Plastic Pollution Countermeasures: Effective Global Actions and Case Studies from East Asia

ERIA
Economic Research Institute for ASEAN and East Asia

IGES
Institute for Global Environmental Strategies

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Foreword

Plastic pollution has become one of the most pressing environmental challenges of our time. The Association of Southeast Asian Nations (ASEAN) region – home to rich marine biodiversity and economics deeply connected to coastal and oceanic resources – faces an urgent need to address this issue. Studies indicate that seven ASEAN+3 countries are amongst the top 10 contributors to annual plastic emissions into the ocean, underscoring the region's central role in tackling this global concern.

In response, ASEAN Member States have made commendable progress at both national and regional levels. The adoption of the ASEAN Declaration on Plastic Circularity at the ASEAN Summit in October 2024 marked a significant milestone, reaffirming the region's shared commitment to transitioning towards a circular economy for plastics. At the national level, seven ASEAN Member States have already developed and begun implementing their national action plans, while the remaining three are in the process of doing so.

Despite these positive strides, Member States continue to face complex challenges. Across the plastic value chain, data on plastic waste management remain limited, while existing waste management infrastructure and systems struggle to keep pace with rapid population and economic growth. Addressing these gaps in knowledge and capacity is essential to advancing effective and sustainable solutions. Yet, beyond a few analytical reports, comprehensive materials focusing on these issues remain scarce.

Against this backdrop, the Economic Research Institute for ASEAN and East Asia (ERIA) has developed this handbook, *Plastic Pollution Countermeasures: Effective Global Actions and Case Studies from East Asia*, in collaboration with ASEAN+3 experts. The publication seeks to support policymakers and researchers across the region and beyond by presenting an integrated understanding of cross-country challenges, policy developments, and best practices in addressing plastic pollution. It offers balanced, evidence-based, and practical guidance for designing and implementing effective countermeasures across diverse contexts.

I hope this handbook will serve as a valuable reference for policymakers, researchers, and practitioners in ASEAN and other emerging economies, contributing to a shared vision of a cleaner and more sustainable future. I extend my sincere appreciation to the ERIA and Institute for Global Environmental Strategies (IGES) teams, the ERIA Expert Working Groups, and all ASEAN+3 experts for their dedication and collaboration in producing this important work.

Tetsuya Watanabe

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List of Abbreviations

4Rs	refuse, reduce, reuse, and recycle
ADB	Asian Development Bank
AIT	Asian Institute of Technology
ALDFG	abandoned, lost, or otherwise discarded fishing gear
AMS	ASEAN Member State(s)
APEC	Asia-Pacific Economic Cooperation
ASEAN	Association of Southeast Asian Nations
BI	Behavioural Insights
BRIN	National Research and Innovation Agency, Indonesia
CIL-NUS	Centre for International Law, National University of Singapore
COBSEA	Coordinating Body on the Seas of East Asia
EPR	extended producer responsibility
ERIA	Economic Research Institute for ASEAN and East Asia
GDP	gross domestic product
GEF	Global Environment Facility
GHG	greenhouse gas
IDE-JETRO	Institute of Developing Economies, Japan External Trade Organization
IGES	Institute for Global Environmental Strategies
ILBI	international legally binding instrument
INC	Intergovernmental Negotiation Committee on Plastic Pollution
IPCC	Intergovernmental Panel on Climate Change
KEI	Korea Environment Institute
MOP	Ministry of Planning, Cambodia
MOE	Ministry of Environment, Cambodia
MSW	municipal solid waste
NCSD	National Council for Sustainable Development, Cambodia
NIS	National Institute of Statistics, Cambodia
NOWPAP	Northwest Pacific Action Plan

NPAP	National Plastics Action Plan, Lao PDR
OECD	Organisation for Economic Co-operation and Development
NGO	non-governmental organisation
PEMSEA	Partnerships in Environmental Management for the Seas of East Asia
PPCA	Phnom Penh Capital Administration
PPP	public–private partnership
RDF	refuse-derived fuel
RGC	Royal Government of Cambodia
RKC-MPD	Regional Knowledge Centre for Marine Plastic Debris, ERIA
RRC.AP	Regional Resource Centre for Asia and Pacific, AIT
SIDA	Swedish International Development Cooperation Agency
SMEs	small and medium-sized enterprises
SUP	single-use plastic
TEI	Thailand Environment Institute
UNCLOS	United Nations Convention on the Law of the Sea
UNDP	United Nations Development Programme
UNEA	United Nations Environment Assembly
UNEP	United Nations Environment Programme
VWF	volume-based waste fee
WWTP	wastewater treatment plant
WEF	World Economic Forum

Chapter 1

Overview of Plastic Pollution in East Asia

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1. Introduction

In recent years, plastic pollution has emerged as a growing threat around the globe. The gravity of this issue called for negotiations on an international legally binding instrument. As an area that is heavily influenced by and reliant on its marine resources, the Association of Southeast Asian Nations (ASEAN) region views plastic pollution as a pressing issue to be addressed. At the same time, the ASEAN+3 region[1] has been regarded as a hotspot of plastic pollution. For example, Meijer et al. (2021) showed that seven ASEAN+3 countries – China, Indonesia, Malaysia, Myanmar, the Philippines, Thailand, and Viet Nam – are amongst the top 10 countries with the highest annual plastic emissions into the ocean. Emissions from these seven countries account for about 65% of annual global emissions.

Based on this, ASEAN Member States (AMS) have taken steps at the national and regional levels to address the issue. At the regional level, AMS adopted their first declaration on combating marine debris in 2019. This was followed by a framework of action released the same year and a regional action plan for combating marine debris in AMS in 2021. More recently, at the ASEAN Summit in October 2024, AMS adopted the ASEAN Declaration on Plastic Circularity, which was developed under the ASEAN Chairmanship of the Lao People's Democratic Republic (Lao PDR). This declaration builds upon the previous documents and the progress that has been made in the region, while emphasising the need to transition to a circular economy for plastics. This entails the adoption of sustainable practices across the full life cycle of plastics, including eco-design, reuse and refill systems, and plastic leakage prevention. At the national level, seven AMS have developed and are implementing national action plans, while three AMS are formulating them.

Despite their great ambition and commitment to addressing plastic pollution in the region, AMS often face challenges. A report by the Economic Research Institute for ASEAN and East Asia (ERIA) and the Institute for Global Environmental Strategies (IGES) highlighted the challenge of data gaps in the ASEAN+3 region (Asokan, Abeynayaka, and Hotta, 2023). While the Organisation for Economic Co-operation and Development (OECD) countries in the ASEAN+3 region, Japan and the Republic of Korea (henceforth, Korea), and increasingly China, have the ability to collect and make available data on plastic waste management throughout the plastic value chain, the ability of five AMS to collect such data is limited. In four AMS, the dataset is still in development. OECD (2022) showed another challenge related to waste management practices. Non-OECD Asian countries, including AMS, still fall behind in proper waste management. While the global average waste mismanagement ratio[2] is 22%, in non-OECD Asian countries, the percentage is 43% or almost double the global average. ERIA RKC-MPD (2024), summarising publicly available statistics, revealed the gap in waste management capacity in AMS. While the average waste collection coverage in ASEAN has surpassed 50%, the plastic recycling rate still struggles to reach beyond 35%.

[1] The ASEAN+3 countries are the 11 ASEAN Member States (Brunei Darussalam, Cambodia, Indonesia, the Lao People's Democratic Republic (Lao PDR), Malaysia, Myanmar, the Philippines, Singapore, Thailand, Timor-Leste, and Viet Nam) plus China, Japan, and the Republic of Korea.

[2] According to OECD (2022), 'mismanaged waste' is defined as waste that is not captured by any state-of-the-art waste collection or treatment facilities. It includes waste that is burned in open pits, dumped into seas or open waters, or disposed of in unsanitary landfills and dumpsites.

Moving plastic pollution countermeasures forward, there is a strong need to build knowledge and capacity, including filling in gaps related to information on plastic pollution and waste management. However, materials to provide such capacity building are not available.[3] Some books focus on sharing scientific evidence on plastic pollution, while others provide policy information, but their focus is country-specific and does not cover the ASEAN or ASEAN+3 region.

Against this backdrop, this handbook – *Plastic Pollution Countermeasures: Effective Global Actions and Case Studies from East Asia*– aims to reach a target audience of academia and policymakers who research and combat plastic pollution, focusing on the ASEAN region and AMS. This handbook aims to deepen understanding of the ASEAN+3 region as a hotspot for plastic pollution and identify the type of measures needed or being implemented to combat such pollution. It also could provide a reference for academics and policymakers from emerging economies in other regions to learn about the development and application of policy measures in emerging economies at a similar level of development.

2. Overview and Motivation

In recent years, increased attention has been paid to marine plastic debris, leading to various global and regional initiatives addressing it as a form of marine pollution (Chapter 10).

One notable turning point was the 2011 report by the Global Environment Facility, which highlighted that existing measures were ineffective in addressing marine plastic pollution and called for new approaches (Scientific and Technical Advisory Panel, 2011). Additionally, Jambeck et al. (2015) and the World Economic Forum (2016) gained significant global attention as scientific efforts to quantify marine plastic. Thus, the ongoing plastic pollution issue initially came to be addressed as the 'marine plastic pollution' problem.

Issues surrounding plastic have gained significant attention in international trade. A major turning point was China's ban on the import of plastic waste in 2017. This led to a surge in plastic waste flowing to Southeast Asian countries surrounding China. In 2019, the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal amended its provisions to restrict the transboundary movement of contaminated plastics (Chapter 10).

Scientific studies highlighting the harmful nature of plastic itself began to be published around the same time. These studies described the potential impact of microplastics on ecological systems (Chapter 3) and human health (Chapter 4). While research in these areas is ongoing and evolving rapidly, no definitive conclusions can be drawn at this stage. However, these studies have raised awareness of plastic-related issues, particularly in light of the precautionary principle.

[3] One of the exceptions is Akenji et al. (2019).

As mentioned above, the plastic pollution issue, which initially began as a marine issue, has come to be recognised as a broader challenge surrounding plastic itself. In this context, the United Nations Environment Assembly (UNEA) Resolution 5/14, adopted on 7 March 2022, called for the need for a legally binding instrument based on a comprehensive approach to address the 'full-life-cycle approach'. That approach encompasses the entire plastic value chain from its production to disposal and recycling. Ongoing negotiations on a treaty to address plastic pollution (Intergovernmental Negotiating Committee on Plastic Pollution (INC)) are significantly influenced by the broader concerns surrounding plastic pollution.

Why do we focus on the ASEAN and East Asia region?

With the start of treaty negotiations, plastic pollution has been recognised as a global issue. Why does this book focus on ASEAN and East Asia? The reasons for this can be summarised as follows.
First, this region is recognised as a major source of pollution by various scientific studies. The ASEAN region includes emerging economies experiencing robust economic growth and population increases, leading to rising plastic consumption. Addressing this issue in such a region presents greater challenges than in other areas. To cope with these issues, this region has extended its policies to address plastic pollution through the establishment of a regional action plan, as well as national action plans.

Second, this region has been significantly impacted by China's ban on plastic waste imports mentioned above. Consequently, plastic countermeasures are progressing both regionally and nationally.

Third, there is a gap in the literature since few comprehensive research publications address the region's plastic problems holistically. Based on these concerns, this book was conceived to create a handbook focused on the ASEAN and East Asia region.

3. Plastic Pollution Status Quo, Outlook, and Countermeasures in East Asia

This handbook is composed of two parts, designed to provide practical insights into plastic waste management across the ASEAN+3 countries. Part I – Plastic Pollution Status Quo, Outlook, and Countermeasures in East Asia – consists of 11 chapters, including this introductory chapter.

Chapters 2–4 focus on the status quo of and outlook for plastic pollution, scaling from a global perspective to regional problems surrounding AMS, and further to the impacts on human health and the ecosystem. In Chapter 2, Dr Yasuhiko Hotta, Dr Chika Aoki-Suzuki, and Dr Ngoc-Bao Pham of the IGES summarise the status of plastic pollution globally and in the ASEAN region, emphasising that this growing international issue is a critical entry point for mainstreaming circular economy policies, particularly in the ASEAN region. While the Global North generates the most plastic waste, developing countries, especially in Asia, are the main sources of environmental emissions due to a large proportion of uncollected or mismanaged waste. The chapter utilises key findings from the OECD's *Global Plastics Outlook* (OECD, 2022) and *Regional Plastics Outlook for Southeast and East Asia* (OECD, 2025), which warn that under baseline scenarios, global plastic use and waste are projected to triple by 2060 and the ASEAN+3 region's plastic use could nearly double by 2050, overwhelming waste management systems. The reports stress that a radical shift in policy and substantial improvements in waste management are necessary, asserting that investing in proper waste management is far more cost-effective than cleaning up plastic that has already entered the environment. To address this, emerging economies face challenges that require a focus on capacity development in data-driven policymaking and monitoring, significant investment in technology and infrastructure for proper waste management, and the establishment of formal markets for circular plastics. Consequently, the chapter concludes that regional and international cooperation is vital to address the transboundary nature of the pollution and support these necessary policy interventions.

In Chapter 3, Dr Junko Toyoshima of the IGES introduces recent research outcomes on the ecological impacts of plastic pollution. This chapter highlights that plastic pollution is now a widespread and persistent threat to marine ecosystems globally. While a significant amount of plastic debris is found even in remote areas and polar regions, the ASEAN region – a major source of pollution – has a higher concentration of marine plastic debris. This chapter explains that macroplastics, such as fishing nets and packaging, can cause direct harm to marine life through entanglement and ingestion, leading to injury or death. Microplastics also pose a threat as they can be ingested and transferred through the food chain, potentially causing physical and chemical harm. Although scientific research has grown, there remains a lack of quantitative data and many uncertainties regarding the full ecological impacts of marine plastics, especially in the ASEAN region. The chapter concludes by reviewing the latest findings and emphasising the critical need for more research and targeted policy interventions to address these knowledge gaps and protect marine biodiversity.

In Chapter 4, Dr Ngoc-Bao Pham and Mr Ezra Daasin Osorio of the IGES focus on the human health aspects of plastic pollution. This chapter highlights that humans are widely exposed to micro- and nanoplastics through diet, drinking water, and inhalation. This exposure is particularly significant in the ASEAN+3 region due to mismanaged waste and unsustainable consumption. Laboratory studies have demonstrated that these plastic particles and their associated chemical additives can cause a range of adverse health outcomes, including endocrine disruption, inflammation, and potential cardiovascular risks. This chapter also underscores a critical disconnect between these alarming laboratory findings and the persuasive epidemiological evidence. Despite growing concern, significant knowledge gaps remain, particularly regarding long-term impacts and dose–response relationships. This leads to another gap between scientific findings and policy action. This chapter stresses the urgent need for a more comprehensive approach, including source reduction, product redesign, and international collaboration.

Chapters 5–9 outline practical measures being taken to address plastic waste, covering the full life cycle of plastics. In Chapter 5, Mr Dwayne Appleby and Dr Atsushi Watabe of the IGES discuss how the consumption of single-use plastics (SUPs) can be controlled through behavioural change and awareness raising. This chapter argues that traditional policy tools like bans and fees are insufficient on their own to curb the use of SUPs. Instead, the authors advocate for the use of behavioural insights, which draw on psychology and social science to influence consumer behaviour by understanding decision-making processes. This chapter details four pilot projects in Southeast Asian communities that tested behavioural insights interventions in schools and universities. These projects demonstrated the need for a holistic approach that combines behavioural insights with policy and infrastructure development to achieve systemic change. The lessons learned from the projects emphasise the importance of leveraging team expertise, fostering collaboration, and designing emotionally resonant messaging to drive change. This chapter concludes that future efforts should focus on expanding collaboration and creating platforms for information exchange to drive a broader societal shift towards a SUP-free future in the Asia-Pacific region.

In Chapter 6, Mr Fusanori Iwasaki and Mr Michikazu Kojima of ERIA showcase the extended producer responsibility (EPR) and recycling measures that have been adopted in the ASEAN+3 region. This chapter explains that EPR, which originated in developed countries in the 1990s, is being increasingly adopted in the ASEAN+3 region. The chapter outlines the concept of EPR and the different types of responsibilities in its implementation, including physical, financial, and information-related aspects. While Japan and Korea have long-standing EPR schemes, countries like China, Indonesia, the Philippines, Viet Nam, and Singapore have enacted their own regulations and frameworks more recently. This chapter also highlights the roles expected to be played by stakeholders such as governments, industry, and the private sector in implementing these EPR policies. Challenges in implementing EPR in Southeast Asian countries, such as limited waste collection services in rural areas, are also identified.

In Chapter 7, Dr Nirmala Menikpura and Dr Yasuhiko Hotta of the IGES approach plastic waste management from the life cycle viewpoint in the ASEAN region. Based on a life cycle assessment focusing on the greenhouse gas emissions from each option to dispose of or recycle plastic waste, this chapter finds that open burning has the highest climate impact, while mechanical recycling offers the most significant benefits for climate mitigation and resource conservation. Although landfilling has lower climate impacts, it poses serious risks through microplastic emissions and long-term ecosystem harm. The authors highlight that advanced technologies such as refuse-derived fuel production and chemical recycling show strong potential for climate mitigation and reducing the demand for new fossil resources. This chapter also highlights that AMS face significant barriers to improving their waste management. These challenges include low waste collection rates, high costs for advanced technologies, weak regulations, and limited technical capacity. Despite this, the chapter notes that opportunities for improvement exist through the enforcement of policies like EPR, enhanced regional cooperation, and the integration of the informal waste sector into formal management systems.

In Chapter 8, Dr Huno Solomon Kofi Mensah and Dr Borongan H. Guilberto of the Regional Resource Centre for Asia and the Pacific at the Asian Institute of Technology (RRC.AP AIT) clarify the measures to prevent plastic leakage into the environment that are applicable in the ASEAN region. This chapter points out that inadequate waste management and post-consumer plastic recycling systems are the main causes of plastic leakage in ASEAN cities. It also reveals a paradox: recycling facilities can be sources of pollution due to the conflict between profit maximisation and environmental stewardship, which is exacerbated by outdated infrastructure, fragmented governance, and weak regulatory enforcement. To address this, the authors highlight pilot projects carried out in six cities across four AMS to improve waste management in urban river basins and promote a circular economy for plastics. Concrete solutions tailored to the identified problem of recycling facilities are identified. The chapter notes that the informal recycling sector, which handles 50%–70% of plastic recycling in the region, operates with rudimentary conditions and lacks pollution controls. The authors propose multi-scalar interventions, including technological upgrades, institutional improvements, and the integration of the informal sector, to mitigate leakage and strengthen plastic circularity.

In Chapter 9, an ERIA team consisting of Ms Aulia Salsabella Suwarno, Ms Aulia Ulfatunnisa, and Mr Reo Kawamura, and an IGES team consisting of Dr Junko Toyoshima, Dr Ngoc-Bao Pham, and Mr Erza Osorio, summarise sectoral countermeasures against plastic pollution. The chapter highlights that plastic pollution from the agricultural sector is a concern due to the widespread use of items like mulch films and nets that can contaminate the environment and harm soil quality. Countermeasures include adopting sustainable materials and promoting the proper collection and recycling of plastic waste. For the fishery sector, abandoned, lost, or otherwise discarded fishing gear is a major source of marine plastic debris. To combat this, countermeasures focus on implementing tracking systems for fishing gear and promoting better disposal practices. In the wastewater sector, wastewater treatment plants are a significant pathway for both macro- and microplastics to enter the environment. Countermeasures involve upgrading wastewater treatment plants with advanced filtration technologies and promoting source reduction of plastics that enter the wastewater system.

Chapters 10 and 11 introduce transnational efforts aimed at tackling plastic pollution and explain how to analyse the key issues. In Chapter 10, Dr Sayaka Ono of the United Nations Environment Programme (UNEP) and Mr Fusanori Iwasaki of ERIA summarise global and regional initiatives functioning as pathways to a plastic pollution convention. This chapter highlights the growing global and regional momentum to address plastic pollution, providing an overview of key intergovernmental processes, including the Group of Seven (G7), Group of Twenty (G20), Basel Convention, and the UNEA, all of which have advanced commitments to combat the issue. Regionally, the chapter highlights efforts and programmes led by organisations such as ASEAN, the Coordinating Body on the Seas of East Asia (COBSEA), the Northwest Pacific Action Plan (NOWPAP), Partnerships in Environmental Management for the Seas of East Asia (PEMSEA), Asia-Pacific Economic Cooperation (APEC), and ERIA. Beyond these intergovernmental processes, the chapter presents relevant projects led by UNEP, the World Bank, and the Asian Development Bank (ADB). Through this overview, the chapter demonstrates that the Southeast and East Asian region is not merely following global trends but is actively contributing to the advancement of plastic pollution countermeasures.

In Chapter 11, Dr Azusa Uji of Kyoto University, Mr Fusanori Iwasaki of ERIA, and Dr Chika Aoki of the IGES analyse the formulation process of the UNEA/INC plastics pollution convention. This chapter examines the negotiation dynamics and outcomes of the United Nations treaty to end plastic pollution, drawing on official negotiation documents and country submissions. It traces developments from the adoption of UNEA Resolution 5/14 in 2022 through six INC sessions held between 2022 and 2025. The analysis focuses on two overarching issues – scope and depth – that shaped substantive disagreements, particularly between the High Ambition Coalition to End Plastic Pollution and the Like-Minded Group. While many states favoured binding obligations across the plastic life cycle, others prioritised sovereignty and development flexibility. In the end, the treaty text (to be agreed in INC5.2) reflects negotiated compromises between ambitious environmental commitments and flexible, nationally determined implementation. While this chapter pays special attention to the most politically contentious articles – Articles 3 (plastic products), 6 (sustainable production), and 11 (financial mechanism) – it also analyses key provisions on product design, waste management, plastic leakage, national action plans, and reporting. It emphasises that procedural challenges, such as consensus rules, transparency, and small-group dynamics, compounded the difficulties in reaching agreement. The last section of the chapter highlights that ASEAN+3 countries during the treaty negotiations generally supported downstream-focused measures and nationally determined approaches. Overall, this chapter contributes to understanding the political dynamics and complexities of designing a global environmental agreement to combat plastic pollution.

4. Key Topics of ASEAN+3 Countries

The second part of this handbook – Part II: Country Case Studies on Key Topics – consists of chapters on 11 of the ASEAN+3 countries: Cambodia, Indonesia, the Lao PDR, Malaysia, Myanmar, the Philippines, Singapore, Thailand, China, Japan, and Korea. In addition to the country profile, status quo, and trends of plastic pollution in the introductory sections, each chapter addresses a key topic related to plastic pollution and its countermeasures in the ASEAN+3 countries. The collective findings stress the urgent need for enhanced regional and international cooperation, sustained investment in sustainable infrastructure, and a focus on data-driven policymaking to achieve lasting progress in addressing plastic pollution.

The chapters show that many AMS struggle with inadequate and uneven infrastructure, necessitating greater investment and public–private partnerships (PPPs). In Chapter 12, Dr Yim Mongtoeun and Mr Hoy Sereivathanak Reasey Royal University of Phnom Penh report on the status of plastic waste management and trends in Cambodia. They explain that plastic waste management in Cambodia is a pressing environmental challenge due to rapid urbanisation, increased consumerism, and limited infrastructure. This chapter highlights the unique challenge of riverine plastic pollution, noting that an estimated 203,000 kilograms of plastic are released daily from Phnom Penh into the Mekong River during the rainy season. To combat this, the country has government-led initiatives and community campaigns promoting the 4Rs framework: refuse, reduce, reuse, and recycle. The authors note that to improve plastic waste management, Cambodia must prioritise the development of sustainable infrastructure, enforce stricter regulations, and encourage PPPs for recycling.

Chapter 13 highlights the struggle of Indonesia. Dr Muhammad Reza Cordova National Research and Innovation Agency (BRIN) and Dr Attar Hikmahtiar Ramadan of Institut Teknologi Bandung discuss how to ensure infrastructure and policy implementation to drive better plastic waste management in Indonesia. This chapter highlights that Indonesia is one of the largest contributors to plastic pollution in the oceans due to a large population, extensive coastline, and inadequate waste management systems. Key challenges include uneven infrastructure, low waste collection rates, and insufficient policy implementation, which are complicated by a lack of public awareness. The authors propose a multifaceted strategy to address this crisis, emphasising the need for collaboration amongst stakeholders, industry leaders, and the community. Prospective solutions include leveraging PPPs to enhance the circular economy and reinforcing EPR schemes. The chapter also stresses the importance of promoting community engagement through educational frameworks and developing tailored approaches for different regions.

Chapters 14 and 17 mainly discusses community-led initiatives and innovative local networks to tackle low collection rates. In Chapter 14, Ms Valy Phommachak Econox Laos introduces the people-led plastic reduction measures implemented in the Lao PDR. This chapter explains that despite being a landlocked nation with limited waste management infrastructure, particularly in rural areas, the Lao PDR has made notable progress through community-led and policy-supported plastic reduction initiatives. The government has established legal frameworks, such as the Environmental Protection Law No. 29/NA, 2013 and the National Plastics Action Plan, 2024–2030. These initiatives are complemented by local efforts, including school-based waste collection activities, reuse movements in the tourism sector, and innovations from local start-ups. However, the author also highlights persistent systemic challenges, such as underfunded waste services, a reliance on informal workers, and gaps in public awareness and financial resources. This chapter concludes that long-term progress will require stronger national coordination, integration into government systems, and sustained investment in environmental education and infrastructure.

Chapter 17 addresses the case of the Philippines. Ms Melissa May F. Cardenas of Environweave Integrative Environmental Research describes plastic waste management in the 'middle island regions' of the Philippines. This chapter highlights that tropical archipelagic countries like the Philippines face inherent challenges in solid waste management due to geographical features, such as long coastlines and mountainous terrain, and increased urbanisation along riverine and coastal areas. These factors contribute to a high likelihood of plastic leakage. This chapter focuses on the 'geographic middle' of the Philippines, which consists of medium-sized and small islands struggling with a lack of proper sanitary landfill sites. The logistical cost of collecting and transporting plastics for recycling is also prohibitive due to economies of scale. Proper waste management is critical in these islands as they are significant hotspots of marine and terrestrial biodiversity. Concrete solutions include the adoption of marine litter action plans by key coastal cities, a recycling market hub and network to address the logistical challenges of transporting plastics from smaller islands to recycling facilities on larger ones, and increasing the readiness of local material recovery efforts towards integration into EPR programmes to ensure the economic viability and sustainability of these efforts.

Chapters 15, 16, 18, 19, and 20 focuses on the policy evolution in each country. In Chapter 15, the author team led by Dr Wan Izatul Asma Wan Talaat of Universiti Malaysia Terengganu highlights marine plastic pollution, reflecting the ocean-relevant global and regional commitments and domestic framework in Malaysia. This chapter notes that marine plastic pollution, 80% of which originates from land, is an emerging threat to the marine environment, with growing concerns about microplastic pollution affecting human health through seafood consumption. Although Malaysia is ranked as one of the top plastic polluters globally, the country has incorporated legal obligations from international agreements like the United Nations Convention on the Law of the Sea (1982) and the Basel Convention into its domestic legal and policy frameworks. These frameworks and long-term strategies, such as the phased approach to a nationwide ban on plastic bags, demonstrate Malaysia's commitment to transitioning to a circular economy model and safeguarding its marine ecosystem.

In Chapter 16, Mr Friedor Jeske of Thant Myanmar highlights Myanmar's unique solution to the plastic pollution problem – exploring the reuse and refurbishment of products and the reform of the design system in a resource-restricted society, which strengthens local production and consumption. This chapter explains that Myanmar's historically restrictive import policies and ongoing trade challenges have driven up the cost of imported materials. After a brief period of liberalisation, authorities reinstated import restrictions on plastic materials and goods in 2021. In response, the economy has leaned on traditional mechanisms, with a renewed emphasis on the reuse and repair of consumer goods and stronger reliance on local production systems. The author argues that this system-based approach in the midstream of the plastic life cycle can significantly reduce reliance on plastics, making a substantial contribution to addressing plastic pollution. These systems are grounded in traditional knowledge and practices that support and strengthen local economies and offer a shared foundation for regionally rooted, practical solutions to counter plastic pollution in all AMS.

In Chapter 18, Dr Yulu Liu of the Centre for International Law of the National University of Singapore introduces the city state's comprehensive countermeasures against plastic pollution in Singapore. This chapter explains that as a city state with limited land resources and constrained landfill, Singapore relies heavily on incineration for waste reduction and energy recovery. Its Zero Waste Masterplan (2019) outlined ambitious goals to reduce landfill dependency, which are complemented by initiatives like the upcoming Beverage Container Return Scheme. The country's strict anti-littering regulations have also helped cultivate a culture of cleanliness and responsibility amongst the public. Additionally, Singapore collaborates with neighbouring states and through regional intergovernmental organisations to enhance waste management efforts. Through these multifaceted approaches, Singapore serves as a model for sustainable waste management and provides valuable insights into regional environmental policy and urban planning.

In Chapter 19, Dr Benjamas Chotthong, Ms Yanisa Ngamsa-ard, and Ms Sirinthip Boonyoung of the Thailand Environment Institute analyse plastic waste management in Thailand, focusing on policy challenges and lessons from voluntary initiatives to reduce SUPs. This chapter examines Thailand's policy framework for managing plastic pollution throughout its life cycle, highlighting key policy instruments and their progress, and assessing gaps in the country's efforts. This chapter discusses various voluntary initiatives to reduce SUPs, such as the nationwide campaign to ban plastic bags in retail stores and the promotion of environmentally friendly alternatives. The effectiveness of these initiatives depends on clear product standards, appropriate economic incentives, and sustained public awareness and engagement. The authors also outline the consideration process of the new legal framework to control SUPs under the EPR principle in Thailand.

In Chapter 20, Dr Daoji Li and Dr Lixin Zhu of East China Normal University examine the evolution of China's plastic pollution control efforts. China has made significant progress in tackling plastic and microplastic pollution by synergising scientific advancement with robust governance. The country's achievements include implementing key national policies, such as phased bans on SUPs and the Zero-Waste City initiative, which are informed by scientific research on the sources, distribution, and ecological risks of contamination. Furthermore, the chapter highlights how grassroots, bottom–up innovations, including smart waste collection technologies and circular economy practices, complement the top–down regulations. This approach has created an iterative feedback loop between science and policy, where monitoring, risk assessment, and standard-setting are increasingly institutionalised into the country's decision-making processes.

Finally, Chapters 21 and 22 showcase a successful transition, demonstrating a clear path towards managing the entire plastic life cycle and achieving high circularity. In Chapter 21, the ERIA team, comprising Mr Reo Kawamura, Mr Michikazu Kojima, and Mr Fusanori Iwasaki, examines the history of waste management infrastructure in Japan. The authors describe Japan's transformation from a country with significant public health issues due to unmanaged waste to a nation with a highly effective waste management system. Since the 1960s, a series of policy interventions, including legal acts for financing infrastructure, national grants, and inter-municipal collaboration, has led to expanded coverage of waste collection and the establishment of waste management infrastructure, centred on incinerators. As plastic waste became a new challenge in the 1970s, causing a shortage of landfill capacity by the 1990s, Japan pivoted its strategy. This prompted the introduction of the Package Recycling Act, 1995, based on the principle of EPR. This policy shift, along with other recycling laws, successfully increased recycling rates and extended the lifespan of landfill sites, demonstrating a continuous evolution in policy to address changing waste composition and volume.

In Chapter 22, Dr Sora Yi of Korea Environment Institute provides Korea's plastic packaging EPR as a concrete example of how a recycling-oriented plastic value chain can be transformed to one that drives circularity. This chapter traces the historical evolution of Korea's plastic policy through three distinct phases. Beginning with a government-led 'waste deposit system', the policy transitioned to a private sector-centred EPR system, successfully boosting recycling rates. The introduction of the volume-based waste fee and waste separation systems further strengthened collection. However, a major turning point occurred during the 2018 waste vinyl crisis, which, combined with national carbon neutrality goals, prompted a new, third phase focused on circularity. This latest phase incorporates mandatory recycled content requirements, packaging recyclability grade assessments, and an expanded EPR framework that includes design requirements and material restrictions – managing the entire plastic life cycle rather than just its end-of-life disposal.

5. About this book

The handbook – *Plastic Pollution Countermeasures: Effective Global Actions and Case Studies from East Asia* – is an invaluable resource for policymakers and researchers in the ASEAN+3 region. Part I of the book provides a crucial macro-level understanding by outlining the global and regional context of plastic pollution, including its scientific basis and environmental impacts. It details various countermeasures, from promoting behavioural change and applying EPR to leveraging advanced technologies for waste reduction. This section also places regional efforts within the broader context of a potential global plastics treaty, offering strategic guidance for those involved in international policy negotiations.

Complementing this, Part II presents a series of in-depth country case studies, which provide practical, ground-level insights. These chapters highlight the unique experiences of 11 countries in the ASEAN+3 region, offering a rich repository of lessons and best practices. For example, researchers can examine how Japan transformed its waste management infrastructure or how Korea evolved its EPR system to prioritise circularity. Policymakers can learn from China's success in bridging the gap between scientific research and policymaking. The book also touches upon the notable efforts of other AMS, such as Indonesia's multi-stakeholder strategy, Thailand's reliance on voluntary initiatives to reduce SUPs, and the Lao PDR's community-led initiatives. Together, these two parts of the book offer a balanced, comprehensive, and highly practical guide for developing and implementing effective strategies to combat plastic pollution across the region.

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Chapter 2

Global and ASEAN Status of Plastic Pollution

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1. Introduction

The environmental impact of plastics on the natural environment has been frequently discussed over the past decade (Cottom, Cook, and Velis, 2024; Jambeck et al., 2015). A discussion at the World Economic Forum in 2016 sparked a global debate and prompted a call for action on plastics as well as research to address the projected increase in plastic pollution (World Economic Forum, 2016). Around the same time, global policy efforts to combat plastic pollution gained momentum following the 2015 Group of Seven (G7) Elmau Summit in Germany and the adoption of the Ocean Plastics Charter at the G7 Charlevoix Summit in Canada in 2018 (despite non-adoption by the United States and Japan). Then, in 2019, the Group of Twenty (G20) Summit held in Osaka agreed on the Osaka Blue Ocean Vision, aiming for zero additional marine plastic pollution by 2050. At the United Nations Environment Assembly (UNEA) 5.2 in Nairobi in 2022, Resolution 5/14 to End Plastic Pollution: Towards a Legally Binding International Agreement was adopted, establishing an Intergovernmental Negotiating Committee on Plastic Pollution (INC) to draft a treaty.

The increased priority placed on policies that tackle plastic pollution has stimulated research that provides policy implications. Developing countries are hotspots for plastic pollution, as they experience economic development but have limited waste management and recycling capacity. Policy and infrastructure development are particularly urgent and increasingly prioritised in such countries.Various research articles and reports have shown that huge amounts of plastic have been produced, resulting in plastic waste generation and emissions into the environment. Cottom, Cook, and Velis (2024) identified that the largest amount of plastic waste is generated in the Global North, whereas uncollected waste is the dominant source of emissions across the Global South. Most of these studies have suggested that developing countries in Asia, including some Association of Southeast Asian Nations (ASEAN) Member States (AMS), are the main sources of emissions of plastic waste into the environment, including the ocean (Akenji et al., 2020; Jambeck et al., 2015).

A report by Plastics Europe (2024) estimated that more than 50% of all plastics are produced by countries in Asia (including China, Japan, and the rest of Asia).[1] At the same time, AMS apart from Malaysia, Singapore, and Thailand have limited chemical and manufacturing industries involved in the production of plastics and related products. Nevertheless, the consumption of plastics in those countries is likely to keep growing due to rapid urbanisation and the growth of the manufacturing, service, and tourism industries. Continued economic growth is also anticipated to lead to an increase in plastic production. In those countries, full life-cycle downstream initiatives such as waste management and pollution control have been major countermeasures for plastic pollution (Akenji et al., 2019).

[1] According to Plastics Europe (2024), the rest of Asia includes Asian countries (except China and Japan), Oceania, Türkiye, and Ukraine.

Meanwhile, discussions have intensified regarding the need for cooperation amongst developed, middle-income, and emerging economies on plastic pollution countermeasures, as well as the need for infrastructure to improve waste management in developing countries. Rapid economic growth and urbanisation in emerging economies, particularly AMS, have boosted plastic production, increased demand, and led to more imports of plastic products (OECD, 2025). The coronavirus disease (COVID-19) pandemic further accelerated plastic consumption patterns in these regions due to the rapid expansion of e-commerce and food delivery services (Liu et al., 2025).

However, emerging economies face significant challenges in establishing adequate waste collection, recycling, and treatment systems for plastic materials. This issue is particularly pronounced in rural and suburban areas, leading to increased discharge of plastic waste into the natural environment, including rivers and coastal regions (Hibino et al., 2024). With the major contribution made to the economy by the tourism sector in AMS (about 12.1% of the combined gross domestic product (GDP) of all AMS) (ASEAN, 2024), awareness is increasing regarding the link between tourism and plastic pollution. AMS are now prioritising actions to reduce plastic pollution in the environment. For example, ASEAN's Regional Plastic Action Plan for Combating Marine Debris in 2021 clearly stated that '(g)rowing plastic pollution will not only worsen pollution of our waterways and endanger marine wildlife; it also has the potential to damage human health via microplastics entering the food chain and could decimate the tourism and fishing industries that are so vital to the region's economies' (ASEAN, 2021: vii).

The *Regional Plastics Outlook for Southeast and East Asia*, published by the OECD in July 2025, emphasised the inadequate performance of waste management systems in the ASEAN region. The report also provided policy scenario modelling analyses showing that if the countries undertook strict policy and management measures, they would be able to reduce plastic waste emissions to the environment significantly (OECD, 2025).

Against this backdrop, policy awareness on actions against plastic pollution was raised and strongly influenced by the recognition of the need for international efforts to realise the 3Rs (reduce, reuse, recycle), achieve proper waste management, and mainstream the circular economy.

2. Key Issues and Challenges of Global Life Cycles of Plastics

The previous section argued that heightened interest in tackling plastic pollution has become the gateway to global mainstreaming of the circular economy. This section highlights key issues and challenges from the viewpoint of the plastic life cycle – from production and consumption to waste disposal and recycling, and emissions to the environment – at the global level.

2.1 Production

At the global level, Jambeck et al. (2015) pointed out that plastic production increased to 288 million tons (Mt) in 2012, which is 6.2 times higher than in 1975, due primarily to the expanded use of plastic as packaging. Geyer, Jambeck, and Law (2017) argued that a global shift from reusable containers to single-use containers accelerated the use of plastic packaging. The research also mentioned that global production of resins and fibres increased significantly from 2 Mt in 1950 to 380 Mt (about 5% of total plastic production) in 2015. The total resins and fibres manufactured from 1950 to 2015 amounted to 7,800 Mt, half of which were produced between 2002 and 2015. Non-fibre plastics make up around 92% of the total plastic production. The increased use of plastics is dominated by non-fibre plastics, with 36% made up of polyethylene (PE), 21% by polypropylene (PP), and 12% by polyvinyl chloride (PVC), followed by polyethylene terephthalate (PET), polyurethane (PUR), and polystyrene (PS) (< 10% each). Plastic packaging accounted for about 42% of the non-fibre plastic production in 2015 (Geyer, Jambeck, and Law, 2017). These studies suggest the importance of paying attention to the global production of plastic packaging, resins, and fibres. At the same time, the OECD has emphasised that car tyres and washing of textile and apparel products are key sources of microplastic pollution (OECD, 2022a).

2.2 Consumption

The increasing consumption of products using plastic containers and packaging is driven by economic development. At the same time, proper waste collection and management of these items can prevent the leakage of plastic into the environment (Chapter 8). As an example of a high-income economy, Japan is the second-highest consumer of plastic containers and packaging in the world (Heinrich Boell Stiftung, Break Free From Plastic, and IGES, 2022). Nonetheless, it has shown major progress in the treatment and recycling of plastic waste, thanks to the development of relevant policies and establishment of infrastructure. In middle-income and developing countries, consumption involving plastic use increases in line with economic growth, often without the necessary waste management systems or infrastructure. These countries tend to face severe plastic waste and pollution problems. While expanding waste recycling systems and infrastructure is fundamental, changes in the upstream aspects of the plastic life cycle such as the business and service model for product consumption are also crucial.

2.3 Plastic waste disposal and recycling

According to Plastics Europe (2024), about 91.3% of plastic production comes from fossil-based production, and the circularity contribution (i.e. reused or recycled plastics) is around 8.7%. The use of recycled plastic is still low globally, although the importance of effectively using recycled plastic to replace single-use plastics (SUPs) is widely recognised (UNEP, 2018). According to Geyer, Jambeck, and Law (2017), the contamination of collected plastics and mixed use of different polymer types result in a lower value or limited use of secondary (i.e. reused or recycled) plastics. Thus, swapping primary plastic production for recycled plastics is difficult. Geyer, Jambeck, and Law (2017) also noted that the global production capacity of bio-based or biodegradable plastics is very limited, at only 4 Mt or about 0.05% of total plastic production.

2.4 Emissions to the environment

Jambeck et al. (2015) ranked East and Southeast Asian countries high in terms of marine plastic generation and pollution. Amongst the ASEAN Plus Three (ASEAN+3) countries,[2] six are ranked in the top 10 emitters of plastic pollution: China (1st), Indonesia (2nd), the Philippines (3rd), Viet Nam (4th), Thailand (6th), and Malaysia (8th).[3] Jambeck et al. (2015) was mainly based on analysing improper plastic waste management and marine plastic debris estimation through data estimation of the coastal population, the population-based waste generation rate, and the plastic waste generation rate in each country.

Cottom, Cook, and Velis (2024) estimated the varying levels of plastic emissions amongst countries depending on their level of economic development. They showed that about 69% of the world's plastic emissions are from 20 countries: four low-income countries, nine lower middle-income countries, and seven upper middle-income countries. The emissions from high-income countries are low because of well-functioning collection systems and controlled disposal (Cottom, Cook, and Velis, 2024). Countries in the low- and middle-income categories generate lower plastic waste than higher-income countries, but a large proportion of the waste they generate is either uncollected or disposed of using uncontrolled dumping (Cottom, Cook, and Velis, 2024).

The OECD's *Global Plastics Outlook* stated that mismanaged plastic waste is the main source of environmental impacts from macroplastic waste (OECD, 2022a). The report also affirmed that non-OECD countries are the main source of plastic leakage into the environment, contributing around 86% of global plastic pollution caused by mismanaged waste (OECD, 2022a). It also pointed out that leakage into the aquatic environment overwhelmingly accumulates in rivers and lakes or ends up on coastal land and in the sea close to the shoreline, where it remains for a long time (OECD, 2022a). Since AMS are heavily dependent on the lifestyles and activities of communities and companies located close to the marine environment, OECD's *Regional Plastics Outlook for Southeast and East Asia* asserted that '(p)lastic pollution, especially in the marine environment, harms many communities and companies in the APT that rely on the ocean for livelihoods and production' (OECD, 2025: 74).[4]

3. Plastic Pollution and Chemicals of Concerns

Plastic pollution is generally considered to extend beyond a simple waste problem. Plastic also contributes to products that pose chemical hazardous risks. Therefore, it is crucial to ensure appropriate management of plastics, as well as regulation of chemicals of concern, to mitigate plastic pollution and its associated impacts.

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[2] The ASEAN+3 countries refer to the 10 AMS (Brunei Darussalam, Cambodia, Indonesia, the Lao People's Democratic Republic (Lao PDR), Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Viet Nam) plus China, Japan, and the Republic of Korea.

[3] Chapter 22 suggests that Jambeck et al. (2015) may have overestimated the plastic pollution emissions of these countries.

[4] APT refers to ASEAN+3.

Chemicals of concern are chemical substances that can negatively impact human health and the environment (Ghobish et al., 2025). Such substances have been found in plastics that are utilised across a wide range of sectors and product value chains – including toys and other children's products; packaging (including food contact materials); electrical and electronic equipment; vehicles; synthetic textiles and related materials; furniture; building materials; medical devices; personal care and household products; and agriculture, aquaculture, and fisheries (UNEP and Secretariat of the Basel, Rotterdam, and Stockholm Conventions, 2023). Extensive scientific data specify the potential adverse impacts of about 7,000 substances associated with plastics, more than 3,200 of which have one or more hazardous properties of concern (UNEP and Secretariat of the Basel, Rotterdam, and Stockholm Conventions, 2023). Aside from the chemical characteristics, microplastics have been identified as a key concern in the natural environment, causing environmental and health risks and impacts such as those found in seawater, sea creatures, and associated biological processes (Zhao et al., 2025) (Chapters 3 and 4).

4. Global Outlook

Some research articles have discussed the outlook for plastic pollution under different policy case scenarios. Borrelle et al. (2020) stated that plastic waste generation could be reduced in the coming decades through immediate, concerted, and vigorous action, but even in the best-case scenario, huge quantities of plastic will continue to accumulate in the environment. Lau et al. (2020) valued that the potential effectiveness international collaborative efforts to reduce plastic pollution, could result a 78% reduction in impacts in 2040 compared with 2016. The study stated that it would be difficult to reduce the carbon dioxide (CO_2) emissions associated with continued plastic production and improper waste management through the circular use of plastics alone. Thus, to synthesise the circular use of plastics and reduction of CO_2 emissions, Lau et al. (2020) as well as OECD (2022b) discussed the importance of upstream measures to change business and infrastructure models so that they can be supported by policy interventions such as innovation in resource-efficient and low-emission business models, reuse and refill systems, and sustainable substitute materials.

Amid growing attention on marine plastic pollution, the OECD released two reports in 2022: *Global Plastics Outlook: Economic Drivers, Environmental Impacts and Policy Options* (OECD, 2022a) and *Global Plastics Outlook: Policy Scenarios to 2060* (OECD, 2022c). Both reports showed the status quo of and outlook for global plastic pollution through synthetic analysis of land-based plastic pollution sources from the life-cycle point of view. The results of the analysis emphasised the unsustainable status of global plastic resource circulation, the expected increase in negative environmental impacts due to plastic pollution without any policy intervention, and the necessity of appropriate policy intervention to control the plastic pollution (Box 1).

Box 1: OECD Global Plastics Outlook

lThe OECD's *Global Plastics Outlook* (OECD, 2022a) linked macroeconomic analysis with various projections to indicate the direction of policy approaches and international collaboration for solving the plastic pollution problem. This outlook was not limited to OECD countries, but covered global challenges and the direction of international collaboration to overcome the challenges paused by plastic pollution through realising the G20's Osaka Blue Ocean Vision.

The report consists of two parts. Part 1 analysed the current state of plastic production and consumption and their environmental impacts, the impact of the COVID-19 pandemic on plastic production and consumption, the market for recyclable plastics, technological trends based on plastic-related patent information, policy trends in various countries, and international cooperation. Part 2 presented projections of economic growth; plastic use; plastic waste generation; and plastic leakage into the environment and its environmental impacts throughout the life cycle of plastic materials and products until 2060. Based on these projections, the report analysed scenarios in which existing initiatives are strengthened without international cooperation, scenarios in which international cooperation is strengthened to achieve zero new plastic emissions into the ocean by 2050, and the interaction between plastic resource recycling policies and climate change mitigation policies.

