, reuse, and proper disposal. These campaigns would best be tailored to different demographic groups and regional contexts (Zhang et al. 2022; Ye 2023).

In addition, the government could develop incentives and penalties that support consumer plastic reduction behaviour, such as deposit-refund systems for plastic bottles, mandatory charges for single-use items, and rewards for reusable container use. These economic signals would help motivate behavioural change more effectively than awareness alone (Liu & Liu, 2023, Ye 2023).

Finally, educational institutions also bear responsibility and could integrate plastic pollution and sustainable consumption into formal curricula at all levels, from primary schools to universities. This would help foster a new generation of environmentally conscious citizens and consumers.

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