Consequently, the report identified five implications for the status quo of and outlook for global plastic pollution (OECD, 2022b; 2022d).

First, the state of plastic resource circulation in 2019 was not sustainable. Between 2000 and 2019, the amount of plastic increased more than twofold, from 156 Mt to 353 Mt. Only 9% of waste plastic was recycled, 19% was incinerated, 50% was disposed of in sanitary landfills, and 22% was openly dumped.

Second, although the overall use of plastic decreased due to the COVID-19 pandemic, the consumption and waste of single-use plastics and of plastic personal protective equipment increased. With the economic recovery, an increase in plastic waste is expected.

Third, how to clean up the 19 Mt of plastic already accumulated in freshwater systems, such as rivers, is a major challenge.

Fourth, without any policy intervention, global plastic use will triple by 2060, driven by the significant increase in sub-Saharan African and Asian countries, while it will double in OECD countries. By 2060, global plastic waste will also triple, with half of it still being landfilled. Recycled plastic will only meet 12% of plastic demand. As a result, the amount of plastic entering the environment by 2060 will be about double the current level. Additionally, environmental impacts such as carbon dioxide emissions will double due to increased plastic production.

Fifth, the report concluded that it is possible to achieve the G20 Osaka Blue Ocean Vision (reducing annual plastic inflows into the aquatic environment by 98% compared with the 2060 baseline scenario) by raising the ambition of each country, implementing harmonised policies based on international agreements, and promoting international cooperation.

To achieve the G20 Osaka Blue Ocean Vision, the report emphasised implementing:

(i) basic infrastructure development for waste management and collection to curb plastic leakage and measures to address litter,

(ii) mechanisms to incentivise recycling and separate collection through extended producer responsibility and deposit refund systems, and

(iii) policies to curb demand and optimise design to make the plastic value chain more circular.

Advanced countries are expected to implement ambitious circular economy policies to promote recycling, while developing countries will need to invest in waste collection and treatment infrastructure in addition to promoting recycling.

As a result of these policy interventions, it is estimated that greenhouse gas emissions from the plastic life cycle can be approximately halved. When combined with greenhouse gas mitigation measures, this amounts to a 67% reduction. On the other hand, the effect on GDP is estimated to be a reduction of 0.3%–0.8% by 2060, indicating a low economic impact. The report also concludes that investing in recycling and waste management is far more cost-effective than cleaning up plastic that has already entered the ocean or the environment, emphasising that reducing waste generation and leakage and proper management are key.

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OVID-19 = coronavirus disease, G20 = Group of Twenty, GDP = gross domestic product, Mt = million tonnes, OECD = Organisation for Economic Co-operation and Development.

Source: OECD (2022a).

To highlight the importance of collaborative efforts amongst developed countries, emerging economies, and developing countries, the OECD conducted an analysis on the Southeast and East Asia region, focusing on the ASEAN+3 countries. The ASEAN+3 countries are one of the major drivers of global economic growth and development, with a combined gross domestic product (GDP) accounting for nearly one-third of global output. This region is also rapidly becoming the global centre of plastic product utilisation, consumption, and pollution. This trend poses serious threats to ecosystems and biodiversity, causes substantial economic losses to marine economies, and exposes its citizens to significant health risks. Without a radical shift in policy and substantial improvements in waste management efficiency, the crisis is expected to intensify.

In July 2025, the OECD published its *Regional Plastics Outlook for Southeast and East Asia* (OECD, 2025), which evaluated the consequences of the plastic value chain in the ASEAN+3 region. The report affirmed that the ASEAN+3 region is one of the major global hotspots of plastic pollution and called for highly ambitious policy interventions, including the mobilisation of financial resources and capacity building (Box 2).

Box 2: OECD Regional Plastics Outlook for Southeast and East Asia

This box presents key takeaways and policy recommendations from the OECD's Regional Plastics Outlook for Southeast and East Asia (OECD, 2025), tailored to inform policy and decision-making in the region.

According to projections in the OECD's Regional Plastics Outlook for Southeast and East Asia (OECD, 2025), under current policies (the baseline scenario), plastic use in the region is expected to nearly double to 280 Mt by 2050. This surge will likely overwhelm existing waste management systems, increasing the volume of mismanaged plastic waste by 69%, reaching 59 Mt annually, and tripling the total stock of plastics accumulated in the region's rivers, lakes, and oceans.

Meanwhile, the ASEAN+3 region is marked by significant diversity in economic development, ranging from high- and upper middle-income countries like China, Japan, the Republic of Korea, Brunei Darussalam, Malaysia, Singapore, and Thailand, to lower middle-income countries such as Cambodia, Indonesia, the Lao PDR, Myanmar, the Philippines, and Viet Nam.

Consequently, this distinction is critical for shaping effective policy responses. In general, high- and upper middle-income countries generally have more developed waste management systems and higher per capita plastics use. In contrast, lower middle-income countries face substantial challenges due to high rates of mismanaged plastic waste (e.g. 27% in Thailand and 91% in Indonesia, in 2022); therefore, significant improvements in waste management infrastructure are urgently needed to address this issue. This nuanced understanding is essential for designing effective, tailored policies that reflect the varied capacities and contributions to plastic pollution across the region.

The OECD's regional outlook also outlines pathways for ambitious policy actions. It highlights that while plastics deliver numerous societal benefits, their life cycle poses serious environmental and health challenges. Consequently, tackling these challenges requires comprehensive, context-specific strategies underpinned by robust data and strengthened multi-stakeholder collaboration.

1. **The ASEAN+3 region is one of the major global hotspots for plastic pollution, with plastic consumption rapidly growing in the region** (OECD, 2025: Chapters 2 and 5). This is driven by increasing volumes of mismanaged plastic waste, inefficient waste segregation at source, and limited recycling and use of recycled materials in manufacturing. In 2022 alone, the ASEAN+3 region was responsible for 8.7 Mt of plastic leakage, accounting for over one-third of the global total, with China and ASEAN low- and middle-income countries as key contributors.

2. **Improving the performance and efficiency of plastic waste segregation, collection, treatment, recycling, and final disposal systems is critical** (OECD, 2025: Chapter 3). To improve plastic waste management in the region, substantial investments are urgently needed to scale up formal waste management systems, eliminate open burning, and prevent illegal dumping, particularly in the lower middle-income countries, where mismanagement of plastic waste remains widespread.

3. **Comprehensive, stringent, and life cycle–based policies are essential to eliminate plastic leakage by 2050** (OECD, 2025: Chapter 6). The outlook emphasised the necessity of policy approaches for (i) curbing production and demand; (ii) designing the circularity of plastic products and packaging; (iii) enhancing recycling by improving separate collection, sorting, and processing of plastic waste; and (iv) closing leakage pathways by strengthening waste collection, sorting, and overall management to minimise environmental losses.

4. **Implement strong upstream measures to curb plastics demand and promote eco-design; critical roles of downstream measures and infrastructure development must also be emphasised** (OECD, 2025: Chapters 6 and 7). The 'high ambition scenario' includes measures such as a $1/kg plastic packaging tax by 2030, extended producer responsibility schemes, and eco-design policies to extend product lifespans by 15% and reduce plastic inputs by 17% through substitution. These measures could reduce packaging waste by 17 Mt by 2050.

5. **Scale up recycling and modernise waste management systems** (OECD, 2025: Chapter 6). The 'high ambition scenario' projects the average recycling rate in the ASEAN+3 region to increase significantly from 12% in 2022 to 54% by 2050, raising the total recycled plastic drastically from 14 Mt to 100 Mt. This will require major investments in infrastructure for sorting, cleaning, and processing, along with incentives for recyclable product design and stronger domestic and international markets for secondary plastics. A significant challenge remains the lack of robust demand for recycled plastic, as virgin plastics are often cheaper and preferred by industry due to their higher quality and reliability of supply. To address this, it is essential to implement strong policy measures, such as recycled content requirements, which can help level the playing field with primary plastics.

6. **Integrating and professionalising the informal waste sector within formal waste management systems is essential for improving both waste management outcomes and social equity** (OECD, 2025: Chapters 2 and 7). Informal waste pickers play a vital role in plastic waste collection and recycling across many ASEAN Member States and China, particularly in recovering high-value materials such as PET. Formalising and professionalising this workforce is not only a matter of equity, ensuring protection, dignity, and rights, but also a strategic approach to expand plastic waste collection, increase recovery rates, and enhance recycling efficiency. Key strategies include registering waste pickers, recognising their contributions in national waste management frameworks, providing access to equipment and social protections, offering skills training, and integrating them into extended producer responsibility schemes as service providers or subcontractors.

7. **Unlock and mobilise significant financial resources and investments for a circular plastics economy** (OECD, 2025: Chapters 6 and 7). Eliminating plastic leakage by 2050 will require substantial cumulative investments and interventions across the entire plastic life cycle. To attract such investments, governments must establish clear and consistent policy frameworks that build investor confidence. This challenge highlights the critical need to strengthen regional and international cooperation, including through technical assistance and financial support, to ensure all countries have the capacity and resources to transition toward a circular plastics economy.

8. **Strengthen enforcement, governance, and data systems to enhance policy effectiveness** (OECD, 2025: Chapter 7). Effective implementation of plastic pollution policies requires strong enforcement mechanisms, sound governance structures, and robust data systems. In particular, the development of comprehensive data systems to track plastic flows, waste generation, and pollution sources is essential for evidence-based policymaking and for measuring progress towards policy goals.

9. **Address microplastic leakage and emerging threats to the environment and human health** (OECD, 2025: Chapters 6 and 7). In addition to macroplastics, microplastic pollution presents a growing threat to both environmental and human health. Priority should be given to 'no-regrets' interventions that provide multiple co-benefits, even in the face of scientific uncertainty.

10. **Strengthen regional and international cooperation to address the transboundary nature of plastic pollution** (OECD, 2025: Chapter 7). Regional platforms and initiatives play a vital role in fostering comprehensive yet context-specific strategies that enhance policy effectiveness, facilitate knowledge exchange, and support capacity-building amongst ASEAN+3 countries.

ASEAN+3 = ASEAN Plus Three, ASEAN = Association of Southeast Asian Nations, kg = kilogram, OECD = Organisation for Economic Co-operation and Development, Mt = million tonnes , PET = polyethylene terephthalate.

Source: OECD (2025).

5. Policy implementation challenges of emerging economies

As indicated by OECD (2025), AMS – particularly emerging economies such as Indonesia, Malaysia, the Philippines, and Thailand – have made progress in policies that contribute to plastic pollution control and design for the environment of plastic products. Nevertheless, AMS are facing policy challenges that are similar in other emerging and developing countries. It is crucial to focus on capacity development on data-driven policymaking for effective policy planning and implementation.

OECD (2022a; 2022b; 2025) highlighted the necessity of concerted international efforts in developing capacity for (i) effective policy planning and implementation, (ii) data-driven policymaking, (iii) capacity for monitoring the progress of policies, (iv) investment in technology and infrastructure development, (v) collaborative mechanism development for urban and rural areas, (vi) financial incentive establishment, and (vii) market establishment for the circular plastic economy.

(i) Effective policy planning and implementation (governance)

Since around 2010, emerging countries in the region – such as Indonesia, Malaysia, the Philippines, Thailand, and Viet Nam – have gradually prepared and clarified legislation on waste management and policies on recycling and sorting of waste materials (UNCRD, IGES, and Ministry of the Environment, 2018). On the other hand, the roles of different government agencies and the division of roles between central and local governments are still often ambiguous, especially in terms of promoting recycling policies and developing infrastructure for integrated waste management (Hotta, 2013).

As highlighted in section 2 of this chapter, the key to combating plastic pollution lies in efforts at each stage of the plastic life cycle: plastic production, use and consumption, waste plastic management and recycling, plastic leakages into the environment, and the coordination of these efforts. However, with certain exceptions, governments have not been good at creating the mechanisms for cooperation amongst multiple ministries and agencies, nor at promoting efforts through the industry–academia–government collaboration to nurture innovative solutions.

On the other hand, in countries such as Indonesia, the Philippines, Thailand, and Viet Nam, there are moves towards the formulation of national strategies and the formation of industry–academia–government partnerships. Thailand developed a Roadmap on Plastic Waste Management (2018–2030) (Pollution Control Department, 2019) and the Action Plan on Plastic Waste Management Phase II (2023–2027) (Pollution Control Department, 2023), as well as establishing the Science, Technology, and Innovation (STI) platform for closed loop plastics packaging (Palapleevalya, 2024). Viet Nam developed a National Action Plan for Management of Marine Plastic Litter by 2030 and launched a National Plastic Action Partnership as a multi-stakeholder implementation process of the action plan, with support from the World Economic Forum (Asokan et al., 2023). The Philippines also launched a National Plan of Action for the Prevention, Reduction, and Management of Marine Litter in 2021, outlining 10 actions to address plastic leakage into the environment (Department of Environment and Natural Resources, 2021). Like Viet Nam and Indonesia, the Philippines also launched a National Plastic Action Partnership in 2025 to implement the national action plans (UNDP Philippines, 2025). Furthermore, the Philippines enacted the Extended Producer Responsibility Act of 2022, focusing on the role of industry players in the recovery of plastic.

(ii) Data-driven policymaking

Capacity development on data management and harmonisation is becoming an urgent task for ASEAN. Increasing emphasis is being placed on long-term policy goal-setting and the development of the corresponding indicators, including amongst the Sustainable Development Goals, as well as on the expected reporting system for implementing national actions under the global plastics treaty and other global reporting mechanisms (Hotta, Tasaki, and Koide, 2021). Thus, it is becoming crucial for the region to continue its efforts to harmonise measurement processes for policy monitoring on the circular economy, waste management, and plastic pollution. Increasingly, international programmes emphasise the importance of data quality and capacity development for evidence-based policymaking (Akenji et al., 2019; ASEAN, 2021). There is a need to have a regional function either under ASEAN or ASEAN+3 as a regional collaborative framework to ensure comparable and credible data across countries. For this reason, institutional capacity should be strengthened to improve data management for evidence-based policymaking throughout the region.

At the same time, academic research with policy recognition and influence on plastic pollution issues (e.g. Jambeck et al., 2015; Geyer, Jambeck, and Law, 2017; and Lau et al., 2020) tends to emphasise the contribution of land-based sources rather than the environmental and hazardous impacts of marine plastic pollution. This tendency aligns with the mainstreaming trend of the circular economy as a policy theme, requiring international cooperation. Consequently, as seen in OECD reports (OECD, 2022a; 2022c; 2025), it has been linked to the importance of policy approaches focused on improving waste management, mainstreaming the circular economy, and developing waste and recycling infrastructure as well as some upstream product measures, rather than on specific pollution or management of risks associated with specific products or uses of plastics. For evidence-based policymaking beyond the circular economy towards life-cycle approaches to plastic products and associated impacts, it will be necessary to enhance scientific research that focuses on priority initiatives, target products, and environmental and health impacts of substances. This should shift from macro-level plastic pollution estimates to address local-level policy needs for promoting national efforts for risk management as well as sustainable business model development to reduce plastic pollution, while paying attention to more local and micro-level health issues and direct pollution problems. For this, it is essential to improve communication amongst academia, business, and government.

(iii) Capacity for monitoring the progress of policies

AMS tend to lack time-series waste-related data in general, with a few exceptions (UNCRD, IGES, and Ministry of the Environment, 2018). Even when time-series data do exist, they may be rough estimates such as waste generation per population multiplied by population growth (UNCRD, IGES, and Ministry of the Environment, 2018). One of the biggest challenges for data collection and management is the lack of a mechanism for data sharing between central and local governments or amongst different ministries (Hotta, 2013). Data on plastics are also lacking in most cases, either because the data necessary to depict economy-wide material flows are not available or because of lack of data that can be cross-referenced (Asokan et al., 2023). Even when data on the production and consumption of plastics exist, they are not linked to downstream plastic waste generation and flows according to the means of its disposal (Asokan et al., 2023).

In terms of research and analytical capacity, there is a relatively large pool of experts, universities, and government agencies in China, Indonesia, Japan, the Republic of Korea, Malaysia, and Thailand that can collect and estimate data on such waste management and provide policy implications. However, in some cases, such as in Cambodia, the Lao People's Democratic Republic (Lao PDR), and Myanmar, official government data as well as national specialised agencies and even experts are only sporadically available. Furthermore, the collection and recycling of valuable materials by the informal sector, open dumping into rivers and other waterways in urban poor areas and rural areas where waste collection services are inaccessible, and plastic waste and other spills that litter towns and suburbs during the monsoon season, make it difficult to ascertain relevant data for policy formulation and monitoring (Hibino et al., 2024). It is therefore important to break the vicious circle in which the lack of data prevents clear policies and measures from being put in place, exacerbating the situation. Fortunately, the circular economy and the prioritisation of plastic pollution issues appear to be breaking this vicious circle in some countries.

(iv) Investment in technology and infrastructure development

In many cases, basic plastic pollution prevention measures have not been implemented due to the lagging development of infrastructure and systems for waste collection and management. This is especially true in least developed countries such as Cambodia and Myanmar, as well as in rural areas and small municipalities. On the other hand, basic measures such as improving waste management, preventing littering and run-off, and cleaning up rivers and coastal areas are likely to have a significant effect. Coordination between the plans indicated by the central government and the efforts of local governments will also be crucial.

Collaborative mechanism development for urban and rural areas

Infrastructure and technology disparities between urban and rural areas and between advanced and less developed regions make it challenging to implement national policies. This could cause unintended trade in collected recyclables due to inconsistencies in policies and infrastructure for managing the targeted recyclables (Hotta et al., 2008). At the same time, compared with large cities, rural towns and regions have limited capabilities in terms of budget, personnel, and infrastructure. They face significant challenges in properly managing waste – which is the source of plastic pollution – and preventing environmental pollution in rivers, lakes, and seashores. It is essential to recognise that rural towns pose a risk of becoming major sources of plastic pollution.

Financing to implement action plans

In less developed economies such as Cambodia, the Lao PDR, and Myanmar or in rural local governments, a lack of national or local budget allocation for policy implementation is one of the major issues. Governments have started to develop action plans, but there is no budget planning/allocation. This leads to a lack of leadership and capacity on the part of the central government, which finds it difficult to coordinate various initiatives by local communities and governments as well as aid projects from international organisations. As suggested by OECD (2025), more comprehensive financial mechanisms, including multilateral ones, need to be considered and developed to implement national action plans that can be harmonised and coordinated with global and regional agreements.

Market establishment for circular plastic economy

In terms of domestic supply chains in the region, only a few countries cover the entire supply chain of plastic materials, products, and end-of-life products. Many countries are dependent on imports of plastic products and containers, or they rely on exports to other countries for proper recycling. Therefore, when introducing policy approaches such as extended producer responsibility, it is necessary to consider the implications from the perspective of international trade. As discussed in section 1, countermeasures against plastic pollution are deeply intertwined with mainstreaming the circular economy. From this perspective, realising national action plans for plastic pollution requires formalising markets for collected recyclable plastics and adopting an industrial policy perspective on determining what products and materials should be covered.

6. Conclusion

This chapter has discussed how comprehensive efforts throughout the plastic life cycle are crucial, as indicated by policy agreements by the G20, G7, and UNEA; reports from international organisations, such as those from the OECD; and academic research. Both the OECD's *Global Plastics Outlook and Regional Plastics Outlook for Southeast and East Asia* highlighted the importance of policy implementation cooperation and infrastructure investment through collaboration and coordination amongst developing countries, emerging economies, and developed nations. Consequently, institutional development, industry–academia–government collaboration, capacity building, and investment in emerging and developing countries such as AMS has become crucial for addressing plastic pollution.

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Chapter 3

Ecological Impacts of Plastic Pollution

Junko Toyoshima

1. Introduction

Plastic pollution has emerged as one of the most pervasive and persistent threats to marine ecosystems worldwide. Due to its durability and resistance to natural degradation, plastic debris accumulates rapidly, with projections suggesting that by 2050, the total mass of plastics in the oceans could surpass that of fish (World Economic Forum, Ellen MacArthur Foundation, and McKinsey & Company, 2016). Recent scientific research has revealed that plastic pollution is not confined to highly populated coastal areas, but extends to remote islands, the deep sea, and even the polar regions (Nakajima, 2019).

Marine plastic debris exists in various forms, from large macroplastics such as fishing nets and packaging materials to microplastics (less than 5 millimetres) and nanoplastics (less than 1 nanometre. Both pose serious risks to marine organisms, including entanglement, ingestion, physical injury, and chemical exposure (UNEP, 2021). While the ecological impacts are increasingly recognised on a global scale, significant knowledge gaps remain in understanding the situation in the Association of Southeast Asian Nations (ASEAN) region. Therefore, this chapter focuses on the ASEAN region to review current research on the ecological impacts of macroplastics, microplastics, and nanoplastics – highlighting the most affected species and habitats, identifying data gaps, and considering the broader implications for marine biodiversity conservation.

2. Distribution of marine plastic in the world's oceans

Global plastic production exceeds 400 million tons (Mt) annually, and a total of 8.3 billion tons of plastic were manufactured from 1950 to 2015 (Geyer, Jambeck, and Law, 2017). According to Williams and Rangel-Buitrago (2022), about 150–400 Mt (1.8%–4.7% of total production) are estimated to have entered the oceans already, and about 10 Mt are estimated to enter the oceans every year. With the current pace of economic growth, global plastic production is projected to almost triple by 2060 (OECD, 2022). Plastic is resistant to natural decomposition in the environment and is estimated to take hundreds of years to decompose (Barnes et al., 2009). As a result, the amount of plastic in the ocean is rapidly accumulating. The World Economic Forum predicted that the total amount of plastic in the world's oceans will exceed the total amount of fish by 2050 (World Economic Forum, Ellen MacArthur Foundation, and McKinsey & Company, 2016).

The ecological impacts of marine plastic pollution have been studied since around the 1970s, and recent research results indicate that the impacts of plastic pollution have been widespread, including remote islands and the deep sea (Nakajima, 2019). Polar regions – Antarctica and the Arctic Ocean – are no exceptions since macroplastics and microplastics are observed in the ice, snow, air, and seawater (Toyoshima, 2021). Microplastics are also found not only in the ocean but also in lakes, streams, soils, and the atmosphere (Thompson et al., 2024). Furthermore, plastic debris in the ocean is not uniformly distributed. Since the pollution source is concentrated in the Northern Hemisphere, megaplastics and macroplastics have accumulated in higher densities in the Northern Hemisphere, adjacent to urban centres, in enclosed seas, and at water convergences (Barnes et al., 2009). The ASEAN region, recognised as a major source of plastic pollution, also has relatively high concentrations of marine plastic debris in its nearby oceans (Eriksen et al., 2014). Once plastic debris has entered the ocean, it is transported by ocean currents and tends to concentrate in five subtropical ocean gyres (van Sebille et al., 2015). Eventually, the plastic either gets washed up on the seashore or sinks to the bottom of the ocean floor through physical or biological processes (Chen et al., 2025; Zhao et al., 2025). Microplastics, which are relatively small particles (< 5 millimetres) of plastics, are found throughout surface and subsurface water columns in the ocean but exist in higher concentrations near the coast compared with the open ocean (Zhao et al., 2025).

3. Ecological impacts of macroplastics

Marine plastic litter poses a serious threat to marine biodiversity. For example, Gall and Thompson (2015) reviewed 340 original publications and found that at least 690 different species have been impacted by marine debris, 92% of which was plastic. These involved 44,006 individuals from 395 species for entanglement and 13,110 individuals from 208 species for ingesting marine debris. However, there are likely to be far more numerous cases that have not been documented. All sea turtle species, 54% of marine mammal species, and 56% of seabird species were affected by entanglement in or ingestion of marine debris. Moreover, at least 17% of the impacted species appear on the International Union for Conservation of Nature Red List of Threatened Species (IUCN Red List) as 'near threatened' or 'threatened' (Gall and Thompson, 2015). Despite the growing concerns shown by this research, it is hard to estimate the exact degree of the impacts due to lack of quantitative data collection and surveys.

Entanglement of marine life is mostly caused by fishing nets and ropes, and the most affected species include sea turtles such as the green sea turtle (*Chelonia mydas*) and hawksbill turtle (*Eretmochelys imbricata*), marine mammals such as the North Atlantic right whale (*Eubalaena glacialis*), and seabirds (Gall and Thompson, 2015). Seventy-nine percent of reported cases of entanglement caused direct harm or death of the individuals, which is far greater than ingestion (4%) (Gall and Thompson, 2015). The impact of marine pollution caused by fishing gear and its countermeasures is discussed in more detail in Chapter 9.

Many species of marine life mistake plastics for food and ingest them. Gall and Thompson (2015) reported that the incidence of ingestion of marine debris by species was most numerous for the green sea turtle (*C. mydas*), northern fulmar (*Fulmaris glacialis*), and loggerhead turtle (*Caretta caretta*). Schuyler et al. (2012) investigated 115 sea turtles stranded in Queensland, Australia and found that 54.5% of pelagic feeding turtles had ingested debris compared with only 25% for benthic feeding turtles. The turtles showed a preference for soft, clear plastic and rubber items such as balloons, which supports the hypothesis that sea turtles ingest marine debris because it resembles their natural prey such as jellyfish (Schuyler et al., 2012). Roman et al. (2021) identified high-risk plastic items that can cause the death of individuals. These items included plastic bags/sheets/packaging, rope/fishing nets, fishing hooks, and balloons/latex. Ingestion of plastics may also have less conspicuous, sublethal influences such as reduced body condition or physiological changes, but these are not yet well understood (Puskic, Lavers, and Bond, 2020).

Amongst avian species, Procellariiformes are the most threatened group globally with the highest frequency of ingesting marine debris (Roman et al., 2019). Roman et al. (2019) analysed data for the cause of death of 1,733 seabirds covering 51 species and demonstrated that ingesting a single item of debris can cause a 20.4% chance of death. The mortality rate rises as the number of items ingested increases, reaching 100% after consuming 93 items. Obstruction of the gastrointestinal tract was the leading cause of death. Again, balloons are the highest-risk debris item, with a mortality rate 32 times higher than when hard plastic is ingested. According to Poon et al. (2017), the degree of susceptibility to the impact of plastic waste varies according to the feeding styles of seabirds. Compared with species that dive into the water to capture prey, such as the thick-billed murre (*Uria lomvia*) and black guillemot (*Cepphus grille*), surface feeders such as the northern fulmar (*Fulmarus glacialis*) and black-legged kittiwake (*Rissa tridactyla*) had a higher rate of ingesting plastics. Amongst these, the northern fulmar is probably the most well-studied species because of its status as an indicator species in the international marine debris monitoring programme under the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR Convention). For example, in a study carried out on the Svalbard Islands, an average of 15.3 pieces of plastic were found in the stomachs of 35 out of 40 birds (87.5%) (Trevail et al., 2015). Similarly, in a study conducted in the Canadian Arctic, plastic fragments were found in the stomachs of 84% of birds (Provencher, Gaston, and Mallory, 2009).

As for cetaceans, more than 48 species have been reported to ingest plastic debris, with rates of ingestion as high as 31% in some populations (Baulch and Perry, 2014). These include killer whales, pygmy sperm whales, and manatees (Gall and Thompson, 2015). For example, in 2008, two dead male sperm whales (*Physeter macrocephalus*) were found stranded on the northern California coast, with large amounts of fishing net scraps, rope, and other plastic debris in their stomachs (Jacobsen, Massey, and Gulland, 2010). One of them had a ruptured stomach that was compacted with plastic debris, and gastric impaction was suspected as the cause of their death. There are many examples of such reports in the literature, but they are thought to be only a fraction of numerous unreported cases. Debris-related mortality rates of 0%–22% amongst stranded cetaceans were documented, suggesting that debris may be a significant conservation threat to some species (Baulch and Perry, 2014).

Compared with the impact of marine plastic debris at the organism level, the impact at the ecosystem and/or population level is less studied. There are some studies on the impacts of plastic debris on coral reef ecosystems, such as de Carvalho-Souza et al. (2018), which found 418 reef species across various taxa interacting with plastic debris. Entanglement in abandoned fishing gear was most observed. Smothering or covering of reef species is also common, leading to physical damage such as breaking the branches of colonial corals or causing severe lesions on polyps and tissues (de Carvalho-Souza et al., 2021). Coral polyps are usually able to recover from damage, but severe damage can cause colony mortality or invasion by pathogens, leading to deterioration of reef ecosystems

4. Ecological impacts of microplastics and nanoplastics

Microplastics are also ingested by many types of marine organisms, such as fish, invertebrates, and zooplankton. Tanaka and Takada (2016) investigated microplastics in the digestive tracts of Japanese anchovy (*Engraulis japonicus*) collected in Tokyo Bay, and microplastics were detected in 77% of 64 fish, with 2.3 pieces per fish on average including plastic fragments and microbeads. This raises a concern that humans are ingesting microplastics when they consume dried fish such as niboshi and shirasu. Similarly, Rochman et al. (2015) sampled fish and shellfish sold at fish markets in Indonesia and the United States, and around one-third of the fish contained microplastic particles. Microplastics are found not only in marine fish but also in freshwater fish in the Amazon River (Andrade et al., 2019). According to a review conducted by Wootton, Reis-Santos, and Gillanders (2021), globally, 49% of all fish sampled for microplastic ingestion were found to have ingested plastic, with an average of 3.5 pieces per fish, and fish from North America had ingested more plastic than fish from other regions. They also pointed out that more than 80% of research subjects were from marine environments, although on average freshwater fish ingested more plastic than marine fish.

Most ingested microplastics are excreted from the body without being absorbed, but small microplastics and nanoplastics may be absorbed into the body and accumulate in organs such as the liver and brain (Collard et al., 2017). The effects of ingested plastic are now well understood, but both physical and chemical effects are considered possible. For example, in experimental studies with Pacific oysters, reproductive capacity was significantly reduced after exposure to microplastics (Sussarellu et al., 2016). Microplastics are taken into the body by organisms such as coral and sea anemones, and may disrupt their symbiotic relationship with zooxanthellae (Okubo, Tamura-Nakano, and Watanabe, 2020). Microplastics that have accumulated in the brain may cause damage to the tissue and affect its function (Mattsson et al., 2017).

According to Andrady (2011), the chemicals of concern associated with microplastics are divided into three categories: (i) residual monomers and toxic additives from manufacture present in the plastic, which may leach out of the ingested plastic; (ii) some intermediates produced in the process of natural degradation of plastics, which may be toxic; and (iii) persistent organic pollutants that are present in seawater and absorbed and concentrated in the microplastic fragments. By ingesting microplastics, these toxic chemical compounds are absorbed into the body of organisms and accumulate in the organs. For example, amongst fin whales in the Mediterranean Sea, chemicals such as phthalates and persistent, bioaccumulative, and toxic (PBT) chemicals were detected in the blubber, and the whales showed signs of toxicological stress (Fossi et al., 2016). Similarly, toxic substances are found in seabirds (Tanaka et al., 2015) and even in deep sea organisms (Jamieson et al., 2017). Microplastic particles can also provide surface areas on which marine microbes can colonise and may serve as vectors of dispersal of microorganisms (Onda et al., 2020).

5. Ecological impacts in the ASEAN region

Southeast Asia is widely recognised as one of the most biologically diverse marine regions globally, supporting a high abundance and variety of species, including numerous endemic taxa. Nevertheless, recent assessments estimate that the region cumulatively contributes about one-third of total global marine plastic pollution. Such pollution constitutes substantial threats to riverine, marine, and coastal megafauna, ecosystems, and ecosystem services, although scientific understanding of their extent and long-term implications remains limited.

According to Veettil et al. (2023), mangrove ecosystems, dunes, and subsoil are considered as major sinks of coastal plastic litter in Viet Nam, whereas seagrass meadows and deep oceans are major sinks of marine plastic debris, in addition to the coastal margins. The urban coastal area is also heavily polluted. According to Gajanur and Jaafar (2022), 25,532 items of abandoned, lost, or otherwise discarded fishing gear (ALDFG) were recovered in Singapore from 2000 to 2019, with 1,052 trapped organisms covering 124 species. The entanglement of corals, fish, and crabs with ALDFG in Thailand is also documented by Mehrotra et al. (2024). There have also been a few studies on microplastic concentrations in the Mekong River and its tributaries (Vongkhampheng et al., 2024; Mendrik et al., 2025). In a study by Mendrik et al. (2025), the downstream samples contained a much higher concentration of microplastics compared with upstream water samples, which were 64 pieces and 2 pieces of microplastics per cubic meter, respectively, suggesting significant leakage from the downstream urban area.

Omeyer et al. (2022) conducted a structured literature review of 338 publications on species of cartilaginous fishes, marine mammals, marine reptiles, and seabirds present in Southeast Asia, but only a few studies were conducted in Southeast Asian countries (5 studies for entanglement and 13 studies for ingestion). Moreover, published cases of plastic ingestion by wildlife were mostly available for marine mammals and fish, and information on seabirds in the region was entirely lacking. This study by Omeyer et al. (2022) showed that the information on the interaction between wildlife and plastic debris and on its ecological impacts is very limited in this region. One of the reports was from the Philippines on a stranded whale shark, which had pieces of plastic in its gills and inside its stomach (Abreo, Blatchley, and Superio, 2019). A drinking straw found in the stomach of a whale shark stranded in Thailand was suspected to have been the cause of death of the individual (Haetrakul et al., 2009). Prampramote et al. (2022) investigated the records of 388 stranded sea turtles in the Central Gulf of Thailand from 2017 to 2020 and concluded that the ingestion of fishing net fragments and fibres is a significant cause of sea turtle stranding. Coram et al. (2022) used social media to collect data on marine mammal stranding and identified the Philippines as a hotspot of interaction of marine debris and cetaceans, with the Irrawaddy dolphin (*Orcaella brevirostris*) and pygmy sperm whale (*Kogia breviceps*) being particularly vulnerable species.

Omeyer et al. (2022) identified 21 key research questions and highlighted the importance of better understanding the fate of marine plastic pollution, as well as the impacts on and risks to ecosystem services. Additional research funding to collect baseline data and answer these research questions is urgently and critically needed to inform political decisions so that the necessary actions can be taken.

6. Discussion and conclusion

Marine plastic pollution is a global environmental crisis with profound ecological consequences. Macroplastics cause direct harm through entanglement and ingestion, threatening a wide range of species, including sea turtles, seabirds, marine mammals, and coral reef organisms. Microplastics and nanoplastics, while less visible, infiltrate marine food webs, potentially bioaccumulating in tissues and introducing harmful chemicals to organisms, with implications for both ecosystem health and human food security.

In addition, there seem to be significant knowledge gaps in the current research of ecological impacts. As for entanglement issues, most studies concentrate on turtles, birds, and marine mammals, while fish and invertebrates are less studied. Overall, there are more studies on entanglement compared with ingestion (Gall and Thompson, 2015). Furthermore, the physiological impacts of ingesting microplastics and nanoplastics are not well understood, especially in the wild. Most physiological studies are based on experimental exposure to microplastics in aquariums, with a higher concentration than in the natural environment. Such conditions are not realistic but may occur in the future if microplastic concentration continues to increase in the ocean as predicted by some researchers (Isobe et al., 2019). Lastly, for macroplastics, microplastics, and nanoplastics, most of the existing literature addresses the impacts at the organism level, and knowledge on impacts at the ecosystem level is significantly lacking. Amongst the types of ecosystems, coral reefs are perhaps most well studied, and there are very limited studies on other types of ecosystems such as mangrove forests, seagrass beds, or estuaries.

In the ASEAN region, despite being a significant contributor to global marine plastic pollution, research on ecological impacts remains sparse. The limited available studies indicate that the region's rich biodiversity – including mangrove ecosystems, seagrass meadows, coral reefs, and marine megafauna – is vulnerable to plastic debris. Addressing these knowledge gaps through targeted research is critical for understanding the full scope of impacts and for informing effective policy interventions. Mitigating plastic pollution will require coordinated global and regional actions, combining improved waste management, reduction of plastic production and consumption, and enhanced monitoring of marine ecosystems.

While it is necessary to increase research funding and engage in further efforts to better understand the extent of the ecological impacts of ever-increasing plastic debris on marine ecosystems and make future projections, one of the promising strategies to increase the data seems to be the application of citizen science and the use of social media as a data collection tool. There already exist some examples of such studies. For example, Bergmann et al. (2017) collected pictures of interactions of wildlife with plastic litter from the passengers of an Arctic cruise ship and revealed that plastic litter has deleterious effects on Arctic wildlife including polar bears. Bottari et al. (2024) collected data via social media, such as Google, Facebook, and Instagram, and revealed that ALDFG is the primary contributor to the entanglement of numerous marine species in Italy. Similarly, Abreo et al. (2019) used Facebook to collect data on plastic ingestion by marine megafauna in the Philippines. Mehrotra et al. (2024) carried out 103 surveys over a 3-year period across Thailand involving volunteer underwater divers, resulting in the impact assessment of 606 pieces of ALDFG. This study pointed out, however, that the complexity of survey protocol discourages the divers' motivation, so one challenge is to ensure that survey protocols are kept simple, while maintaining data quality and precision. In citizen science, the role of scientists is important in designing the methodologies and survey protocol, as well as for training of the citizen participants, and data analysis and interpretation.

Applying a precautionary approach is also strongly recommended. We can already see that plastic pollution has a negative impact on the natural environment, as described above, so we need to be more proactive and accelerate our efforts to stop plastic leakage into the environment without waiting for the data to accumulate.

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Chapter 4

Plastic Pollution and Its Detrimental Effects on Human Health

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1. Introduction

Plastics, known for their versatility, durability, and affordability, are ubiquitous in everyday life. Their consumption, particularly of single-use items like packaging – the largest application of plastic resins (UNIDO, 2023) – surged during the coronavirus disease (COVID-19) pandemic and even post-pandemic, driven by increased reliance on packaging for hygiene, the expansion of e-commerce (Patrício Silva et al., 2021; Leal Filho et al., 2021), and the exponential growth in overall production and consumption (OECD, 2024). However, this growing reliance on plastics comes at a substantial environmental cost, driving a global crisis, as plastics constitute the largest, most harmful, and significant fraction of marine litter, accounting for at least 85% of total marine waste (UNEP, 2021; 2023c). Annually, an estimated 19–23 million tonnes (Mt) of plastic waste leaks into aquatic ecosystems such as lakes, rivers, and seas (UNEP, 2021; OECD, 2022).

Once in aquatic environments, plastic debris poses a profound threat to ecosystems and biota, especially in the Association of Southeast Asian Nations (ASEAN) Plus Three (ASEAN+3) region.[1] This region, especially the ASEAN Member States, is a global hotspot for plastic pollution (Curren et al., 2021), driven by increasing volumes of mismanaged waste, inefficient source segregation, and limited recycling. These issues led to about 33 Mt of mismanaged plastic waste in 2022, which is projected to rise to 56 Mt by 2050 (OECD, 2025).

Plastic waste, normally ranging from large items to microscopic fragments, is ingested by a vast array of aquatic organisms. Microplastics are ingested by over 220 marine species, including commercially vital fish stocks (Meaza, Toyoda, and Wise, 2021; Lusher, Hollman, and Mendoza-Hill, 2017), with high contamination by fibres and small fragments confirmed in Southeast Asian biota (Ali et al., 2024). Through the consumption of contaminated seafood, these plastics and their associated chemicals bioaccumulate and transfer to humans (Galloway, Cole, and Lewis, 2017; Smith et al., 2018; Traylor et al., 2024). Consequently, seafood-dependent Southeast Asian nations have the world's highest dietary microplastic intake, while microplastic daily ingestion in China, Japan, and the Republic of Korea (henceforth, Korea) can reach 153–269 milligrams per capita (Cho et al., 2019; Zhao and You, 2024).

The combination of high plastic leakage and seafood dependency magnifies the global plastics crisis into a direct human health risk. Beyond seafood, dietary exposure occurs through contaminated salt (Karami et al., 2017), honey (Gilani et al., 2025), beer (Liebezeit and Liebezeit, 2014), and drinking water (Koelmans et al., 2019). Microplastics also pollute agricultural soils (Rillig, 2012), enter the food supply via crops (Li et al., 2020), and harm essential soil organisms (Huerta Lwanga et al., 2016). Compounding this, atmospheric deposition ensures that contamination is ubiquitous (Allen et al., 2019), while the particles' ability to adsorb and transport harmful chemicals presents a significant, widespread health concern (Rochman et al., 2013).

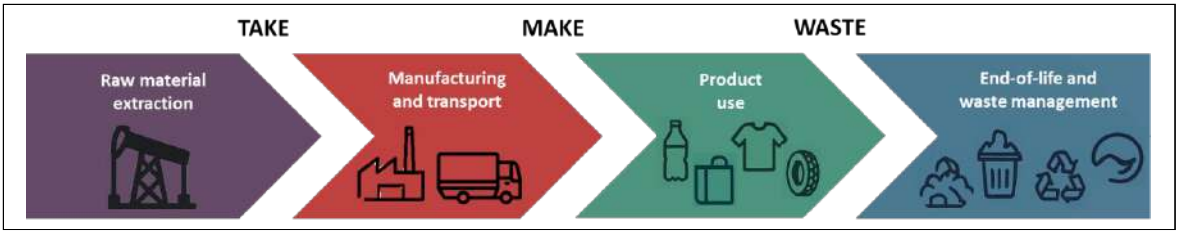
[1] The ASEAN+3 countries are the 11 ASEAN Member States (Brunei Darussalam, Cambodia, Indonesia, the Lao People's Democratic Republic (Lao PDR), Malaysia, Myanmar, the Philippines, Singapore, Thailand, Timor-Leste, and Viet Nam) plus China, Japan, and the Republic of Korea.

To address these complex and growing concerns, this chapter offers a comprehensive review of the latest scientific evidence on the human health impacts of plastics across their entire life cycle. Drawing on recent peer-reviewed studies and authoritative reports from international organisations such as the World Health Organization (WHO), the United Nations Environment Programme (UNEP), and the Organisation for Economic Co-operation and Development (OECD), it traces the evolution of research since 2000. While early studies focused primarily on the effects of larger plastic debris, research has increasingly shifted towards the significant risks posed by microplastics and nanoplastics. This chapter synthesises key findings from more than 100 recently published peer-reviewed articles in high-impact journals, along with related publications from well-recognised international organisations, providing a critical foundation to guide future research and inform evidence-based policy development.

2. Stages of the Plastic Life Cycle and Potential Environmental Contaminations

Health risks from plastics occur at every stage of their linear 'take-make-waste' life cycle (Figure 4.1). This process begins with the extraction of fossil fuels, the feedstock for over 99% of all plastics (UNEP, 2021). During manufacturing, potentially hazardous chemical additives are incorporated to achieve the desired properties (Zimmermann et al., 2019). After their use phase, most plastics are discarded. Due to inadequate waste management, 75% of all plastic ever produced has become waste, ending up primarily in landfills or the natural environment (Geyer, Jambeck, and Law, 2017). Land-based sources account for about 80% of plastic leaking into the oceans (Jambeck et al., 2015).

Figure 4.1. Take-Make-Waste Linear Model of Plastics



Source: Authors.

Throughout this life cycle, microscopic plastic particles are generated. These are broadly categorised as primary or secondary microplastics (Hanke et al., 2013) (Figure 4.2). Primary microplastics are intentionally manufactured particles, such as industrial pellets (nurdles) or cosmetic microbeads, which are released directly into the environment (Eerkes-Medrano, Thompson, and Aldridge, 2015; Patil et al., 2024). The majority, however, are secondary microplastics, which form as larger plastic items break down due to ultraviolet (UV) radiation, mechanical abrasion, and chemical oxidation (Andrady, 2011; Gewert, Plassmann, and MacLeod, 2015). Key sources of secondary microplastics include fibres shed from textiles and particles from vehicle tyre wear (Boucher and Friot, 2017; UNEP, 2023c).

Figure 4.2. Shape, Common Sources, and Polymer Composition of Microplastics (Primary and Secondary)

Shape	Common source	Polymer composition
Fragment	Cutlery, bottles, bags, films, caps	PET, PE, PVC, PP, PS, PC
Fiber	Textiles, cigarette filters, diapers, nets	PET, PP, PA, nylon
Foam	Disposable packaging, food containers	PS (EPS), PU
Microbead	Personal care products, cosmetics	PET, PE, PVC, PP, PS, PMMA
Pellet	Manufactured pellets (raw materials)	PET, PE, PVC, PP, PS

EPS = expanded polystyrene, PA = polyamide (commonly known as nylon), PC = polycarbonate, PE = polyethylene, PET = polyethylene terephthalate, PMMA = polymethyl methacrylate, PP = polypropylene, PS = polystyrene, PU = polyurethane, PVC = polyvinyl chloride.
Source: Authors.

Crucially, this fragmentation continues relentlessly, creating nanoplastics (particles < 1 micrometre) (WHO, 2019). A single litre of bottled water can contain an average of 240,000 detectable plastic fragments, 90% of which are nanoplastics (Qian et al., 2024). These nanoparticles are a heightened toxicological concern because their small size enhances their ability to penetrate biological barriers, such as cell membranes and the blood–brain barrier, leading to systemic exposure within an organism (Kopatz et al., 2023).

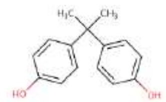
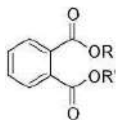
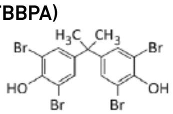
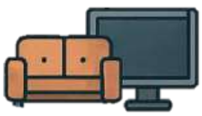
The health risks posed by plastics also extend beyond the physical presence of the particles themselves. Plastics are not pure, inert polymers but complex chemical composites. To achieve desired properties like flexibility, colour, flame resistance, and UV stability, manufacturers incorporate a vast array of chemical additives (Geyer, Jambeck, and Law, 2017). There are over 13,000 distinct chemicals associated with plastics, of which more than 3,200 have one or more hazardous properties of concern (UNEP, 2023b). Critically, some of the additives are not chemically bound to the polymer matrix. This allows them to leach out during a product's use and disposal, a process that is dramatically accelerated by environmental degradation (Zimmermann et al., 2019).

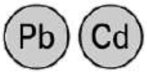
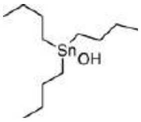
The physical fragmentation of plastics into microplastics and nanoplastics is not just a physical process but is also a chemical accelerant. As larger plastic items break down, their surface area–volume ratio increases exponentially. This exposes vast new surfaces, which significantly enhances the rate at which unbound chemical additives can leach from the plastic's core into the surrounding environment and, ultimately, into organisms (Hahladakis et al., 2018). Consequently, aged and fragmented plastic debris acts as a mobile point source for toxic chemical release, becoming progressively more hazardous over time (Thompson et al., 2024).

This dynamic creates a fundamental challenge for waste management and the concept of a circular economy. While recycling is promoted as a key solution, it can inadvertently perpetuate a 'toxic loop'. The plastic waste stream is a heterogeneous mix of different polymers containing thousands of poorly regulated additives. Standard mechanical recycling processes are not designed to identify or remove these embedded chemicals. As a result, the recycled plastic pellets, or 'recyclate', carry a legacy of these hazardous substances (Gregory, 2023). When this contaminated recyclate is used to manufacture new products – especially those for food contact, personal care, or toys – it can re-expose consumers to the very chemicals that health and environmental policies aim to control.

Many of these leached chemicals are of high concern due to their endocrine-disrupting, carcinogenic, or neurotoxic properties (Rochman, 2015). Table 4.1 summarises some of the most prevalent chemical classes found in plastics and their documented health effects.

Table 4.1. Common Chemical Additives in Plastics and Their Uses and Potential Primary Health Concerns

Chemical/Class	Common polymer/use	Primary health concerns	Reference
Bisphenol (e.g. BPA) 	Polycarbonate (food/drink containers), epoxy resins (can linings) 	Oestrogen mimicry, obesity, cardiovascular disease, reproductive risks	(Campanale et al., 2020; Rochester, 2013; UNEP, 2023b)
Phthalates (e.g. DEHP) 	PVC flooring, tubing, food wrap, toys 	Anti-androgenic, developmental neurotoxicity, reproductive harm	(Hlisníková et al., 2020; UNEP, 2023b)
Brominated flame retardants (e.g. TBBPA) 	Electronics, housing, furniture foam, textiles 	Neurodevelopmental, thyroid disruption, cancer, persistent chemicals	(Costa et al., 2008; Legler, 2008; UNEP, 2023b)
PFAS (e.g. PFOA) 	Non-stick cookware, grease-proof packaging, textiles 	Cancer, immunosuppression, developmental and thyroid effect	(Fenton et al., 2021; Blum et al., 2015; UNEP, 2023b)

Chemical/Class	Common polymer/use	Primary health concerns	Reference
Heavy metals (e.g. lead, cadmium) 	PVC stabilisers, pigments 	Neurotoxicity, kidney disease, developmental delays, cancer	(Campanale et al., 2020; UNEP, 2023b; WHO, 2010)
Organotins (e.g. TBT) 	PVC stabilisers, antifouling paints 	Endocrine and neurotoxicity, ecotoxic impacts	(Antizar-Ladislao, 2008; UNEP, 2023b)

BPA = bisphenol A, DEHP = diethylhexyl phthalate, PFAS = per- and polyfluoroalkyl substances, PFOA = perfluorooctanoic acid, PVC = polyvinyl chloride, TBBPA = tetrabromobisphenol A, TBT = tributylin.
Source: Authors, based on supporting scientific evidence from the cited sources.

These hazardous additives are integral to a vast range of consumer and industrial products. Bisphenols like bisphenol A (BPA) are found in polycarbonate food and drink containers, while various phthalates are used to make polyvinyl chloride (PVC) flexible for products such as toys, flooring, and food wrap (UNEP, 2023b). To ensure safety and durability, other chemicals are added; brominated flame retardants (BFRs) are applied to electronics and furniture to prevent fires, while heavy metals and organotins have been used as stabilisers in PVC (Costa et al., 2008; Antizar-Ladislao, 2008). Furthermore, per- and polyfluoroalkyl substances (PFAS) chemicals provide grease- and water-resistant properties to textiles and food packaging (Blum et al., 2015).

The health risks associated with these common chemicals are significant and varied. A primary concern is endocrine disruption, where chemicals mimic or block the body's natural hormones. Bisphenols, for instance, are known to mimic oestrogen (Rochester, 2013), while certain phthalates exhibit anti-androgenic effects that can lead to reproductive harm (Hlisníková et al., 2020). Many of these additives also pose a threat to neurological and developmental health. BFRs, heavy metals like lead, and organotins are all linked to neurotoxicity and can impair proper neurodevelopment (Legler, 2008; WHO, 2010; Antizar-Ladislao, 2008). Moreover, several of these chemical classes are associated with an increased risk of cancer and immune system dysfunction, particularly PFAS (Fenton et al., 2021), creating a complex web of health threats from everyday plastic products (Campanale et al., 2020).

3. Human Exposure Pathways and the Detection of Plastic inside the Human Body

Humans are inevitably exposed to plastics through three primary routes: ingestion, inhalation, and dermal contact (Gasperi et al., 2018; UNEP, 2021) (Figure 4.3). It is now confirmed that these particles cross biological barriers to invade deep tissues and organs (Vethaak and Legler, 2021).

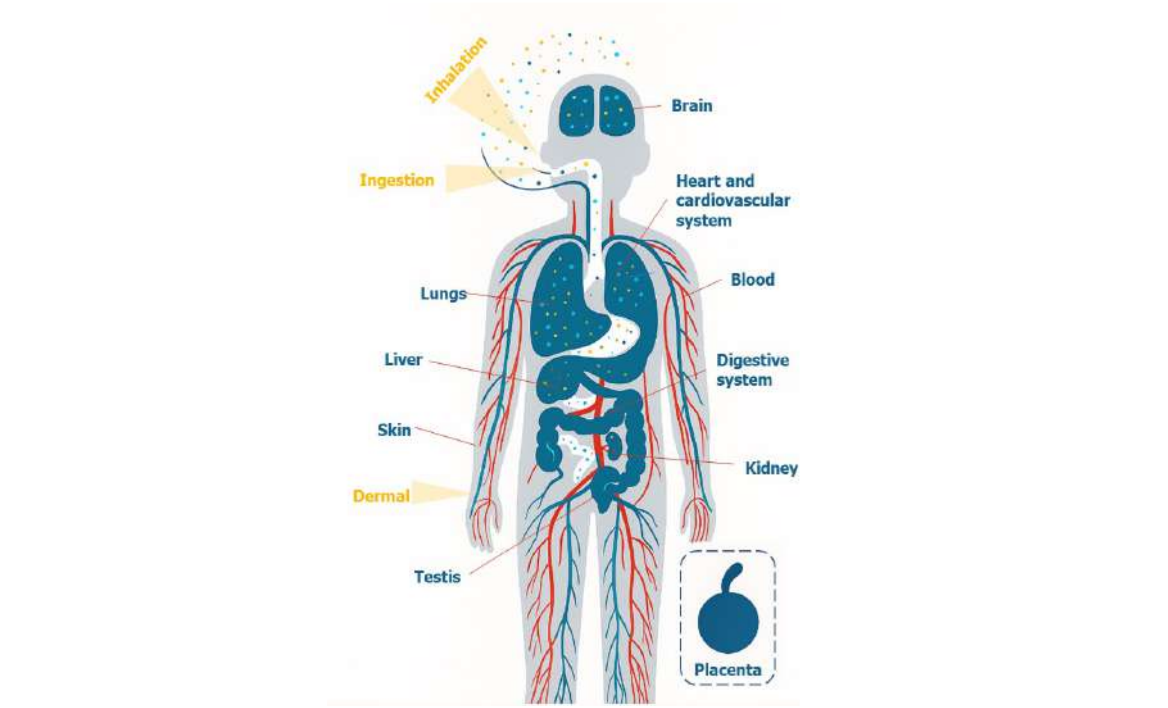
Ingestion is the dominant exposure pathway. This occurs through the food chain via contaminated seafood (Hantoro et al., 2019), and through common consumables like salt, honey, and beer (Cox et al., 2019; Gilani et al., 2025; Karami et al., 2017; Liebezeit and Liebezeit, 2014). Drinking water is another major source, as opening plastic bottles can release hundreds of thousands of nanoplastics (Qian et al., 2024). Particles also migrate from food packaging, a process accelerated by heat (Zimmermann et al., 2019). Inhalation of airborne particles from textiles and tyre wear is also a key route, allowing particles to lodge deep in the lungs (Boucher and Friot, 2017; Jenner et al., 2022). Dermal contact with cosmetics or clothing is a third pathway, with nanoplastics potentially penetrating compromised skin (Feng et al., 2023; Nawab et al., 2024).

This exposure leads to systemic contamination, with particles translocating from the gut and lungs into circulation (Enyoh et al., 2023; Dzierżyński et al., 2025; Thapliyal et al., 2025). Evidence of this invasion is now widespread (Figure 4.3):

- **Blood**: Polymers like polyethylene terephthalate (PET) and polyethylene (PE) are found in the blood of healthy donors, confirming systemic uptake (Leslie et al., 2022; Brits et al., 2024). Their presence has been linked to biomarkers for thrombosis (Lee et al., 2024).
- **Brain**: Following animal studies (Kopatz et al., 2023), autopsy research has confirmed that PE and polystyrene (PS) microplastics can cross the blood–brain barrier and accumulate in human brain tissue, raising neurotoxicity concerns (Prüst, Meijer, and Westerink, 2020).
- **Heart and cardiovascular system**: Microplastics have been found in human heart tissue and saphenous veins (Yang et al., 2023; Rotchell et al., 2023). Crucially, their presence in atherosclerotic plaques is linked to a significantly higher risk of heart attack, stroke, and death (Marfella et al., 2024).
- **Digestive system**: Microplastics, such as polycarbonate (PC) and polyamide (PA), are found embedded in human colon tissue (Ibrahim et al., 2021), and faecal concentrations are correlated with inflammatory bowel disease (Yan et al., 2022).
- **Lungs**: Plastic fibres and fragments are confirmed deep within the lung tissue of living patients and in fluid washed from the lungs (Pauly et al., 1998; Amato-Lourenço et al., 2021; Jenner et al., 2022; Tokito et al., 2025).
- **Reproductive system and early life**: Particles cross the placenta, leading to foetal exposure (Ragusa et al., 2021; Zhu et al., 2023). They are found in meconium, breast milk, and infant faeces, with infants showing higher concentrations than adults (Liu et al., 2023; Zhang et al., 2021). Microplastics have also been detected in human testes and semen (Zhao et al., 2023; Hu et al., 2024).
- **Skin and excretory system**: While healthy skin is a strong barrier (Wang and Wang, 2014), nanoparticles may penetrate via hair follicles (Yee et al., 2021; Menichetti, Mordini, and Montalti, 2025). The detection of plastics in urine also confirms systemic absorption and kidney filtration (Pironti et al., 2023; Massardo et al., 2024).

- **Other organs**: Consistent with animal studies (Deng et al., 2017), microplastics, including PE, PP, and PET, have been identified in human liver, spleen, and kidney tissues (Horvatits et al., 2022; Exacoustos et al., 2023).

Figure 4.3. Human Exposure Pathways and Microplastic Detection in Human Organs



Source: Authors.

Annex A-1 summarises findings from numerous studies regarding the concentration, size, and polymer types of microplastics detected in various human organ systems and biological samples.

4. Health Impacts of Plastics

Recent scientific evidence confirms that exposure to plastics is not superficial, as microplastics and nanoplastics can breach biological barriers and accumulate systemically, posing health risks through a dual-threat mechanism of physical and chemical toxicity (Leslie et al., 2022; Dzierżyński et al., 2025; Ragusa et al., 2021; Feng et al., 2023) (Figure 4.4).

The physical toxicity of the particles themselves can induce inflammation and cellular damage. The physical particle effects are triggered by the mere presence of foreign particles in tissues. This can initiate a cascade of host responses, including persistent, low-grade inflammation, the generation of reactive oxygen species (ROS) leading to oxidative stress, and direct cytotoxicity and genotoxicity, which can damage cell structures and DNA (Feng et al., 2023; Thapliyal et al., 2025). On the other hand, chemical toxicity stems from the thousands of hazardous additives like bisphenols, phthalates, and PFAS that are not chemically bound to the polymer and can leach out (UNEP, 2023b; Hahladakis et al., 2018). After entering the body, the plastic particles can act as vectors, delivering a localised, high-concentration dose of these chemicals directly to internal tissues (Rochman et al., 2013; Campanale et al., 2020).

These dual toxicities manifest in various physiological system impacts (Figure 4.4). In terms of metabolic disorder, leached chemical additives are strongly linked to obesity, diabetes, and thyroid dysfunction (Rochester, 2013; Campanale et al., 2020; UNEP, 2023b).

For reproductive and developmental toxicity, adverse outcomes are tied to both the physical presence of particles in the testis and the endocrine-disrupting effects of leached chemicals on fertility, with the developing foetus being particularly vulnerable (Hu et al., 2024; Rochester, 2013; Ragusa et al., 2021).

Regarding neurotoxicity, nanoplastics can physically cross the blood–brain barrier to induce neuroinflammation, while chemical additives are independently associated with neurodevelopmental and neurodegenerative disorders (Kopatz et al., 2023; Prüst, Meijer, and Westerink, 2020; Rochester, 2013).

The evidence for cardiovascular effects is particularly compelling, as the physical presence of microplastics and nanoplastics within atherosclerotic plaques is strongly correlated with a higher risk of heart attack, stroke, and death (Marfella et al., 2024).

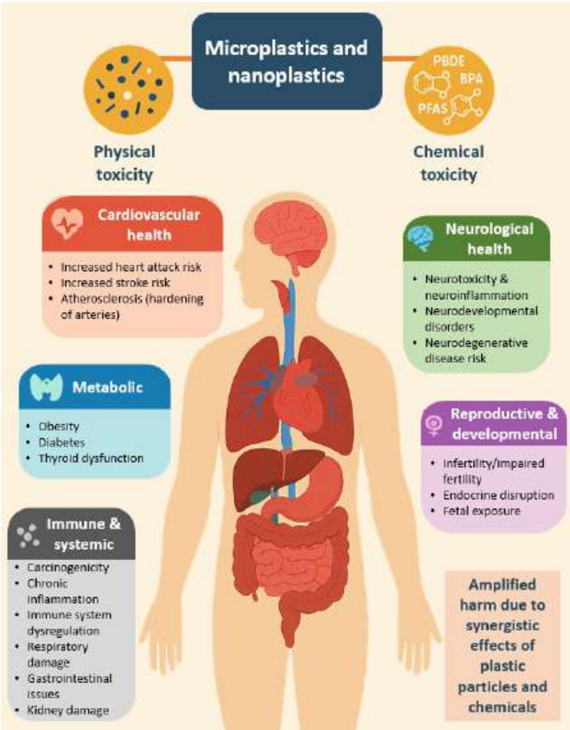
Furthermore, the immune response is chronically activated by attempts to clear the non-degradable particles, and this inflammation is central to the damage observed in the respiratory, gastrointestinal, and renal systems (Jenner et al., 2022; Yan et al., 2022; Exacoustos et al., 2023).

Crucially, these toxic effects can be synergistic; physical abrasion of the gut lining can increase the systemic absorption of leached chemicals, which in turn can dysregulate the immune system and worsen the initial inflammation, creating a vicious cycle of damage (Yan et al., 2022; Fenton et al., 2021; Feng et al., 2023).

Annex A-2 provides an exhaustive summary of the potential health impacts associated with exposure to plastics (particularly microplastics and nanoplastics) and their chemical additives. The impacts are organised by physiological system, describing the nature of the effect, its chronicity, a description of the underlying mechanisms, the status of the scientific evidence, and the corresponding source literature.

The health burden of plastic pollution is not distributed equally, with vulnerable populations bearing a disproportionate risk. This includes the developing foetus, infants, and children, who face heightened dangers from prenatal and early-life exposure through placental transfer, contaminated breast milk, and infant formula (Ragusa et al., 2021; Liu et al., 2023; Zhang et al., 2021). Their developing organ systems are particularly susceptible to neurotoxic and endocrine-disrupting chemicals (Costa et al., 2008; Hlisníková et al., 2020). Women may face specific reproductive health risks, while workers in plastic production, recycling, and waste management sectors experience higher levels of occupational exposure to toxic chemicals and airborne particles (UNEP, 2021). These direct health impacts translate into immense indirect costs, with the health-related expenses from plastic-associated chemicals estimated to be in the hundreds of billions of dollars annually, placing a severe strain on the diverse and often over-stretched healthcare systems across the world including in the ASEAN+3 region (UNEP, 2023b).

Figure 4.4. Effects of Microplastics and Nanoplastics on Human Health



Source: Authors.

5. Research Gaps and Directions

While the body of scientific evidence linking plastic pollution to adverse health outcomes is growing, research is still in its early stages. Global health authorities and bodies like the Intergovernmental Negotiating Committee on Plastic Pollution (INC) agree that while enough is known to warrant precautionary action, significant knowledge gaps hinder definitive risk assessments and the design of targeted public health interventions (UNEP, 2023b; WHO, 2019; 2024). A globally coordinated, well-funded, and multidisciplinary research agenda is urgently required to understand the full magnitude of the threat.

Unfortunately, the ongoing key research gaps persist across several critical areas, creating a disconnect between alarming laboratory findings and the persuasive epidemiological evidence needed to drive stronger policy interventions. While numerous studies demonstrate that plastic particles and their associated chemicals can cause harm in controlled settings, a primary challenge is translating this potential risk into proven, population-level effects. There is a critical scarcity of long-term longitudinal studies that can establish clear causal links between chronic plastic exposure and the development of non-communicable diseases (Li et al., 2023). This lack of definitive human data is compounded by several related uncertainties. Although it had been reported that particle accumulation may cause inflammation and organ damage (WHO, 2024), the lack of defined dose–response relationships and established toxicity thresholds hinders the development of regulatory limits (Vethaak and Legler, 2021). Another major uncertainty is the unique threat posed by nanoplastics. These sub-micron particles are exceptionally difficult to detect, yet their small size may allow them to penetrate biological barriers like the gut, lungs, and even the brain, leading to systemic exposure whose consequences are not yet understood (WHO, 2019; Kopatz et al., 2023). Furthermore, the synergistic or cumulative effects of the complex cocktail of thousands of plastic polymers and chemical additives that humans are exposed to are almost entirely unknown (UNEP, 2023b). In essence, while the mechanistic evidence raises significant concern, the absence of robust human epidemiological data makes it difficult to quantify the full scale of the public health burden, hindering the development of targeted and stringent policy responses. Furthermore, a critical research gap exists beyond the biomedical sphere, as scientific publications on the health effects of microplastics do not typically analyse the communication and reception of such evidence or the broader social drivers of plastics use, which are essential for crafting effective, real-world interventions (Thompson et al., 2024).

These global research gaps are particularly pressing in the ASEAN+3 region. The area's status as a hotspot for plastic pollution, combined with its high population density and heavy dietary reliance on seafood, creates a scenario of potentially heightened exposure and risk (Ali et al., 2024; Zhao et al., 2024). However, there is a scarcity of region-specific data on exposure levels (Solikhin et al., 2025), the prevalence of plastic-related health impacts, and the specific vulnerabilities of its diverse populations, including children and workers in the informal waste sector who are often disproportionately exposed to health hazards (WHO, 2024). Addressing this requires a tailored research approach that considers the unique environmental, economic, and social context of the region.

To address these challenges, future research directions must be strategic and collaborative, with a strong focus on the ASEAN+3 region:

- Adopt a 'One Health' Framework: A holistic 'One Health' approach, which integrates human, animal, and environmental health, is essential for the ASEAN+3 region (WHO, 2024). This framework acknowledges that human health is inextricably linked to the health of the region's vital ecosystems, from its agricultural soils to its marine environments. Experts call for mainstreaming this framework in all research stages and promoting collaboration amongst specialists in medicine, environmental science, and public health to tackle the multifaceted nature of plastic pollution (Solikhin et al., 2025).
- Establish foundational methodologies: A critical first step, emphasised by numerous health organisations, is the development and standardisation of methods for detecting, characterising, and quantifying microplastics and nanoplastics in complex samples like food, water, and human tissues. WHO emphasises that although human health risks are not yet fully understood, internal exposure demands significant attention in future research, particularly through standardised detection methods and long-term toxicological studies to assess potential pathological consequences (WHO, 2022). For the ASEAN+3 region, this includes a call for developing regionally harmonised protocols and laboratory infrastructure to ensure that data are consistent, comparable, and effective for building regional risk assessments (WHO, 2019; Solikhin et al., 2025).
- Prioritise mechanistic and epidemiological studies: Future funding and research efforts should prioritise in-depth toxicological studies to understand the fundamental mechanisms by which plastic particles and their chemical leachates cause cellular damage, inflammation, and endocrine disruption. These must be complemented by long-term epidemiological studies in exposed populations, particularly within the ASEAN+3 region, to definitively link plastic exposure to specific health outcomes and identify the risks for vulnerable groups (UNICEF, 2024).
- Assess life cycle and circular economy risks: To support a safe transition to a circular economy, rigorous risk assessments of recycled plastics are needed. Such assessments must identify and manage hazardous legacy chemicals, harmful substances, and non-intentionally added compounds that can re-enter the supply chain (Gregory, 2023; WHO, 2024). In parallel, the health and environmental safety of alternative materials proposed to replace conventional plastics must be thoroughly evaluated to avoid regrettable substitutions and ensure they are genuinely safer.

6. Policy Frameworks and Mitigation Strategies

The scientific uncertainty detailed above directly influences the global policy response. While awareness of the plastic pollution crisis is high, the translation into comprehensive, health-protective policies remains inconsistent. In the ASEAN+3 region, significant strides have been made in acknowledging the problem at a high level. Most countries have recognised that plastic pollution mitigation as a policy priority, with national action plans or roadmaps present in nine of the 13 ASEAN+3 countries and under discussion in the remaining four (OECD, 2025). Key initiatives like the Bangkok Declaration on Combating Marine Debris in the ASEAN region (2019) and the ASEAN Regional Action Plan for Combating Marine Debris in the ASEAN Member States (2021–2025) signal a strong political commitment to tackling plastic pollution through policy support, research, and private sector engagement (ASEAN, 2021). At the national level, countries are beginning to implement foundational policies, such as the Philippines' Extended Producer Responsibility (EPR) Act of 2022 (Republic Act No. 11898) and Malaysia's National Marine Litter Policy and Action Plan (2021–2030), which aim to establish circular economy principles and reduce plastic waste (Ministry of Environment and Water, 2021).

However, despite the existence of these important frameworks, a significant implementation gap remains, particularly in the regulation of specific hazardous components and the establishment of health-based standards. That is partly because of the research gap, which was discussed in the previous section. Without definitive epidemiological evidence and clear dose–response relationships, governments may lack the impetus to enact stringent, harmonised regulations, often opting for weaker or more fragmented policy actions. This disparity is especially evident in the differing approaches to regulating a single, well-known pollutant: intentionally added plastic microbeads. Within the ASEAN+3 region, regulatory action remains a patchwork rather than a coordinated effort.

- **Legally binding bans**: Several countries have implemented legal bans on plastic microbeads in certain products. Korea prohibited the sale of cosmetics with microbeads from July 2017 (Zhou, 2017). Following this, Indonesia banned the use of microbeads in rinse-off cosmetic products in 2019, aligning with recommendations from the ASEAN Cosmetic Committee meetings (Caldwell, 2019). Thailand subsequently banned the production, import, and sale of cosmetics containing plastic microbeads effective 1 January 2020.[2] Finally, China enacted a phased ban, halting the production of cosmetics with microbeads by the end of 2020 and banning their sale after 31 December 2022.[3]

- **Voluntary measures**: Japan has not implemented a legal ban but has relied on voluntary industry action. The Japan Cosmetic Industry Association prompted members to self-regulate, and major manufacturers reported phasing out microbeads from their products by the end of 2018 (Xu, 2018).

[2] Notification of the Ministry of Public Health on a Ban on the Production, Import, and Sale of Cosmetics Containing Plastic Microbeads (2019).

[3] Notice No. 80 dated 16 January 2020 on Opinions on Further Strengthening the Control of Plastic Pollution.

- **Regulation gaps**: A significant number of ASEAN Member States have not enacted specific, legally binding bans. In the Philippines, multiple bills to ban microbeads have been filed in Congress over the years, but none have been passed into national law. Similarly, Malaysia, Singapore, and Viet Nam lack specific national laws prohibiting the manufacture or sale of products containing microbeads. Their environmental policies have focused more broadly on packaging waste and post-consumer plastic management. For other members like Brunei Darussalam, Cambodia, the Lao People's Democratic Republic (Lao PDR), and Myanmar, there is no evidence of specific microbead bans; their regulations generally default to the standards of the ASEAN Cosmetic Directive, which, while recommending discontinuation, has not formally listed plastic microbeads as a prohibited substance across the region.

This regulatory inconsistency is not necessarily a neglect of established science but rather a direct consequence of the critical research gaps discussed in the previous section. Without definitive human epidemiological data and clear dose–response relationships (WHO, 2022), policymakers in the ASEAN+3 region face substantial challenges in justifying and designing costly, stringent, health-based standards. This informational gap is a primary reason for the absence of targeted policies addressing hazardous additives such as bisphenols, PFAS, and certain phthalates (UNEP, 2023b), and it underpins a major policy gap in the protection of public health.

This situation contrasts with regions like the European Union, which has often employed the precautionary principle more forcefully through regulations like the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) regulation, restricting chemicals even when scientific certainty is incomplete. The approach in many ASEAN+3 countries, however, appears more cautious, awaiting more conclusive evidence before enacting uniform, legally binding regulations. Consequently, there are currently no established, legally binding threshold limits for microplastic concentrations in drinking water, food, or air, nor are there standardised monitoring requirements for these compartments (WHO, 2022). This absence of health-centric regulations, rooted in scientific uncertainty, hinders the ability of governments to assess public exposure effectively and mitigate the health risks associated with plastic pollution.

Effective mitigation requires a multi-pronged approach that targets the entire life cycle of plastics, from production to disposal, underpinned by strong governance with robust enforcement; comprehensive data systems to track plastic flows for evidence-based policymaking; the mobilisation of significant financial resources through clear and stable investment frameworks; and strong international cooperation. The primary goal is to transition from a linear 'take-make-waste' model to a safe and sustainable circular economy. Key strategies include:

- **Upstream interventions: source reduction and redesign**
  The most effective strategy is to prevent plastic waste from being generated in the first place. This involves implementing policies such as bans on the most problematic and unnecessary single-use plastics and establishing robust EPR schemes. EPR policies incentivise producers to design products that are durable, reusable, free of hazardous chemicals, and that minimise direct microplastic release (e.g. improved design for tyres and textiles), making them financially and legally responsible for the end-of-life management of their products (UNEP, 2023a). Crucially, this includes upstream regulation to phase out and restrict hazardous chemical additives like PFAS and endocrine-disrupting phthalates at the plastic design and manufacturing stage.

- **Downstream measures: improved waste management and leakage prevention**
  For plastics already in circulation, mitigating environmental leakage is paramount. This requires significant investment in waste management infrastructure, particularly given the wide regional disparities where collection rates range from over 95% in Japan to less than 50% in countries like Cambodia and the Lao PDR. With the regional recycling rate at a mere 12%, vastly overshadowed by a mismanaged waste rate of 31%, scaling up sorting and recycling capacity is an urgent priority (OECD, 2025). Integrating and supporting the informal waste sector, which plays a vital role in waste collection in many ASEAN Member States, is essential for a just and effective system. Furthermore, upgrading wastewater and drinking water treatment plants with advanced filtration technologies (e.g. membrane filtration) can effectively capture microplastics, reducing their release into aquatic ecosystems and their presence in potable water supplies (WHO, 2019).

- **International and regional cooperation**
  As plastic pollution is a transboundary issue, coordinated international action is indispensable. The ongoing negotiations for a legally binding global plastic treaty under the auspices of UNEP represent a landmark opportunity to create a harmonised global framework. For the ASEAN+3 region, cooperation is key to aligning standards on packaging, recycling, and chemical regulations to prevent the trade of hazardous materials and waste. Facilitating technology transfer and providing financial assistance to developing nations are critical components for ensuring equitable and effective implementation of mitigation strategies across the globe (UNEP, 2023a).

7. Conclusion and Recommendations

Plastic pollution represents a complex and escalating global challenge with profound implications for human health. This chapter has synthesised evidence demonstrating that human exposure to plastics, particularly microplastics and nanoplastics, is ubiquitous, occurring through ingestion of contaminated food and water, inhalation of airborne particles, and to a lesser extent, dermal contact. The detection of these particles within various human organs and tissues, including blood, lungs, placenta, and even the brain, confirms systemic uptake and distribution, raising direct concerns about physiological impacts.

The health consequences are driven by a dual-threat mechanism: (i) the physical toxicity of the particles themselves, which induces chronic inflammation, oxidative stress, and cellular damage; and (ii) the chemical toxicity from the thousands of hazardous additives that leach from the plastic matrix. Emerging clinical evidence and mechanistic studies link this exposure to a range of adverse outcomes, including gastrointestinal disturbances, endocrine disruption leading to reproductive and metabolic problems, neurological impacts potentially involving neuroinflammation and neurodegeneration, increased cardiovascular risk, respiratory ailments, and immune system dysregulation. Vulnerable populations, notably children, pregnant women, and older persons, face heightened risks due to specific physiological susceptibilities.

While the scientific understanding of these health impacts is advancing rapidly, significant knowledge gaps remain concerning the precise long-term consequences, dose–response relationships, and causal mechanisms in humans. Methodological challenges, particularly in detecting and quantifying nanoplastics and assessing complex real-world exposures, hinder definitive conclusions. Nevertheless, the weight of current evidence, demonstrating widespread exposure, internal accumulation, plausible mechanisms of harm, and initial links to severe clinical outcomes, strongly suggests that plastic pollution poses a substantial threat to human health. This threat is particularly acute in areas like the ASEAN+3 region, characterised by high plastic leakage, reliance on potentially contaminated aquatic food sources, and gaps in specific public health-focused policies.

A strategic and collaborative research agenda must be pursued to close critical knowledge gaps. This agenda should prioritise long-term human epidemiological studies in high-risk regions to establish clear causal links between plastic exposure and disease, while developing standardised methodologies to accurately assess emerging threats like nanoplastics and the synergistic effects of chemical mixtures. Adopting a holistic 'One Health' framework is crucial to integrate the human, animal, and environmental dimensions of this research.

In parallel, addressing the human health dimensions of plastic pollution requires more than incremental policy adjustments. It demands a fundamental paradigm shift in governance and attitude. Although evidence on human health impacts is still preliminary, the established facts of widespread human exposure and systemic accumulation, combined with plausible links to severe outcomes, provide a compelling rationale to move away from a reactive mindset that focuses only on waste. A precautionary approach that prioritises health is essential, even while research continues to fill remaining knowledge gaps.

This new paradigm compels governments, particularly within the ASEAN+3 region, to prioritise upstream prevention. This includes implementing legally binding regulations that phase out hazardous chemical additives at the source and establishing clear standards protective of public health for microplastic contamination in drinking water, food, and air. To ensure these regulations are effective, they must be supported by robust EPR schemes. Such schemes are critical for holding industries accountable, compelling them to design safer, nontoxic, and sustainable products, and making them responsible for the entire life cycle of those products.

Finally, these national and regional actions must be embedded within a global commitment to a safe circular economy. This requires not only investing in waste management but also innovating to address the 'toxic loop' by developing methods to decontaminate plastic waste streams, ensuring that recycled materials are free of legacy chemicals. Supporting a strong, health-centric global plastic treaty is the indispensable mechanism to harmonise these efforts, drive innovation, and promote the multi-stakeholder collaboration and public awareness needed to protect current and future generations from the pervasive threat of plastic pollution.

Supplementary Material

Annex A.1. Microplastic Concentration Detected in Human Organ Systems and Biological Samples

Type of sample (organ/fluid)	Sample size	Abundance of microplastics	Particle size	Identified polymers	References
Cardiovascular system					
Blood	22	1.6 µg/mL	>700 nm	ABS, EPS, PE, PET, PMMA, PS	(Leslie et al., 2022)
Thrombi (blood clots)	26	87 particles	2.1–26.0 µm	Chromium oxide, LDPE, phthalocyanine, pigment	(Wu et al., 2023)
Vein (saphenous)	5	20 particles or 14.99±17.18 microplastic/g of tissue	16–1,074 µm	Alkyd resin, nylon-ethylene-vinyl acetate, nylon-EVA, poly(vinyl propionate), tie layer	(Rotchell et al., 2023)
Heart tissue	15	Nine types of microplastics detected in 5 types of tissue	N/A	PET, PMMA, PVC	(Yang et al., 2023)
Atheromatous plaques	257	Microplastics detected in 150 patients (58.4%) Mean concentration: 21.7±24.5 µg/g of plaque	N/A	PE, PVC	(Marfella et al., 2024)
Digestive system					
Colorectal cancer tissue	11	331 microplastics per individual or 28.1±15.4 particles/g tissue	0.8–1.6 mm	PA, PC, PP	(Ibrahim et al., 2021)
Liver	11	0–13 particles per sample or 3.2 particles/g tissue	4–30 µm	PET, PMMA, POM, PP, PS, PVC	(Horvatits et al., 2022)
Faeces (stool)	8	9 particles in total	50–500 µm	PA, PC, PE, PET, POM, PP, PS, PU, PVC	(Schwabl et al., 2019)
Faeces (stool)	8	129 particles (20.4–138.9 particles/g)	N/A	PET, PMMA, PVC	(Yang et al., 2023)
Faeces (stool, healthy)	50	3,070 particles (28.0 items/g)	4.4–333.2 µm	AS, EVA, PA, PBT, PC, PE, PET, PMMA, POM, PP, PS, PTFE, PVC, TPU	(Yan et al., 2022)
Faeces (stool, IBD)	52	5459 particles (41.8 items/g)	1.7–393.8 µm	AS, EVA, PA, PBT, PC, PE, PET, PMMA, POM, PP, PS, PTFE, PVC, TPU	(Yan et al., 2022)
Faeces (stool, coastal)	11	3.33–13.99 µg/g	<5 mm	HDPE, LDPE, LLDPE, PET, PP, PS	(Luqman et al., 2021)

Type of sample (organ/fluid)	Sample size	Abundance of microplastics	Particle size	Identified polymers	References
Faeces (stool, farming)	11	6.94–16.55 µg/g	<5 mm	HDPE, LDPE, PE, PET, PP, PS	(Wibowo et al., 2021)
Faeces (adult)	10	Median: 2,600 ng/g (PET); PC also detected	N/A	PC, PET	(Zhang et al., 2021)
Faeces (adult)	24	1–36 particles/g	20–800 µm	PA, PC, PE, PET, PP, PS, PU, PVC	(Zhang et al., 2021)
Endocrine & reproductive systems					
Placenta	N/A	12 particles	>5 µm	PP	(Ragusa et al., 2021)
Placenta	N/A	N/A	>50 µm	PE, PP, PU	(Braun et al., 2021)
Placenta	17	149 microplastics particles	20.34–307.24 µm	AS, EVA, PA, PBT, PC, PE, PET, PMMA, POM, PP, PS, PTFE, PVC, TPU	(Yan et al., 2022)
Placenta	18	N/A	20–500 µm	PA, PC, PE, PET, PU	(Liu et al., 2023)
Meconium	2	N/A	>50 µm	PE, PP, PS	(Braun et al., 2021)
Meconium	12	54.1 particles/g	>20 µm	CPE, EVA, PA, PE, PET, PLA, PMMA, POM, PP, PS, PSF, PTFE, PU, PVC	(Liu et al., 2023)
Meconium	3	12,000 ng/g for PET and 110 ng/g for PC	N/A	PC, PET	(Zhang et al., 2021)
Breast milk	34	58 particles in total	1–12 µm	ABS, CPE, NC, PA, PC, PE, PEMA, PES, PEVA, PP, PS, PVC, PVOH	(Ragusa et al., 2022)
Breast milk	7	20.2 particles/g	>20 µm	CPE, EVA, PA, PE, PET, PLA, PMMA, polybutadiene, POM, PP, PS, PSF, PTFE, PU, PVC	(Liu et al., 2023)
Infant faeces	12	26.6 particles/g	>20 µm	CPE, EVA, PA, PE, PET, PLA, PMMA, polybutadiene, POM, PP, PS, PSF, PTFE, PU, PVC	(Liu et al., 2023)
Infant faeces	6	Median: 36,000 ng/g (PET); median: 78 ng/g (PC)	N/A	PC, PET	(Zhang et al., 2021)
Testis	6	11.60 ± 15.52 particles/g	N/A	PE, PS, PVC	(Zhao et al., 2023)
Testis	23	Mean: 328.44 µg/g	N/A	ABS, N6, N66, PC, PE, PET, PMMA, PP, PU, PVC, SBR	(Hu et al., 2024)
Semen	25	24 microplastics in 11 of 25 samples (0.23±0.45 particles/mL)	21.76–286.71 µm	PA, PE, PET, PP, PS, PVC	(Zhao et al., 2023)

Type of sample (organ/fluid)	Sample size	Abundance of microplastics	Particle size	Identified polymers	References
Semen	10	16 microplastics in 6 of 10 samples	2–5 μm	Acrylic, PC, PET, POM, PP, PS, PVC	(Montano et al., 2023)
Integumentary system					
Face skin	2,000	4,265 microplastics particles	100–500 μm	PE, PET, PS, PVC	(Abbasi & Turner, 2021)
Hand skin	2,000	4,051 microplastics particles	100–500 μm	PE, PET, PS, PVC	(Abbasi & Turner, 2021)
Hair	2,000	7,462 microplastics particles	100–500 μm	PE, PET, PS, PVC	(Abbasi & Turner, 2021)
Saliva	2,000	645 microplastics particles	100–500 μm	PE, PET, PS, PVC	(Abbasi & Turner, 2021)
Lymphatic system					
Spleen	3	4 particles per sample or 1.1 particles/g tissue	5–25 μm	PET, PMMA, POM, PP, PS, PVC	(Horvatits et al., 2022)
Respiratory system					
Lung tissue	20	31 particles	1.6–16.8 μm	CA, Cotton, PA, PE, PP, PS, PU, PVC	(Amato-Lourenço et al., 2021)
Lung granule nodules	100	65 particles	>20 μm	Cotton, PA, phenoxy resin, polyester, denim	(Chen et al., 2022)
Lung tissue	13	39 particles	12–2475 μm	PAN, PE, PES, PET, PMMA, PP, PS, PTFE, PUR, Resin, SEBS, TPE	(Jenner et al., 2022)
Lung tissue	114	Fibres in 87% of samples (99/114)	N/A	Cellulosic, Plastic (e.g., polyester)	(Pauly et al., 1998)
Sputum	22	18.75–91.75 particles/10 mL	20–500 μm	Alkyd varnish, chlorinated PE, PES, PU	(Huang et al., 2022)
Bronchoalveolar lavage fluid	30	Median: 684.7 particles/mL	N/A	PET, PS, PVC	(Tokito et al., 2025)
Urinary system					
Kidney tissue	10	17 fragments in 7 of 10 samples (mean 1.7±2.11 per sample)	N/A	PE, PS, styrene-isoprene	(Exacoustos et al., 2023)
Kidney	3	0 particles per sample	10–20 μm	N/A	(Horvatits et al., 2022)
Urine	6	7 particles in total	4–15 μm	PE, PP, PVA, PVC	(Pironti et al., 2023)
Urine	10	9 fragments in 7 of 10 samples (mean 1.28±0.49 per sample)	N/A	PE, PS, styrene-isoprene	(Exacoustos et al., 2023)

μm = micrometre; μg/mL = microgram per millilitre; ABS = acrylonitrile butadiene styrene; AS = acrylonitrile styrene; CA = cellulose acetate; CPE = chlorinated polyethylene; EPS = expanded polystyrene; EVA = ethylene-vinyl acetate; g = gram; HDPE = high-density polyethylene; IBD = inflammatory bowel disease; LDPE = low-density polyethylene; LLDPE = linear low-density polyethylene; mm – millimetre; N6 = nylon 6; N66 = nylon 66; N/A = not available; NC = nitrocellulose; ng = nanogram; nm = nanometre; PA = polyamide; PAN = polyacrylonitrile; PBS = polybutylene succinate; PBT = polybutylene terephthalate;

PC = polycarbonate; PE = polyethylene; PEMA = poly(ethyl methacrylate); PES = polyethersulfone; PET = polyethylene terephthalate; PEVA = polyethylene vinyl acetate; PLA = polylactic acid; PMMA = polymethyl methacrylate; POM = polyoxymethylene; PP = polypropylene; PS = polystyrene; PSF = polysulfone; PTFE = polytetrafluoroethylene; PU/PUR = polyurethane; PVA = polyvinyl acetate; PVC = polyvinyl chloride; PVOH = polyvinyl alcohol; SBR = styrene-butadiene rubber; SEBS = styrene-ethylene-butylene-styrene; TPE = thermoplastic elastomer; TPU = thermoplastic polyurethane.
Source: Authors, based on Roslan et al. (2024).

Annex A.2. Summary of Potential Human Health Impacts of Plastics (Micro- and Nanoplastics) and Associated Chemicals

Impact	Effect	Description	Status/Strength of evidence	References
Cardiovascular system				
Atherosclerosis & cardiovascular events (myocardial infarction, stroke, all-cause mortality)	Long-term	Micro- and nanoplastics (e.g. polyethylene, polyvinyl chloride) have been detected in human atherosclerotic plaques. Their presence is strongly associated with local inflammation (e.g. elevated inflammatory biomarkers within the plaque) and a significantly higher risk (hazard ratio 4.53) of a composite of myocardial infarction, stroke, or death from any cause over a ~34-month follow-up period. This inflammatory process involves micro- and nanoplastics-induced oxidative stress and apoptosis in endothelial cells, promoting plaque instability and rupture.	Clinical research (human observational study with strong correlation)	Marfella et al. (2024); Rotchell et al. (2023); Thapliyal et al. (2025); Feng et al. (2023); Nawab et al. (2024); Campanale et al. (2020)
Systemic inflammation & blood clotting (thrombosis)	Acute & long-term	Micro- and nanoplastics have been identified in human blood and in thrombi (blood clots). They can interact directly with blood components, absorbing plasma proteins to form a 'corona', adhering to red blood cell surfaces (causing hemolysis or cell rupture), and inducing platelet aggregation and activation. This can disrupt normal blood coagulation pathways and potentially lead to thrombosis.	Clinical research (human detection)	Leslie et al. (2022); Wu et al. (2023); Lee et al. (2024); Brits et al. (2024); Marfella et al. (2024); Feng et al. (2023); Thapliyal et al. (2025)
Cardiac tissue damage & dysfunction	Long-term	Various micro- and nanoplastics (e.g., PMMA, PVC, PET) have been detected in multiple human cardiac tissues, including the pericardium, myocardium, and adipose tissue surrounding the heart. Animal and in-vitro studies suggest micro- and nanoplastics can induce cardiotoxicity through oxidative stress, inflammation, energy metabolism disorders, and altered gene expression, leading to effects like myocardial fibrosis and hypertrophy.	Clinical research (human detection) and animal/in-vitro studies	Yang et al. (2023); Thapliyal et al. (2025); Nawab et al. (2024)

Impact	Effect	Description	Status/Strength of evidence	References
Hypertension	Long-term	Exposure to BPA, a common plastic additive, is associated with increased incidence of hypertension in human epidemiological studies.	Clinical research (human epidemiological association for additives)	Rochester (2013)
Respiratory system				
Inflammation, fibrosis, and lesions	Acute & long-term	Inhalation is a primary exposure route. Micro- and nanoplastics (e.g. PP, PET, resin) have been detected deep within human lung tissue, including in the lower lung regions, indicating they can bypass respiratory clearance mechanisms. Occupational exposure to high levels of plastic dust is linked to respiratory symptoms. Animal and in-vitro studies show micro- and nanoplastics can induce inflammation, oxidative stress, epithelial barrier dysfunction, cytotoxicity, and pulmonary fibrosis.	Clinical research (human detection & occupational link) and animal/in-vitro studies	Jenner et al. (2022); Amato-Lourenço et al. (2021); Pauly et al. (1998); Tokito et al. (2025); Huang et al. (2022); Campanale et al. (2020); Feng et al. (2023); Thapliyal et al. (2025)
Asthma & allergic reactions	Long-term	Prenatal and early childhood exposure to the plastic additive BPA is associated with increased odds of wheezing and asthma. Phthalates, another class of additives, can act as allergens and cause irritation of airways. The physical presence of micro- and nanoplastics particles may exacerbate inflammatory responses in susceptible individuals.	Clinical research (human epidemiological association for additives)	Rochester (2013); Campanale et al. (2020); Thapliyal et al. (2025)
Gastrointestinal system				
Inflammatory bowel disease	Long-term	Faecal micro- and nanoplastics concentrations are significantly higher in IBD patients compared with healthy individuals, and a positive correlation exists between micro- and nanoplastics concentration and disease severity. The mechanism is unclear: micro- and nanoplastics may exacerbate inflammation by disrupting the gut barrier and microbiome, or the pre-existing condition of IBD may increase micro- and nanoplastics retention.	Clinical research (human correlation)	Yan et al. (2022); Ibrahim et al. (2021)
Gut microbiota dysbiosis & barrier dysfunction	Long-term	In animal models, micro- and nanoplastics ingestion consistently alters the composition and function of the gut microbiome (dysbiosis). This can disrupt metabolic homeostasis, impair the intestinal barrier's integrity, increase its permeability ('leaky gut'), and contribute to systemic inflammation and metabolic disorders.	Animal studies	Yee et al. (2021); Nawab et al. (2024); Thapliyal et al. (2025); Feng et al. (2023)

Impact	Effect	Description	Status/Strength of evidence	References
Liver damage (hepatotoxicity)	Long-term	Micro- and nanoplastics accumulate in the liver. Animal studies show that micro- and nanoplastics exposure can lead to liver inflammation, oxidative stress, impaired energy metabolism, disruptions in lipid metabolism, and signs of tissue damage (elevated liver enzymes). Co-exposure with BPA can worsen hepatotoxicity.	Clinical research (human detection)	Horvatits et al. (2022); Rochman et al. (2013); Yee et al. (2021); Thapliyal et al. (2025)
Endocrine system				
Endocrine disruption (general)	Long-term	Many plastic additives are proven or suspected endocrine-disrupting chemicals. They interfere with the body's hormonal systems by mimicking or blocking natural hormones, or by altering their production, metabolism, and receptor function. This can lead to a wide range of health issues throughout the life course.	Proven (for specific chemicals like BPA and certain phthalates) and animal/in-vitro studies	Campanale et al. (2020); UNEP (2023b); Hlisníková et al. (2020); Rochester (2013); Legler (2008); Hahladakis et al. (2018)
Metabolic disorders (obesity, type 2 diabetes, insulin resistance)	Long-term	Exposure to endocrine-disrupting chemicals like BPA and phthalates is strongly and consistently associated with obesity, type 2 diabetes, and insulin resistance in human epidemiological studies. Micro- and nanoplastics are hypothesised to be 'obesogens', with animal studies showing that they alter lipid metabolism and energy balance, and can cause metabolic disorders in offspring after maternal exposure.	Proven (for additives like BPA and other endocrine-disrupting chemicals) and animal studies	Rochester (2013); Nawab et al. (2024); Campanale et al. (2020); Yee et al. (2021); Hlisníková et al. (2020)
Thyroid dysfunction	Long-term	Endocrine-disrupting chemicals like polybrominated diphenyl ethers and PFAS are structurally similar to thyroid hormones and can disrupt thyroid signalling. Human studies link exposure to these chemicals with altered thyroid hormone levels (e.g. T4, TSH) in adults and during pregnancy, which can impact fetal development.	Clinical research (human epidemiological association for additives) and animal/in-vitro studies	Costa et al. (2008); Fenton et al. (2021); Rochester (2013); Campanale et al. (2020); Legler (2008)
Reproductive system				
Impaired male fertility (reduced sperm quality & function)	Long-term	Micro- and nanoplastics (e.g. PET, PVC, PS) are detected in human testis and semen. Exposure to certain microplastics and chemical additives (e.g. BPA, phthalates) is associated with adverse semen parameters, including reduced sperm concentration, count, motility, and normal morphology, as well as increased sperm DNA damage.	Clinical research (human correlation) and animal studies	Zhao et al. (2023); Hu et al. (2024); Hlisníková et al. (2020); Rochester (2013); Thapliyal et al. (2025); Feng et al. (2023)

Impact	Effect	Description	Status/Strength of evidence	References
Impaired female fertility & ovarian dysfunction	Long-term	Phthalate exposure is linked to premature ovarian failure, anovulation, and disrupted follicular development in human and animal studies. BPA exposure is associated with poorer IVF outcomes. Micro- and nanoplastics accumulate in ovarian tissue in animal models, leading to inflammation, reduced ovarian reserve, and smaller litter sizes.	Clinical research (human epidemiological association for additives)	Hlisníková et al. (2020); Rochester (2013); Feng et al. (2023); Thapliyal et al. (2025)
Adverse pregnancy outcomes (miscarriage, preterm birth, intrauterine growth restriction)	Acute & long-term	Higher maternal exposure to BPA is associated with recurrent miscarriage and premature delivery. Phthalate exposure is linked to miscarriage. Micro- and nanoplastics cross the placenta, and their accumulation may contribute to adverse outcomes like intrauterine growth restriction, though this link in humans is still emerging.	Need more basis	Rochester (2013); Hlisníková et al. (2020); Ragusa et al. (2021); Feng et al. (2023)
Neurological system				
Neurotoxicity & neuroinflammation	Acute & long-term	Nanoplastics can cross the blood–brain barrier in animal models, sometimes within hours of exposure. Animal and in-vitro studies show that micro- and nanoplastics can induce oxidative stress, neuroinflammation, inhibit key enzymes (e.g. acetylcholinesterase), alter neurotransmitter levels, and cause neuronal cell death.	Proven (in animals) and clinical research (human detection)	Kopatz et al. (2023); Prüst, Meijer, and Westerink (2020); Thapliyal et al. (2025); Nawab et al. (2024); Feng et al. (2023)
Neurodevelopmental & behavioural disorders	Long-term	Prenatal exposure to the additive BPA is associated with behavioural issues in children (e.g. anxiety, depression, aggression). Additives like flame retardants such as polybrominated diphenyl ethers are known developmental neurotoxicants. Animal studies link in-utero micro- and nanoplastics exposure to cognitive deficits and autistic-like traits in offspring.	Clinical research (human epidemiological association for additives) and animal studies	Rochester (2013); Costa et al. (2008); Campanale et al. (2020); Feng et al. (2023)
Neurodegenerative disease risk (e.g. dementia, Alzheimer's, Parkinson's)	Long-term	Mechanistic parallels exist between micro- and nanoplastics-induced neuroinflammation/oxidative stress and the pathology of neurodegenerative diseases. In laboratory studies, micro- and nanoplastics promote the aggregation of key pathological proteins (amyloid-β, α-synuclein). Recent studies have found significantly higher micro- and nanoplastics concentrations in the brains of deceased dementia patients compared with controls.	Emerging research (human correlation & mechanistic plausibility)	Prüst et al. (2020); Thapliyal et al. (2025); Feng et al. (2023); Kopatz et al. (2023)

Impact	Effect	Description	Status/Strength of evidence	References
Other systemic impacts				
Carcinogenicity	Long-term	Several plastic additives are classified as known or probable human carcinogens by regulatory bodies (e.g. certain heavy metals like cadmium and lead, some phthalates). BPA is linked to hormone-dependent cancers (breast, prostate). Long-term micro- and nanoplastics exposure promoted preneoplastic liver lesions in one rat study.	Proven (for specific additives) and animal studies	Campanale et al. (2020); Hlisníková et al. (2020); Rochester (2013); Nawab et al. (2024); UNEP (2023a)
Allergy & immune system disruption	Long-term	Exposure to some micro- and nanoplastics and additives (e.g. phthalates) can trigger allergic reactions and cause immune dysregulation by altering cytokine production. PFAS exposure is linked to a suppressed immune response to vaccines in children. Micro- and nanoplastics may contribute to autoimmune diseases.	Clinical research (human epidemiological association for additives) and animal/in-vitro studies	Campanale et al. (2020); Fenton et al. (2021); Thapliyal et al. (2025); Costa et al. (2008)
Kidney damage (nephrotoxicity)	Long-term	Micro- and nanoplastics accumulate in kidney tissue. Animal and in-vitro studies show that PS particles can induce oxidative stress, inflammation, mitochondrial dysfunction, and cell death in kidney cells. Exposure to PFAS is also associated with kidney disease and kidney cancer in human studies.	Clinical research (human detection & association for additives) and animal/in-vitro studies	Exacoustos et al. (2023); Massardo et al. (2024); Fenton et al. (2021); Thapliyal et al. (2025)

BPA = bisphenol A, IBD = inflammatory bowel disease, IVF = in vitro fertilisation, PE = polyethylene, PET = polyethylene terephthalate, PFAS = per- and polyfluoroalkyl substances, PMMA = polymethyl methacrylate, PP = polypropylene, PS = polystyrene, PVC = polyvinyl chloride, T4 = thyroxine, TSH = thyroid-stimulating hormone.
Source: Compiled by authors.

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Chapter 5

Single-Use Plastics in Southeast Asia: Leveraging Behavioural Science to Reduce Consumption and Waste

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1. Introduction

Single-use plastics (SUPs) have become one of the most pressing environmental, social, and economic challenges facing the world, contributing significantly to the triple planetary crisis of biodiversity, climate change, and pollution (Schmidt et al., 2024). While many governments have developed a range of policy solutions to the problem of SUPs – most notably through the inclusion of bans, fees, and better regulation of waste management systems in national plastic action plans – these efforts have largely been limited to traditional policy tools. New policy approaches are needed to move beyond framing the challenge as one of individual consumer behaviour hindered by lack of information and understanding to integrate new approaches informed by the behavioural sciences, which seek to take a holistic, encompassing approach to behaviour change across sectors that places the individual, businesses, and the public sector within the larger plastic consumption and production system.

1.1 The SUP Challenge in the Global and Regional Context

In 2022, the Organisation for Economic Cooperation and Development (OECD) estimated that global plastics production topped 430 million metric tonnes (Mt) (OECD, 2022a). Two-thirds of the plastics produced quickly become waste, with roughly 139 Mt (Charles, Kimman, and Saran, 2021) being discarded after just one use. Research has indicated that without extensive interventions, these figures will continue to rise (Borrelle et al., 2020), perhaps tripling by 2060 (OECD, 2022b).

As Southeast Asia has continued to experience rapid economic development, it has become a plastic pollution hotspot. Increased consumption and production of plastics have outpaced national capacity for waste management. Efforts to map and quantify plastic pollution have indicated that many countries in the region are major contributors to plastic leakage into the marine environment, particularly Indonesia, Malaysia, and the Philippines (Meijer et al., 2021). Southeast Asia is also home to half of the world's top 10 worst contributors to riverine and oceanic plastic leakage (Meijer et al., 2021). Indeed, Asia as a whole contributes roughly 80% of global plastic pollution to the ocean, with Malaysia and the Philippines being home to the top eight rivers emitting plastic into the ocean (Meijer et al., 2021; Ritchie, 2021). A recent analysis indicated that Indonesia and Thailand are amongst the top producers of plastic waste globally (World Population Review, 2025).

Compounding the challenge of plastic consumption is the rapid growth in the use of plastics and the mismanagement of plastic waste and leakage of plastics into the environment. Globally, plastic waste generation more than doubled between 2000 and 2019, with 63% of plastic waste being short-lived and single-use items from the food, consumer goods, and textiles industries (OECD, 2022b). The OECD, in its Global Plastic Outlook, reported that as much as 45% of plastic waste in Asia is mismanaged, with just 9% being recycled (OECD, 2022a). This represents both an incredible challenge and an opportunity for policymakers, the private sector, and households to develop home-grown solutions to the plastic pollution crisis.

To reduce and manage the flows of plastic waste effectively, efforts must be made to address demand-side (consumption) and waste management behaviours in addition to production-centred efforts. Priority actions can be taken in critical sectors responsible for large quantities of plastic waste, such as food and consumer goods, and policies can be put in place to support individuals and businesses to shift their behaviours. Recent research has suggested that nearly half of all plastic waste is directly attributable to plastic packaging in the food and beverage sector, including polyethylene terephthalate (PET) bottles, fast food containers, grocery items, snack foods, as well as SUP such as straws, utensils, cups, trays, dishes, and containers (Ncube et al., 2021). Enhanced efforts to shift consumption and waste management behaviour for these sources of plastic are particularly important in light of the predicted 50% increase in global demand for food by 2050 (Guillard et al., 2018).

Given this context, it is essential for Southeast Asian nations to develop innovative policy approaches to eliminating SUP waste. Such policies can draw on the growing body of behavioural science research and practice that is revealing the long-term benefits of applying behavioural insights (BI) for shifting consumption and production patterns. This approach will better equip policymakers, businesses, and institutions to understand the motivations, barriers, values, and aspirations of individuals and tailor policies that work with rather than against these factors.

1.2 Behavioural Insights for Environmental Policymaking

Insights derived from the behavioural sciences reveal that traditional policy approaches, which typically rely on methods such as increasing consumer information, introducing fees, or new regulations, are often insufficient to achieve sustainable shifts in behaviour. Indeed, a recent meta-analysis of the behavioural and socio-structural determinants of behaviour change revealed that interventions based on information campaigns (targeting knowledge, attitudes, and beliefs) and regulatory, legal, and institutional sanction demonstrate the least impact on shifting behaviour (Albarracín, Fayaz-Farkhad, and Granados Samayoa, 2024). Simply stated, awareness raising or coercive or incentivising policies are often not enough to bring about a sustainable change in behaviour.

These approaches tend to overlook the value of more behaviourally informed approaches, such as leveraging social influences, emotions, and choice architecture to better target and work with, rather than against, entrenched societal norms. Such behaviourally informed approaches require a deeper understanding of the motivations and values of individuals and can generate stronger and more lasting impacts on individual and group behaviours (Heidbreder et al., 2019). They are powerful, science-based tools that can help policymakers identify winning strategies for effective change, build trust with constituencies, and work with prevailing local and national contexts to shift unsustainable habits and norms around SUP use. Moreover, in many cases, smart use of traditional and behaviourally informed strategies together can realise greater impact (Bujold, Williamson, and Thulin, 2020).

Additionally, the behavioural sciences underline the foundational lesson that policy interventions cannot simply be transplanted from one context to another and realise the same results. Policy, in order to be effective, must either be tailored to fit a given context, or be intentionally home-grown, ensuring that it is grounded in local values, aspirations, and capacities. As with all interventions, behavioural or otherwise, what works in one context may be ineffective or even counterproductive in another (Szaszi et al., 2025).

Empirical evidence demonstrates the benefits of incorporating behaviourally informed policy levers in policy planning and intervention when compared with a standard approach to policy formation (Bujold, Williamson, and Thulin, 2020) Two examples are instructive, drawn from Peru and Switzerland, covering waste management behaviours and the adoption of green energy at the household level.

In Peru, researchers tested several different interventions to encourage residents to engage in recycling and composting, discovering that messaging and information was insufficient to shift behaviour (Chong et al., 2015). Despite testing many ways of framing recycling, residents simply did not want to keep store recyclables in their houses due to fears of insects, smells, and a lack of available space. Waste segregation activities were also socially associated with informal 'scavengers', presenting an additional socio-cultural barrier to adoption. The solution was to provide residents with designated recycling bins, which were much more convenient, removing or bypassing physical and social barriers. As Bujold, Williamson, and Thulin (2020) pointed out, this strategy 'was much more effective than any kind of messaging, be it information on environmental or social benefits, social comparisons, social sanctions, rule and regulation concerns, and reminders' (Bujold, Williamson, and Thulin, 2020: 86).

In Switzerland, the solution to low uptake of green energy by the general population was to switch the default energy tariff to prefer green energy. This resulted in a nearly tenfold increase in green energy use, as revealed by a randomised control trial (Ghesla, Grieder, and Schubert, 2020). While these results were impressive, the study also revealed that any government policy that utilised this approach would also need to take into account the disproportionate burden placed on poorer households by the slightly more expensive green energy option. This highlights the importance of gaining a deeper understanding of how people in different living contexts have varying values and capabilities, which ultimately shape their practices and behaviours. By designing policies that account for these real-life factors – the lives people live, their capacities, and the choices they face – we can create more effective and impactful solutions (Szaszi et al., 2025). Such considerations can also go a long way towards devising contextually relevant solutions to the intention–action gap that often obtains when addressing environmental challenges.

Such examples are indicative of the growing body of research demonstrating the effectiveness of behaviourally informed policy interventions for taking on environmental challenges. Moreover, they demonstrate the benefits of utilising BI to complement traditional policy approaches. The application of these innovative approaches to policy formation is relatively new to the plastics policy sphere, especially in Southeast Asia. Yet a growing momentum around plastic use and waste – partly because of the work of the Intergovernmental Negotiating Committee on Plastic Pollution (INC) to develop an international legally binding instrument on plastic pollution, including in the marine environment – has highlighted the critical importance of identifying novel approaches to addressing plastic waste. As the world moves forward with efforts to curb plastic pollution in general, strategies that engage with consumers and the business sector to shift their behaviours in sustainable ways will be more important than ever.

2. Potential of Applying Behaviourally Informed Approaches in Plastic Reduction

Understanding the psychological, social, and environmental factors that influence plastic-use behaviours is crucial for designing effective interventions to reduce plastic pollution. Recent research has underscored that behaviour change strategies rooted in the behavioural sciences can have substantial impacts, especially when they address specific psychological and contextual motivations and barriers (Szaszi et al., 2025). For example, shifting the framing of messages about plastic waste, providing timely prompts, and increasing individuals' confidence in their ability to act sustainably have been shown to motivate behavioural change more effectively than traditional information campaigns alone (Bujold and Williamson, 2025).

Many current plastic reduction campaigns rely heavily on disseminating information and enforcing regulations. While raising awareness is important, it often results in only temporary or superficial changes in intentions unless complemented with strategies that address deeper motivators or barriers (Osman et al., 2020). This is evident in sectors such as tourism, where travellers may be aware of environmental issues but still engage in plastic-intensive behaviours due to convenience, cost, or situational factors (Abrahamse and Matthies, 2018). This 'intention-action gap' does not typically lead to long-term, sustainable behavioural shifts unless coupled with practical tools and social cues that facilitate action. Crucially, people may also feel incapable of addressing the systemic issue; even when individuals consider or actually refrain from using and wasting plastics, they may perceive that the current economic systems are actually increasing plastic production and consumption year after year, which reinforces a sense of futility.

Behavioural science offers powerful solutions to close this gap and increase the likelihood of long-term changes to unsustainable patterns of behaviour. Tools that provide individuals with simple heuristics or skills, making it easier to put intentions into practice, can be highly effective and support individuals in following through on their intentions or navigating complex decisions (Banerjee et al., 2022). For example, interventions that communicate the community benefits of proper recycling, use memorable rhymes to remember correct recycling procedures, and establish social expectations about recyclable items have successfully increased correct recycling behaviours (Kramer, Yoeli, and Rand, 2023). Such thoughtfully designed strategies effectively translate pro-environmental intentions into sustained actions by providing structured and actionable information.

Beyond informational approaches, regulatory measures like fines and bans can influence behaviour but also have limitations related to enforcement and cultural acceptance. Combining regulations with behaviourally informed policies such as incentives, social norm campaigns, and nudges can yield better results (Schnurr et al., 2018). However, research emphasises that human decision-making involves more than rational evaluation of costs and benefits. Emotions, personal goals, social identities, and framing significantly shape behaviours (Cinner, 2018). Emotions often signal the importance of a decision to an individual, prompting closer scrutiny when potential positive or negative outcomes are highlighted (Frijda, 2004). Similarly, social norms (perceptions of what others are doing) powerfully influence individual behaviour, as people tend to mimic behaviours prevalent in their community (Gigerenzer and Gaissmaier, 2011).

Choice architecture, or the ways in which options are presented in physical and digital environments, also plays a pivotal role. Techniques like nudges subtly guide individuals towards more sustainable choices by directing attention, simplifying options, or creating convenient shortcuts. For instance, structuring store layouts to promote reusable bags or designing online interfaces that highlight eco-friendly products can significantly influence behaviour without restricting freedom of choice (Bujold and Williamson, 2025).

However, for behavioural interventions to succeed across diverse communities, they must be contextually relevant, i.e. culturally and socially appropriate. What works in one context may be less effective in another due to differences in cultural and social norms, political climates, or resource availability. Hence, understanding shared motivations and barriers across communities is essential for tailoring interventions effectively (Bates and Glennerster, 2017).

Looking ahead, the integration of behavioural science into plastic pollution mitigation efforts offers promising avenues. As research continues to demonstrate the effectiveness of nudges, social norm campaigns, and behaviourally informed policies, their wider adoption could lead to meaningful reductions in plastic use and waste. Importantly, combining these strategies with community engagement and cultural sensitivity will maximise their impact, ultimately contributing to healthier ecosystems and more sustainable societies.

Many fields, including environmental sustainability, are increasingly turning to BI as a tool to drive change through smart policy. While practical policies are being adopted, designing and implementing effective behaviourally informed interventions is a complex process that often takes longer and requires more resources than standard policy approaches. Such efforts require a deep understanding of people's needs and mindsets, as well as the context of their actions, to adjust settings and information delivery. This work is not a quick fix, though it does hold the promise of deeper, more systemic impact; it is a long-term process of mutual learning that involves many stakeholders. Therefore, seeing these interventions as a 'silver bullet' that can instantly solve problems and apply similarly across diverse policy contexts is a significant overestimation. This deep, continuous process of stakeholder engagement and learning is frequently omitted from the literature. To address this, this chapter examines case studies from four Southeast Asian cities where BI were used to reduce plastic consumption and waste. Our goal is to highlight the importance of this ongoing process of understanding, collaboration, and learning and the potential for scalability to the policy level.

3. Analysis: BI Pilot Projects in Four ASEAN Member States

In 2022, the Institute for Global Environmental Strategies (IGES) launched a project to test how BI can reduce SUP use and waste in cities and communities. Funded and jointly implemented with the Economic Research Institute for ASEAN and East Asia (ERIA) Regional Knowledge Centre for Marine Plastic Debris (RKC-MPD), the Survey and Piloting of the Application of Behavioural Insights Approaches for Plastic Reduction project focused on testing practical ways to shift consumer behaviour related to SUP consumption and waste. The approach emphasised pragmatic behaviour modification, recognising that sustainable plastic reduction occurs through multiple pathways beyond individuals' environmental attitudes or values (ERIA, 2022). In March 2024, the chapter authors, along with ERIA, published a report summarising the results of the four pilot projects and a tool to support behaviourally informed project design titled Breaking the Plastic Habit: A Guidance Note and Practical Toolkit Lessons from Single-Use Plastic Behaviour Change Interventions in Indonesia, the Philippines, Thailand, and Viet Nam (Appleby et al., 2024).

The pilot projects were implemented across four countries in Southeast Asia: Indonesia, the Philippines, Thailand, and Viet Nam. The projects focused on applying BI to curb SUP consumption, largely driven by the proactive engagement of the educational community.

The interventions were implemented across three main location types:

- **University Campuses**: Canteens, food stores, and kiosks on the University of Indonesia campus and the University of the Philippines Diliman campus.
- **Markets/Flea Markets**: The Chulalongkorn University (CU) flea market and the Samyan Flea Market in Thailand.
- **High Schools**: Thanh Loc High School and Hiep Binh High School in Viet Nam.

The following section summarises the results and policy implications of the four pilot projects from this report.

3.1 What worked and did not work in the four pilot projects

3.1.1 Indonesia: Multiple Nudging Approaches for Plastic-Free Campuses

Project Setting

The Center for Southeast Asian Studies (CSEAS) implemented an SUP reduction initiative at the Faculty of Social and Political Sciences (FISIP UI), University of Indonesia. The project targeted a traditional canteen and Maxx Coffee shop within Indonesia's largest faculty, serving over 150 lecturers and 3,500 students. The strategic selection of FISIP UI enabled comparative analysis across different business models and consumer demographics within the same academic environment.

Table 5.1. University of Indonesia (Faculty of Social and Political Sciences), Indonesia

Location: Traditional canteen and Maxx Coffee shop on university grounds **Target groups:** 150+ lecturers, 3,500+ students		
Plastic issues addressed	**Behavioural change levers**	**Key results**
• Plastic straws in traditional canteen • Plastic cups at Maxx Coffee • Limited waste segregation system • Lack of plastic recycling facility	• Choice architecture • Material incentives • Emotional appeals • Information	• Straw reduction: 98% (6,825 → < 100 pieces/month) • Cup reduction: Variable (3,000 → 529–2,601 pieces/month) • High student acceptance • Vendor cost savings

Source: Authors.

Table 5.1 summarises the high-level information for the Indonesian pilot project implementation, including the location, target groups, aspects of plastic consumption and waste behaviour being addressed, behavioural levers used, and key results. Challenges and lessons learned are discussed at the end of this section.

Environmental Context

The project addressed SUP consumption, targeting plastic straws in the traditional canteen and plastic cups in Maxx Coffee. SUPs represent one of the most environmentally damaging waste categories due to massive consumption rates and recycling challenges. Despite existing Indonesian legislative frameworks, including the Waste Management Act (Law No. 18 of 2008), limited initiatives are in place for other SUPs. This intervention aligned with emerging national environmental objectives, supporting Indonesia's timeline to achieve 30% waste reduction by 2025 (Government of Indonesia, 2020) and to phase out SUPs by 2029 (Antara, 2023).

Implementation Strategy and Activities

The project employed several approaches from the behavioural sciences combined with comprehensive campaign strategies. Following baseline data collection in February 2023 and a knowledge, attitude, and practice survey of 300 respondents, interventions launched on 15 March 2023.

In the traditional canteen, plastic straws were moved from display cases to behind-counter positions, requiring explicit customer requests. An Rp2,000 surcharge was imposed for straw usage while straw-free purchases maintained normal pricing. Emotional messaging was reinforced through seller aprons displaying 'Juicenya Asik, Sedotannya Toxic' (The Juice is Great, the Straw is Toxic) and informational banners.

At Maxx Coffee, customers received 10% discounts for bringing personal tumblers. Staff wore message-bearing aprons, and posters were strategically placed near cashiers, leveraging choice architecture, information, and appeals to customer values. A plastic-free campaign titled 'FANTASTIK' was carried out over 16–17 May 2023 to expand engagement through pledge ceremonies, environmental film screenings with Greenpeace and Carbon Ethics, plastic transformation workshops, expert talks, and social media content.

Results, Including Successful Outcomes

The behavioural approaches taken by the project achieved remarkable success in straw reduction in the traditional canteen. Straw usage plummeted from 6,825 pieces monthly to consistently under 100 pieces (61 in March, 82 in April, 83 in May, and 69 in June), representing a 98% reduction. This success reflected minimal impact on the drinking experience and no replacement requirements. Of note, straw usage did not rebound after the Ramadan fasting period the way that cup use did in the private café.

Interestingly, Maxx Coffee showed significant but fluctuating reductions in the use of plastic cups due to several social factors. Before the intervention, about 3,000 pieces of single-use cups were used monthly. During the project intervention, the number of cups used lowered to 529 in March and 465 in April but rebounded to 2,459 in May and 2,601 in June. The initial decrease was driven by external factors like national holidays, Ramadan fasting in March and April,[3] and a semester break in April, which resulted in dramatic reductions before rebounding in May and June. Contributing to the reductions during the Eid period, cafes such as Maxx Coffee reduced their operating hours and experienced significantly lower customer visits compared with May and June. During May and June, while consumption patterns rebounded, they still demonstrated a marked drop in the use of SUPs.

Overall, the community response to the interventions targeting SUPs was overwhelmingly positive, with students adapting readily and vendors benefiting from reduced expenses.

Challenges and Lessons Learned

The application of behavioural science theory proved more challenging at Maxx Coffee due to students' unfamiliarity with bringing personal tumblers, representing complex behavioural change. Limited supervision at Maxx Coffee also constrained monitoring. External factors, including national holidays, Ramadan, and semester breaks, significantly influenced outcomes as the number of customers visiting both the traditional canteen and Maxx Coffee dropped substantially during these periods. Throughout Ramadan, most faculty, staff, and students refrained from purchasing beverages during daytime hours due to fasting obligations. Initial vendor difficulties in explaining new practices also required adjustment periods.

The project demonstrated that BI approaches combining consumer choice with information campaigns that leverage emotional and values-based appeals provide more practical solutions than rigid regulations, fees, or information alone. However, nearby off-campus establishments using SUP continued attracting students, highlighting the need for broader community-wide interventions to maximise environmental impact.

[3] During Ramadan, able-bodied Muslims abstain from food, drink, and other physical needs from dawn until sunset. The practice is observed during the ninth month of the Islamic calendar, and in 2023 spanned 22 March–20 April. As a result, during the pilot project implementation, many students abstained from purchasing drinks for the Ramadan period before resuming their purchasing behaviours on 21 April.

3.1.2 Philippines: A Comprehensive Campus Approach to Plastic Waste Reduction

Project Setting

The project was implemented at the University of the Philippines Diliman (UPD) campus, a large 493-hectare facility located in Quezon City, National Capital Region. UPD accommodates thousands of students, faculty, staff, and formal and informal residential communities. The target group encompassed the entire academic and non-academic community, including students, faculty, staff, guests, and informal residents who purchased food and drinks on campus. The project partnered with seven food vendors: three ambulant vendors (street vendors, kiosks, and stalls) and four non-ambulant vendors (restaurants, cafeterias, and canteens), serving a diverse clientele across the campus.

Table 5.2. University of the Philippines Diliman, Philippines

Location: 493-hectare campus **Target groups:** • 7 food vendors (3 ambulant, 4 non-ambulant) • Students, faculty, staff, visitors		
Plastic issues addressed	**Behavioural change levers**	**Key results**
• Plastic cups, bags, plates, utensils • Plastic labo (thin film bags) • Poor waste segregation • Limited recycling facilities • Lack of systematic waste management	• Material incentives • Choice architecture • Information	• Overall SUP reduction: 43% • Improved waste segregation • 66% customer willingness to pay more for sustainable options • Positive vendor experiences • Enhanced community awareness

SUP = single-use plastic.
Source: Authors.

Table 5.2 summarises the high-level information for the Philippine pilot project implementation, including the location, target groups, aspects of plastic consumption and waste behaviour being addressed, behavioural levers used, and key results. Challenges and lessons learned are discussed at the end of this section.

Environmental Context

The project addressed SUP consumption and waste behaviour in the food sector, targeting plastic cups, bags, plates, and utensils used for takeaway. A significant challenge was UPD's lack of systematic waste segregation and plastic recycling facilities, resulting in non-biodegradable waste ending up in landfills. While the university operated a materials recovery facility for compostable waste, poor segregation hindered effectiveness. The project also aimed to find sustainable alternatives for plastic labo (thin film plastic bags), a major component of plastic waste in the Philippines.

Implementation Strategy and Activities

The project employed BI through a multifaceted approach, including a comprehensive communication campaign with informative and strategically placed posters at vendor locations promoting reusable containers and proper waste segregation. Policy interventions sustained bans on plastic bottled water sales at non-ambulant vendors, provided water refilling stations encouraging tumbler use, and offered ₱5 discounts for customers using reusable food containers at two sites. The ban on plastic water bottles was applied only to non-ambulatory vendors at UPD since the sale of bottled water remains one of the primary sources of revenue for ambulatory vendors. With no viable alternatives on offer, banning such sales would significantly impact the livelihoods of ambulatory vendors.

Alternative provision included supplying vendors with compostable plates, utensils, cups, straws, and packaging materials during a 3-week trial period, with customer satisfaction surveys and vendor feedback collected. A structured waste segregation system was implemented using dedicated bins with clear labels, managed by the Diliman Environmental Management Office, with two small electric vehicles acquired for waste collection. Daily monitoring collected quantitative data through tally sheets and qualitative data through individual and focus group discussions with vendors and customer surveys.

Results, Including Successful Outcomes
Interventions achieved a remarkable 43% decrease in daily SUP use and disposal from participating vendors. The communication campaign proved highly effective, increasing customer numbers and significantly raising waste segregation awareness, with physical posters being particularly impactful. Customers responded positively to compostable alternatives, with 66% expressing willingness to pay slightly higher costs for sustainable options ranging from ₱2.5 more for straws to ₱4.5 more for plates, bowls, and cups, and ₱5 more for takeaway boxes. The plastic bottled water ban, coupled with refill stations, successfully encouraged students to bring reusable tumblers. The average additional cost to vendors per SUP piece far exceeded the cost to source compostable alternatives, suggesting that the business model can sustain the switch away from SUPs. Waste segregation improved considerably after adding physical visual cues to bin labels. Vendors reported positive experiences and pride, finding that customer support outweighed initial cost concerns.

Challenges and Lessons Learned
The ₱5 discount for bringing personal reusable containers had limited impact, with only a few customers participating. Some compostable alternatives had drawbacks, including wooden utensils leaving aftertastes and items becoming flimsy with hot liquids. High costs of compostable alternatives compared with plastics posed a perceived barrier; however, customers' willingness to pay more for sustainable options more than compensated for this price difference. Further, no sustainable alternative was identified for plastic labo bags, which are ubiquitous. Initial waste segregation challenges during the intervention stemmed from low customer awareness and insufficient labelling, but were overcome through a redesign of the project intervention by leveraging more strategic bin placement and clear communication that used images to guide customer behaviour. Limited waste collection equipment hindered campus-wide operations. Key barriers included ensuring consistent, affordable supply chains for alternatives and developing infrastructure for increased compostable waste volumes. The voluntary nature of policies limited broader campus impact, highlighting the need for mandatory implementation and systematic infrastructure development.

3.1.3 Thailand: Expanding Nudging from the On-Campus to Public Markets

Project Setting
The project was implemented at Chulalongkorn University (Chula) in Bangkok, Thailand, focusing on two flea markets within the university's vicinity: Chula Flea Market (CU market) and Samyan Flea Market. CU market primarily serves Chula students and staff and is managed by the Office of Physical Resources Management. Samyan Flea Market operates as a public venue for tourists and surrounding communities, with consumers primarily consisting of individuals working at or residing near the university, operated by the Property Management of Chulalongkorn University. Shopkeepers and customers at both markets comprised the key target groups.

Table 5.3. Chulalongkorn University, Thailand

Location: Chula Flea Market (university community) and Samyan Flea Market (public/tourists) **Target groups:** Students, staff, shopkeepers, customers		
Plastic issues addressed	**Behavioural change levers**	**Key results**
• Plastic bags, containers, cutlery, plastic cups, bottles, straws • Poor waste management	• Material incentives • Rules and regulations • Choice architecture	• Chula Flea Market: 43.4% SUP reduction, 94% plastic bag reduction • Samyan Market: 0.2% SUP reduction • High university community acceptance • Limited cup campaign success (1.9%)

SUP = single-use plastic.
Source: Authors.

Table 5.3 summarises the high-level information for the Thai pilot project implementation, including the location, target groups, aspects of plastic consumption and waste behaviour being addressed, behavioural levers used, and key results. Challenges and lessons learned are discussed at the end of this section.

Environmental Context

The project addressed SUP consumption and waste reduction, targeting the food industry as a major producer of SUP waste, with an estimated 95% of all SUP packaging being discarded after just one use. Before the intervention, CU market averaged 1.87 kilograms of daily SUP usage per shop, while Samyan market averaged 1.51 kilograms daily. Specific targeted items included plastic bags, containers, cutlery, cups, bottles, plates, straws, and packaging materials. Challenges included significant differences in the maturity of pre-existing environmental efforts in the markets, with Samyan market lacking established food and plastic waste management systems and vendors demonstrating significantly lower levels of engagement and interest compared with CU market, and high costs of bioplastic alternatives with limited design options. CU market also benefited from an established relationship with Chula University based on previous zero waste collaborations since 2017, which resulted in vendors being more willing to work with Chula researchers.

Implementation Strategy and Activities

Implementation strategies differed between the two target markets due to the endogenous factors discussed above. In both markets, consumer information campaigns were launched through posters and signage to encourage customers to avoid plastic and bring their own bags. The campaign made use of locally relevant messaging and imagery to better target market clientele. Waste management infrastructure, present in both markets, established new segregation systems enabling revalorisation of food waste as fish feed, plastic waste recycled by cement manufacturers, and compostable cups.

At CU market, the project employed BI through comprehensive interventions including a ‘no free single-use plastic bags’ policy charging B2, with free tote and paper bags provided at the Chula Zero Waste booth. Food vendors were encouraged to shift to biodegradable packaging available at the CU cooperative store. The ‘My Cup’ campaign offered discounts for reusable containers, while #Yourcupwetreat provided free drinks for bringing reusable cups. Communication strategies at the CU market included plastic-free campaigns online and offline, prominent shop banners, social media promotion, campus-wide broadcasts, and student-created promotional materials.

At Samyan Flea Market, some stronger interventions, such as the B2 charge for plastic bags and distribution of free tote bags, could not be implemented since the university and project team had not yet established the mutual trust and cooperation with shop owners that they had built at the CU market through previous collaborations. Points of friction emerged, with vendors at Samyan expressing a belief that the B2 charge was too high for customers to tolerate. Similarly, the Samyan market did not have a distribution system similar to the Chula Zero Waste booth to support the free tote bag programme.

Results, Including Successful Outcomes

Interventions achieved significant plastic waste reduction, particularly at the CU market, which saw a 43.4% decrease in total SUPs after 3 months, while Samyan achieved a 0.2% reduction. The 'no free plastic bags' campaign at the CU market proved highly effective, achieving a 94.0% reduction in plastic bag use at the CU market, prompting consumer shifts to reusable bags. The CU market demonstrated significantly higher acceptance and compliance compared with Samyan. The communication campaign secured widespread academic community support, becoming integral to university identity. Student co-creation of promotional materials fostered ownership and relatability. Collaboration with external cement companies for plastic recycling provided valuable circular economy examples.

Challenges and Lessons Learned

There were two main categories of challenges for the Chula implementation. First, universal challenges existed that effected both participating markers These universal challenges included the fact that biodegradable alternatives to SUPs were more expensive, with limited versatility and opaque designs affecting product visibility and sales. Plastic cup reduction also remained challenging, with only 1.9% reduction despite campaigns. Similarly, in both markets, the voluntary nature of policies resulted in varied compliance levels. Monitoring challenges included inconsistent shop opening hours, varied cooperation levels, and inaccurate information from non-owner respondents. Continued public relations needs were identified for new customers unfamiliar with the campaigns.

Second, the level of interest and engagement by vendors at Samyan market demonstrated the challenge of implementing in a location with less experience in sustainability transition. Since vendors and market management did not have previous experience, they demonstrated lower levels of trust and willingness to implement many aspects of the Chula project plan. Implementation needed to be more gradual and less ambitious in this case, as trust was being built, resulting in minimal reduction in overall plastic consumption and an 8.7% increase in container usage associated with delivery services and tourist preferences.

An additional unexpected lesson emerged as a result of the different levels of cooperation and compliance between the markets. Since Samyan market only implemented a communication campaign and provided waste segregation bins, implementation in the two markets provided evidence of the enhanced benefits that accrue when behaviour change efforts go beyond simple information campaigns to include other behaviour change levers such as social influences, regulatory change, and choice architecture.

3.1.4 Viet Nam: Student-Led Initiatives for Plastic-Free Schools

Project Setting

The project was implemented in partnership with the Southern Institute of Ecology (SIE) at Thanh Loc High School and Hiep Binh High School in Ho Chi Minh City, Viet Nam. The primary target group comprised students, particularly youth, focusing on behaviour change towards plastic pollution control, information provision on plastic alternatives, and capacity building on leadership and social responsibility. Students from science, technology, engineering, and maths (STEM) clubs and the Youth Union were involved in the implementation, with 10th grade students identified as the core group for developing future activities. The project's scope extends to broader district-level application involving elementary to secondary schools.

Table 5.4. Ho Chi Minh City High Schools, Viet Nam

Location: Thanh Loc High School and Hiep Binh High School **Target groups:** Students (focus on 10th grade), STEM clubs, Youth Union		
Plastic issues addressed	**Behavioural change levers**	**Key results**
• SUPs from food and beverages (takeaway containers, plastic bags, and beverage bottles) • Limited waste segregation • External food stores using SUPs • Limited public understanding of plastic impact	• Choice architecture • Information • Social influences • Material incentives	• Thanh Loc: 4.8% SUP reduction • Hiep Binh: 12.4% SUP reduction • 75%–100% of students reported increased knowledge • High student participation • Effective waste segregation motivation • Strong co-creation model with STEM clubs

STEM = science, technology, engineering, and mathematics; SUP = single-use plastic.
Source: Authors.

Table 5.4 summarises the high-level information for the Vietnamese pilot project implementation, including the location, target groups, aspects of plastic consumption and waste behaviour being addressed, behavioural levers used, and key results. Challenges and lessons learned are discussed at the end of this section.

Environmental Context

The main issue addressed was significant daily solid waste collection, predominantly consisting of SUPs from food waste including takeaway containers, plastic bags, and beverage bottles. While high-value plastic waste like PET bottles was recycled, other plastics were mixed with general waste and sent to treatment facilities, indicating limited segregation practices. Broader challenges included limited public understanding of plastic waste's environmental and health impacts. External food and beverage stores near schools extensively using SUP containers, polystyrene foam boxes, polypropylene plastic boxes, and polyethylene plastic bags hindered efforts, as students frequently purchased items from these outside vendors, significantly contributing to school plastic waste.

Implementation Strategy and Activities

The project employed comprehensive baseline and post-intervention monitoring through questionnaire surveys and plastic waste audits in February and May 2023, involving 5-day waste collection, classification, counting, and weighing. Partnership agreements were established with schools, and project design was co-created with school STEM clubs, enabling student-led activities with teacher and researcher support.

Project co-design and participatory implementation of behavioural interventions were the two major features of the Vietnamese project. Students served as key actors, supported by teachers and SIE researchers, in co-designing pilot projects with their school STEM clubs. Detailed interviews and discussions were conducted with STEM club members to identify target behaviours for intervention. Quantitative surveys were implemented to understand students' knowledge, attitudes, and practices regarding SUPs. In-depth interviews were conducted with teachers to assess existing conditions related to waste management and waste problems at schools.

Infrastructure improvements included providing labelled recycling bins indicating different types of recyclable waste (e.g. plastics, paper and cardboard, glass, and metals), which were installed at both schools. Awareness raising and capacity building activities included training sessions for STEM clubs on SUPs; the distribution of 1,500 pamphlets on SUP impacts and reduction strategies; visits and tours to the SIE office and the waste management facilities at Ajinomoto Vietnam Co., Ltd.; environmental contests (painting, model, photography, and video contests); and gamified clean-up activities that included waste-sorting competitions. Awareness raising and communication efforts made innovative use of the social media accounts of the schools' Youth Unions to engage the larger student body. Students participated in regular meetings to evaluate activities and explore alternatives to SUPs.

Results, Including Successful Outcomes

The post-intervention surveys conducted at both schools provide insights into the effectiveness of the project activities. Overall, the school interventions targeting SUPs from food waste (e.g. water bottles, takeaway containers, and plastic bags) achieved plastic waste reductions of 4.8% at Thanh Loc and 12.4% at Hiep Binh High School compared with the pre-project baseline. All activities successfully increased student awareness of the proper use of and waste practices for plastics, with 75%–100% of students at Thanh Loc and 82.4%–100% at Hiep Binh reporting increased knowledge. Waste segregation emerged as the most practical daily activity, with 94.1% of students at Hiep Binh and 77.6% of students at Thanh Loc responding positively to the behaviour. Awareness raising efforts, including brochures, posters, and social media campaigns, also proved particularly effective at Thanh Loc, with 93.3% of students reporting a positive reception. Off-site activities like visits to SIE's offices and the Ajinomoto Vietnam Co., Ltd. waste management facilities were also highly motivating for the students at Hiep Binh (70.4%). The co-creation model ensured that activities aligned with student interests and integrated well with existing curricula, fostering enthusiastic participation and building a sense of collective ownership of the project.

Challenges and Lessons Learned

The greatest challenge for this project was the intensive waste monitoring, which required significant time and effort due to high waste volumes, with collection during non-school hours limiting student participation. The 3-month implementation duration was insufficient for meaningful knowledge-to-behaviour shifts. Project timing during the final school months reduced participation, particularly amongst 12th graders preparing for exams. The close presence of external food vendors outside school jurisdictions also hindered the impact, especially at Thanh Loc, which had greater nearby shop access. Collaboration with these external shops proved difficult, despite being a key objective, and resulted in a steady flow of plastic onto the campuses. Varying levels of engagement on the part of school administrations also affected implementation effectiveness, highlighting the need for long-term reinforcement and continued behavioural adjustment support.

3.2 Comparing Pilot Implementations

Behavioural Approaches Comparison Across the Four Countries

The four pilot projects applied BI in diverse ways, adapted to local contexts, revealing both common strategies and unique approaches. **Material incentives** were a shared feature across all countries but produced mixed results. Indonesia's plastic straw charge (Rp2,000) was highly effective, achieving a 98% reduction. In contrast, the Philippines' and Thailand's small discounts for reusable containers or cups had limited impact. Viet Nam used tumblers as contest rewards, offering modest encouragement.

Choice architecture also featured prominently but showed varying success. Indonesia moved straws behind counters and offered water refill stations, reducing straw use. The Philippines focused on infrastructure improvements like labelled bins and water stations. Thailand provided biodegradable packaging options and redesigned waste disposal with colour-coded bins. Viet Nam introduced labelled recycling bins. Simple elimination behaviours (e.g. removing visible straws) and the redesign and clear labelling of waste segregation bins tended to be more successful than replacement behaviours (e.g. bringing containers).

Information and social influence strategies were employed to both motivate students into action and to enhance the reach and impact of information efforts by utilising the language and media that were most relevant to the target groups. Indonesia implemented a comprehensive campaign featuring movies, workshops, and social media outreach through student groups. Thailand's Chula Zero Waste project integrated student-led initiatives and environmental themes into the university's identity. In Viet Nam, STEM club students from two high schools took leadership roles in peer-led activities and environmental competitions, promoting broader community engagement.

Emotional appeals were used with varying sophistication. Indonesia employed catchy, culturally resonant slogans like 'Juicenya Asik, Sedotannya Toxic'. Thailand encouraged identity-based commitment through university affiliation, while Viet Nam used fun contests to engage students. The Philippines' appeals centred on subtle themes of community participation.

Regulatory approaches differed markedly. Indonesia and the Philippines used soft mandates, such as charges for plastic items, with Indonesia seeing notable success. Thailand adopted voluntary measures, resulting in mixed compliance, particularly between university-affiliated and public markets. Viet Nam emphasised education without monetary penalties, leading to moderate outcomes.

The four pilot projects employed diverse **communication and information campaigns** that proved crucial for raising awareness and facilitating behavioural change, though with varying degrees of success. The Indonesian pilot's comprehensive 'FANTASTIK' campaign combined memorable messaging ('Juicenya Asik, Sedotannya Toxic') on seller aprons with movie screenings, expert talks, and social media engagement, resulting in positive student responses, and expressed interest amongst the target audiences in extending plastic reduction to other items. The Philippines utilised physical posters and social media to promote waste segregation and compostable alternatives, with physical posters proving more effective than online content and visual cues such as actual waste samples significantly improving segregation practices over time. Thailand's approach integrated the established 'Chula Zero Waste' project with student co-created promotional videos, banners, and campus-wide broadcasts, securing widespread academic community support and becoming integral to university identity, though the 'My Cup' campaign showed limited effectiveness with only 1.9% plastic cup reduction. Viet Nam focused on educational approaches through pamphlet distribution to 1,500 students, site visits to waste management facilities, environmental contests, and Youth Union social media engagement, successfully increasing knowledge amongst over 75% of students, with site visits proving particularly effective for providing concrete visual information.

Across all projects, **physical and visual communication methods consistently outperformed digital approaches**, with student involvement in content creation enhancing relatability and acceptance, while the most successful campaigns integrated multiple channels and maintained consistent messaging aligned with institutional identity and values.

Importantly, communication campaigns alone proved insufficient for achieving significant behavioural change – their effectiveness was maximised when combined with complementary interventions such as choice architecture modifications (relocating straws, providing refill stations, and relocating and clearly labelling bins), participatory actions (student-led activities and co-creation processes), and material incentives (pricing strategies and discounts). **The synergistic effect of layered approaches was evident in the most successful outcomes**, such as Indonesia's 98% straw reduction achieved through strategic placement changes reinforced by memorable messaging, and Thailand's contrasting results between markets where comprehensive communication support varied significantly.

Overall, **successful behaviour change emerged through layered interventions**: material incentives for immediate action, choice architecture to support decisions, and contextually relevant information to sustain change through shifting beliefs and values. Effectiveness varied depending on target demographics, institutional backing, and community readiness, with university settings generally showing stronger engagement than broader or younger populations.

However, significant differences emerged in implementation approaches and outcomes. Policy frameworks varied from Indonesia and the Philippines' specific charges and incentives to Thailand's explicitly voluntary approach and Viet Nam's participatory and educational focus. Infrastructure support ranged from the Philippines' comprehensive waste management systems with electric vehicles to Viet Nam's basic school facilities. Target demographics also influenced results, with university communities generally showing higher engagement than high school students or tourist markets.

The contrasting success rates further illuminates these differences. Indonesia achieved dramatic straw reduction (98%) but limited reductions in cup use, the Philippines accomplished comprehensive 43% overall plastic reduction, Thailand showed stark contrasts between university-affiliated (43.4%) and public markets (0.2%), while Viet Nam achieved modest reductions (4.8% and 12.4%) with emphasis on knowledge building. These variations suggest that while certain challenges are universal, successful implementation requires tailored approaches accounting for local contexts, stakeholder readiness, and available institutional support systems.

Challenges Across Four Pilot Projects

The pilot projects in Indonesia, the Philippines, Thailand, and Viet Nam revealed both universal challenges and context-specific implementation difficulties. Despite varied settings and approaches, all projects encountered several common barriers that appear inherent to plastic reduction initiatives in educational and commercial environments.

The **cost and availability of alternatives** emerged as the most pervasive challenge across all locations. Alternative materials consistently proved more expensive and less available than conventional plastics,

affecting both consumer willingness to pay and vendor adoption rates. This problem, evident from Indonesia's sustainable alternatives to the Philippines' costly compostable options, Thailand's biodegradable packaging, and Viet Nam's resource limitations, highlights the fundamental economic disadvantage of sustainable alternatives in current Southeast Asian market conditions. Crucially, alternative products are most effective when they are part of a broader systemic change. This involves shifts in the provision of food and containers, retail policies, pricing, public information, and waste management infrastructure and behaviour. While this will require time and proactive engagement from local businesses, vendors, and policymakers, addressing the economic disparity through systemic reform is a necessary step to overcome the cost–availability barrier.

Behavioural change resistance presented another universal challenge, manifesting differently across contexts but consistently proving difficult to overcome. Indonesia faced challenges establishing tumbler-bringing habits, the Philippines found insufficient impact from monetary incentives (suggesting that the fee was placed too low), Thailand's 'My Cup' campaign achieved only 1.9% plastic cup reduction, and Viet Nam identified the need for long-term behavioural reinforcement. These findings suggest that changing established consumption patterns requires more comprehensive, iterative, and sustained interventions than initially anticipated.

External factors beyond the project's control also significantly undermined efforts across all locations. Indonesia experienced consumption fluctuations due to holidays and semester breaks, the Philippines struggled with off-campus vendors using SUPs, Thailand faced external market dynamics and tourism patterns, and Viet Nam encountered nearby food stores operating outside school jurisdictions. This commonality underscores the importance of broader systemic approaches rather than isolated interventions.

Practical challenges in monitoring and implementation were common across projects. The high volume of waste in schools in Viet Nam required significant time and effort for waste sorting and weighing during monitoring. Indonesia's Maxx Coffee project faced limited monitoring capacity due to the coffee shop's long operational hours. The Philippines also highlighted the limitations of available waste collection equipment, which was insufficient for efficient collection across various campus locations. Thailand noted issues with unstable shop opening hours affecting data collection and sometimes non-shop-owners (employees) providing less accurate questionnaire responses.

A final fundamental challenge across the projects was the understanding that **deep behavioural change is a gradual and long-term process** that requires sustained effort. Viet Nam noted that the brief duration of its project (3 months) was too short to induce a full knowledge-to-behaviour shift. Thailand's Samyan Flea Market, being in a 'pre-mature stage' of environmental transition compared with Chula Flea Market, showed lower acceptance and less satisfactory plastic reduction rates – even an increase in plastic container usage. This underscores that voluntary policies, without mandates, may see varied adherence, with some consumers and retailers willing to comply while others are not. Addressing this requires patience, continuous reinforcement, and a medium- to long-term view of systems change.

3.3 Factors Influencing Successful Interventions

The four pilot projects in Indonesia, the Philippines, Thailand, and Viet Nam shared several key success factors in their innovative approaches to curb plastic consumption:

Proactive engagement and ownership: The projects thrived due to the educational community's proactive engagement with local partners, including vendors, teachers, and learners. This collaborative approach fostered shared commitment and a willingness to experiment, with partners proposing and refining interventions.

Early stakeholder involvement and empowerment: Early and diverse stakeholder involvement (vendors, consumers, students, faculty, and administration) was critical. This engagement deepened their understanding of plastic issues and empowered them as co-creators, leading to a holistic approach and increased capacity.

Commitment to continuous learning and adaptability: A strong commitment to continuous learning and adaptability was vital for reshaping established behaviours. Partners understood that immediate results were not always guaranteed and made real-time adjustments based on feedback, enhancing the initiatives' relevance and reach.

Emotionally appealing and strategically placed messaging: Designing emotionally appealing messages and strategically placing them in high-impact areas was crucial for capturing a wider audience. Communication tools that incorporated positive emotional appeals, resonated with social norms and values, and were displayed in unconventional or high-impact locations proved highly effective. These materials were also adapted to specific audiences through various modes, such as contests or radio programming.

Leveraging existing experience and institutional knowledge: The projects significantly benefited from the existing experience and institutional knowledge of team members, faculty, administrators, business operators, and students. This facilitated understanding of supply chains, effective communication, and existing waste management policies, building momentum by framing the project as a continuation of familiar actions.

Alignment with systemic efforts and existing success: Embedding efforts within larger, systemic behavioural change initiatives proved highly valuable. Interventions were most successful when aligned with existing institutional sustainability roadmaps, local governance priorities, and shifting social values, fostering a purpose-driven movement and building cross-stakeholder partnerships.

Forward-thinking planning: A key lesson was the importance of incorporating future considerations into project planning, implementation, and monitoring and evaluation. This forward-looking approach helped cultivate long-term partnerships, build trust with the target audience, and generate momentum, particularly for engaging policymakers in reinforcing waste reduction strategies.

4. Conclusion: Lessons learned and Way Forward

For years, SUP consumption has been deeply ingrained behaviour in Southeast Asia, posing complex challenges for sustainable transformation. The pilot projects across Indonesian, Filipino, Thai, and Vietnamese campuses explored behavioural interventions to promote sustainable alternatives, yielding crucial insights into effective 'nudges' despite modest immediate consumption reductions. These pilot projects established essential baselines for consumption patterns and intervention responses, providing vital foundations for future local government engagement and demonstrating the significant potential of behavioural change methodologies in addressing regional plastic pollution challenges.

The journey towards sustainable plastic consumption in Southeast Asia reveals that effective behavioural change transcends simple intervention implementation – it requires a fundamental shift in how we conceptualise, measure, and sustain transformation. The pilot projects demonstrated that while technical solutions and policy interventions are necessary, they are insufficient without deep understanding of local contexts, genuine stakeholder collaboration, and sustained commitment to iterative learning and adaptation.

The contrasting outcomes across different settings – from Indonesia's remarkable 98% straw reduction to Thailand's divergent results between university and public markets – underscore that successful behavioural interventions must be carefully calibrated to specific communities, institutional contexts, and cultural environments. The effectiveness of nudging approaches, material incentives, and communication strategies varied significantly based on target demographics, existing infrastructure, and community readiness for change.

Perhaps most significantly, these pilot projects revealed that sustainable behavioural change emerges not from isolated interventions but from comprehensive ecosystem transformation involving multiple stakeholders, layered approaches, and long-term commitment to continuous improvement. The expanded second phase, with its emphasis on cross-sector collaboration, practitioner training, and systematic monitoring frameworks, represents a maturation of understanding about what it takes to create lasting environmental behaviour change.

The successes, challenges, and lessons learned from these pilot projects illuminate the need to reconsider where and how we evaluate the effectiveness of policies and practices applying behavioural change approaches. While BI are already widely applied across various fields – from road designs enhancing traffic safety to information strategies promoting water and energy conservation – the effectiveness of these interventions is typically assessed through indicators such as user adoption rates or behavioural sustainability over time. These remain essential and valid measures, yet insights from our four pilot projects remind us that fostering deeper behavioural change requires improving the contexts in which people make choices, which inevitably takes time and demands broad, sustained collaboration with stakeholders including local governments, businesses, and service providers.

Crucially, meaningful behavioural transformation depends on active participation from target groups and feedback mechanisms that nurture motivation and engagement. The true value of behavioural approaches may therefore lie not solely in changing isolated consumer or disposal behaviours, but in enabling individuals to become more engaged and collaborative in maintaining or transforming the environments that shape daily life – influencing how we purchase, use, and dispose of products; share meals; or spend time with others. While individual behaviours remain important elements of broader change, they should not constitute the sole criteria for success.

Building on the successes and key challenges of the four pilot projects, the chapter authors with ERIA launched the next phase of BI initiatives entitled *Breaking the Plastic Habit in ASEAN*, with an expanded scope and enhanced implementation support, in October 2024. Recognising the need to extend beyond academic settings, the programme now targets diverse contexts including the business sector, tourist sites, and sports events, enabling collaboration with regional and local partners across varied demographic and cultural environments. The new phase runs from October 2024 to December 2025 and includes projects in six countries: Cambodia, Indonesia, the Lao People's Democratic Republic (Lao PDR), the Philippines, Thailand, and Viet Nam (ERIA, 2024). As Southeast Asia continues to grapple with plastic pollution, these insights provide a roadmap for future initiatives that prioritise context-sensitive design, collaborative implementation, and holistic measurement of success. The ultimate goal extends beyond reducing plastic consumption to fostering engaged communities capable of sustaining environmental stewardship and driving broader societal transformation towards sustainable futures. The lessons learned here offer valuable contributions not only to regional environmental efforts but also to the global understanding of how BI can effectively address complex sustainability challenges in diverse cultural and economic contexts.

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Chapter 6

Extended Producer Responsibility on Plastic Waste in ASEAN+3 Countries

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Introduction

Extended producer responsibility (EPR) is an environmental policy approach that extends producers' accountability to the post-consumer stage of a product's life cycle, aligning end-of-life costs and incentives with the entities that place the products on the market (OECD, 2001; 2016). The modern diffusion of the concept of EPR can be traced from early deposit refund schemes (DRSs) in North America to Germany's 1991 Packaging Ordinance. However, adoption by the Association of Southeast Asian Nations (ASEAN) has unfolded amid socio-economic, infrastructural, and market conditions distinct from the settings of the Organisation for Economic Co-operation and Development (OECD), warranting a developing-economy analytical lens (Johannes et al., 2021; ERIA RKC-MPD, 2022a). In the ASEAN+3 countries,[1] both Japan and the Republic of Korea (henceforth, Korea) have applied EPR to waste polyethylene terephthalate (PET) bottles, other packaging and containers, e-waste, and end-of-life vehicles. After following two countries, in more recent years, EPR has been applied in some ASEAN Member States and China to packaging and containers, e-waste, and end-of-life vehicles.

The regional stakes are high. The World Bank has estimated that in Malaysia, the Philippines, and Thailand, over 75% of the material value of recyclable plastics is lost annually (about US$6 billion) as collection/sorting gaps allow recoverable materials to leak or be down-cycled. These losses are compounded by damage to tourism, fisheries, and shipping (Kwakwa and García Mora, 2021; World Bank, 2021). Concurrently, the Basel Convention's plastics amendments (effective 1 January 2021) reshaped regional waste flows and tightened quality/traceability requirements, elevating the importance of domestic capacity and enforcement and highlighting ambiguities around 'environmentally sound management' (Basel Convention Secretariat, n.d.; van der Marel, 2022).

This chapter makes four main contributions. First, it synthesises the theory and practice on plastics EPR design under developing-economy conditions, highlighting binding constraints and feasible responses. Second, it clarifies the instrument families and governance choices – take-back, fee-based instruments (e.g. minimum post-consumer recycled content), and information tools. Third, it describes EPR implementation in the ASEAN+3 countries. Fourth, it frames ASEAN-level alignment opportunities – shared producer definitions, recyclability criteria, fee-setting principles, and reporting templates – while situating national choices within evolving international regimes (OECD, 2016; ERIA RKC-MPD, 2022a).

[1] The ASEAN+3 countries are the 11 ASEAN Member States (Brunei Darussalam, Cambodia, Indonesia, the Lao People's Democratic Republic (Lao PDR), Malaysia, Myanmar, Philippines, Singapore, Thailand, Timor-Leste, and Viet Nam) plus China, Japan, and the Republic of Korea.

1. Extended Producer Responsibility

The first modern DRS for beverage containers was enacted in Oregon, United States (US) in 1971, followed by Vermont, US in 1972, and other North American jurisdictions in subsequent years (Kaffine and O'Reilly, 2015). The broader trigger to disseminate EPR to the world was Germany's Packaging Ordinance in 1991, under which the producer bears the responsibility for the disposal of packaging (OECD, 2001),

The implementation of EPR systems is driven by a suite of interconnected objectives aimed at transforming the linear take-make-dispose economic model. The primary goals are:

(i) **Generating sustainable funding**: EPR creates a dedicated and ongoing funding stream from producers to finance the collection, sorting, and recycling of post-consumer waste, relieving the financial burden on local governments and taxpayers.

(ii) **Increasing collection and recycling rates**: By establishing clear targets and providing recompense, EPR systems are proven to significantly boost material recovery and recycling rates, diverting waste from landfills and the environment.

(iii) **Incentivising eco-design**: The objective of EPR is to influence upstream product design. By making producers financially responsible for end-of-life management, the policy creates a direct incentive to design products and packaging that are more durable, easier to repair, and readily reusable or recyclable (e.g. design for recycling).

(iv) **Reducing overall waste generation**: Through the promotion of eco-design and by encouraging a shift towards more sustainable consumption patterns, EPR ultimately aims to reduce the total volume of waste generated at the source.

EPR schemes allocate different types of responsibilities to producers, such as information responsibility, physical responsibility, and financial responsibility. Information responsibility refers to the obligation to disseminate information on EPR schemes, such as targeted waste and waste collection mechanisms, to consumers. Physical responsibility encompasses the logistics involved in collecting targeted waste and recycling. Financial responsibility covers the recycling cost of targeted waste, including the cost of transportation, recycling, and disposal of residual waste.

The application of these three types of responsibilities differs depending on the prevailing regulations and country contexts. In addition, targeted waste streams under EPR and responsibilities by producer, consumer, and governments are different. OECD (2001) summarized the various EPR policy instruments, such as take-back, DRS, material tax, advanced disposal fee (ADF), combined upstream tax/subsidy, and recycled contents (Table 6.1).

Table 6.1. Implementation Components of EPR Policy Instruments

Items	Product or waste stream	Stage in product chain	Direct response to intervention	Implementing body
Deposit refund system	Specific products (e.g. beverage containers)	Disposal, with signals to design stages	Re-use and design	All levels of government, industry based- firm level or private sector organisation
Take-back	Product and waste streams (and sectors)	Disposal with strong signals to resource extraction and design stages	Re-use, recycling some source reduction and design	All levels of government, industry based -firm level or private sector organisation
Material tax	Product (specific inputs)	Resource extraction and design stages	Reduced inputs of targeted materials and design	National and sub-national governments
Advanced disposal fee	Product	Disposal stage	Recycling and some reuse and recovery	All levels of government, private sector organisation
Combined upstream tax/ subsidy	Product	Design and disposal stages	Reduced material input and recycling	National and sub-national government, private sector organisation (waste management)
Recycled content	Product (e.g. paper and plastics)	Design, signals to disposal stage	Design, reduced raw material input	All levels of government, industry based -firm level, or private sector organisation

Source: OECD (2001: 47).

Take-back mandates open formal return pathways but depend on convenience, clarity of scope, and credible enforcement (OECD, 2016). DRSs add a refundable price signal and typically deliver higher return rates and cleaner feedstock for bottle-to-bottle applications. Cross-market evidence finds no definitive sales depression attributable solely to DRSs when evaluated with actual time-series data (Reloop and Container Recycling Institute, 2023). Multi-instrument approaches such as DRS are likely to be more efficient than single-instrument policies such as ADF, as they target multiple margins of adjustment by firms and households (Kaffine and O'Reilly, 2015). ADF, as a non-refundable upstream fee, can fund net system costs for hard-to-recycle formats but requires statutory ring-fencing and audited reporting to prevent diversion (OECD, 2016).

Encouraging eco-design is also an important element of EPR. Uniform, weight-based fees stabilise tonnage but weakly incentivise design change. By contrast, eco-modulation differentiates fees by recyclability, mono-materiality, additives, separability, and post-consumer recycled (PCR) content, aligning private incentives with system outcomes. Public bonus/malus schedules and independent technical panels help keep signals credible (OECD, 2016; ERIA RKC-MPD, 2022a).

In addition, whether fees are pooled in a producer responsibility organisation (PRO) or a national fund, ring-fencing and independent assurance are essential. Publishing a concise annual funds use and outcomes report – covering tonnage, quality, leakage proxies, social inclusion metrics, and prices paid to service providers – improves legitimacy and bankability (OECD, 2016; World Bank, 2021).

Comprehensive producer definitions must include manufacturers, importers, brand owners, contract packers, and e-commerce entities. Harmonised reporting templates and verified registries lower free-riding and facilitate cross-border comparison (OECD, 2016; ERIA RKC-MPD, 2022a).

2. EPR in ASEAN's Framework and Declaration

In line with the global trend, ASEAN frameworks have elevated circular economy and marine-debris concerns but intentionally avoid prescribing national measures. A voluntary 'core' could still align definitions, data templates, recyclability guidance, modulation principles, and quality standards for secondary materials (ERIA RKC-MPD, 2022a; OECD, 2016). The Basel plastics amendments oblige exporters and importers alike to improve quality control and traceability and to interpret 'environmentally sound management' rigorously, which in practice argues for regional alignment on B3011/A3210-consistent contamination thresholds and testing protocols (Basel Convention Secretariat, n.d.; van der Marel, 2022).

2.1 ASEAN Framework of Action on Marine Debris

The ASEAN Framework of Action on Marine Debris was developed in 2019, based on the recommendations from the ASEAN Conference on Reducing Marine Debris in the ASEAN Region in Phuket in November 2017, taking into accounts the East Asia Summit Conference on Combating Marine Plastic Debris in Bali in September 2017. The framework mentioned EPR, such as 'Develop and implement extended producer responsibility (EPR) policies and schemes including design for environment, deposit refund, and take-back for reusing and recycling' (ASEAN, 2019: 2).

2.2 Bangkok 3R Declaration

The Bangkok 3R Declaration Towards Prevention of Plastic Waste Pollution through 3R and Circular Economy mentions the 'adoption of Extended Producer Responsibility principle for packaging products' (UNCRD, 2019: 2). The declaration was developed at the Ninth Regional 3R Forum in Asia and the Pacific, held on 4–6 March 2019 in Bangkok, Thailand. The preamble to the Bangkok 3R Declaration emphasised the importance of EPR in the context of waste management (UNCRD, 2019: 2, emphasis added):

> … promote environmentally sound waste management on the whole stage of the collection, treatment and disposal to minimize the leakage of plastic waste into the ocean, and adoption of Extended Producer Responsibility principle for packaging products.

2.3 Framework for Circular Economy for the ASEAN Economic Community

The Framework for Circular Economy for the ASEAN Economic Community was developed in 2021. The framework did not mention EPR but pointed out the importance of protecting the rights of both producers and consumers under the circular economy model (ASEAN, 2021b: 3, emphasis added):

> There also needs to be a mechanism to ensure the rights of both producers and consumers will continue to be protected under the CE model. A coordinated effort to reskill ASEAN entrepreneurs, and improve educational programs for individuals in the region, on CE is also critical.

3. EPR Regulation in ASEAN+3 Countries

Amongst ASEAN+3 countries, Indonesia, Malaysia, the Philippines, Singapore, Thailand, Viet Nam, China, Japan, and Korea have evolved their EPR policies in different ways, based on their varied national circumstances. In the context of plastic pollution, single-use plastic bags, plastic packaging, and plastic containers are major target items. But EPR should also be applied to electrical and electronic waste, automotives, furniture, toys, and other items, which contain plastics. Amongst these products, EPR is applied to waste packaging and containers, e-waste, and end-of-life vehicles. Here the authors introduce the country cases which exist or develop EPR schemes.

3.1 Indonesia

Indonesia's roadmap regulation (Ministry of Environment and Forestry (MOEF) Regulation No. 75 of 2019) requires producer plans up to 2029 and is complemented by a shift to mandatory EPR from 2025 (MOEF, 2019). According to Antara (2025b), the environment minister mentioned that the implementation will be gradual. The Indonesia Packaging Recovery Organisation (IPRO) demonstrates how voluntary platforms can seed capacity before regulation (ERIA RKC-MPD, 2022a).

The Roadmap to Waste Reduction by Producers (MOEF Decree No. P.75/MENLHK/SETJEN/ KUM.1/10/2019) requests producers and shops to develop plans to reduce the use of packaging and containers and to report the reduction to the ministry (MOEF, 2019). Producers were requested to submit plans to reduce packaging and to report the results.

3.2 Malaysia

Malaysia's plastics roadmap sets a transition to mandatory EPR by 2026, with an independent PRO and eco-modulated fees under development (Aoki, 2022).

The Malaysian government has published several documents on the circular economy and plastic pollution, such as the Malaysia Plastics Sustainability Roadmap (Ministry of Environment and Water, 2021), which mentioned EPR.

On September 2024, the Ministry of Investment, Trade and Industry issued the Circular Economy Policy Framework, which will introduce EPR (MIDA, 2024). On 9 May 2025, the Malaysia National Circular Economy Council approved the proposed EPR Policy Framework in principle (Bernama, 2025). The council also agreed to the mandatory implementation of eco-design.

3.3 Philippines

The Philippines' EPR Act of 2022 (Republic Act No. 11898) mandates escalating recovery targets on plastic packaging, with individual/PRO compliance and penalties for non-registration/non-compliance (Republic of the Philippines, 2022). The implementing rules and regulations were signed by the Environment Secretary on 24 January 2023 (DENR, 2023). Target items for EPR are sachets, labels, laminates, and other flexible plastic packaging products (single/multi-layer); rigid plastic packaging products; plastic bags; and expanded polystyrene (EPS or styrofoam). Mandatory recovery rates for both rigid and flexible plastic packaging are 20% of the previous year's plastic packaging footprint in 2023, 40% in 2024, 50% in 2025, 60% in 2026, 70% in 2027, 80% in 2028 (Republic of the Philippines, 2022; DENR, 2023).

The 20% rate of collection and diversion was achieved in 2023. Out of the 486,000 metric tons of audited footprint for 2022, 163,000 metric tons were recovered and diverted in 2023 (WWF Philippines, 2024).

3.4. Singapore

Singapore's Resource Sustainability Act, 2019 underpins e-waste EPR and a S$0.10 deposit return for PET/metal beverage containers (150 millilitres–3 litres) beginning 1 April 2026 (which used to be planned from April 2025, but extended one year) through a licensed, industry-led operator (National Environment Agency, n.d.; 2023).

Singapore has very strict regulation on littering. Under the Environmental Public Health Act, first-time offenders may be fined up to S$2,000, while repeat offenders may be fined up to S$10,000 (National Environment Agency, n.d.).

The National Environment Agency introduced a regulated e-waste management system in July 2021 to ensure the proper collection and handling of e-waste and the extraction of valuable resources from it. The regulated e-waste management system also safeguards the environment and our health. The system is based on the EPR approach, where producers bear responsibility for the collection and treatment of their products when they reach the end of their lives.

To promote circularity of plastics, Singapore will apply a DRS to all pre-packaged beverages in plastic bottles and metal cans (150 millilitres–3 litres) from April 2026. The transition period will be 1 April to the 30 September 2026, when bottles with and without deposits/refunds coexist. From 1 October 2026, all plastic bottles will be included under the deposit scheme.

3.5. Thailand

Thailand is preparing a sustainable packaging management act with a government-certified PRO model and fee concepts that include service and compensation components, with just-transition provisions recommended given the scale of informal recycling (SecondMuse, 2024; ERIA RKC-MPD, 2022a).

However, EPR regulations have not yet been approved by ministries and/or parliament. According to The Nation (2024), the European Union (EU) requires trading partners to implement EPR. The sustainable packaging management act is expected to be presented in 2025–2026 and implemented by 2027 (Enviliance ASIA, 2024).

3.6. Viet Nam

Viet Nam operationalised a hybrid model in 2024 under the Law on Environmental Protection in 2020 and Decree No. 08/2022/ND-CP – own-recycling (individual/PRO/third-party) or contributions to the Vietnam Environmental Protection Fund using material-specific fees × mandated rates – with clarifications in Decree No. 05/2025/ND-CP (DEPOCEN, 2024; KPMG Vietnam, 2025).

EPR was mentioned in the Law on Environmental Protection in 2020, and Decree 08/2022/ND-CP stipulated that enforcement of EPR would begin on 1 January 2024. The first target waste streams were packaging and containers, batteries, lubricants, and tyres. EPR has gradually been applied to various target wastes in Viet Nam, including waste electrical and electronic equipment from 2025. EPR will also apply to end-of-life vehicles and motorcycles in 2027.

3.7 China

China's tightening of plastic waste imports and single-use plastic countermeasures catalysed domestic capacity and reshaped regional flows, underscoring the need for clean, high-value streams (Basel Convention Secretariat, n.d.; van der Marel, 2022).

The Chinese government issued the Plastic Reduction Order in 2007, which restricted single-use plastic bags less than 0.025 millimetres thick. Enforcement of this order began on 1 June 2008, when all supermarkets, shopping malls, bazaars, and other retail outlets were required to sell plastic shopping bags (Jiang et al.., 2023). In 2020, the government issued the Order on Single Use Plastic Ban, which prohibited the production and sale of food containers made from styrofoam, cotton buds, and some products using micro-beads, amongst others (Jiang et al., 2023).

3.8 Japan

Japan's packaging EPR couples municipal sorting obligations with producer-financed recycling via PRO-run tenders. Design guidance has improved PET bottle recyclability, though questions remain about cost-sharing and occasional municipal bypassing of PROs (ERIA RKC-MPD, 2022a; OECD, 2016). The Containers and Packaging Recycling Law was enacted in April 1995. In 1997, glass containers, PET bottles for drinks and soy source, and cardboard boxes[2] were initial target items under this law. The law allows local governments to ask residents to separate plastics at source before disposal.

The Home Appliance Recycling Law was enacted in 1998 and came into force in 2001, requiring producers to recycle TVs, air conditioners, washing machines, and refrigerators. Article 9 stipulates the responsibilities of manufacturers:

> Persons who manufacture small electrical and electronic equipment in the course of trade must endeavour to reduce costs for recycling small waste electrical and electronic equipment by devising product design and selection of types of components or raw materials for small electrical and electronic equipment and also use items and materials obtained through the recycling of small waste electrical and electronic equipment.

However, the Act on Promotion of Recycling of Small Waste Electrical and Electronic Equipment, enacted in 2012, does not mention EPR.

[2] Except paper cartons with aluminum foil.

3.9 Republic of Korea

Korea implemented the Deposit-Refund System in 1992, under which producers paid a deposit to the Ministry of Environment for their products. Producers were eligible to obtain a refund if they collected the waste and recycled the target items. Consumers were not entitled to a refund. The rate of refunds increased from less than 5% in 1992 to more than 44% in 1998, meaning that the majority of deposits were retained rather than refunded to producers.

In 2003, the Deposit-Refund System was replaced with the EPR model, which requires producers to cover the recycling cost based on their production volume. The recycling rates have increased from 40.6% in 2002 to 72.9 % in 2021 (Da-hyun, 2024).

Korea's sequenced mix – DRS, ADF, and target-based EPR – was consolidated into a single packaging PRO to reduce administrative overhead and stabilise fees and guidance. An online marketplace improved price discovery and supply stability (OECD, 2016; ERIA RKC-MPD, 2022a).

The DRS was established via the Act on the Promotion of Saving and Recycling of Resources, which was amended in February 2002. Article 8 (1) states that 'the Government may recommend matters necessary for the saving of resources, control of generation of wastes and recycling of wastes to producers and consumers or guide them'. The Ministry of Environment may order producers (manufacturers or importers of packing material) to recycle. In 2003, the government introduced another recycling scheme, the EPR system, which stipulates the amount of waste to be recycled by each producer.

In 2008, the Act on the Resource Circulation of Electrical and Electronic Products and Automobiles mandated the establishment of a collection system to recycle wastes from products released by manufacturers or importers, specifying the responsibilities of state and local governments, business operators, and citizens for the system to function. According to Jang et al. (2022), the recovery of 803,000 tons of reusable and recyclable materials resulted in the processing of about 1 million tons of end-of-life vehicles in 2020 through dismantling and shredding treatment, which resulted in 78,300 of automobile shredded residues.

4. Complementary Policy Conditions for Effective EPR

EPR cannot function as a stand-alone instrument. Three complementary conditions determined whether EPR fees and take-back mandates translate into circularity: packaging and product design that enables high quality recovery, quality standards for secondary materials that build market confidence, and eco-modulated fee structures that transmit the right economic signals to producers. The following section describes each condition, focusing on ASEAN+3 countries.

4.1 Design for Recycling (DFR)

The recyclability of packaging is largely determined at the design stage, before a product reaches the end of its life. Therefore, the concept of the Design for Recycling (DFR) is a prerequisite for EPR to deliver quality materials. The DFR core principle is to prioritise mono-material constructions with established reprocessing routes, to minimise multilayer format unless separability is demonstrably feasible, and ensure all components are compatible with existing sorting and washing infrastructure (OECD, 2016; ERIA RKC-MPD, 2022a).

For PET bottles, clear material should be standard, while component choices for sleeves, labels, and closures must support optical sorting and float–sink separation, and adhesives and inks should be water-washable to avoid quality loss. For instance, it is difficult to recycle multiple plastic wastes with different melting points (e.g. thermoplastics). Specific gravity can resolve issues with some plastics (Table 6.2). For example, PET, whose specific gravity is 1.30–1.38, sinks in water. The specific gravity of polyvinyl chloride (PVC) is 1.30–1.50. It is difficult to separate PET and PVC in the washing process. But the specific gravity of polyethylene (PE) is less than 1. In the washing process of shredded PET bottles with water, the PET sank, but the PE floated on the surface of the water. One of the designs for recycling of PET bottles is to use plastic caps and labels whose specific gravity is different from that of the PET bottles.

Where barrier layers such as ethylene vinyl alcohol (EVOH) or polyamides are necessary, concentrations should remain within bottle-to-bottle specifications or be compensated by advanced decontamination, so that the recycled resin remains eligible for food-contact application (Eunomia Research & Consulting and Zero Waste Europe, 2022; EFSA, 2024).

Table 6.2. Examples of Various Types of Plastics – Melting Points and Specific Gravity

Plastic type	Melting point	Specific gravity
Polypropylene (PP)	168C	0.90–0.91
Polyethylene (PE)	210–270 (high-density PE) 180–240 (low-density PE)	0.91–0.96
Acrylonitrile butadiene styrene (ABS)	190–270	1.04–1.06
Polystyrene (PS)	170–280	1.04–1.07
Polycarbonate (PC)	280–320	1.20–1.22
Polyethene terephthalate (PET)	260–280	1.30–1.38
Polyvinyl chloride (PVC)	85–210	1.30–1.58

Sources: Encyclopaedia of Industrial Information and Manufacturing Practice (n.d. a; n.d. b).

DFR guidance is the most effective when it is linked to EPR fee structure. When recyclability criteria determine the magnitude of eco-modulated fee, the economic signal and the design signal reinforce each other. An annually updated ‘positive list’ of accepted formats and ‘watch list’ of formats attracting a malus penalty give producers the lead time needed to reformulate packaging before penalties take effect. For example, Italy’s CONAI and France’s CITEO have demonstrated that such lists, maintained by a standing technical committee of producer and recycler representatives, can be updated without creating regulatory uncertainty (Laubinger et al., 2021).

ASEAN countries are at an early stage of formalising DFR guidance. Indonesia, Malaysia, and Thailand have each incorporated DFR concepts into national plastics roadmap, but binding recyclability criteria tied to EPR fee schedule remain largely absent. Given the dominance of multilayer flexible packaging in the regional product mix – sachets, laminates and multi-material pouches that are unrecyclable under current infrastructure – establishing clear positive and watch lists aligned with existing sorting capacity should be an early priority for PROs as EPR system mature (ERIA RKC-MPD, 2022a).

4.2. Industrial Standards for Recycled Products

Another side of EPR is an industrial standard for recycled goods. This is important to meet the demand for recycled products. Some recycled products may not satisfy the level of quality desired by customers or may not guarantee product quality under conventional industrial standards for products made from virgin materials. To ensure an adequate level of quality for recycled products, and to reduce the transaction cost between suppliers and buyers, industrial standards for recycled products should be developed.

Market confidence in recycled plastics is dependent on technical standards. Existing frameworks such as the Japanese Industrial Standards (JIS), the Standard and Industrial Research Institute of Malaysia (SIRIM) standards, and the Indonesian National Standard (SNI) provide product-class specifications that governments can use to create as the basis for green public procurement rules, pairing minimum PCR thresholds with defined performance requirements (Laubinger et al, 2021; ERIA RKC-MPD, 2022b).

The Japanese government has supported the creation of industrial standards for plastic recycling goods. Some of these industrial standards are utilised not only by the private sector but also by government agencies, such as for public investment in infrastructure (Table 6.3). The Act on Promotion of Procurement of Eco-friendly Goods and Services by the State and Other Entities in 2000, requires governments and government-related organisations to prioritise green public procurement. This initiative has secured the demand of eco-products. Such initiatives stimulate recycling industries to utilise recycled material for products and reduce the waste management cost by reducing waste generation.

Table 6.3. Industrial Standards on Recycled Plastics in Japan

JIS Code	Title
JIS A5731	Recycled plastics inspection chambers and covers for rainwater
JIS A5741	Products of wood-plastic recycled composite
JIS A5742	Products of wood-plastic recycled composite – assembled decks
JIS K6930	Reclaimed granulate moulding materials of agricultural polyvinyl chloride film
JIS K6931	Reclaimed plastics bars, rods, plates, and piles
JIS K6932	Recycled plastics stakes
JIS A9401	Recycled plastics medial strip block
JIS A9402	Recycled plastics buffer for parking
JIS K9797	Un-plasticised PVC-U three-layer pipes with recycled solid core
JIS K9798	Un-plasticised PVC-U three-layer pipes with recycled foamed core

JIS = Japanese Industrial Standards, PVC-U = polyvinyl chloride.
Source: Japanese Standards Association (various years).

In Malaysia, SIRIM, an agency under the Ministry of Investment, Trade and Industry, has developed various standards, including an industrial standard on the recovery and recycling of plastics (MS ISO 15270:2008) (Table 6.4).

Table 6.4. SIRIM Eco-Labelling Standards for Recycled Plastic and Biodegradable Plastics in Malaysia

Standard	Title of SIRIM Standards
MS 1904 2006	Specification for polyethylene plastics moulding and extrusion materials from recycling post-consumer (HDPE) sources
MS ISO 15270: 2008	Plastics – Guidelines for the recovery and recycling of plastic waste
SIRIM ECO 001:2018	Eco-labelling criteria – Biodegradable and compostable plastic and bioplastic
SIRIM ECO 009:2019	Eco-labelling criteria – Biodegradable and compostable biomass products
SIRIM ECO 018:2024	Eco-labelling criteria – Recycled plastic products
SIRIM ECO 098:2023	Eco-labelling criteria – Degradation of polyolefin plastic in an open-air terrestrial environment

HDPE = high-density polyethylene, ISO = International Organization for Standardization, MS = Malaysian Standard, SIRIM = Standard and Industrial Research Institute of Malaysia.
Sources: Global Ecolabelling Network (n.d.); and ERIA RKC-MPD (2022b).

Indonesia has also issued industrial standards related to plastics (Table 6.5), including PET resin. In 2023, Indonesian plastics recycling companies started to produce 100% rPET to facilitate bottle-to-bottle recycling for Coca-Cola Europacific Partners Indonesia (Circular Technology, 2024).

Table 6.5. Indonesian SNI Standard on Eco-Plastics

SNI No.	Title
SNI 7188.7:2022	Eco-Labelling Criteria Part 7 category for plastic and bioplastic shopping bags that easily decompose
SNI 8424:2017	Recycled polyethylene terephthalate (PET) resin
SNI/ISO 14021	Environmental labels and declarations – Self Declared environmental claim (type II environmental labelling)

ISO = International Organization for Standardization, SNI = Indonesian National Standard.
Source: SIRIM QAS International (n.d.).

PCR requirements should be phased in pragmatically, calibrated to the maturity of collection infrastructure and reprocessing capacity. The EU Packaging and Packaging Waste Regulation provides a useful reference: mandatory recycled content for PET beverage bottles is set at 30% by 2030 and 65% by 2040 (European Commission, 2025). For other plastic packaging categories – including HDPE containers and rigid PP – no binding international benchmarks yet exist, and appropriate thresholds will depend on the availability of colour-sorted feedstock, decontamination capacity, and end-use performance requirements. ASEAN countries are encouraged to set initial targets that stretch industry practice without outpacing recycling infrastructure, with scheduled reviews as collection system and secondary material market mature.

Biodegradable plastic use would be a complementary approach to single-use plastic waste. According to Antara (2025a), the Indonesian industry minister stated that such technology offers a concrete solution to the problems caused by plastic waste, particularly single-use plastics and that Indonesia has the potential to become a regional pioneer in the development and use of biodegradable plastics.'

5. Achievements and Challenges to Implement EPR in the Southeast Asian Region

The success of EPR outcomes depends on financing stability; sequencing; logistics; social inclusion; the treatment of hard-to-recycle formats; and the governance of registration, data, and audits (OECD, 2016; Johannes et al., 2021). EPR implementation in developing country contexts benefits from a sequenced approach that builds collection and reprocessing capacity before tightening targets or introducing advanced fee modulation (OECD, 2016; Johannes et al., 2021). Pre-treatment near the source materially reduces transport costs, while multifunctional transfer stations serving clusters of municipalities buffer seasonal variability in quality and volume (Johannes et al., 2021; Kwakwa and García Mora, 2021).

The inclusion of informal collectors in the formal economy through contracted services improves equity and raises recovery and quality, provided that occupational health and safety, service-fee remuneration, and accessible grievance mechanisms are in place (Johannes et al., 2021; OECD, 2016).

Producer scope should include manufacturers, importers, brand owners, contract packers, and e-commerce entities that first place packaged goods on the market, while registries with unique IDs and annual declarations, harmonised reporting templates, and third-party assurance for large entities underpin compliance (OECD, 2016; ERIA RKC-MPD, 2022a). Transparent reporting on collection volumes, recycling rates, and compliance performance is essential to system legitimacy and public accountability (OECD, 2016). These measures lead to the success of EPR implementation in the region. However, several challenges (waste collection system, recycling rate, recycling industry park, and international trade issues) remain in Southeast Asian countries as detailed below.

5.1 Waste Collection Services and Target Recycling Rate

In some ASEAN Member States, municipal solid waste collection services are limited, particularly in rural areas. It is important to expand these services to include the collection of recyclable waste. For example, according to the price list of Wongpanit, a large-scale recycling business with a network of junk shops and recycling centres, certain types of plastic waste, such as 'waste hard water hoses', 'waste PP.TD10, 20', and 'waste PVC pipe (grey)', have no value (as of 22 August 2025) (Wongpanit, n.d.). It is also important to create demand for recycled plastic waste by developing industrial standards for recycled products and introducing green public procurement programmes.

If the generation of municipal solid waste increases, the government should invest in the capacity to transport waste and in waste treatment and disposal facilities, such as sanitary landfills and waste-to-energy plants. In Japan, for example, many municipalities have formed coalitions to collect, treat, and dispose of municipal solid waste due to economies of scale (Ministry of the Environment Japan, 1997).

5.2 Recycling Industrial Parks

The recycling industry may be regarded as a not in my back yard (NIMBY) facility. In such cases, local governments should allocate space for recycling industries. In Japan, for example, the central government supports local governments in securing industrial areas for recycling, known as eco-towns (recycling industrial parks), which are located within industrial areas (Ministry of the Environment Japan, n.d.).

Japan has developed 26 recycling industrial parks (Ministry of the Environment Japan, 2018). In some cases, recyclers have faced the NIMBY issue when investing in recycling facilities. For example, Tokyo's Super Eco-Town, located near a landfill site in Tokyo Bay, is home to 10 companies, including two construction waste recyclers, two e-waste recyclers, two food waste recyclers, two landfill waste recyclers, one gasification melting furnace, and one printed circuit board treatment facility (Tokyo Super Eco-Town, n.d.). Another well-known eco-town is in Kitakyushu City in Fukuoka Prefecture. The Kitakyushu Eco-Town Plan was approved in 2002 (Ministry of the Environment Japan, 2018: 6). The Kitakyushu Eco-Town hosts various recycling facilities for PET bottles, home appliances, office equipment, automobiles, construction waste, non-ferrous metals, small home appliances, rechargeable batteries, cooking oil, organic solvents, wastepaper, cans, pachinko machines, waste wood, waste plastics, metal-contaminated sludges, waste mobile phones, and anti-foaming agents for recycled paper.

5.3 International Trade and EPR

Another example is to reinforce EPR implementation to trade counterparts. The EU has requested that partner countries, including some in Asia, introduce EPR regulations as part of trade negotiations. For example, the EU Packaging and Packaging Waste Regulation has exerted growing influence on trading partners, including Thailand, where export-oriented manufacturers are already redesigning packaging to meet EU standard (European Commission, 2025; Nikolova, 2025). This EU initiative could lead to the introduction of EPR regulations, industrial standards for recycled products, and investment in recycling industries.

6. Regional Cooperation and the Global Plastics Treaty: A Platform to Accelerate ASEAN EPR Convergence

Strong national EPR frameworks are the essential building blocks of circularity, but their effects are amplified when countries move in step. In Southeast Asia, ASEAN already has an institutional platform – the ASEAN Regional Action Plan for Combating Marine Debris (2021–2025) – that can be used to deepen alignment across key design choices without requiring supranational legislation. The action plan recognises the need for coordinated, land-to-sea responses and provides a pragmatic venue for Member States to translate shared objectives into compatible policies (ASEAN, 2021a). As shown in the previous section, recent ASEAN (and ASEAN+3) knowledge work underscores the centrality of EPR to tackling plastic leakage and highlights the practical value of common reference points as countries design or upgrade their systems (ERIA RKC-MPD, 2022a). Building on these resources, ASEAN can reduce compliance frictions for firms operating across several markets by converging on what counts as 'recyclable' packaging, who is an 'obligated producer', how fees are computed, and how outcomes are reported (ASEAN, 2021a; ERIA RKC-MPD, 2022a).

Regional cooperation is also critical to the economics of secondary materials. Financing high-quality reprocessing capacity hinges on assured feedstock quality and predictable market access. Here, ASEAN can complement national EPR laws by adopting harmonised quality standards for recycled plastics and by reviewing tariff and non-tariff classifications to prioritise trade in clean, single-polymer streams. Such steps are consistent with, and indeed reinforced by, the Basel Convention's plastic waste amendments, which took effect on 1 January 2021. These amendments clarified the scope of plastic wastes presumed to be hazardous (A3210) or non-hazardous and almost free from contamination (B3011) and created a new Annex II entry (Y48) for plastic waste not covered by A3210 or B3011, subject to prior informed consent procedures, raising the bar for quality and traceability in transboundary movements (Basel Convention Secretariat, n.d.). Aligning ASEAN practice with these entries would facilitate legitimate cross-border shipments of high-quality feedstock for manufacturing while strengthening controls against the illicit dumping of low-grade plastics mis-declared as recyclables (Basel Convention Secretariat, n.d.).

The global plastics treaty process provides a timely external driver for regional policy convergence. Following the 2022 mandate from the United Nations (UN) Environment Assembly to negotiate a legally binding instrument covering the full life cycle of plastics, the Intergovernmental Negotiating Committee on Plastic Pollution (INC) has produced successive drafts that explicitly consider national measures consistent with EPR approaches (UNEP, n.d.). At the resumed fifth session (INC 5.2) held in Geneva during 5–15 August 2025, the chair issued a draft text and then a revised one. Both retained the language of the article-level provisions on plastic waste management, which encourage parties to establish or promote EPR approaches and product circularity alongside other economic instruments (UNEP, n.d.; 2025). Although negotiations adjourned without reaching an agreement on the final text, both UN reports and independent summaries emphasised that the delegations intended to continue engaging to finalise the instrument, ensuring that EPR remained at the heart of the negotiations (UN, 2025a; UN. 2025b; IISD, 2025).

For ASEAN, the implications are twofold. Substantively, EPR-related obligations are likely to feature in whatever treaty ultimately emerges; procedurally, a unified regional position would increase the bloc's influence over the instrument's final contours. By articulating a shared EPR core – common definitions, eco-modulation principles, data/reporting standards, and Basel-consistent quality criteria – ASEAN can both smooth its own implementation path and contribute constructively to treaty design (ERIA RKC MPD, 2022a; OECD, 2016). Expert dialogues convened in the region have already explored how treaty-level EPR provisions would interact with ASEAN Member State systems, indicating appetite and momentum for convergence (ERIA RKC MPD, 2024; UNEP, 2025). In this sense, the treaty is not merely an external pressure; it is a catalyst for internal cohesion that can help overcome long-standing fragmentation in regional environmental governance (UN, 2025; ERIA RKC MPD, 2024).

A practical roadmap can be used to align regional steps with the treaty timeline. In the near term, ASEAN working groups could issue non-binding model definitions of 'recyclable' and 'producer', a short guideline on eco-modulated fees, and a common reporting template. These could be nested in the 2021–2025 action plan to enable early convergence even before the treaty is finalised (ASEAN, 2021a; ERIA RKC-MPD, 2022a). As the treaty text stabilises, these documents could be updated to ensure legal and technical interoperability. Upon entry into force, ASEAN could then adopt a regional quality protocol for recycled polymers that is aligned with the Basel Convention to facilitate the lawful movement of high-quality secondary feedstock and deter trade in mixed or contaminated plastic waste (Basel Convention Secretariat, n.d.). Taken together, these steps would transform EPR from a patchwork of national measures into a cornerstone of a unified, regional circular economy strategy – boosting investment, increasing recycled content, and reducing leakage across the region (OECD, 2016; UNEP, 2025).

Although strong national policies form the basis, their impact will be amplified through regional cooperation. ASEAN should leverage its existing platforms, particularly the ASEAN Regional Action Plan, to promote greater policy alignment (ASEAN, 2021a). Aligning key EPR elements, such as the definitions of 'recyclable' and 'producer', methodologies for calculating fees, and standards for data reporting, would significantly reduce the complexity and cost of compliance for businesses operating across the region.

Furthermore, regional cooperation is vital to establishing a viable market for recycled materials on the necessary scale. This involves developing harmonised quality standards for recycled plastics to build trust amongst buyers and reviewing regional trade classifications (Brown & Börkey, 2024). Such a review would facilitate the smoother cross-border movement of high-quality secondary raw materials for manufacturing, while simultaneously strengthening controls to prevent the illicit dumping of low-quality plastic waste as recyclables.

Conclusion

EPR has become the most credible policy lever for reconciling rising plastic use with finite waste management capacity in the ASEAN+3 region, provided it is implemented as a market-shaping regime rather than a narrow cost transfer. Evidence from OECD countries and early adopters in East Asia suggests that EPR is effective when financing is ring-fenced and auditable, fee signals are aligned with design outcomes, and material flows are clean and traceable from collection to recycling (OECD, 2001; 2016; Hotta et al., 2009). Recent reforms in the Philippines and Viet Nam illustrate a pragmatic combination of international guidance and domestic realities, including mandatory recovery or fund contributions, clearer producer responsibilities (including importers and brand owners). Meanwhile, Singapore's operator-licensed beverage container return scheme signals a regional shift towards high-quality collection streams (DEPOCEN, 2024; KPMG Vietnam, 2025; National Environment Agency, n.d.).

The priority for the next phase is to implement credible incentives and verifiable outcomes. While uniform, weight-based fees raise revenue, they do little to change packaging portfolios. In contrast, eco-modulated fees tied to recyclability, mono-materiality, separability, additives, and PCR content transmit the design signal that EPR was created to deliver (OECD, 2016; Laubinger et al., 2021; ERIA RKC-MPD, 2022a). DRSs consistently increase return rates and provide cleaner feedstock for bottle-to-bottle applications, eliminating the sales penalties often anticipated and strengthening the business case for domestic reprocessing (OECD, 2016; Reloop and Container Recycling Institute, 2023). As market confidence hinges on quality, technical specifications for rPET, rHDPE, and rPP must be incorporated into standards and public procurement to align demand and supply (Eunomia and Zero Waste Europe, 2022; Brown & Börkey, 2024). Equally, informal collectors must be contracted in.

The priority for the next phase is to lock in credible incentives and verifiable outcomes. Uniform, weight-based fees raise revenue but do little to change packaging portfolios; eco-modulated fees tied to recyclability, mono-materiality, separability, additives, and PCR content transmit the design signal that EPR was created to deliver (OECD, 2016; Laubinger et al., 2021; ERIA/RKC-MPD, 2022a). Deposit-return systems consistently raise return rates and supply cleaner feedstock for bottle-to-bottle applications, with evidence finding no definitive link to the beverage sales declines often assumed by industry, strengthening the business case for domestic reprocessing (OECD, 2016; Reloop and Container Recycling Institute, 2023). Because market confidence depends on quality, technical specifications for rPET, rHDPE and rPP should be embedded in standards and public procurement so that demand-pull matches supply-push (Eunomia & Zero Waste Europe, 2022; Aoki, 2022). Equally, informal collectors must be contracted in – with transparent pay-for-performance, occupational safety, and grievance channels – so that social inclusion and system efficiency advance together (Johannes et al., 2021; World Bank, 2021).

Regional alignment now offers the largest marginal gain. ASEAN can reduce compliance frictions and raise overall system performance by converging on producer definitions, recyclability criteria, fee-setting principles, and reporting templates, while adopting Basel-consistent quality thresholds that facilitate lawful trade in clean, single-polymer streams and deter movements of mixed or contaminated waste (ASEAN, 2021a; Basel Convention Secretariat, n.d.; van der Marel, 2022). This pathway is also coherent with the global plastics treaty process, where successive INC drafts have retained language encouraging EPR and product circularity. Although negotiation at INC 5.2 adjourned without agreement and the process faces significant uncertainty, the sustained engagement of delegations provides a useful external anchor for domestic reforms and regional convergence (UNEP, n.d.; 2025; IISD, 2025; UN, 2025).

In short, EPR in ASEAN+3 countries should be executed as a disciplined, auditable financing and design framework that rewards recyclable packaging, secures high-quality returns, and professionalises inclusion of the informal sector. If governments and PROs deliver on these fundamentals, plastics could shift from a leakage liability to a circular economy asset – raising recycling rates, improving material quality, creating better jobs, and lowering public costs over time.

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Chapter 7

Status of Plastic Waste Management and Its Life Cycle Impacts: Challenges and Opportunities

Nirmala Menikpura
Yasuhiko Hotta

1. Introduction: Overview of Plastic Waste Management in the ASEAN Region

Plastic, which makes up 10%–13% of daily municipal solid waste at a global level, is a major component of solid waste (Kibria et al., 2023). The growing population, rapid urbanisation, and ongoing industrial development are key drivers behind the escalating plastic waste crisis, leading to serious, human-made environmental challenges that threaten ecosystems and human well-being. By 2060, global plastic consumption is projected to exceed 1,200 million tonnes (Mt), nearly four times today's level. This relentless surge in demand, combined with the inability of recycling and waste management systems to keep up, has placed the world on a trajectory where plastics manufacturing could account for 20% of global oil and gas consumption by 2050 (Anderson and Fletcher, 2022). This trend poses a serious threat to the depletion of the world's finite fossil resources. A significant portion of end-of-life plastics is expected to leak into the natural environment, contributing to severe environmental degradation and posing serious risks to human health (OECD, 2022).

In the Association of Southeast Asian Nations (ASEAN) region, plastic pollution poses a significant challenge to the future, with over 31 Mt of plastic waste generated annually across six of the 10 ASEAN Member States (AMS). The region carries a responsibility to address the biodiversity, environmental, and health issues caused by outdated and primitive plastic waste management practices. Moving towards innovative solutions and promoting circular business models are essential steps towards reducing pollution, conserving resources, and creating a more sustainable and resilient waste management system (Zorzi, 2023).

In the ASEAN region, inadequate waste collection, followed by disposal in open dumps and landfills, has been a significant contributor to plastic leakage into the ocean. Open dumping and open burning of waste is prevalent in most AMS (UNEP, 2022). These methods not only harm the environment but also facilitate the leakage of plastics into waterways, eventually reaching the ocean. In fact, landfills, as long-term storage sites for plastic waste, can become significant sources of microplastics through gradual decomposition, posing environmental risks and potential health hazards – including cancer, endocrine disruption, and reproductive disorders – for nearby communities (Ratiwi, Achmadi, and Kurniawan, 2024). Identifying existing inefficiencies in plastic waste collection and treatment systems, and proposing more advanced methods and technologies, is essential for effectively addressing the growing plastic pollution challenge.

ASEAN (2021) emphasised that developing national and regional action plans, such as the ASEAN Regional Action Plan for Combating Marine Debris (2021–2025), is essential for addressing marine litter in the region. However, effective implementation of these strategies requires tangible, science-based evidence to guide decision-making. A life cycle–based evaluation of existing and potential future treatment options would provide more concrete insights to support policy and decision-making in the ASEAN region. Furthermore, climate impact and abiotic resource depletion are key concerns in plastic waste management due to the heavy use of fossil fuels in plastic production, collection, transport, and treatment. These processes lead to high greenhouse gas emissions (GHG) and the depletion of non-renewable resources, highlighting the need for more circular and resource-efficient solutions. Therefore, this chapter will assess key impacts such as climate impacts from all the GHG emissions (measured as kilograms of carbon dioxide equivalent (kg CO2-eq) and abiotic resource depletion (measured as kilograms of crude oil equivalent (kg crude oil-eq) potential of current plastic waste management approaches, including the transition to advanced technologies such as recycling and the production of secondary raw materials, energy recovery through incineration, and the use of refuse derived fuel (RDF) to replace coal in cement kilns.

No detailed life cycle–based assessments are available for all existing and proposed plastic treatment technologies. Therefore, the authors have gathered background data and conducted an impact assessment using the Institute for Global Environmental Strategies (IGES) Emissions Quantification Tool (EQT) version III (IGES, 2025),[1] which will provide tangible impacts on end-of-life plastic waste treatment options. These findings will offer critical insights to help policymakers and stakeholders prioritise solutions that reduce marine pollution, mitigate climate change, conserve resources, and advance circular economy goals.

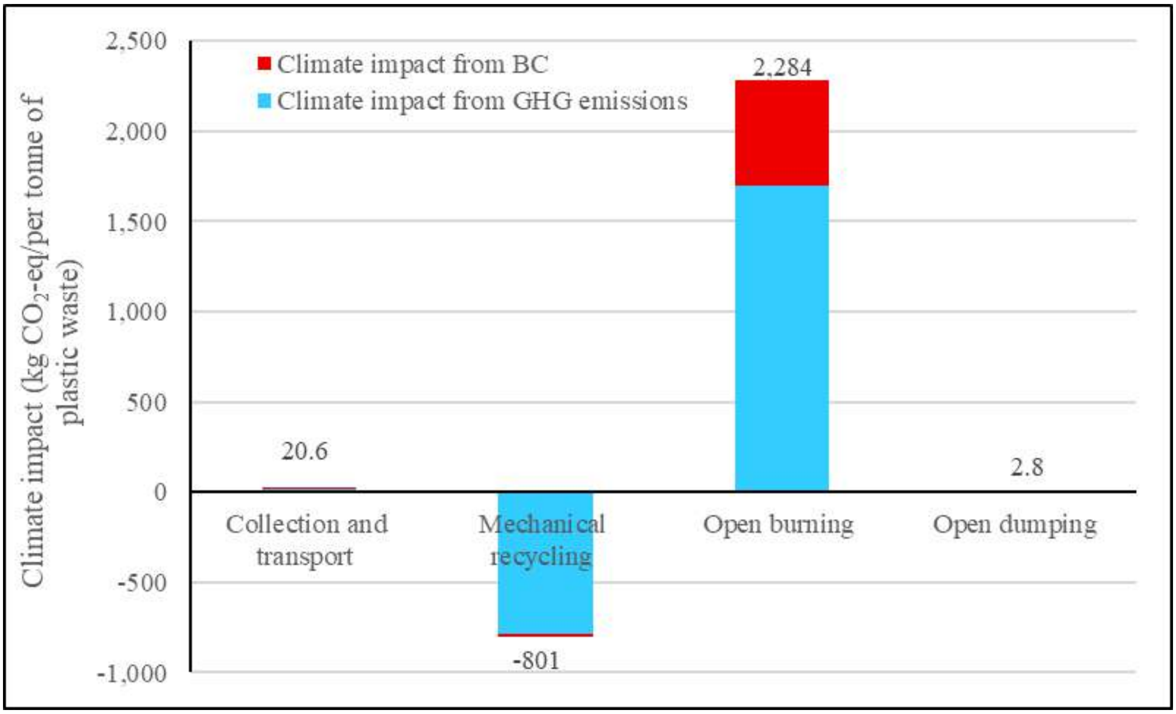
2. Plastic Waste Collection Rate and Its Consequences

In many AMS, waste collection rates are low and vary widely. Municipal waste collection in ASEAN is uneven, with urban areas like Malaysia, Singapore, and Thailand exceeding 80%, while rural and coastal regions in countries like Cambodia and Indonesia often remain less than 50% (OECD, 2025; World Bank, 2022), with the largest gaps observed in remote and underserved areas. This gap in waste collection and the lack of appropriate treatment infrastructure represents a critical challenge across the ASEAN region. It significantly contributes to marine plastic pollution, as unmanaged waste is highly prone to leakage into rivers and oceans, posing severe threats to marine ecosystems, biodiversity, and the livelihoods of coastal communities (Jambeck et al., 2015).

[1] The IGES EQT was developed to support policy and decision-making through quantitative analysis of life cycle–based carbon emissions, considering all phases of the life cycle, including both emissions and savings, through resource recovery. It also accounts for total energy consumption and the energy recovery potential from different waste management options. In this study, the authors used the latest EQT Version III, published in 2025, to quantify climate impacts in terms of emissions/savings and calculating fossil fuel depletion/saving potential using net energy consumption potential from different plastic waste treatment options. This version incorporates updated emission factors from the Intergovernmental Panel on Climate Change (IPCC) and national/regional datasets, along with methodological improvements based on IPCC guidelines, to provide more accurate and context-specific results.

In terms of the impact on plastic waste collection, field surveys conducted by the authors in Indonesia found that 5–6 litres of diesel (the primary fuel) are consumed per tonne of plastic waste collection and transportation, using various types of collection vehicles used in the ASEAN region (IGES, unpublished data, 2024). Many of the collection vehicles are ageing and often overloaded, which increases the risk of plastic leakage during transport (UN-Habitat, 2010). This not only reduces collection efficiency but also contributes to environmental pollution, particularly the unintended release of plastic waste into surrounding areas and waterways. The combustion of fossil fuels contributes to climate change due to the emission of greenhouse gases such as carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and black carbon (BC), and leads to fossil resource depletion, as fuels like diesel and gasoline are derived from crude oil. Using the IGES EQT (IGES, 2025), the estimated climate impact from plastic waste collection is about 20.6 kg CO_2-eq per tonne of plastic waste collected (Figure 7.1). The fossil fuel depletion potential from diesel use for collection is estimated at 5.8 kg crude oil-eq (Figure 7.2).

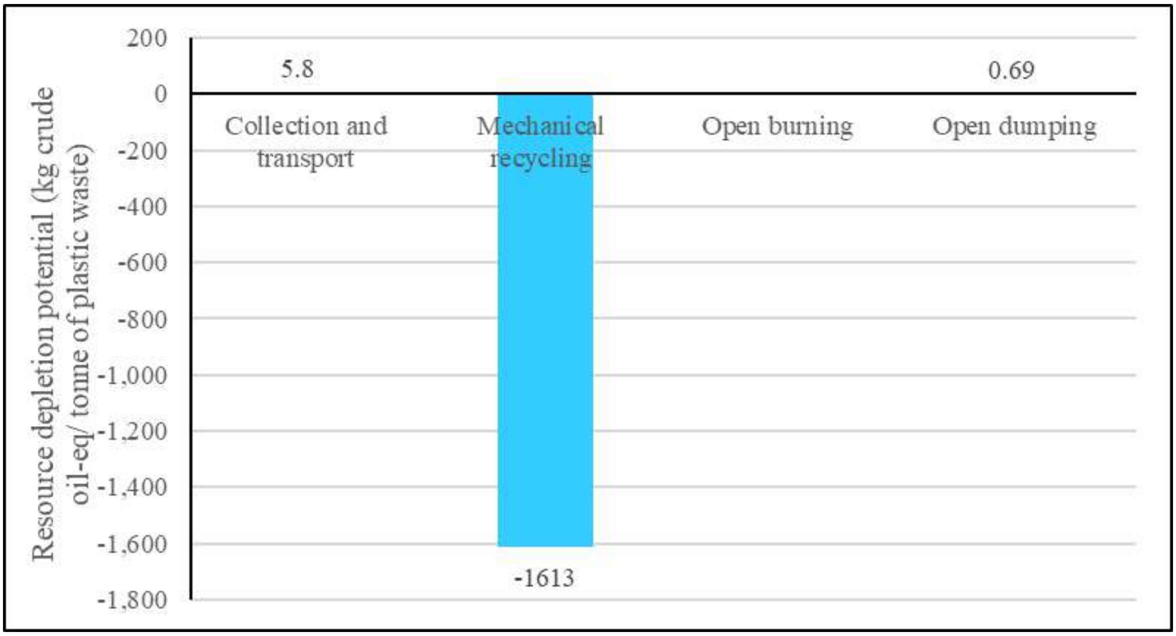
Figure 7.1. Carbon Emissions/Savings from Existing Plastic Waste Management in the ASEAN Region



BC = black carbon, GHG = greenhouse gas, kg CO2-eq = kilogram of carbon dioxide equivalent.

Source: IGES (2025).

Figure 7.2. Abiotic Resource Depletion Potential/Savings from Existing Plastic Waste Management in ASEAN



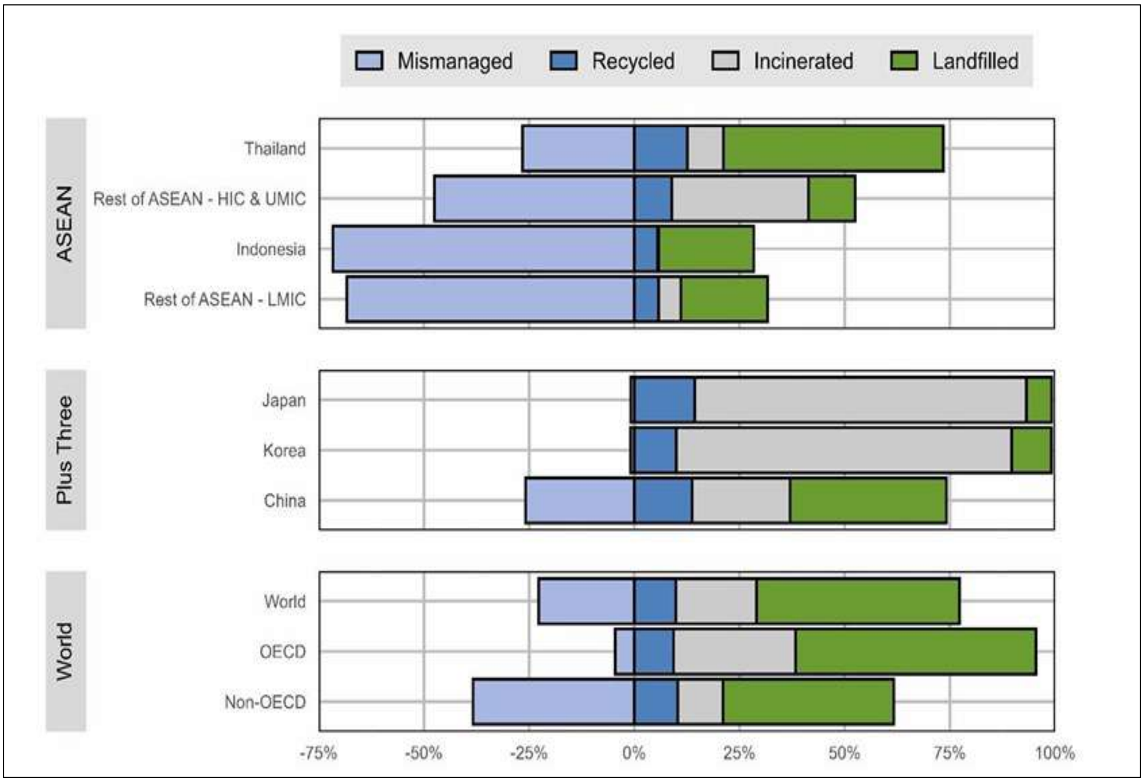
ASEAN = Association of Southeast Asian Nations, kg crude oil-eq = kilogram of crude oil equivalent.

Source: IGES (2025).

3. Existing Plastic Waste Management Options and Their Impacts

Inadequate waste collection, followed by improper disposal practices such as open dumping, burning, and landfilling, remains widespread across the ASEAN region (Akenji et al., 2019). These practices exacerbate pollution and pose serious risks to human health. Plastic recycling rates remain below 10% (Figure 7.3) in most AMS (OECD, 2025), hindered by insufficient infrastructure, lack of market incentives, and limited public awareness. Improper and premature disposal methods significantly contribute to climate change and resource depletion. In contrast, proper waste sorting and recycling offer substantial potential for climate change mitigation and resource conservation. This section evaluates these impacts from a Life Cycle Assessment (LCA) perspective.

Figure 7.3. Plastic Waste Management in ASEAN+3 and the Rest of the World



ASEAN = Association of Southeast Asian Nations, LMIC = low- and middle-income country, OECD = Organisation for Economic Co-operation and Development, UMIC = upper middle-income country.

Note: ASEAN+3 refers to the 11 ASEAN Member States plus China, Japan, and the Republic of Korea.

Source: OECD (2025).

3.1 Segregation for Recycling

Plastic waste segregation rates in AMS remain generally low, especially at the household and community levels (OECD, 2025). While some urban areas have introduced source separation initiatives, widespread segregation practices are still limited. As a result, a large portion of recyclable plastics is mixed with general waste, making recycling more difficult and costly (Geyer, Jambeck, and Law, 2017). Due to inadequate sorting, contamination and the mixing of different polymer types in collected plastic waste significantly degrade the technical quality and economic value of recycled plastics, limiting their usability and market demand (Geyer, Jambeck, and Law, 2017). Poor segregation significantly reduces the quality and quantity of recyclable materials, leading to higher rates of plastic leakage into the environment and contributing to the growing marine plastic pollution problem across the region. At present, in the ASEAN region, the segregation of recyclables, including plastics, is primarily carried out by informal collectors. In fact, in China, Indonesia, the Philippines, Thailand, and Viet Nam, 85% of the plastic extraction for recycling occurs at the waste-picking stage by informal pickers (Barends, 2019). This process typically requires little to no fossil fuel or electricity, so the associated emissions from segregation are assumed to be minimal.

3.2 Mechanical Recycling

Plastic recycling in ASEAN is low, with countries like Indonesia, Thailand, and Viet Nam recycling only 8%–25% of urban plastic waste (Suradja et al., 2024). Economic interventions, along with aligned policies, incentives, and technology, are needed to boost recycling and build a sustainable plastic value chain (Bouloukos, Lechtenberg-Kasten, and Wang, 2021). Furthermore, the low recycling rate may be partly due to the limited demand for secondary plastics produced through recycling in AMS. To address this issue, it is important to promote local markets for recycled plastics by encouraging public procurement policies, supporting industries that use recycled content, and strengthening regional standards and certifications to build trust in the quality of recycled materials. However, the ASEAN Regional Action Plan for Combating Marine Debris is creating momentum for more ambitious and co-ordinated policy responses, and these countries are already making progress in areas like waste segregation at source, recycling, and the use of recycled materials in manufacturing (OECD, 2025)

The production of plastics from virgin crude oil has significant impacts on fossil fuel use and the accompanying GHG emissions. About 4% of the world's oil production goes into the production of virgin (new) plastic (Prevented Ocean Plastic, 2020). Polyethylene, particularly in the form of low-density polyethylene (LDPE) and high-density polyethylene (HDPE), is one of the most widely used materials for single-use plastics such as plastic bags, films, and containers (Geyer, Jambeck, and Law, 2017). Producing just 1 tonne of these types of plastic typically requires 2.0–2.5 tonnes of crude oil, highlighting the significant fossil fuel demand associated with their manufacture (Futurestradingltd, 2025).

Recycling plastic helps avoid the production of an equivalent amount of virgin plastic, significantly reducing both carbon emissions and the consumption of finite natural resources that would otherwise be required for virgin plastic production. According to estimates using the IGES EQT (IGES, 2025), the overall climate impact from plastic recycling is estimated at –801 kg CO_2-eq per tonne of plastic waste (Figure 7.1). Although some energy is required during the recycling process, there is still a significant reduction in abiotic resource depletion, indicated by –1613 kg crude oil-eq (Figure 7.2). This is primarily due to the avoidance of virgin plastic production through the use of recycled plastics. The negative values reflect the potential for carbon savings and resource conservation achievable through effective recycling and resource recovery. These results provide compelling evidence for stakeholders in the recycling industry, highlighting the environmental benefits of strengthening plastic recycling efforts.

3.3 Open Dumping and Landfilling

Open dumping and landfilling remain the most common methods of disposal of collected plastic waste in many AMS, despite their serious environmental risks (Figure 7.2). About 75% of the plastic waste disposed of in dumpsites or landfills has the potential to threaten the soil and other environments through microplastic contamination (Ratiwi, Achmadi, and Kurniawan, 2024). In addition, uncollected plastic waste in the ASEAN region is often discarded through scattered dumping or ends up in mismanaged landfills, including open burning and disposal in unsanitary sites (OECD, 2025). These disposal sites release leachate that contaminates soil and groundwater with microplastics and toxic chemicals, and much of the plastic eventually leaks into rivers and oceans (Ratiwi, Achmadi, and Kurniawan, 2024). The study conducted at the Depok City landfill in Indonesia found a significant average microplastic abundance of 60,111 particles per kg of soil, indicating widespread contamination across all sampled locations (Ratiwi, Achmadi, and Kurniawan, 2024).

As far as key environmental impacts are concerned, in general, a small amount of fossil fuel (diesel) is used for operating machinery (e.g. backhoes) at these disposal sites. However, some developing AMS use second-hand machinery at disposal sites, which may not be energy efficient and could result in higher emissions. Based on IGES EQT–based emission estimations, the associated climate impact and abiotic resource depletion potential are estimated at 2.8 kg CO_2-eq and 0.69 kg crude oil-eq per tonne of plastic waste, respectively (IGES, 2025). Although these impacts are relatively minor, inappropriate disposal methods can lead to the highest levels of microplastic contamination in water bodies and ecosystems.

3.4. Open Burning of Mismanaged Plastic

Open burning of plastic waste is common in ASEAN due to poor collection and limited treatment options (OECD, 2025). It releases toxic pollutants like dioxins and furans, harming health and the environment. Burning plastic also emits carbon dioxide and BC, worsening air pollution and contributing to climate change (Menikpura, Singh, and Dickella Gamaralalage, 2022). This harmful practice remains widespread at dumpsites, roadsides, and homes, highlighting the urgent need for improved waste management infrastructure.

Open burning also has a significant impact in terms of GHG emissions. Since plastics have a fossil-based origin, their combustion releases a large amount of fossil-derived carbon dioxide (CO_2). Additionally, BC, a major component of soot produced during the incomplete combustion of plastic, is a significant contributor to climate change (Menikpura, Singh, and Dickella Gamaralalage, 2022), which has a global warming potential 900 times stronger than CO_2 over a 100-year time horizon (Liu et al., 2023). On average, burning 1 tonne of plastic waste emits about 0.65 kg of BC (Bond et al., 2013). Taking into account both fossil CO_2 and BC emissions, the IGES EQT (IGES, 2025) estimates that the overall climate impact from burning 1 tonne of plastic waste is 2,284 kg CO_2-eq (Figure 7.4).

4. Implementation of Appropriate End-of-life Plastic Treatment Methods

The improvement of plastic waste management in ASEAN needs urgent investment (OECD, 2025). As shown in section 3, current practices of open burning and open dumping cause environmental and health risks. Solutions must be tailored to waste type, regulations, and local socio-economic and geographical conditions. In many AMS, rising plastic use has not been matched by proper waste collection, leading to leakage into waterways (OECD, 2025). Source separation, followed by improved formal waste collection, is a crucial first step to reducing plastic leakage into the environment.

4.1 Implementation of Proper Sorting Process

Introducing a proper sorting process after waste collection offers significant advantages. It enables the separation of different waste fractions more effectively, reduces the residual fraction, and improves overall recycling efficiency. According to Jeswani et al. (2021), sorting mixed plastic waste requires about 308 megajoules (MJ) of electricity per tonne. That results in a climate impact of 56 kg CO_2-eq and would contribute to an abiotic resource depletion potential of 19 kg crude oil-eq per tonne (IGES, 2025) (see also Figures 7.4 and 7.5). While these impacts are associated with the energy used during the sorting process, the improved material recovery efficiency through proper sorting processes would enable substantial reductions in overall climate impact and greater savings in virgin resource consumption.

4.2. Incineration for Energy Recovery

In the ASEAN region, waste incineration is still limited due to high capital and operational costs, the high moisture content of municipal solid waste, and the lack of adequate sorting and pretreatment systems (OECD, 2025). However, waste-to-energy technologies offer significant potential to reduce landfill dependency, recover energy, and support climate goals (Brunner and Rechberger, 2015). AMS can benefit by adapting proven waste-to-energy practices and technologies from more advanced systems through regional cooperation and technology transfer. Despite challenges such as lack of public awareness, insufficient public–private partnerships, limited stakeholder engagement, funding constraints, and climate-related factors, some AMS have made a reasonably successful step towards waste-to-energy technologies (Tun et al., 2020).

In general, incorporating a high fraction of plastic waste into the incineration feedstock increases the potential for energy recovery, as plastic has a high calorific value, exceeding 31,000 MJ per tonne (IGES, 2025). However, due to its fossil origin, incinerating plastic results in significant emissions of fossil-based CO_2 and BC, both of which contribute substantially to climate change (Figure 7.4).

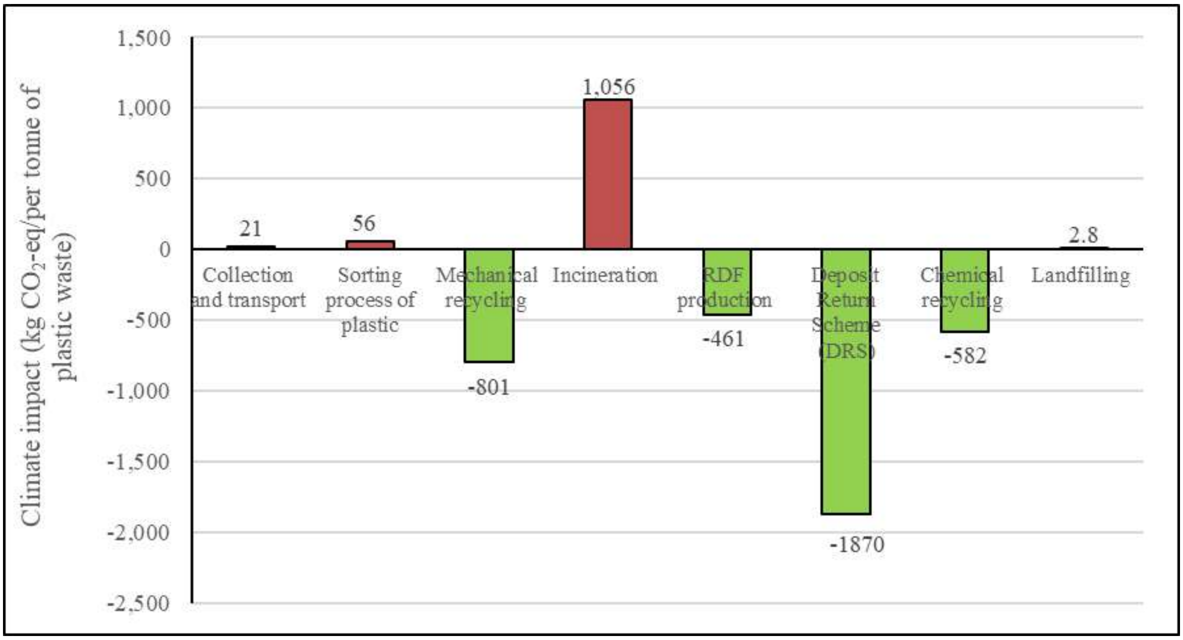
On the other hand, plastic incineration offers higher energy recovery potential than other components of municipal solid waste. According to estimates using the IGES EQT (IGES, 2025), 1 tonne of plastic waste can generate about 2,362 kilowatt-hours of electricity and 8,977 MJ of heat through a combined heat and power incineration facility. From a life cycle perspective, this recovered energy can partially displace conventional electricity and heat production, avoiding some GHG and BC emissions and contributing to the conservation of abiotic resources (Jiao et al., 2024).

Despite this energy recovery potential, climate impact calculations based on the IGES EQT model (IGES, 2025) indicate that incinerating plastic waste still results in a net climate impact of 1,056 kg CO_2-eq per tonne (Figure 7.4). This is mainly attributed to the emissions of fossil-based CO_2 and BC during combustion. The avoided emissions from energy recovery are not sufficient to fully offset the climate burden (IGES, 2025). However, the energy recovery has a notable positive effect on abiotic resource depletion, with the model estimating a net reduction of –747 kg crude oil-eq (Figure 7.5). This negative value reflects the replacement of fossil fuels that would otherwise be required to produce an equivalent amount of electricity and heat.

In summary, while plastic incineration with energy recovery cannot be considered a climate-friendly solution, it can play a role in enhancing energy security by reducing reliance on primary fossil energy sources. However, beyond GHG emissions, incineration facilities also release a range of harmful pollutants, including dioxins, nitrogen oxides (NOx), and ultrafine particulate matter, which pose serious risks to human health and the environment.

Given these significant trade-offs, a more holistic assessment is essential. The application of Multi-Criteria Decision Analysis (MCDA) offers a structured approach to evaluate the complex environmental, health, and energy implications of plastic waste incineration (Vlachokostas, Michailidou, and Achillas, 2020). This can lead to more informed and balanced decisions, ensuring that waste management strategies align with broader sustainability and public health goals.

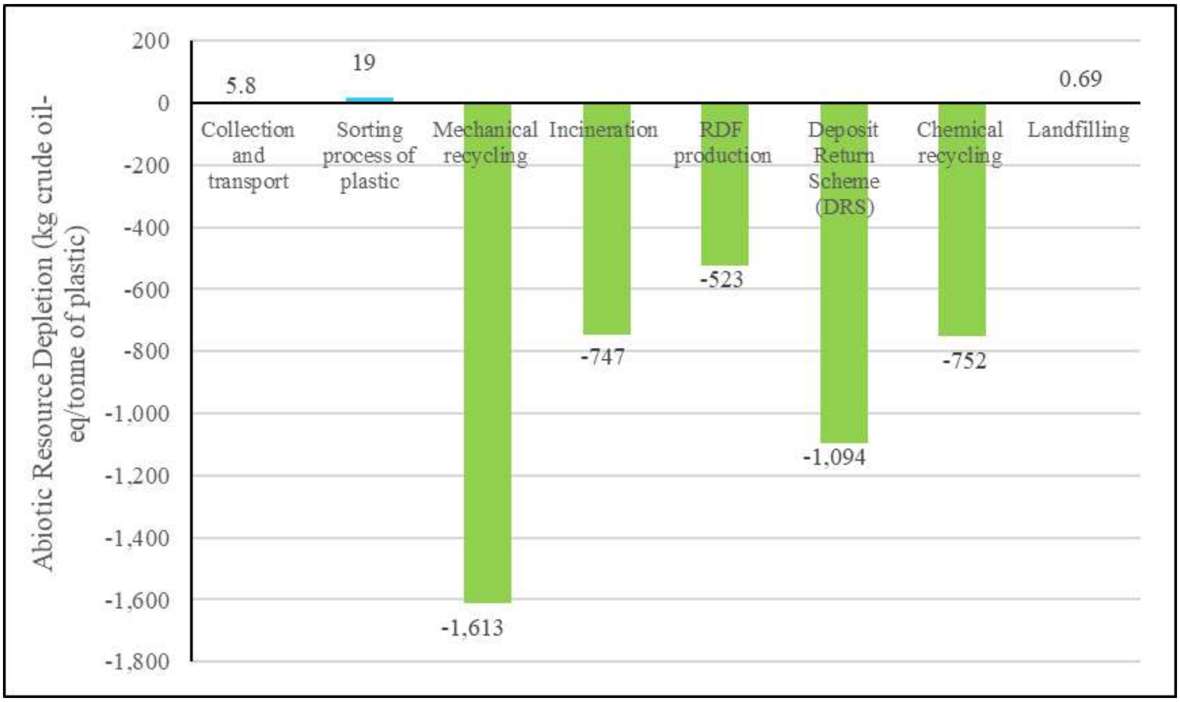
Figure 7.4. Life Cycle–Based Carbon Emissions/Savings from All Kinds of Plastic Treatment Options



kg CO_2-eq = kilogram of carbon dioxide equivalent, RDF = refuse derived fuel.

Source: IGES (2025).

Figure 7.5. Abiotic Resource Depletion/Savings Potential from All Kinds of Plastic Treatment Options



kg CO_2-eq = kilogram of carbon dioxide equivalent, RDF = refuse derived fuel.

Source: IGES (2025).

4.3. RDF Production

Refuse derived fuel (RDF) offers a practical and cost-effective solution to urban waste management by converting non-recyclable waste into valuable resources. It helps reduce carbon emissions from both landfills and fossil fuel combustion by replacing coal in energy-intensive industries like cement kilns (Stadler, 2024). RDF not only generates electricity when used in power plants but also contributes directly to cement production through ash utilisation. Its use creates revenue opportunities for local governments through sales to industrial offtakes, making RDF a sustainable option for both waste reduction and energy recovery (Reza et al., 2013). In Indonesia, for example, the use of RDF in the cement industry has been identified as a promising decarbonisation pathway (Indonesian Cement Association, 2024).

Producing RDF from plastic waste offers a cost-effective waste management solution that also creates economic value. According to the author's interview with the Department of Environment of Daerah Khusus Ibukota (DKI) Jakarta, special capital region of Jakarta, the cement industry purchases RDF at prices ranging from US$24 to US$44 per tonne.[2] Leading plants such as Indocement have already begun using RDF, primarily derived from single-use plastics, as a substitute for coal. With a calorific value of 4,000–4,600 kilocalories/kg, RDF provides energy output comparable to fossil fuels. Beyond cement kilns, plastic-based RDF can also be used in municipal solid waste incinerators or combined heat and power systems to generate electricity and heat, further supporting the transition away from fossil fuels in the ASEAN region.[3]

Life cycle assessment using the IGES EQT (IGES, 2025) indicates that 1 tonne of plastic waste can yield around 500 kg of RDF. This amount of RDF can replace about 815 kg of coal in cement kilns, avoiding substantial fossil-based CO_2 emissions. Despite the fossil origin of plastic, its high calorific value leads to a net climate benefit when used as RDF. The estimated climate impact is –460 kg CO_2-eq per tonne of RDF produced, 84% of which is due to avoided CO_2 and 16% to avoided BC emissions (Figure 7.4). If RDF is not utilised, equivalent energy output would require more coal, resulting in significantly higher GHG and short-lived climate pollutants (SLCPs) emissions.

Furthermore, the use of RDF contributes to abiotic resource conservation. When used to replace low-grade coal in cement or brick production, RDF use results in an abiotic resource depletion avoidance of about –523 kg crude oil equivalent per tonne. This negative value reflects the savings in fossil resource extraction that RDF enables (Figure 7.5).

These co-benefits from RDF clearly indicate that producing RDF from contaminated or non-recyclable plastic fractions is a good option to be practised at the municipality or city level to avoid plastic pollution and mitigate microplastic issues.

4.4. Chemical Recycling

One potential approach for managing plastic waste is chemical recycling via pyrolysis, which breaks down plastic into chemical feedstocks that can be used to produce virgin-quality polymers (Plastics Europe, 2025). This technology provides a promising solution for plastic waste streams that are otherwise destined for incineration or landfilling. Chemical recycling is best suited for hard-to-recycle, multilayer, or heavily contaminated plastics.

In Europe, planned investments in chemical recycling are expected to increase significantly, rising from €2.6 billion by 2025 to €8.0 billion by 2030. As a result, the production of chemically recycled plastics is projected to grow from 0.9 Mt in 2025 to 2.8 Mt by 2030 (Plastics Europe, 2025). There is growing interest in chemical recycling within the ASEAN region as well. Notably, PETRONAS Chemicals Group has approved the construction of Asia's largest advanced chemical recycling plant in Pengerang, Johor, Malaysia, with a capacity of 33 kilotonnes (Kt) per year. The facility is expected to begin operations in early 2026 (PETRONAS Chemicals Group Berhad, 2023).

[2] Interview in February 2025.
[3] All these data were gathered from the interview in February 2025.

Chemical recycling presents a promising solution for addressing marine plastic pollution in the ASEAN region by converting plastic waste into raw materials for new polymers. However, there is a lack of regional studies evaluating the life cycle climate impacts and contributions to resource depletion associated with this technology. The IGES EQT (IGES, 2025), which has been used for impact calculations in this chapter, does not cover chemical recycling processes. Therefore, the authors used literature-based data to assess the environmental performance of chemical recycling.

Key information, such as the type of energy used in chemical recycling, material recovery efficiency, and the energy and material requirements for virgin plastic production, were obtained from the study by Jeswani et al. (2021). Using these data, emissions were calculated based on ASEAN-specific grid and thermal energy emission factors. According to Jeswani et al. (2021), 1 tonne of mixed plastic waste processed via pyrolysis yields about 507 kg of ethylene. The life cycle climate impact and abiotic resource depletion potential of this chemical recycling route were then compared with those of virgin plastic production. The climate impact and resource depletion associated with producing an equivalent amount of virgin plastic were estimated using the same study's inventory data. The impacts associated with energy use and raw material consumption in the virgin production process were credited as avoided burdens in the chemical recycling system, representing what would have occurred in conventional plastic production.

As a result, the net climate impact of chemically recycling mixed plastic waste via pyrolysis was found to be about –582 kg CO_2-eq per tonne of plastic processed (Figure 7.4). This net negative impact is largely due to the carbon savings achieved by displacing virgin naphtha with pyrolysis oil.

In addition to climate benefits, chemical recycling offers substantial advantages in terms of abiotic resource conservation. The net abiotic resource depletion potential is estimated at –752 kg crude oil equivalent per tonne of plastic waste (Figure 7.5), indicating strong potential for saving virgin fossil resources. This benefit stems primarily from the recovery of naphtha, which can be reused in the production of recycled plastics, reducing dependence on fossil-based feedstocks.

Although chemical recycling offers the opportunity for closed loop recycling by converting plastic waste back into chemical feedstocks for virgin-quality polymers, it also presents several environmental trade-offs beyond the quantified climate and resource impacts. The process typically involves the use of additional chemicals and auxiliary materials, which may lead to the release of various emissions, including hazardous air pollutants and process residues (Sharp and Goff, 2025). These emissions could pose risks to ecosystems and human health if not properly managed. Therefore, a comprehensive LCA study is essential to evaluate the full range of environmental impacts of chemical recycling in the ASEAN context, including toxicity, ecosystem degradation, and potential human health effects.

4.5. Initiating of Deposit Return Schemes

The deposit return scheme (DRS) concept is not well established in the ASEAN region (OECD, 2025). However, implementing DRS for single-use drink containers (e.g. polyethylene terephthalate (PET)) could significantly increase recycling rates, reduce litter, and support national climate change targets (KPMG and EuroCham Singapore, 2021). A DRS can cover beverage containers such as metal cans (e.g. aluminium and steel); plastic bottles (e.g. PET and polypropylene (PP)); beverage cartons; glass bottles; and different types of pre-packaged beverages such as alcohol, soft drinks, dairy, juice, water, and other ready-to-drink beverages (KPMG and EuroCham Singapore, 2021)

DRS is also a key part of the extended producer responsibility scheme, which has successfully reduced plastic waste and increased recycling in over 40 countries around the world (Keep Britain Tidy, 2025). It enables the efficient collection of clean materials for reuse or recycling. Singapore is the only AMS that has decided to introduce a DRS (National Environment Agency, n.d.). Regional adoption requires phased implementation, effective governance, cost-efficient design, and public awareness. The success of the 2019 pilot scheme in Singapore, which saw nearly 3.65 million containers collected through 50 reverse vending machines (RVMs), demonstrates strong public participation and feasibility for a DRS. With each RVM in Singapore collecting around 200 containers per day – four times the volume of the 2018 pilot – the system showed significant potential (KPMG and EuroCham Singapore, 2021). Under a national DRS, consumers would pay a small deposit on plastic bottles and aluminium cans, refundable upon return via RVMs. This approach not only incentivises recycling but also helps reduce litter and supports a circular economy.

PET has been identified as the most recycled plastic in Europe, consistently leading the way in terms of recyclability and sustainability. One of PET's key advantages is its relatively low melting point, which makes the recycling process significantly less energy-intensive compared with other plastics. PET can be efficiently broken down, purified, and repolymerised multiple times, supporting closed loop recycling systems and helping to reduce overall plastic waste (BlueSky, 2023).

Given these properties, DRS schemes would be a highly effective approach for the ASEAN region, especially in densely populated urban areas. Implementing DRS systems could enhance PET bottle recovery rates, reduce litter, and promote a more circular economy by ensuring that high-quality PET is collected and returned for recycling.

The collection and recycling of PET bottles through a DRS enables the collection of clean, less-contaminated bottles, improving recycling efficiency. Bales of PET from DRSs generally have a yield rate of about 85%, meaning that recycling 1 tonne of PET bottles typically produces about 850 kg of recycled plastic (Container Recycling Institute, 2025). The GHG emissions associated with recycling 1 tonne of PET bottles, mainly due to energy consumption during the process, are estimated at 1,105 kg CO_2-eq (IGES, 2025).

In contrast, the production of virgin plastic begins with crude oil extraction, followed by its conversion into naphtha in refineries. Through thermal cracking, naphtha is transformed into monomers such as ethylene and propylene, which are then polymerised to form long molecular chains. Producing the equivalent amount of virgin plastic (850 kg) through this virgin manufacturing process results in about 2,975 kg CO_2-eq of emissions). By recycling PET bottles and avoiding virgin plastic production, the net GHG emissions were –1,870 kg CO_2-eq per tonne of PET recycled, indicating a 63% reduction in GHG emissions compared with virgin production (Figure 7.4).

Despite the additional energy requirements associated with operating RVMs, transport logistics, and material recovery facilities, DRSs still enable PET bottle recycling to follow a significantly lower-energy pathway compared with virgin plastic production. This is primarily due to the high-quality, low-contamination feedstock collected through DRSs, which increases the efficiency of the mechanical recycling process (BlueSky, 2023). Considering all the energy consumption in both the recycling and virgin production process chains, the estimated net energy savings from recycling PET bottles via the DRS system is about –1,094 kg of crude oil-eq per tonne (IGES, 2025.). The negative value reflects the energy recovery potential, indicating that recycling not only consumes less energy but also offsets the need for virgin fossil resources, demonstrating a substantial environmental benefit (Figure 7.5).

5. Comparative Assessment and Recommendations

A life cycle–based comparative assessment of key environmental impacts associated with existing and future end-of-life plastic waste management technologies has been conducted using available data and modelling approaches. The results clearly highlight that current practices, such as open burning, generate the most severe climate impacts, estimated at about 2,248 kg CO_2-eq per tonne of plastic waste, primarily due to emissions of BC and other GHGs. Despite the limited application of recycling (less than 10% in most AMS), mechanical recycling demonstrates the highest benefits in terms of climate impact reduction and abiotic resource savings (Figures 7.4 and 7.5). While open dumping and landfilling do not show extremely high climate or resource depletion impacts, these primitive disposal practices pose a major risk of microplastic emissions to ecosystems. Such emissions can result in long-term contamination and present severe threats to human health and biodiversity, impacts that are not easily reversed or managed.

The analysis confirms that improving plastic waste collection, introducing effective sorting systems, and adopting treatment methods that maximise resource recovery are critical to addressing the region's plastic waste crisis. Amongst all advanced technologies assessed, incineration stands out as the only option with net positive climate impacts due to fossil-based CO_2 emissions. The carbon savings from energy recovery in incineration are not sufficient to offset these emissions, making it a less favourable solution than the other technologies.

In contrast, all the other advanced treatment technologies – including mechanical recycling, RDF production and use as an energy source, DRS for PET bottles, and chemical recycling – demonstrate strong potential to act as carbon sinks, delivering substantial carbon savings and resource recovery benefits (Figures 7.4 and 7.5). Given that plastics are derived from crude oil, these technologies offer significant potential to reduce abiotic resource depletion by displacing the need for virgin fossil-based materials/crude oil to produce virgin plastics.

However, AMS face multiple barriers in adopting advanced plastic treatment technologies such as RDF, DRSs, and chemical recycling. Key challenges include low collection and segregation rates, high investment and operational costs, and limited technical expertise. Weak regulatory frameworks, the absence of market incentives, and inadequate data further hinder adoption. The informal sector's dominance and community resistance to new facilities add complexity, while underdeveloped circular economy systems limit the effectiveness of advanced solutions. However, these challenges also present opportunities. Strengthening waste collection systems, enforcing extended producer responsibility policies, and improving data availability can create a more enabling environment. Regional collaboration like the Southeast Asia Regional Program on Combating Marine Plastics (SEA-MaP) platform could be utilised to enhance capacity building and support technology transfer in order to bridge technical gaps. Furthermore, integrating the informal sector and creating stable markets for recycled products and RDF could enhance resource recovery. With targeted investments and strong policy support, AMS have the opportunity to transition towards more sustainable, circular plastic waste management systems that reduce pollution and support climate goals.

The findings of this study provide valuable insights for policy and decision-making, enabling stakeholders to evaluate trade-offs and identify optimal treatment pathways for managing plastic waste. Implementing advanced treatment options offers multiple co-benefits, including climate change mitigation, resource conservation, reduced marine pollution, and support for circular economy transitions. These actions also contribute meaningfully towards achieving the net zero targets by 2050–2060. However, one critical gap remains: the lack of robust, life cycle–based data on microplastic emissions from various treatment technologies. Without a clear understanding of the fate of microplastics through treatment processes, it is not possible to comprehensively assess their long-term impacts. Further research is urgently needed to evaluate this aspect and integrate microplastic emissions into future LCA frameworks.

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Chapter 8

Measures to Prevent Plastic Leakage into the Environment

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1. Introduction

Plastic pollution is a pressing environmental challenge facing the Association of Southeast Asian Nations (ASEAN) region. Several studies spotlight the ASEAN region as a global hotspot for plastic pollution, contributing over half of the world's ocean plastic leakage (UNEP, 2018; Ryberg et al., 2019). Plastic pollution in the region largely stems from the unintended consequences of rapid urbanisation, shifting consumption patterns, and the rising volumes of plastic waste, much of which remains inadequately managed (UNESCAP, 2020; UNEP, 2024). Over the past decade, the ASEAN region has experienced sustained economic growth and urban expansion, which, while improving living standards, have simultaneously intensified pressures on municipal waste management systems (ADB, 2023; Herrador and Van, 2024). In many cities, the surge in plastic consumption has outpaced the capacity of existing waste management infrastructure, leading to systemic inefficiencies in the collection, sorting, and disposal of waste (Hiratsuka-Sasaki and Kojima, 2020; Agamuthu and Babel, 2023). These gaps are particularly profound in secondary cities and peri-urban areas, where waste collection services are inadequate, institutional capacities are weaker, and informal actors dominate waste recovery. Consequently, growing volumes of inadequately managed plastic wastes contribute to pervasive leakage into terrestrial and aquatic environments, increasing risks to ecosystems, public health, and regional development objectives. Without effective solutions, plastic leakage not only undermines national and regional marine debris reduction targets but also threatens coastal livelihoods, public health, and the ecological integrity of critical ecosystems.

Over the decades, post-consumer plastic recycling has been championed as a worthwhile solution to the plastic waste challenge. While recycling is crucial in closing the value loop, growing evidence now shows that plastic recycling, particularly in developing countries, is not a closed-loop system. Inadequately managed plastic recycling operations themselves have become substantial sources of plastic leakage into the environment, contributing to pollution and undermining the very objectives they were intended to achieve. Across ASEAN, the informal recycling sector, comprising waste pickers, junk shops, and small- to medium-sized family-run recyclers, is responsible for an estimated 50%–70% of plastic recycling (Tong, Huynh, and Khong, 2021; Kubota, Rawlins, and Vongthavilay, 2024). The role played by the informal sector is often performed outside formal regulatory oversight, mostly under rudimentary conditions, without pollution control measures. Formal recycling systems, on the other hand, vary widely in terms of capacity, regulatory oversight, and integration with the municipal solid waste (MSW) streams of cities. Many recycling facilities face challenges related to limited investment, environmental compliance, and cleaner production practices. Operating without adequate pollution control measures, wastewater management, and leak-proof storage often results in inadvertent losses of plastic particles into surrounding soil and waterways. These systemic gaps and weaknesses are compounded by limited public and private investment, fragmented institutional mandates, and the absence of extended producer responsibility (EPR) mechanisms to internalise the environmental costs of plastic waste.

Recognising these challenges, ASEAN Member States (AMS) have advanced targeted interventions at both local and national scales, aligning with regional commitments to curb plastic pollution and improve waste management systems. These interventions have increasingly focused on strengthening recycling systems and enhancing plastic material recovery, with the strategic aim of retaining plastics within the value loop and reducing leakage into the environment (EU and ASEAN Business Council, 2025; OECD, 2025). The governance frameworks required to operationalise these transformative policies and interventions have not evolved to match emerging demands, thereby constraining their effectiveness and limiting the full realisation of their objectives. Consequently, pervasive systemic challenges including ineffective regulatory enforcement, overlapping mandates across agencies, weak inter-stakeholder coordination, data scarcity, and limited financial and technical resources continue to undermine the operationalisation of well-intentioned policies and programmes in the recycling sector in many cities in the region (Akenji et al., 2020; Maruf, Chang and Yang, 2024).

At the regional level, ASEAN has adopted a suite of forward-looking and ambitious policy frameworks aimed at addressing plastic pollution and advancing circularity. Such policies include the ASEAN Framework of Action on Marine Debris, the ASEAN Regional Action Plan for Combating Marine Debris in the ASEAN Member States (2021–2025), and the Bangkok Declaration on Combating Marine Debris in the ASEAN Region. More recently, ASEAN has reinforced its commitment through the ASEAN Declaration on a Circular Economy for Plastics and the ASEAN Declaration on Plastic Circularity (2024). The frameworks signal a collective recognition of the challenges and a strategic regional shift of interest in the region towards integrated plastic waste management, with an emphasis on interventions, cross-sectoral collaboration, and sustainable materials innovation. Despite some progress, the realisation of these policy objectives remains constrained by uneven implementation, especially in tackling leakage risks at the post-consumer stage of the plastic life cycle. At this stage, recycling facilities and waste disposal sites often function as critical nodes of vulnerability, where inadequate controls can result in significant environmental leakage.

At the global level, negotiations are under way towards a future global plastics treaty, under the mandate of developing an international legally binding instrument (ILBI) on plastic pollution. During the second part of the fifth session of the International Negotiating Committee on Plastic Pollution (INC-5.2), the chair released a revised draft text consolidating options under negotiation for a future global plastics treaty. While not yet agreed, the text signals emerging areas of convergence (UNEP, 2025). Importantly, the chair's draft introduces a normative framework that seeks to harmonise global responses to plastic leakage, setting the foundation for potential treaty-aligned action once consensus is reached. Anchored in a comprehensive life-cycle approach, the ILBI underscores the necessity of addressing plastic pollution across all stages of the value chain, from upstream design and production to downstream collection, sorting, recycling, and final disposal. Notably, Articles 6 and 7 of the chair's text explicitly call for the application of best available technologies and best environmental practices as critical instruments to mitigate plastic leakage into terrestrial and aquatic systems.

This provision has direct implications for the ASEAN region, where both formal and informal recycling systems are often constrained by infrastructural deficits, substandard operational protocols, and weak regulatory oversight. Open burning, uncontrolled dumping, and inefficient material flow management within these systems not only exacerbate environmental pollution but also erode the credibility of regional commitments to circularity and sustainability, highlighting the urgent need for systemic reforms. In light of this, it is imperative to examine the prevailing dynamics of plastic pollution in the ASEAN region through the lens of the emerging ILBI principles – analysing the institutional and operational feasibility of deploying best available technologies and best environmental practices within the unique governance and infrastructural contexts of plastic waste recovery and recycling facilities in AMS. Such an analysis necessitates an appreciation of the region's hybrid and multi-scalar waste governance landscape, characterised by divergent regulatory frameworks, heterogeneous institutional capacities, and uneven levels of enforcement.

This chapter undertakes a strategic scoping analysis of the infrastructural, technical, and governance factors driving plastic leakage in the ASEAN region. Drawing on peer-reviewed academic studies, case examples from across ASEAN, and evidence-based insights from the implementation of a region-wide project on preventing plastic leakage from recycling, it identifies critical problem areas and proposes targeted interventions.

2. Pathways of Plastics Leakage from Recycling Facilities

2.1 Emerging Concerns of Plastic Recycling Processes

Within the ASEAN region, plastic recycling continues to serve as a central strategy for recovering post-consumer plastic waste, retaining materials within the value loop, and diverting them from landfills and the natural environment. In practice, plastic recycling encompasses a sequence of interlinked stages: (i) collection of recyclable plastic waste; (ii) temporary storage and transportation to processing facilities; (iii) pre-sorting to remove contaminants and separate polymer types; (iv) size reduction via milling or flaking; (v) washing and drying to remove residues; (vi) secondary sorting to improve material quality; and (vii) extrusion and palletisation, followed by storage and transport for downstream manufacturing applications (Hou et al., 2021; Singh and Walker, 2024).

Across all these stages, plastic losses may occur – both within the facility and along the supply chain – if preventive measures are not systematically and consistently enforced. A diverse range of actors, spanning informal waste pickers, junk shop operators, small and medium-sized family-run recyclers, large-scale formal facilities, transporters, and brokers, play pivotal roles in both retaining material value and, conversely, generating losses that lead to environmental pollution (The Circulate Initiative, 2023; Stapleton et al., 2023). Their varying capacities, operational practices, access to infrastructure, information, and resources can significantly influence the extent to which plastic recycling serves as a circular economy solution or becomes a leakage pathway.

The challenge of plastic pollution also extends to activities undertaken by informal workers – often referred to as scavengers in certain jurisdictions – who operate at landfills and disposal sites. Informal waste pickers typically recover items perceived as 'high-value plastic materials' from waste bound for disposal (Kubota, Rawlins, and Vongthavilay, 2024; Cook, Silva de Souza Lima Cano, and Velis, 2024). However, informal waste workers across cities in the region face persistent challenges stemming from limited access to reliable information on the types of plastic that are in demand in the market, inadequate storage infrastructure, insufficient dismantling equipment, and the absence of systematic training on standardised sorting protocols (Sasaki and Araki, 2013; Pal, Sandberg, and Paras, 2019; Velis et al., 2022). Considering that informal waste workers are highly entrepreneurial and profit-oriented in their approach to plastic recovery, these structural and capacity related challenges undermine both their operational effectiveness and their ability to minimise environmental externalities.

A case study on informal plastic recycling activities in Sai Mai District of Bangkok identified illegal dumping and the mismanagement of unsold, residual, or non-recyclable plastics by waste dealers and recycling facilities as major contributors to environmental plastic leakage (UNESCAP, 2020). Damanhuri (2010) underscored the inherent dilemma faced by informal plastic recyclers, who must constantly navigate the diametrically opposed pressures of profit maximisation and environmental stewardship during their operations. Notably, plastic waste generation during waste handling can be exacerbated by the selective focus of recycling enterprises on high-value plastics. This profit-driven model often sidelines the proper handling of residual and low-value plastics, exacerbating the accumulation of unmanaged plastic waste and its associated environmental impacts.

Evidence from field assessments by the Asian Institute of Technology's Regional Resource Centre for Asia and the Pacific (AIT RRC.AP) and the Economic Research Institute for ASEAN and East Asia Regional Knowledge Centre for Marine Plastic Debris (ERIA RKC-MPD) (ERIA RKC-MPD, n.d.) and several peer-reviewed studies have shown that the recycling sector contributes to plastic pollution. Both formal and informal recycling facilities face inherent risks of leakage and mismanagement, underscoring the need for stronger safeguards, oversight, and environmentally sound practices in recycling systems. Brown et al. (2023) found that a modern plant still discharged an estimated 1,366 metric tonnes of microplastics per year after installing filters. Suzuki et al. (2022) underscored these concerns by estimating microplastics in untreated wastewater discharged from three 1-tonne/day materials recovery facilities (MRFs). Microplastic concentrations from effluents from mechanical recycling of 1.1 × 105–2.0 × 108 microplastic particles per cubic meter, with estimates of 0.014–5.800 tonnes per year of microplastic emissions from recycling facilities, were found. Guo et al. (2022) documented that most microplastics from a polyethylene terephthalate (PET) recycling facility end up concentrated in its wastewater sludge (50,000–70,000 micrograms (μg) per gram (g) of sludge) thereby posing significant disposal challenges (Singh and Walker, 2024). Similarly, Yeoh (2020) found that 25%–30% of plastic waste being processed in some of these facilities is discarded daily along with about 7 million litres of wastewater from washing operations, which is released into open dumps and waterways without proper treatment. The study noted the lack of specific laws and regulations, use of rudimentary technologies that do not meet technical and environmental protection, and low quality and production efficiencies as characteristic factors that underpin the significant health and environmental costs posed by the activities of craft villages.

Considering the multifaceted nature of the plastic pollution challenges from recycling facilities, addressing them necessitates a multilevel, systems-oriented approach that accounts for the intricate linkages between infrastructure, operational practices, and governance mechanisms across the entire recycling value chain. The economic and social positioning of recycling operations must be examined in conjunction with contextual policy frameworks to illuminate the interdependencies and systemic repercussions of changes within the plastic value chain. Employing conjunctive analysis allows for a deeper understanding of how policy shifts, operational modalities, and socio-economic dynamics co-evolve and influence leakage outcomes. The following subsections systematically analyse the principal pathways and underlying drivers of plastic pollution originating from recycling facilities, highlighting both operational and systemic dimensions.

2.2 Pollution from Offsite Handling Methods and Conditions

Plastic pollution related to offsite handling often stems from mismanagement and poor handling of recovered plastics during waste stream processing. Inadequate sorting, unsafe storage, and improper transport practices frequently result in plastic leakage, allowing both macro- and microplastic particles to escape into surrounding environments. In many cities, waste pickers retrieve high-value plastics from streets and garbage bins during the day, and often again at night before formal collectors. In the process, intentional and unintentional littering of low-value plastics occurs. Such situations not only diminish the efficiency of formal waste management systems but also create additional environmental burdens, complicating collection processes and increasing leakage risks (UNDP, 2020; The Circulate Initiative, 2023; Huno, Borongan, and Keotiamchanh, 2024).

Waste pickers and junk shops often temporarily store and sort materials, separating and discarding low-value plastics, while lacking access to market information, proper handling practices, and formal disposal infrastructure. Using basic means of transport such as carts or sacks, and operating without containment measures, they contribute to leakage during transport, especially when open trucks or uncovered containers are used (Cook, Silva de Souza Lima Cano, and Velis, 2024). Residuals like multilayer films, foamed plastics, and contaminated packaging are frequently dumped or burned, releasing microplastics and toxic emissions into the environment. Informal junk shops and small scrap dealers often store plastics with minimal cover, making them vulnerable to storm-related dispersal (Giang et al., 2023). Unsellable materials are frequently dumped or burned, causing land and air pollution. Lacking infrastructure, these sites are typically crowded and poorly contained, allowing rain to wash plastics into drains, animals to spread waste, and untreated rinse water to contaminate soil and water sources (UNDP, 2020; Velis and Cook, 2021). Similarly, operations without dust or overflow controls release microplastics into air and soil, while poor storage can result in collected plastics leaking back into waterways (Staffeld and Kulke, 2011).

2.3 Structural and Infrastructural Shortcomings in Recycling Set-Ups

Facility Design and Siting Challenges

Dozens of low-end recycling factories without proper design and regulatory compliance have sprung up in the region following China's ban on plastic waste import (Wen et al., 2021; Sasaki, 2021). For example, some countries in the region, including Malaysia, became top destinations for plastic waste imports after China's 2018 import ban (Wang et al., 2020; Wen et al., 2021; Lin, Paengsri, and Yang, 2023). In Kuala Langat district of Selangor, Malaysia, for example, authorities discovered 41 illegal recycling plants in 2018, many of which were run by overseas investors, operating with no pollution controls. Authorities were reported to have shut down at least 30 of such sites after nearby communities complained of constant plastic burning and health issues (World Economic Forum, 2018; Liang et al., 2021).

Many of these facilities are located in converted warehouses, makeshift structures, or open-air yards without adequate roofing or structural containment measures. They lack adequate infrastructure and spatial planning, often operating with limited capacity, on unpaved floors, in basic workshops or backyards, manually or with simple machinery (Giang et al., 2023). They also lack the capacity to store and process all incoming material – both domestic and imported – properly. Under such conditions, excess waste and non-recyclable plastics are often illegally dumped or disposed of in landfills and dumpsites or openly burned, creating pollution hotspots (The Circulate Initiative, 2023; Huno, Borongan, and Keotiamchanh, 2024).

In junk shops and MRFs across Indonesia, the Lao People's Democratic Republic (Lao PDR), the Philippines, and Viet Nam (and numerous craft villages), plastics are frequently stockpiled temporarily, and in some cases, stored near vegetation and waterbodies or drainage, and dismantled, sorted, and shredded in open-air yards. Such practices often allow plastic scraps, films, and dust to be carried away by dispersal agents like wind, flood, surface run-off, and even animals (Putri, Fujimori, and Takaoka, 2018; UNDP, 2020). Wastewater is often discharged directly onto unpaved floors or channelled into drainage systems that flow into larger sewers, canals, rivers, or nearby vegetation. Giang et al. (2023) found that the daily activities of some plastic recycling villages near Hanoi, including the purchasing, transporting, manual sorting, and crushing of plastics, generated considerable dust and unpleasant odours, while wastewater from plastic the recycling process is a major source of microplastic fragments and chemical additives in wastewater. The absence of essential features like paved surfaces, leachate management systems, and segregated zones with containment/protective barriers significantly increases the risk of environmental contamination (Thanh, Dung, and Han, 2022; Huno, Diu et al., 2024).

Recycling facilities are often located near canals, waterbodies, flood-prone zones, and wetlands, or residential areas or farm settings that inherently elevate the risk of plastic leakage into the environment. These siting choices, often driven by affordability, the need for water, and proximity to informal markets, can exacerbate environmental pollution risks. For example, in Kuala Langat, Malaysia, defunct recycling factories were operating between palm plantations (World Economic Forum, 2018), while in Minh Khai craft village (Hung Yen, Viet Nam) in Viet Nam, over 580 small recycling facilities accumulated over 124,000 cubic meters of plastic residue dumped along access roads to landfill (Ministry of Agriculture and Environment, Viet Nam, 2025).

Box 8.1. Case Study – Craft Villages

Viet Nam's craft villages present a vivid case of informal recycling's environmental toll. The village of Minh Khai processes up to 1,000 tons of plastic waste daily through hundreds of microenterprises. Over the years, two main dumping zones have developed – including a central landfill in the village – accumulating vast quantities of plastic residue. Despite community efforts, pollution has remained essentially unresolved for more than 20 years, earning the site a national designation as an especially serious pollution hotspot (Ministry of Agriculture and Environment, Viet Nam, 2025). Residents suffer because of foul odours, smoke from incessant burning, and polluted water.

Another example is Indonesia's informal recycling hubs around Greater Jakarta, where small workshops recycle imported and local plastic. Investigations found shredded plastic and pellet waste clogging local canals, and groundwater contaminated with phthalates and other leached chemicals (Nexus3Foundation, 2022; The Circulate Initiative, 2023).

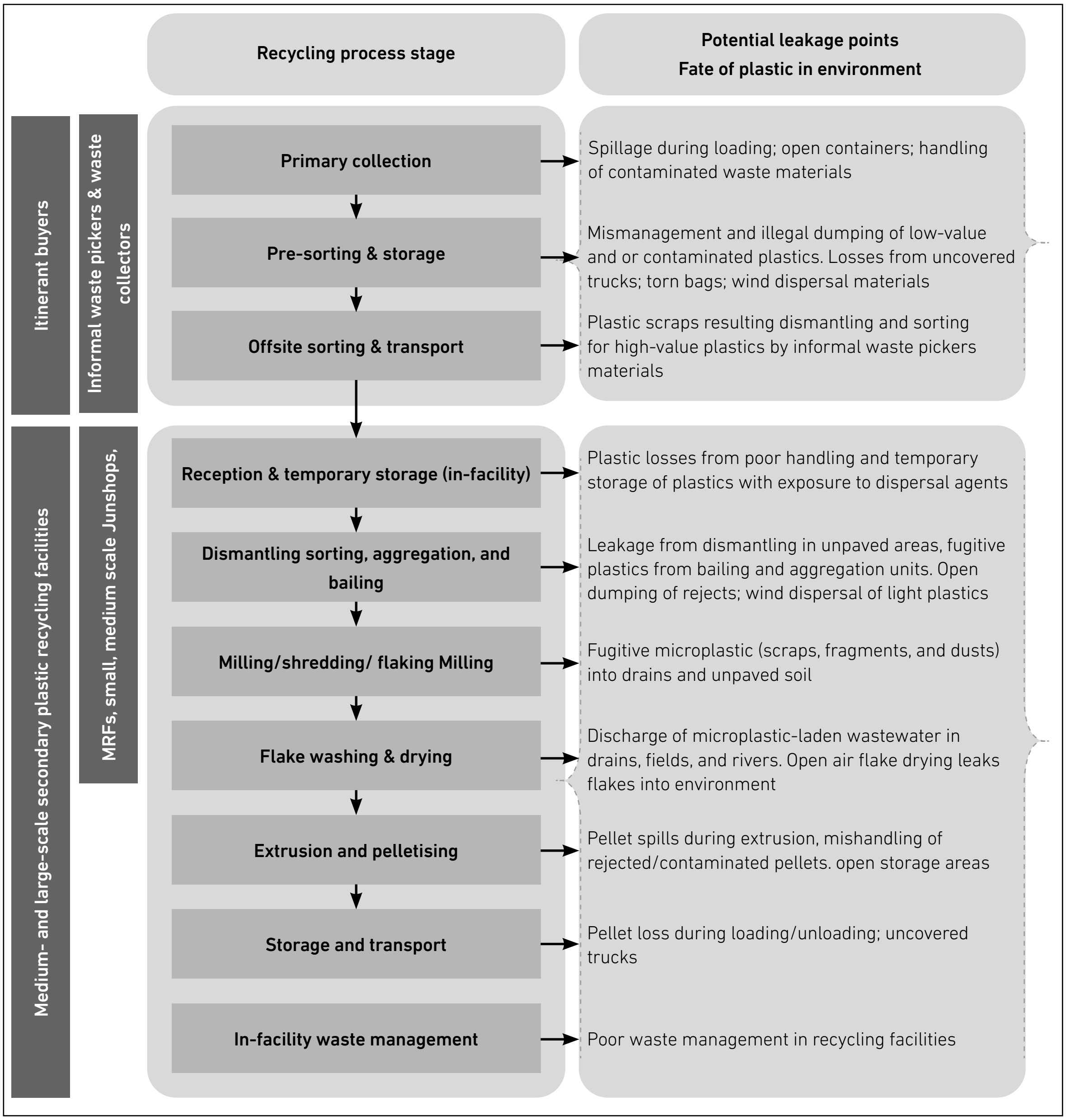
These cases show how informality and lack of oversight can amplify leakage, with the drive to maximise usable recyclate at the lowest cost often leading operators to simply dump or emit any 'leftover' material into the environment.

Source: Compiled by authors.

Structural Obsolescence and Operational Process Leakages

Structural obsolescence is widespread across the region, with many facilities operating outdated leaky washing tanks, inefficient shredders, and uncalibrated conveyors, resulting in significant material losses and reduced mechanical efficiency (UNDP, 2020; Giang et al., 2023). Poor housekeeping such as the accumulation of reject residues in corners or clogged drainage can amplify the scale and frequency of leakage events. Moreover, many recycling operations, especially in the informal sector, function on slim margins and prioritise throughput over environmental compliance. The incentive structure, in the absence of extended producer responsibility (EPR) schemes or performance-based subsidies, favours material quantity over quality, resulting in the processing of contaminated or unsuitable plastics that generate higher rejection rates and subsequent leakage. Key process stages and the related leakage issues are summarised in Figure 8.1.

Figure 8.1. Recycling Process Stages and Potential Plastic Leakage Points of the Recycling Chain



MRF = materials recovery facility.

Note: An MRF is a place where recyclable materials are collected and sorted, by hand or machine, so they can be cleaned, processed, and sold for recycling. There is no universally standardised classification of MRF but widely used benchmarks from waste management guidelines define MRFs by daily throughput capacity (tonnes per day), operational characteristic, and technology level (e.g. small scale (< 10–15 tonnes per day, mostly manual); medium scale (15–100 tonnes per day, semi mechanised); large scale (> 100 tonnes per day, highly mechanised)).

Sources: Authors.

3. Preventive Measures at Source

Advancing effective solutions to plastic leakage and pollution from recycling facilities demands well-designed multi-pronged strategies that increase environmental awareness and stewardship amongst recyclers, upgrade technology and infrastructure, strengthen operational discipline, align economic incentives with environmental objectives, and enforce robust regulatory frameworks (OECD, 2018; Yeoh, 2020; Giang et al., 2023; Aanesen et al., 2024). However, since many plastic recycling facilities operate beyond the reach of formal regulatory oversight, preventive measures must be designed to function across governance tiers and socio-economic contexts. Technical upgrades and operational reforms at the facility level must be reinforced by regulatory authorities from above and by social and economic buy-in from below, to create a coherent system that reduces leakage risks across both formal and informal recycling landscapes. Below are some of the context-specific preventive measures, grounded in operational realities, identified through stakeholder consultations conducted under the AIT RRC.AP and ERIA RKC-MPD project on the Prevention of Plastic and Resin Pellet Leakage from Informal Recycling Facilities in ASEAN.

3.1 Infrastructure and Design Improvements

Upgrades to recycling facilities (both formal and informal) with features that contain plastics and prevent escape into the environment are some of the most direct and effective ways to prevent plastic leakage from recycling facilities.

- **Zoning and siting of recycling facilities**: The siting of plastic recycling facilities near waterbodies, canals, drainage systems, and vegetated areas significantly increases the risk of plastic leakage into the environment (Figure 8.2). These locations often act as conduits that accelerate the transport of plastics, particularly during flooding or heavy rainfall, when surface run-off carries lightweight fragments, polymer dust, and residual waste directly into aquatic ecosystems. Similarly, vegetated areas adjacent to facilities can act as catchments for windblown plastics, where entanglement in foliage and soils leads to localised accumulation and eventual dispersal into rivers or streams.

Figure 8.2. Junk Shop Near River

Source: Solomon Huno.

City regulators and permitting authorities must ensure that recycling facilities are sited in safe zones, away from waterways, drainage systems, farms, and residential areas. Such strategic siting is essential to minimise leakage risks and prevent unregulated, illegal disposal activities associated with recycling operations. Recycling parks or clustered recycling centres with shared infrastructure may be a feasible option for some cities where a centralised wastewater treatment unit that serves many small recyclers or a common dust extraction system may be applicable.

- **Storm water and run-off control**: Many informal sites lack any drainage planning, so creating a simple system to channel dirty water to settling pits or tanks, instead of directly to a river, can localise the pollution and allow for later clean-up (Figure 8.3).

  In flood-prone areas, bales or bags of plastic must be stored on raised platforms or indoors to prevent them from being swept away in heavy rain. Recycling facilities should be designed with basic infrastructure to manage run-off at recycling sites. This could include containment trenches or silt fences around outdoor storage areas and oil/grit separators in drainage channels to trap solids.

Figure 8.3. Shredded Plastics Remnants Near Drainage

Source: Solomon Huno.

- **Enclosed facilities with containment measures**: Where feasible, facilities should be designed as closed spaces, with proper spatial designations within the facility for process operations such as storage, sorting, and shredding in covered, contained, or indoor facilities. Enclosed sorting lines, and crusher, milling, and flaking units must have localised, paved impermeable floors, roofing, and rising berms for containment, to significantly limit the dispersion of plastic particles and debris. Localised and facility-wide containment protocols on handling plastic pellets, flakes, or powders must be widely implemented for facilities engaged in secondary processing. This may involve simple but effective measures encompassing sealed silos or covered containers for storing pellets, and the implementation of spill response plans (with tools like vacuum systems or mesh screens on drains). Further, barriers like raised lips or sieves should be added near loading areas to prevent pellets escaping to yards or water outlets. Employees must be trained in pellet handling etiquette, like immediately cleaning up spills, and plastic leakage clean-up to prevent pellet losses into drains (Figure 8.3). Where possible, the installation of mesh filters in storm water drains on-site is vital to catch stray pellets or flakes before water leaves the facility.

- **Dust and particle capture**: Plastic dust occurs during mechanical recycling processes such as shredding, milling, grinding, and flaking, where plastics are physically reduced in size. The friction and cutting action release fine fragments, fibres, and microplastic particles into the air and surrounding environment (Abd Rahim et al., 2025).

To trap plastic dust in recycling facilities, air filtration or vacuum systems on mechanical shredders and grinders are typically used to capture microplastic dust at the source. Baghouse filters or cyclone separators can trap fine particles before air is vented. Recycling facilities must ensure that the collected dust is disposed of as waste and not released into the environment. For manual sorting areas, the use of local exhaust ventilation and simple vacuum tools are useful for the ventilation and cleaning up of plastic scraps regularly rather than sweeping them outdoors.

- **Wastewater treatment and filtratio**n: Wastewater from recycling facilities contains a substantial concentration of microplastics for which proper handling and treatment are vital to mitigate environmental pollution, particularly the surrounding environments of recycling facilities (Figure 8.4). While some facilities attempt to manage microplastic-laden wastewater through poorly constructed and unlined sedimentation ponds, others discharge it directly into open fields, vegetated areas, drainage channels, canals, or rivers.

  Beyond implementing or upgrading on-site wastewater treatment plants for recycling processes, effective control measures include the installation of lined settling tanks, sand filtration systems, and membrane filters designed to remove microplastics. Research shows that while typical treatment can remove most larger microplastics, particles less than 5–10 micrometre (μm) often remain (Suzuki et al., 2022 Umarie and Bagastyo, 2024). Thus, advanced filtration (e.g. ultrafiltration membranes) may be needed to capture the tiniest fragments. Regular maintenance of these systems is crucial; filters must be cleaned or replaced to remain effective. Importantly, the collected sludge and filter residues, which concentrate microplastics, should be handled as hazardous waste (e.g. sent to secure landfill or used in engineered fuel where safe) so that microplastics are not simply released later (see also Chapter 9).

Figure 8.4. Microplastic Pollution Observed Around Informal Recycling Facilities

Source: Solomon Huno.

3.2 Process and Operational Controls

Planned operational controls can be introduced to modified daily recycling process operations to minimise plastic leakage and pollution risks. This includes making basic adjustments to how materials are handled, process flows and control, maintenance scheduling, and the handling of plastics during downtime.

- **Better sorting and pre-cleaning**: In addition to poorly designed sorting areas, the improper handling of low-value lightweight plastics such as films and multilayer plastics may result in littering dispersal (Figure 8.5).

  The pre-cleaning and removal of contaminants from plastic waste may be done early and thoroughly, so that later processes (shredding and washing) produce less fugitive waste. For example, plastics should be pre-washed in contained systems to get rid of dirt and organic contaminants to prevent clogging and overflow in the main wash lines. Improving sorting accuracy may also decrease the amount of non-recyclable residue generation and associated disposal costs.

Figure 8.5. Poorly Managed Sorting Areas in Recycling Facilities

Source: Solomon Huno.

- **Controlled flaking/shredding**: Size reduction of plastics is carried out via flaking or shredding. Unenclosed or poorly calibrated shredders release plastic dust, flakes, and microplastics into the air and the immediate environment (Figure 8.6). However, the absence of dust-extraction systems and containment barriers increases losses.

  Wet shredding (i.e. spraying water during shredding) has been effective at reducing airborne dust by capturing fine plastic particles that can then be filtered out. However, this produces a slurry that needs treatment. Alternatively, slow-speed, high-torque shredders may be a choice for producing larger pieces and fewer fine particles than high-speed grinders. Regular maintenance and timely changing of cutting blades of shredders are crucial to ensure

Figure 8.6. Plastic Losses During the Shredding and Flaking Process of Mechanical Recycling

Source: Solomon Huno.

clean cuts rather than pulverising of plastic. Where capital investments are possible, advanced approaches of enclosing the shredders in a negative-pressure chamber connected to a dust filter may be installed to ensure that any generated microplastic is sucked into a filter unit instead of escaping. Even semi-formal facilities, though lacking advanced infrastructure, can improvise by constructing simple enclosures and connecting them to vacuum systems.

- **Optimised washing techniques**: Optimising wastewater temperature and detergent use further reduces leakage risks, as overly hot water or harsh chemicals can cause plastics to fragment into smaller particles. Washing tanks should be loaded just enough to avoid spillage and retrofitted to minimise loss from washing processes. Closed-loop water circulation supports cleaner production by running wastewater through filtration units and reusing a portion for subsequent washing, rather than discharging it entirely. This not only reduces total wastewater but also prevents continuous release of microplastics. Any overflow or discharge should pass through fine screens and sedimentation to capture plastic fragments. Installing simple mesh filters at the outfall of wash tanks (with mesh size of about 100 microns or smaller) can catch a lot of plastic debris.

- **Handling of residues and wastes**: Several forms of waste are typically generated in plastic recycling facilities since they serve as both workplaces and sites where recycling activities take place. Such wastes may include, for example, food scraps from workers' meals, rejected or residual plastics, hazardous materials, wastewater, and other by-products arising from machinery and equipment use (Huno, Borongan, and Keotiamchanh, 2024). Where feasible, plastic residues generated during extrusion and pelletising can be recycled or properly disposed of to mitigate both environmental impacts and disposal costs. Conversely, non-recyclable materials such as rejects, labels, film flakes, and pellets must be managed through proper disposal in accordance with regulatory requirements.

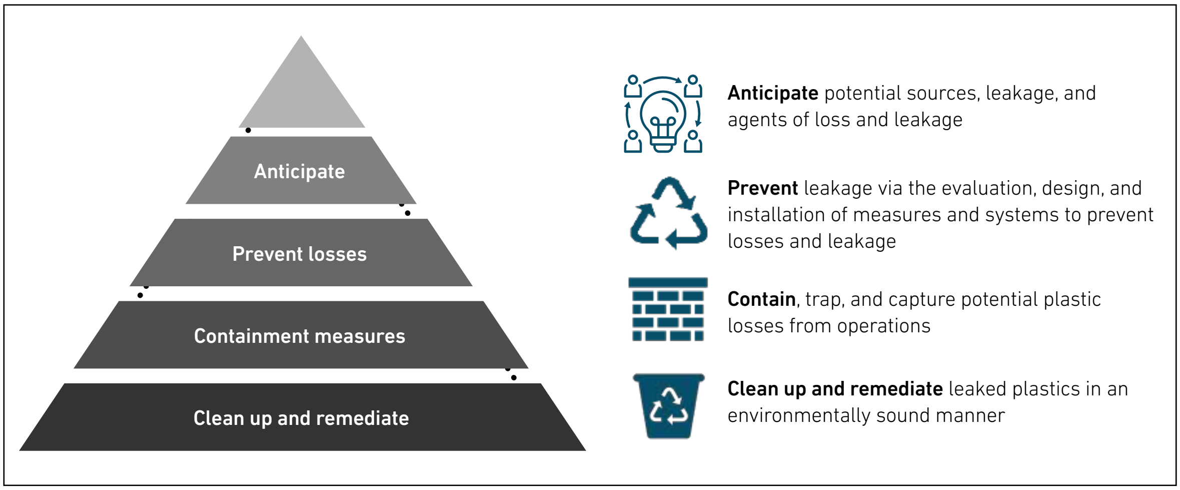
Wastes arising from process residues must be treated as materials that need proper disposal. Similarly, plastic containing sludge from washing (Figure 8.7), dust collected from filters, and rejects from sorting should be bagged and sent to authorised disposal or recycling. Some residues can be co-processed in cement kilns or turned into fuel in compliance with relevant regulation. Similarly, electronic wastes and hazardous wastes from facilities must be properly disposed of in full compliance with the relevant laws. Facilities should account for the full mass balance of inputs – if, for example, 5% of the recyclable plastic material received is contamination, there must be a plan and budget for managing that fraction to prevent leakage (Huno, Nitivattananon et al., 2024). Governments can support this by subsidising the safe disposal of such residues, reducing the incentive for illegal dumping.

Figure 8.7. Plastic Residue Containing Sludge Mechanical Recycling

Source: Solomon Huno.

- **Maintenance and housekeeping**: Instituting regular cleaning schedules inside facilities is a vital aspect of preventing plastic leakage and pollution from recycling facilities, especially in informal settings (Giang et al., 2023). A clean floor policy, where all spilled plastic is swept or vacuumed frequently and stored, prevents accumulation that could exit the door. For informal operations, even basic housekeeping like keeping waste on tarpaulins or in sacks, instead of on the ground, can reduce loss. Educating workers on the environmental impact of seemingly minor spills might motivate better practices. Facility owners should conduct routine inspections for any signs of leakage, e.g. checking perimeter drains for plastic build-up, and if found, immediately cleaning them. Providing training based on the anticipate, prevent, capture, contain, recover (APCCR) approach to housekeeping and routine checks is a simple yet effective way to familiarise facility workers with plastic pollution prevention as part of their daily operational practices (Huno, Diu et al., 2024). The APCCR approach is illustrated in Figure 8.8.

Figure 8.8. The APCCR Approach for Plastic Pollution Prevention in Recycling Facilities



MRF = materials recovery facility.

Source: Huno, Borongan, and Keotiamchanh, 2024.

Table 8.1 summarises the preventive measures in the source and recycling process stages discussed in this section.

Table 8.1. Preventive Measures at Source – Recycling Process Stages and Responsible Actors

Recycling process stage	Potential leakage points	Key preventive measures	Primary responsible actors
Collection of recyclable plastics	Spillage during loading; use of open containers; handling of contaminated waste	• Use sealed or covered collection containers • Train collectors on handling protocols • Incentivise proper pre-cleaning at source	Informal waste pickers, municipal waste services, collection contractors
Temporary storage and transport to facility	Loss from uncovered transport vehicles; damage to bags or containers; wind dispersal	• Use sealed or covered collection containers • Train collectors on handling protocols • Incentivise proper pre-cleaning at source	Transporters, junk shop operators, municipal waste departments
Pre-sorting	Improper segregation; discarding mixed residuals in open areas	• Designate enclosed pre-sorting areas • Provide bins for residuals with secure lids • Establish SOPs for reject handling	Facility managers, sorting line workers
Size reduction (milling/flaking)	Escape of fine particles into air or drains	• Install dust extraction systems • Use mesh covers over milling hoppers • Provide PPE and training	Facility operators, machine operators
Washing and drying	Discharge of microplastic-laden wastewater	• Install on-site wastewater treatment (e.g. settling tanks, sand filters) • Closed-loop water circulation systems • Optimise temperature and detergent use	Facility owners, maintenance staff
Secondary sorting	Open dumping of rejects; wind dispersal of light plastics	• Enclosed sorting bays • Baled rejects for secured disposal • Contracted licensed waste handlers	Facility supervisors, sorting staff
Extrusion and palletisation	Pellet spills; open storage areas	• Sealed silos or covered pellet containers • Install mesh filters on storm drains • Implement pellet spill response plans	Facility management, extrusion line operators
Final storage and outbound transport	Pellet loss during loading/unloading; uncovered trucks	• Raised lips and barriers in loading areas • Covered outbound transport. • Spill kits at loading bays	Facility warehouse staff, logistics providers

PPE = personal protective equipment, SOP = standard operating procedure.

Source: Authors

4. Environmental Recovery Interventions

Environmental recovery interventions target plastic pollution after it has leaked into the environment, aiming to mitigate impacts on terrestrial and aquatic ecosystems. This section analyses a range of post-leakage recovery strategies from organised clean-up operations to technological capture systems and community-driven initiatives. These approaches address the legacy of plastic waste in coastlines, rivers, and oceans, and often involve multi-stakeholder collaborations (governments, nongovernmental organisations (NGOs), communities, and the private sector). While such interventions can remove substantial amounts of debris and raise public awareness, experts caution they must complement, not replace, upstream prevention efforts. Below, we detail key categories of recovery interventions and highlight notable examples in the ASEAN context and beyond.

4.1. Coastal and Riverine Clean-Up Operations

One of the most direct post-leakage strategies is conducting coastal and river clean-up operations, typically through organised volunteer efforts or national or local government-led campaigns. Beach clean-ups and river clean-ups, practised globally, mobilise communities to collect litter manually from shorelines and waterways. For example, the International Coastal Cleanup (ICC) is the world's largest annual beach clean-up campaign and has been operating since 1986. As of 2022, this collective action was estimated to have engaged over 17 million volunteers globally and removed nearly 350 million pounds (about 158 million kilograms (kg)) of rubbish from beaches and waterways (Ocean Conservancy, 2022). Even in 2021, amid the coronavirus disease (COVID-19) pandemic challenges, the Ocean Conservancy estimates that almost 320,000 volunteers worldwide were engaged in collecting about 2.5 million kg of rubbish in a single ICC season. Such large-scale clean-ups not only extract plastic waste but also serve a twin purpose of educating and sensitising the public on plastic pollution impacts. In Southeast Asia, community clean-ups are frequent in countries like Indonesia, the Philippines, and Thailand, often supported by local governments and NGOs (see also Box 8.1).

Box 8.2. Turning the Plastic Tide – A Global Clean-Up Spotlight on the ASEAN+3 Region

Clean-up initiatives in the ASEAN Plus Three (ASEAN+3) region are spearheaded by organisations such as Ocean Conservancy, The Ocean Cleanup, the World Wide Fund for Nature (WWF), and Partnerships in Environmental Management for the Seas of East Asia (PEMSEA). These efforts translate regional declarations and plans into direct action, helping to prevent plastic from entering the environment.

To be effective, these efforts must target major pollution pathways. Rivers are the primary conduits for plastic pollution entering the ocean, and these rivers often flow through densely populated coastal or urban areas, turning these communities and watersheds into 'plastic emissions hotspots' (Meijer et al., 2021). In addition, these buoyant marine plastics released from land-based sources are likely to wash ashore on a coastline (Onink et al., 2021).

Figure B8.1. Annual International Coastal Clean-Up Data in the ASEAN+3 Region, 2023

Countries	Total volunteers	Total kilograms	Total kilometers	Total waste collected
Brunei	751	1,889	39.5	8,303
Cambodia	130	862	0.9	8,238
China	4,455	19,645	1,205.30	15,773
Indonesia	2,374	12,598	73.8	59,332
Japan	3,651	12,475	187	113,440
Malaysia	14,394	48,346	1,540.10	373,547
Myanmar	2	0.5	0.2	-
Philippines	129,154	444,869	1,042.60	2,629,863
Rep. of Korea	2,153	17,710	306.1	65,562
Singapore	1,326	2,664	73.1	22,139
Thailand	2,592	22,248	89.8	928,276
Viet Nam	1,194	2,501	14.6	21,697
Total	162,176	585,808.5	4,573	4,246,170

Source: Authors, based on data from Ocean Conservancy (2024).

Figure B8.2. Annual International Coastal Clean-Up, 21 September 2024, Pasay City, Philippines

Source: DENR (2024).

While clean-up efforts are often viewed as a 'cure' for capturing plastics that have already escaped into the environment, they also serve as a form of prevention. By intercepting plastic waste before it degrades into smaller, harder-to-capture microplastics, clean-ups protect the ecosystem from further harm.

A prominent global initiative is the International Coastal Cleanup (ICC), organised by Ocean Conservancy. Since 1986, the ICC has mobilised millions of volunteers to collect and document shoreline rubbish, providing critical data on pollution sources. The movement's impact in the ASEAN+3 region is significant. In 2023, 162,182 volunteers collected 583,803.5 kilograms of rubbish, comprising over 4.2 million individual items, predominantly single-use plastics like cigarette butts, grocery bags, beverage bottles, and food wrappers (Figure B8.1).

In the Philippines, the country surpassed its previous ICC records on 21 September 2024. Led by the Department of Environment and Natural Resources (DENR), the event spanned 250 coastal sites nationwide and aimed to raise awareness about the impact of plastic pollution on marine life and ecosystems. The government recorded a total of 74,075 volunteers from 1,913 organisations, including government agencies, academic institutions, nongovernmental organisations (NGOs), and private sector partners. Altogether, 52,479 kilograms of rubbish and debris were collected, primarily consisting of plastic waste (Figure B8.2).

While coastal clean-ups involving diverse stakeholders are vital for addressing existing pollution and recovering significant amounts of waste, the ultimate solution lies in preventing plastic from entering waterways in the first place. Given the sheer volume and transboundary nature of marine debris, collection efforts alone are insufficient. A comprehensive strategy must pair clean-ups with sustained political will, robust investment in waste management infrastructure, and effective policies like extended producer responsibility (EPR). This approach should be supported by public campaigns that promote sustainable consumption and technological innovations that intercept plastic before it reaches the sea.

Source: Pham Ngoc Bao and Ezra Daasin Osorio, Sustainable Consumption and Production Area, Institute for Global Environmental Strategies (IGES).

In some cases, government-coordinated clean-up campaigns address heavily polluted sites through multi-agency action. A striking example is Indonesia's Citarum Harum Juara programme to rehabilitate the Citarum River. Launched in 2018, this 7-year initiative deployed more than 7,000 soldiers to physically remove rubbish choking the river, while engaging local communities in waste removal and prevention (Citarum Harum Juara, n.d.). The Citarum clean-up task force, along with NGOs and residents, has been working to clear an estimated 1,500 tons of solid waste that enter the river each day. Community groups and volunteers have also advanced these actions by installing rubbish traps and regularly collecting debris along the river as part of this multi-stakeholder effort. Such coordinated campaigns illustrate how multiple government agencies, including the military, together with civil society, can collaborate to address legacy pollution at scale. Notably, coastal city clean-ups, like annual Manila Bay clean-ups in the Philippines or river clean-ups in Viet Nam's Mekong delta, similarly bring together municipal agencies, companies, and citizens to remove accumulated plastic waste. These operations yield immediate aesthetic and environmental benefits – e.g. clearing blocked waterways and preventing wildlife entanglement – but require sustained commitment as rubbish often re-accumulates without upstream waste management improvements.

4.2 Passive Capture Technologies: Booms and Interceptors

Beyond manual clean-ups, a variety of passive capture technologies have emerged as stop-gap measures to intercept plastic debris in waterways. These environmental clean-up systems are typically installed in rivers, streams, or coastal outfalls to catch floating plastic litter before it disperses into the open ocean. Common capture technologies include floating booms, barriers, skimmers, and automated collection devices.

- **Floating booms and barriers**: Simple rubbish booms or nets are stretched across or along rivers to corral floating debris. They guide plastics to a collection point on the bank for removal. Such booms have been widely deployed in Southeast Asia's rivers; for example, Indonesia and Malaysia have installed river rubbish booms in Jakarta, Bali, and the Klang River to stem the flow of rubbish towards the sea. Low-tech barriers and interceptors are often anchored diagonally to channel the rubbish and have been effective at capturing macroplastics rather than microplastics (Ng et al., 2023). However, they must be regularly emptied and maintained and carefully designed to avoid navigation hazards or wildlife entanglement. The challenges with these installations, however, are their reduced effectiveness in high flow conditions, which means that they may have limited success in reducing spikes in litter reaching coastal waters and polluting urban beaches during very high rainfall events (Helinski, Poor, and Wolfand, 2021; Ryan et al., 2023).
- **Conveyor-based interceptors**: More advanced interceptor systems like The Ocean Cleanup's interceptor are essentially automated barges that collect rubbish from the water. Stationed in rivers or at river mouths, interceptors use V-shape floating guide arms to funnel debris onto a conveyor belt that loads it into dumpsters for periodic offloading (Water Environment Federation, 2023). The Ocean Cleanup, a Dutch non-profit, has deployed these solar-powered interceptor devices in multiple AMS – including Indonesia, Malaysia (Klang River), Thailand, and Viet Nam – through partnerships with local authorities (The Ocean Cleanup, 2023a). In Jakarta and other cities, interceptors and similar conveyor-based 'trash skimmers' continuously remove litter from rivers. While these systems can haul in large volumes of debris, experts note that they are not a comprehensive solution on their own (The Ocean Cleanup, 2023b). They address symptoms – plastic already in water – and must be complemented by waste collection on land to truly 'turn off the tap' of pollution.

- **Trash wheels and other innovations**: In some cities, semi-autonomous devices like 'Mr. Trash Wheel', a wheel-based rubbish conveyor that uses river current or solar power to lift debris onto a barge, are deployed to remove plastics from rivers. Bubble curtains have also been tested: they pump air through perforated tubes on riverbeds to create a curtain of bubbles that guides plastics to one side for collection (Mr. Trash Wheel, n.d.). These innovative approaches are gaining attention as high-visibility technologies in the fight against plastic pollution. Many are in pilot stages in Europe and Asia, and while promising, factors like local flow conditions, maintenance capacity, and cost determine their scalability. Environmental safeguards to avoid harming aquatic life or diverting fish are also important considerations for any in-river apparatus (Falk-Andersson et al., 2023).

It is worth noting, however, that the effectiveness of these installations varies. A 2020 review of 52 emerging clean-up technologies globally found that the majority of these technologies target macroplastic collection, but their coverage is far below the scale of pollution (Schmaltz et al., 2020). Notwithstanding, when strategically positioned at pollution hotspots, passive capture technologies can significantly reduce the amount of rubbish reaching the ocean. Similarly, deployments in Southeast Asian rivers could have an outsized impact. The ASEAN Regional Action Plan for Combatting Marine Debris (2021–2025) encourages AMS to pilot test such 'downstream' capture interventions alongside upstream waste management improvements.

4.3 Community-Based and Incentive-Driven Recovery Initiatives

A critical component of post-leakage intervention is the engagement of local communities and informal waste workers in recovering plastic from the environment. These initiatives recognise that people who are regularly on the water or coast can become key actors in clean-up if given support or incentives. Several innovative programs illustrate this approach:

- '**Fishing for litter' programs**: Borrowing from successful European models, some AMS have begun encouraging fishers to bring back the plastic waste they incidentally catch at sea or in rivers, instead of discarding it (Mannaart and Bentley, 2022). For example, Indonesia's government launched a pilot program in 2022 to pay traditional fishers for any plastic rubbish collected from the sea during fishing downtime. Similarly, programs in Viet Nam's coastal villages have seen fishers using nets to capture floating rubbish on their daily routes, supported by local authorities or NGOs, in exchange for small rewards such as fuel vouchers or food staples (Xuan, Ngoc, and Börger, 2022). These efforts transform fishers into clean-up partners and leverage their routine presence on the water. While relatively short-term, they help remove debris like discarded plastic packaging or ghost nets and spread awareness in fishing communities that a healthy catch depends on a clean sea (Ngoc et al., 2024).
- **Cash-for-trash and buy-back centres**: To increase the collective commitment to plastics recovery by coastal and riverside communities, various incentive schemes and programmes have been launched in many cities across the ASEAN region. In some Indonesian and Philippine villages and communities, NGOs have set up waste banks where citizens can exchange collected plastic litter for cash, groceries, or other benefits. One such initiative is the 'Plastic Bank', a social enterprise operating in countries like Indonesia, the Philippines, and Viet Nam (Huss, 2007; Ngoc et al., 2024). The initiative offers above-market rates for waste plastics collected by locals, incentivising the gathering of plastic from beaches and neighbourhoods. Collected plastics are then recycled, and programme participants, mainly often informal waste pickers, earn income for their efforts (Katz, 2019).

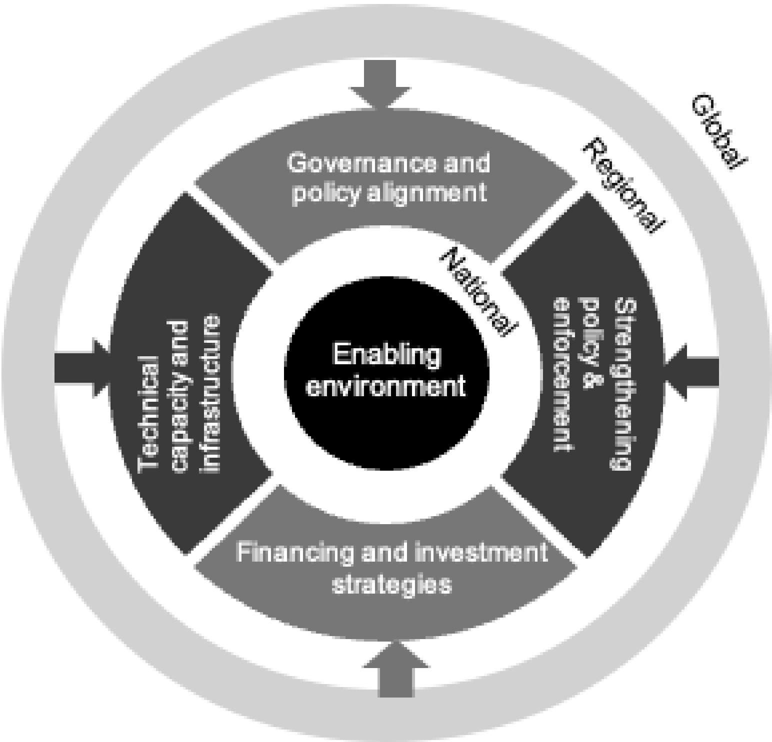
- **Engaging the informal waste sector**: Globally, an estimated 11.4 million informal waste pickers retrieve about 27.4 million tonnes of plastics, acting as 'environmental stewards' in regions lacking robust waste services (Velis et al., 2022). In many ASEAN cities, informal waste pickers collect recyclable materials from streets, dumps, and waterways. Multiple studies and project-based results indicate that partnerships which formalise or support these workers can significantly enhance plastic recovery rates (Zisopoulos et al., 2023; Cook, Silva de Souza Lima Cano, and Velis, 2024). For instance, the Bali-based NGO Sungai Watch employs local waste pickers to empty and sort rubbish from its river barriers. In Indonesia, Sungai Watch partnered with corporate sponsors to fund the installation of 100+ floating booms on rivers and pay community members to collect the trapped plastic daily (Sungai Watch, n.d). This innovative model not only clears the rivers but also provides stable wages to villagers who might otherwise engage in unsafe scavenging. Similar initiatives are emerging in Thailand, the Philippines, and other countries, where 'plastic credit' systems are employed to channel corporate sustainability funds to pay waste pickers for removing specified amounts of plastic from the environment. These market-based mechanisms, analogous to carbon credits, are being trialled across the region to create a sustained financing stream for community clean-up activities, with third-party verifications ensuring the plastic collected is properly accounted for and recycled (World Bank, 2024).

The role of informal and local actors is particularly critical in Southeast Asia, where formal waste collection systems often fail to reach rural and coastal areas. Innovative schemes offering monetary or in-kind incentives can be employed to tap into local knowledge and labour to recover plastic that would otherwise remain in the environment. Just as importantly, these initiatives cultivate a sense of environmental stewardship. Likewise, engaging communities in plastics recovery strengthens public pressure for better waste practices and reinforces educational campaigns (Hardesty et al., 2023; Ferdin, Chook, and Manzano-Fischer, 2025). It is important to recognise, however, that post-leakage recoveries, while vital, remain a reactive measure compared with the preferred active preventive measures. These recovery interventions address the symptoms of plastic pollution – the millions of tonnes already contaminating oceans and landscapes – and can reduce further harm to wildlife, tourism, fisheries, and other sectors. Many ASEAN stakeholders therefore position recovery as one component of an integrated strategy alongside waste reduction, recycling, and improved waste management (ASEAN, 2021). The prevailing view is that clean-up technologies and community initiatives can provide short-term mitigation and reduce immediate risks, but preventing leakage at source remains the only sustainable long-term solution. Environmental recovery efforts are most effective when embedded within a circular economy and pollution prevention framework, ensuring that the legacy pollution addressed today is not continuously replenished by new leakage tomorrow (Mathis et al., 2022; John and Das, 2024).

5. Enabling Conditions and Policy Recommendations

Scaling effective plastic leakage prevention and recovery interventions in recycling facilities across AMS requires a coherent set of enabling conditions that align governance, financing, and technical systems. These enabling conditions may not be shaped in isolation; rather, they may be influenced by external gradients of force – from global commitments and treaty negotiations to national actions and local implementation – that collectively determine the pace and effectiveness of regional responses (Figure 8.8) (Tessnow-von Wysocki and Le Billon, 2019; Maes et al., 2023). Such alignment is essential to achieving the region's transition towards a circular economy for plastics, as envisioned under the ASEAN Framework of Action on Marine Debris and reinforced by emerging and existing global commitments (ILBI on plastics pollution and Basel Convention) (Figure 8.9).

Figure 8.9. Conditions for Creating a Favourable Enabling Environment Preventing Plastic Recycling Related Pollution in ASEAN



Source: Modified from Huno, Borongan, and Keotiamchanh (2024).

5.1 Governance and Policy Alignment

Robust governance remains the cornerstone of and framework for scaling interventions and countermeasures on environmental pollution prevention. In ASEAN, this means integrating national and regional strategies to ensure that plastic leakage prevention is embedded in waste management plans, industrial policies, and trade regulations. Governments should harmonise technical standards for recycled materials, facility operation guidelines, and environmental safeguards to promote cross-border market confidence (John and Das, 2024). Articles 14, 15, and 16 of the draft chair's text of INC-5.2 provides a blueprint for transparency, calling for systematic monitoring and reporting of plastic leakage. ASEAN can adopt this approach to build a common regional baseline for performance measurement. Further, a coordinated governance framework should acknowledge and work with the informal recycling sector, which dominates material recovery in many AMS. Inclusive policies that recognise informal sector cooperatives and include them in extended producer responsibility (EPR) schemes can bridge the gap between formal oversight and on-the-ground realities. This is critical not only for social equity but also for strengthening overall recovery rates and preventing leakage from under-regulated operations. Furthermore, including the voice of informal workers in policy discussions, as recommended by global initiatives, helps design solutions that are socially just and practically effective (Johannes et al., 2021; Tong, Huynh, and Khong, 2021; Mathis et al., 2022).

5.2. Strengthening Enforcement and Policy Implementation

Environmental monitoring and impact assessments for permitting should combine regular inspections, surprise checks, wastewater testing for microplastics, and community-based reporting. Further, stricter facility regulation is essential, with licensing or permitting tied to compliance with waste containment, wastewater treatment, and litter control, backed by penalties for violations and technical support for upgrades. Existing enforcement gaps and noncompliance in certain cities may be linked to illicit trade and in some cases, corruption (Dominish et al., 2020). Law enforcers must demand transparent waste tracking, officer rotation, strong penalties, and coordinated intelligence-sharing amongst AMS. Strengthened global adherence to Basel Convention rules, coupled with ASEAN-wide policy harmonisation, can unify environmental standards, close regulatory loopholes that create 'pollution havens', and support the replication of effective recycling models (van Der Marel, 2022; 2024). Notably, the development of regional guidelines where possible, coordinated training, and a shared certification scheme for compliant facilities could enhance collective enforcement capacity and position ASEAN as a leader in environmentally sound plastics governance.

5.3. Financing and Investment Strategies

Effective interventions require sustained and diversified financing. Governments should allocate greater budgets to modernise recycling facilities while leveraging blended finance models that combine public funds, private investment, and international donor support. Development banks and climate finance mechanisms can back infrastructure upgrades, technology transfer, and capacity building at leakage hotspots. Economic incentives are essential: tax benefits, subsidies for cleaner technologies, and reduced tariffs on recycling equipment can lower adoption barriers (OECD, 2018; 2024). Integrating recovery initiatives into national circular economy roadmaps can further stimulate private sector investment, complemented by monetised incentives such as deposit-refund schemes for plastic packaging or subsidies for environmentally sound residue disposal (World Bank, 2024; Picuno et al., 2025). EPR can channel producer fees into infrastructure upgrades, formalising informal workers and financing leakage prevention, with performance targets ensuring both recycling volume and environmental integrity (Johannes et al., 2021).

5.4. Technical Capacity and Infrastructure

Enhancing awareness and upgrading the technical capacity of recyclers is essential to minimising leakage risks. This includes improving sorting, washing, and pelletising lines to reduce microplastic generation and fugitive losses. Facilities should adopt closed-loop water systems with filtration to minimise discharge, alongside preventive maintenance regimes and standard operating procedures. Regional training programs modelled on the APCCR approach can build the skills of workers in recycling facilities needed to limit plastic leakage and pollution (Huno, Borongan, and Keotiamchanh, 2024). National and city governments should also invest in data infrastructure to track material flows, leakage points, and recovery rates across the recycling value chain. Article 14 of the chair's draft text of INC-5.2 (UNEP, 2025) highlights the importance of standardised reporting, which AMS could integrate into a regional digital platform for monitoring compliance and performance. Such a system would allow real-time identification of underperforming facilities and targeted deployment of technical support.

5.5. Policy Recommendations

- Develop national recycling facility standards to ensure that operational and environmental safeguards are uniformly implemented.
- Institutionalise informal sector participation through cooperation, licensing, cooperative models, and EPR integration.
- Mobilise blended finance for facility upgrades, prioritising leakage hotspots and high-volume processors.
- Implement economic incentives such as tax breaks, subsidies, and deposit-refund mechanisms to encourage compliance.
- Mandate closed-loop water and filtration systems to address microplastic-rich effluent.
- Create a regional leakage monitoring platform aligned with ILBI Article 7 to track progress and guide interventions.
- Invest in capacity building via regional training hubs and exchange programs for recycling facility operators.

6. Conclusion

This chapter has underscored the urgent need for coordinated regional action and strengthened policy frameworks to address plastic pollution through a life-cycle approach, with emphasis on downstream interventions. Evidence from across cities in ASEAN demonstrates that structural deficiencies, inadequate operational controls, and socio-economic drivers contribute significantly to plastic leakage from recycling systems – formal and informal alike. Such leakages, whether micro- or macro-scale, undermine the environmental benefits of recycling and perpetuate pollution in terrestrial and aquatic ecosystems. A downstream-focused lens thus reveals that while upstream measures remain essential, the critical points of leakage often occur during the collection, aggregation, processing, and disposal stages. Addressing these challenges requires integrated policy measures that align infrastructure upgrades, enforcement mechanisms, and economic incentives with local socio-economic realities, especially within the informal sector.

Without recognising and working with informal actors who handle substantial volumes of recyclables into formal waste governance frameworks, interventions risk remaining ineffective or unsustainable. ASEAN is uniquely positioned to lead global efforts in plastics governance, leveraging its regional platforms to harmonise standards, facilitate knowledge exchange, and scale innovations in leakage prevention. By fostering cross-sectoral collaboration, the region can advance regulatory coherence, support the deployment of containment and control technologies, and strengthen community-level engagement. Equally, embedding socio-economic safeguards within policy measures will help ensure that livelihoods are preserved while environmental outcomes improve. Ultimately, the path forward demands both technical and institutional transformation: deploying fit-for-purpose infrastructure, enhancing operational protocols, incentivising compliance, and bridging policy gaps. Through these measures, ASEAN can demonstrate a replicable model for operationalising international commitments into locally grounded, system-wide solutions, ensuring that plastic recycling contributes to a truly circular economy without transferring the environmental burden downstream.

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Chapter 9

Plastic Pollution Countermeasures in Agriculture, Fishery, and Wastewater Treatment

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1. Introduction

As plastics are utilised in a broad range of sectors, there are various kinds of plastic pollution sources. A United Nations Environment Programme (UNEP) report assessing marine litter and plastic pollution identified major land-based pollution sources to the ocean (UNEP, 2021). While landfills are regarded as one of the major sources, other sources include cities (e.g. clothes, carpets, building materials, and single-use plastic (SUP) food packages), roads and traffic (e.g. tyres, road surfaces, and paint), sewage and wastewater treatment plants, and the agriculture sector (e.g. plastic films, fibre textiles for agricultural use, and artificial fertiliser coated with polymer) (UNEP, 2021). In the Association of Southeast Asian Nations (ASEAN) region, a baseline study by the Norwegian Institute for Water Research (NIVA) in 2024 compiled research articles on plastic pollution sources, which include solid waste, agriculture, fishery, aquaculture, wastewater, urban areas, tourism, tyres, textiles, and so on (Collard, Galtung, and Mosberg, 2024).

However, the impact of each pollution source has not been clarified due to lack of information, especially in ASEAN. Both monitoring articles in Indonesia (Ali, Azmi, and Firdaus, 2021) and Malaysia (Sulaiman et al., 2023) have cited agriculture as one of the plastic pollution sources, without quantifying its impact. Another article that reviewed microplastic monitoring articles in the ASEAN region found an increasing trend of articles detecting 'fibre', 'fragment', and 'film' as microplastics in the ASEAN region, but it does not specify which pollution sources generate the microplastics (Nakano et al., 2024).

Analysis and research on agriculture, fishery, and forestry are relatively available. The Food and Agriculture Organization of the United Nations (FAO) publicised a comprehensive assessment report in 2021 on agricultural plastics (FAO, 2021). A number of modelling articles are also available for fishery. In addition, the Institute for Global Environmental Strategies (IGES) team has conducted research on plastic pollution from wastewater treatment.

Considering the information availability, this chapter focuses on countermeasures against plastic pollution from agriculture, fishery, and wastewater, amongst the various land-based pollution sources. Each section utilises secondary sources to consolidate the reviews of existing articles and understand the current situations of plastic issues on agriculture, fishery, and wastewater. Section 2.1 discusses agriculture, Section 2.2 discusses fishery, and Section 2.3 discusses wastewater issues.

2. Status Quo, Outlook, and Countermeasures for Plastic Leakage from Three Sectors: Agriculture, Fishery, and Wastewater

2.1 Agriculture

The uses and impacts of plastic products in the agricultural sector have been analysed by FAO. The comprehensive assessment report (FAO, 2021) identified a wide range of plastic products that help improve productivity. It includes mulch films; tunnel and greenhouse films and nets; irrigation tubes and driplines; bags and sacks for transporting seeds and fertilisers; silage films; bottles containing liquid pesticides and fertilisers; coatings on fertilisers, pesticides, and seeds; non-woven protective textiles or 'fleece' to protect crops, fruits, or plants from extreme temperatures; and nets, ropes, lines, traps, and enclosures. These agricultural plastics provide 'a range of benefits that help farmers, foresters, and fishers to maintain livelihoods, enhance production, reduce losses, conserve water and reduce chemical inputs' (FAO, 2021, p. xiii).

According to FAO, agricultural value chains at a global level used 12.5 million tonnes (Mt) of plastic products in plant and animal production and 37.3 Mt in food packaging in 2019. Despite limited data, Asia was estimated to be the largest user of agricultural plastics – up to 6 Mt annually, almost half of global usage. Moreover, the global demand for greenhouse, mulching, and silage films is estimated to increase by 50% from 6.1 Mt in 2018 to 9.5 Mt in 2030 (FAO, 2021). Exposure to ultraviolet (UV) radiation further accelerates the degradation of these films, particularly mulch films, into microplastics (Thompson et al., 2024). Those beneficial and widely used agricultural plastics are easily turned into plastic pollution sources because only a fraction of them are properly disposed of after use. One of the authors of this book, for example, observed the usage of plastic film in the agricultural field in Indonesia and the Philippines (Figure 9.1). If those films not disposed of appropriately, they could be a source of plastic pollution. Agricultural plastics can contaminate the environment when they become

Figure 9.1. Example of Agricultural Film

Source: Michikazu Kojima, Philippines, 2002.

damaged, degraded, or discarded in the field, breaking down into smaller plastic particles such as macroplastics (> 25 millimetres (mm)), mesoplastics (5–25 mm), microplastics (< 5 mm), or nanoplastics (< 1 micrometer (μm)) (Blettler et al., 2017). In addition, the application of microplastics-contaminated organic amendments and irrigation water can add to agricultural plastic pollution.

2.1.1 Status quo of agricultural plastic pollution

Studies of microplastics in the agricultural context are still significantly fewer in number compared with those in aquatic environments, yet recent trends show that they have been increasing over the last decade (Lotz et al., 2024). Most of these studies were conducted in Asia – collectively comprising up to 60% of all studies on plastic pollution in agricultural lands globally – with China being the major contributor (Sa'adu and Farsang, 2023).

In Southeast Asia, research efforts on this topic are still lacking, but some publications have emerged painting the status quo of the issue. Amongst these, a large share quantifies the occurrence of microplastics in agricultural soils and waters through surveys (summarised in Table 9.1). These studies point out that microplastics have been detected in a range of abundance, sizes, shapes, and colours, and that this variation is largely influenced by surrounding anthropogenic activities. For instance, microplastics abundance in Viet Nam was highest to lowest in the following order: sites adjacent to residential and manufacturing facilities (21,471 ± 12,729 items per kilogram (kg) of soil), sites near agricultural solid waste collection sites (20,188 ± 4,403 items/kg), and sites distant from these facilities (4,418 ± 1,573 items/kg) (Doan et al., 2023).

The categories of activities, and consequently the types of plastics consumed, determine the shapes of the prevalent microplastics. Fragments were the most common shape of microplastics found in two farms in Klang Valley, Malaysia (69.9%–93.8%), which can be traced back to various agricultural plastic products such as plastic net covers, plastic frameworks for vegetation plots, pipes, drums, and trays (Shanmugam et al., 2024). On the other hand, fibres constitute the most prevailing microplastics shape in sites across Viet Nam. Those originated from wastewater irrigation and sewage sludge, which carry cloth fibres released from washing process (Doan et al., 2023). Similarly, the colours and polymer types of collected microplastics serve as an indicator of their sources, such as the case in Klang Valley where black microplastics dominated, indicating that the low-density polyethylene (LDPE) plastic mulching film and nets used across the farms were the largest contributors to microplastics prevalence (Praveena, Hisham, and Nafisyah, 2023).

Another factor that affects microplastic abundance in agricultural lands is elevation. In Iligan City, Philippines, microplastics were found in lower concentrations on elevated terrain (0.56 ± 0.21 items/kg) compared with low-elevation areas (1.11 ± 0.29 items/kg), despite having no significant difference according to the t-test[1] (Gonzales, Shiu, and Bacosa, 2025). Nevertheless, this finding suggests that the transport of plastics by water from higher to lower elevations possibly also accounts for the variation in microplastics abundance.

In addition to surveys, an article by Rahmawati et al. (2023) estimated the loading rate of agricultural plastic waste, which represents the weight of plastic waste accumulating in a given area over a year, in Klaten Regency, Indonesia, using spatial analysis. According to the type of plastic products used in agriculture

[1] The t-test demonstrated that from a statistical standpoint, the densities of microplastics found in the high-elevation and low-elevation areas are not significantly different.

practices, plastic mulch emerges as the plastic type with the highest loading rate compared with other types such as plastic sacks, bags, and bottles, reaching more than 900 kg/year. Plastic mulch has higher loading rates in horticultural areas than paddy field or areas dedicated for secondary crops, particularly due to its wide use in horticultural crops. In consequence, villages with larger areas of horticulture fields exhibit higher plastic loading rates.

Table 9.1. Summary of Agricultural Microplastics Surveys Across the ASEAN Region

Location	Sample	Abundance	Size range	Predominant microplastic shape	Predominant microplastic polymer	Predominant microplastic colour	Source
Abuno barangay, Iligan City, Philippines	Soil	0–1.33 items/kg	1,000–4,000 μm	Film and fragment (47%)	PE (47%)	White (40%)	Gonzales, Shiu and Bacosa (2025)
Semenyih, Klang Valley, Malaysia	Soil	-	1,450–5,255 μm	Fragment (70%)	PVC	White (59%)	Shanmugam et al. (2024)
Puchong, Klang Valley, Malaysia	Soil	-	1,652–4,018 μm	Fragment (94%)	PVC	Black (52%)	Shanmugam et al. (2024)
Samiran, Pamekasan, Indonesia	Soil	140–230 items/kg	100–1,500 μm	Fragment (25%)	PEI and PP	Yellow (34%)	Garfansa et al. (2024)
Klang Valley, Malaysia	Soil	1.5–6.0 items/kg	17–1,247 μm	Fibre or film	LDPE	Black (51%)	Praveena, Hisham, and Nafisyah (2023)
Bac Ninh, Ha Nam, and Ha Noi, Viet Nam	Soil	1,700–38,800 items/kg	< 2,000 μm	Fibre (78%)	PP (48.72%)	Black (28%)	Doan et al. (2023)
Samiran, Pamekasan, Indonesia	Water	0.5–0.9 items/L	100–1,500 μm	Fibre (40%)	PEI	Black (26%)	Garfansa et al. (2024)
Kim Son, Ninh Binh, Viet Nam	Water	0.26–0.92 items/L	302–4,593 μm	Fibre (94%)	-	White (75%)	Nga et al. (2024)

μm = micrometer, ASEAN = Association of Southeast Asian Nations, kg = kilogram, L = litre, LDPE = low-density polyethylene, PE = polyethylene, PEI = polyethyleneimine, PP = polypropylene, and PVC = polyvinyl chloride.

Source: Compiled by authors.

2.1.2 Impacts of agricultural plastic pollution

As microplastics accumulate in agricultural soils and water, concerns regarding their impacts on both the environment and plant growth arise. Soil quality receives the most direct impact from microplastic pollution in agricultural lands, which in turn affects plant growth. Garfansa et al. (2025a) summarised the mechanisms by which microplastics affect soil fertility based on a review of existing literature. First, the presence of microplastics in the soil matrix can occupy pore spaces and reduce soil porosity, limiting water infiltration and air circulation. Furthermore, microplastics disrupt the structure of soil aggregates, heightening the risk of its collapse and the disintegration of essential nutrients. Microplastics were also found to affect the nutrient cycle of carbon, nitrogen, and phosphorus through alterations in their dynamic release into the soil solution. Beyond the impacts on the abiotic factors of soil, microplastics affect the abundance of soil microbes (including bacteria and earthworms) due to elevated physiological stress and neurotoxicity responses.

Considering that plant productivity is closely linked to soil fertility, the adverse impacts of microplastics on soil quality make their impact on plants inevitable. Worldwide, several studies have measured the impact of different polymers of microplastics on the growth of crops, including one conducted in Indonesia (Garfansa et al., 2025b). This study assessed the toxicity of polystyrene (PS) microplastics on the growth of rice, one of the major crops in the ASEAN region. The results show that PS microplastics that have undergone photoaging processes cause a reduction in rice crops' shoots, root length, and fresh weight by 14%, 31%, and 30%, respectively. Moreover, PS microplastics photoaged for 120 hours decreased the carbon and nitrogen concentrations by 31% as a result of the interference of PS microplastics in the root zone that inhibited nutrient absorption. The concentration of chlorophyll also declined by half, which is attributable to the plant's impaired ability to produce and maintain chlorophyll due to exposure to photoaged PS microplastics.

Prolonged exposure to microplastics can affect agricultural productivity, thereby reducing economic gains from the activity. According to one research article that estimated the production losses due to microplastics at the global level, the presence of microplastics can lead to annual production losses ranging from 0.4% to 34.7% (Sutanto et al., 2024). The chemical and physical features of microplastics that inhibit the growth of plants, stimulate oxidative disruption, and increase the uptake of heavy metals can indirectly contribute to the loss or waste of one-third of plant production, leading to repercussions on food security, increased dependence on food imports, and subsequent price increases (Sutanto et al., 2024). Economic losses due to microplastics were reported for rice, wheat, maize, tomato, and pea crops, with overall losses ranging from US$5.77 million to US$12,724.49 million in selected countries (Sutanto et al., 2024).

2.1.3 Countermeasures against agricultural plastic pollution

Efforts to address the microplastics issue in the agricultural sector have emerged in the Dieng Highlands, Indonesia, where plastic mulch has been widely used in potato cultivation. A study conducted by Faqih et al. (2024) utilised LDPE plastic, made from agricultural plastic waste in the target area, as a binding agent for paving blocks. The blocks from the recycled plastics showed promising results, with a compressive strength of 36 megapascal (MPa), which meets the Indonesian National Standard (SNI 03-0691-1996) for Paving Block Quality A intended for road applications, which require a minimum compressive strength of 35 MPa. This was achieved with a mix of 70% plastic content and 30% hot sand, following the compressive strength testing method specified in the Advancing Standards Transforming Markets (ASTM) C140/C140M (ASTM, n.d.). However, the authors noted that further research is needed to identify the most effective percentage of LDPE in composite paving to ensure good mechanical properties.

At the global level, FAO has called for interventions towards sustainable management of agricultural plastics based on the 6R concept: refuse, redesign, reduce, reuse, recycle, and recover (FAO, 2021). After years of global stakeholder consultations, FAO publicised the provisional voluntary code of conduct in 2025 to 'provide voluntary guidance for all agricultural sub-sectors, taking into account the need to secure sustainable agrifood systems around the globe' (FAO, 2025: 2). This guidance stipulated a number of actions to prevent plastic pollution in agriculture:

(i) Harmonise the rules and technical specifications applicable to plastic products used in agriculture, incorporating sustainable design principles.
(ii) Adopt measures to enhance the sustainability of plastics used in agriculture and support their sustainable use and maintenance.
(iii) Adopt regulatory instruments and procedures, such as authorisation and labelling requirements, to monitor and control the manufacture, importation, and use of plastics employed in agriculture.
(iv) Promote and establish the recycling of plastic products used in agriculture.
(v) Support and encourage environmentally sound management of plastic waste generated in agriculture.

When the international legally binding instrument on plastic pollution, including in the marine environment, in the INC process is formulated, FAO will take steps towards further development of the code of conduct (FAO, 2025).

Despite significant progress at the global level, initiatives that tackle agricultural plastic pollution are still limited in ASEAN, especially at the regional level. During FAO's worldwide stakeholder consultations on the countermeasures against agricultural plastic pollution, Asia – including ASEAN – was underrepresented. The process was mainly led by European representatives (Karasik et al., 2024). In addition, no mention of 'agriculture', 'mulch', or 'fertiliser' has been made in the ASEAN regional initiatives tackling plastic pollution, including the Bangkok Declaration on Combating Marine Debris in ASEAN Region in 2019, the ASEAN Framework of Action on Marine Debris in 2019, the ASEAN Regional Action Plan for Combating Marine Debris in the ASEAN Member States (2021–2025), and the ASEAN Declaration on Plastic Circularity in 2024. Those regional initiatives in ASEAN focus on the enhancement and improvement of the process of waste management and recycling, as a plastic pollution countermeasure. This lack of policy measures, especially given the evidence of the prevalence of microplastics in agricultural lands and their negative impact, underlines the need for strengthened actions that address the emission of plastic waste from the agricultural sector.

2.2 Fishery

2.2.1 Status quo of marine plastic pollution by fishing gear

Plastic is widely used in various types of fishing gear, including fishing nets and lines, ropes, traps, buoys, lures, fish aggregating devices, and aquaculture facilities. Fishing gear can get lost in the ocean for various reasons, either intentionally or unintentionally. This type of unmanaged gear is collectively called 'abandoned, lost, or otherwise discarded fishing gear' (ALDFG), also known as 'derelict fishing gear' or 'ghost gear'.

No accurate information is available on how much plastic fishing gear is lost in the marine environment. A 2009 report by UNEP and FAO estimated that between 0.02% and 30% of fishing gear is lost, with the rate of loss varying depending on the location and fishing gear type (Macfadyen, Huntington, and Cappell, 2009). Later, Richardson, Hardesty, and Wilcox (2019) conducted a meta-analysis of gear loss surveys undertaken between 1975 and 2017, and estimated that 5.7% of fishing nets, 8.6% of traps, and 29.0% of fishing lines were lost. The study also pointed out that available scientific data on ALDFG were mostly from Europe and North America, while few studies had been conducted in Asia, Africa, and South America (Richardson, Hardesty, and Wilcox, 2019).

On the other hand, ALDFG has been found in extremely high concentrations in some areas. For example, ALDFG made up 75%–86% of the macroplastic debris collected from the North Pacific Garbage Patch, and most of it seemed to originated in China, Japan, the Republic of Korea (henceforth, Korea) and the United States (US) (Lebreton et al. 2022). Toyoshima and Watanabe (2025) identified the sources of the ALDFG found in Iriomote Island, Okinawa, Japan, and found that 95% of the identified fishing gear originated from China. The same study pointed out that more than half (53.7%) of the fishing gear lacked information regarding its origin, which made it impossible to trace back to the source country. Studies indicate that ALDFG can be transported over long distance from the source, resulting in widespread impacts.

2.2.2 Impacts of marine plastic pollution by fishing gear

Environmental impacts

ALDFG is not only found in abundance but is also known to have significant negative environmental impacts. Many species of marine mammals, sea turtles, and seabirds, including endangered species, become entangled with ALDFG. Although it is difficult to quantitatively evaluate the magnitude of the impact without concrete data, such as the amount of ALDFG in the environment and its encounter rate with wildlife, some studies have addressed this issue. For example, the remains of 32,000 organisms were found in 870 fishing nets that were recovered in the state of Washington, US, including seabirds and marine mammals (Good et al., 2009). In addition, Stelfox, Hudgins, and Sweet (2016) reviewed 76 publications and found references to more than 5,400 individuals of 40 species that were entangled with fishing gear.

The damage to coral reef ecosystems has been reported by several researchers, such as in Hawaii (Donohue et al., 2001; Yoshikawa and Asoh, 2004); Brazil (Beneli et al., 2020); and Thailand waters (Ballesteros, Matthews, and Hoeksema, 2018). These include fragmentation, soft tissue damage, and mortality of reef-building corals, as well as entanglement with other reel-associated invertebrates and fish. Yoshikawa and Asoh (2004) reported that 65% of coral colonies had fishing lines on their surface, and 80% of colonies were either entirely or partially dead on a coral reef in Oahu Island, Hawaii.

Socio-economic impacts

It must be noted that ALDFG also has immense socio-economic impacts. One of the major socio-economic impacts associated with ALDFG is the loss of fishery resources through 'ghost fishing', where the derelict fishing gear keeps catching the target and non-target species, leading to depletion of fish stocks. To give an example, in Chesapeake Bay in the US, where blue crab fishing with pots flourishes, it is estimated that

900,000 crabs die and US$300,000 worth of fishery resources are lost annually due to crab pots that were abandoned in the ocean (Bilkovic et al., 2014). Similarly, Gilardi et al. (2010) estimated a loss of US$19,656 of Dungeness crab to commercial fishery per derelict gill net in Puget Sound, Washington, which is 14.5 times more than the cost of recovering a gill net.

Aside from ghost fishing, ALDFG has broad impacts on human society. For example, fishing gear on beaches ruins the aesthetic value of the scenery, which poses a particularly serious issue for the tourism industry. The collection and disposal of ALDFG puts a burden on the human and financial resources of local municipalities, which are already limited in remote areas. Finally, maritime accidents can be caused by drifting ALDFG that becomes entangled with ship propellers. One of the worst such accidents occurred in Korea in 1993, when a nylon rope became wrapped around the propellers of a large ferry, causing it to sink and cause the loss of 292 lives (Macfadyen, Huntington, and Cappell, 2009).

2.2.3 Countermeasures

Considering the abundance of ALDFG and the significance of its impacts, marine pollution by ALDFG is a priority environmental issue that requires special and immediate actions. Various organisations have proposed countermeasures, which may be categorised into three main types: prevention, mitigation, and retrieval (WWF Japan, 2025). Prevention refers to all measures that are intended to prevent the fishing gear from entering the environment, and mitigation means reducing the impacts of fishing gear lost to the environment, while retrieval means recovering the ALDFG from the environment (Table 9.2).

Table 9.2. Types of Countermeasures Against Marine Pollution by Fishing Gear

Category	Examples
Prevention	Better management of fishing gear Gear marking and reporting of loss Collection and recycling of fishing gear Economic incentives to recycling of fishing gear Port waste reception facilities Training, education, and awareness raising
Mitigation	Development of biodegradable fishing gear
Retrieval	Beach cleaning Marine litter collection scheme Fishing gear tracking Gear loss reporting and retrieval

Source: Modified from WWF Japan (2025).

The marking of fishing gear is recommended by some international organisations. For example, FAO published voluntary guidelines in 2019 (FAO, 2019). The guidelines recommend fishery organisations to introduce and monitor fishing gear marking systems, and to implement the gear marking system in a participatory process that includes fishers and other stakeholders. Various methods are available for marking fishing gear. They range from relatively simple methods, such as colour-coding and tagging, to more sophisticated methods, such as using devices that emit radio waves, have GPS functions, or can be detected acoustically. Some countries and regions, such as Canada, Norway, Taiwan, and the United Kingdom, have already introduced mandatory gear marking programmes. However, gear marking on its own is not sufficient to prevent gear loss, and in many cases, it is combined with a mandatory gear loss reporting system, where fishers can report gear loss to authorities instantly using communication tools such as mobile apps.

The collection of used fishing gear for recycling is also promoted in many countries and regions. However, the volume of fishing gear being recycled remains relatively small compared with the total amount of fishing gear. In Japan, a company called REFINVERSE upcycles about 300 tons/year of nylon gill net into high-quality handbags, carpet tiles, car parts, and so on.[2] In Thailand, the Environmental Justice Foundation, an international nongovernmental organisation (NGO), started a project called 'Net-free Seas' to collect and recycle end-fishing gear, and 200 tons/year of fishing net is being recycled under this project.[3] Fishing gear collection and recycling projects are also taking place in other ASEAN Member States such as the Philippines (Parker, 2018) and Viet Nam (REVFIN, 2025). These initiatives are mostly led by the private sector and need to be expanded.

As for mitigation, Japan has been promoting research on biodegradable alternative materials for fishing gear through industry–government–academia collaboration. For example, as a response to a long-standing problem whereby large amounts of plastic pipe that are used as spacers in oyster farming and end up polluting the coastal areas of the Seto Inland Sea, Nichimo Co., Ltd and Kuraray Co., Ltd. are jointly developing pipes made of biodegradable plastic for use in oyster farming (Toyoshima, 2021).

The removal or retrieval of lost fishing gear is another type of countermeasure. According to Cho (2011), a total of 2,759 tons of ALDFG was removed from the Sea of Japan by Japan between 1999 and 2002, and the Korean government invested US$1.5 million in 2009 and US$2.3 million in 2010 to remove ALDFG from the Sea of Japan. The programme successfully removed a total of 260 tons of marine debris; however, during the operation, one of the participating vessels encountered a typhoon and sank, resulting in the loss of five crew members (Cho, 2011). This case shows the extremely high cost and danger of removing ALDFG from offshore waters, highlighting the importance of prevention. Passive removal of ALDFG is more widely adopted in many countries, such as European Union member states, Japan, and Thailand, where fishers are encouraged to bring back the marine debris that was caught in their fishing nets to the shore, and subsidised by the government to dispose of the debris (MOECC and MOEJ, 2024).

[2] Personal communication with REFINVERSE Group, Inc., 15 August 2022.
[3] Personal communication with the Environmental Justice Foundation, 20 January 2025.

2.3 Wastewater

Wastewater treatment plants (WWTPs) are essential infrastructure that unintentionally act as substantial conduits for plastics, particularly microplastics, into the environment (Sadia et al., 2022). The primary mechanisms by which these microplastics, which are now widely defined as smaller than 5 mm in size, reach aquatic ecosystems are the land application of sewage sludge and treated effluent, both of which are known to have high amounts of microplastics (Hassan et al., 2023; Thompson et al., 2024). Although macroplastics are also introduced into WWTPs, they are frequently intercepted during the basic screening process (Abeynayaka et al., 2022) (Figure 9.2).

Fragments (primarily from the breakdown of macroplastics and tyre wear), fibres (from synthetic textiles shed during washing), pellets (from microbeads from personal care products), and films (from packaging and wrappers) are the primary shapes and sources of microplastic pollution that are frequently observed in wastewater (De Falco et al., 2018; Murphy et al., 2016; Suresh et al., 2020) (Figure 9.3). The biggest contributors to overall microplastic pollution are secondary microplastics, which are derived from bigger plastics. Primary microplastics, which are the direct input to the environment of micro-sized plastic particles from human activities, comprise a minor fraction (Boucher and Friot, 2017; Lassen et al., 2015).

Figure 9.2. Trapped Plastics in the Preliminary Screening Process of a Wastewater Treatment Plant in the Lao PDR

Source: Ezra Osorio, 2025.

Figure 9.3. Different Shapes of Microplastics Extracted from the Influent of a Wastewater Treatment Plan in the Philippines

Source: Ezra Osorio, 2023.

2.3.1 Status quo of plastic pollution from wastewater

WWTPs in the ASEAN Plus Three (ASEAN+3)[4] region can remove from 50% to over 99% of microplastics from wastewater, depending on the technology employed, the scale of operation, and the particle size range being studied (Hidayaturrahman and Lee, 2019; Hongprasith et al., 2020; Le et al., 2023; Lv et al., 2019; Nakao, Ozaki, and Masumoto, 2019; Pham et. al., 2024; Setiadewi et al., 2023; Sheriff et al., 2025; Yang et al., 2019). It is crucial to recognise that these reported efficiencies are tied to the size range of the microplastics analysed. The majority of studies in the ASEAN+3 region targets particles from 20 μm to 5 mm, but wastewater contains vast quantities of smaller microplastics (< 20 μm) and nanoplastics (< 1 μm). These smaller particles are more difficult to remove and are often excluded from monitoring. This implies that actual influent concentrations are likely much higher than reported, and true removal efficiencies for the total microplastic particles load may be lower.

Technologies that integrate tertiary treatment processes like filtration or advanced oxidation consistently yield the best removal rates. For instance, a WWTP in Japan using rapid filtration equipment reports 99.6% efficiency (Nakao, Ozaki, and Masumoto, 2019), while a plant in Viet Nam with a trickling filter and secondary clarifier reached 99.9% (Le et al., 2023). Similarly, combining an advanced activated sludge process with ultra-filtration and ozonation at a high-capacity WWTP in China resulted in 95.16% removal (Yang et al., 2019).

In comparison, conventional systems demonstrate significantly more varied performance. Conventional activated sludge, a typical secondary treatment, exhibits a wide efficiency range from a low of 53.6% in China to a more efficient 94.4% in a WWTP in the Philippines (Lv et al., 2019; Pham et al., 2024). This shows that performance is very susceptible to design and operational conditions.

Despite high removal percentages of at least 50%, the sheer volume of wastewater processed daily leads to a substantial absolute discharge of microplastics. This 'volume paradox' illustrates that a high removal rate does not guarantee a low total discharge. This is clearly demonstrated by several cases. For example, a WWTP in Korea with 89.9% removal still releases effluent containing 33,000 particles per cubic meter due to its extremely high influent load (Hidayaturrahman and Lee, 2019). This paradox underscores that, to mitigate pollution, the focus must shift from removal percentages alone to minimising the absolute number of particles discharged.

Given this magnitude, microplastics released from wastewater pose a significant threat. Once they enter aquatic systems, they can be ingested by various organisms (Lusher, Hollman, and Mendoza-Hill, 2017). This contamination extends to human health through multiple exposure pathways, particularly the consumption of contaminated seafood (Smith et al., 2018). As discussed in Chapter 4, microplastics can adsorb and concentrate other environmental pollutants like heavy metals and persistent organic pollutants, acting as vectors for their transfer into the human body (Campanale et al., 2020). Therefore, effectively tackling microplastic contamination in the wastewater sector requires a multifaceted, integrated strategy that considers upstream, midstream, and downstream solutions, including source control, technological improvements, thorough monitoring, sustainable sludge management, and supportive policies.

[4] The ASEAN+3 countries are the 11 ASEAN Member States (Brunei Darussalam, Cambodia, Indonesia, the Lao PDR, Malaysia, Myanmar, the Philippines, Singapore, Thailand, Timor-Leste, and Viet Nam) plus China, Japan, and Korea.

2.3.2 Countermeasures against plastic pollution from wastewater

Upstream solutions: preventing plastics from entering wastewater

The most efficient and fundamental strategy to handle plastic in wastewater is to halt it at the source. Upstream countermeasures focus on preventing both macroplastics and microplastics from entering the wastewater stream in the first place. Secondary microplastics arising from the breakdown of larger plastic products are the primary form of contamination (Horton et al., 2017). This fact firmly indicates a systematic failing that happens long before rubbish ever reaches a treatment plant: insufficient solid waste management. Improving solid waste management is therefore the single most significant upstream intervention.

When plastic goods like single-use packaging, bags, and food containers are not collected adequately, they pollute the landscape. In open environments, these items are exposed to sunlight and physical stress, causing them to grow brittle and fracture into smaller pieces (Andrady, 2011). Rainfall and wind then mobilise this plastic debris, washing it into stormwater drains. In regions with combined sewer systems, this plastic-laden run-off is transported directly into the same network as sewage, overwhelming WWTPs during wet weather events. Even in areas with separated systems, this run-off directly pollutes rivers and lakes that may serve as water sources for communities (McCormick et al., 2014; Murphy et al., 2016). Furthermore, ageing sewer infrastructure can act as a direct source of plastic pollution, as wastewater exfiltrates through cracks and leaks, contaminating the surrounding environment (Zhang et al., 2022).

Within this broader strategy of source reduction, governments can implement targeted legislation. A prominent example is the ban on microbeads in rinse-off personal care products, which has been effectively enforced in various countries and has considerably decreased this specific source of primary microplastics (UNEP, 2018). Further regulations on single-use plastics could directly lower the volume of high-risk goods that become environmental rubbish. On the technological front, legislation may mandate filters on new washing machines, as synthetic textiles are a substantial and persistent source of microplastic fibres (Hartline et al., 2016).

Educating the public about microplastic sources, including fibres from synthetic clothing, fragments from tyre wear, and particles from personal care items, could empower consumers and inspire behavioural changes. Concurrently, the use of basic yet effective household devices should be promoted. For instance, a four-stage microplastic filter developed for laundry wastewater achieved average removal effectiveness of 98.5% (Park, Yoon, and Park, 2025). Another recent product, the MiniPlast Filter, decreased microplastics in laundry wastewater from an average of 4,710 microplastic particles to 390 microplastic particles, focusing on both price and user-friendliness in its design (Rachman et al., 2025).

Midstream solutions: enhancing WWTP removal efficiency

While comprehensive upstream controls are the most effective long-term solution, a legacy of plastic pollution and inevitable leakages imply that WWTPs will continue to receive microplastic-contaminated influent for the near future. Hence, boosting their removal efficiency remains an important midstream strategy, acting as the last line of defence to prevent microplastics from entering aquatic habitats. The goal is to change WWTPs from being conveyors of pollution into effective barriers.

For the ASEAN region, the most practical approach involves retrofitting existing facilities with innovative and affordable technologies rather than pursuing complete and costly overhauls. Targeted upgrades can yield substantial results. For instance, an anaerobic baffled reactor system in the Philippines, which already achieved a high removal rate of 98.4%, was upgraded with electrolysis technology. This single enhancement boosted the overall efficiency to an exceptional 99.8%, proving that cost-effective additions can drastically reduce microplastic discharge (Pham et al., 2024).

Where feasible, adding advanced tertiary treatment stages (i.e., including disc filters, rapid sand filters, and dissolved air flotation) provides the highest level of capture and can significantly increase removal efficiency, often pushing it above 98% (Jani, Wu, and Venkiteshwaran, 2024). Membrane bioreactors are recognized as a promising technology for removing microplastics (Kurniawan et al., 2023). The small pore size of the membranes (typically < 0.1 μm) provides an almost complete physical barrier to microplastics, achieving removal rates greater than 99.9% (Lares et al., 2018). Advanced oxidation processes like ozonation and UV/hydrogen peroxide (H_2O_2) are being explored for their potential to chemically break down and degrade microplastics (Rizwan and Bilal, 2022). However, their high operational costs and energy consumption are significant barriers to widespread adoption.

Another sustainable approach involves the use of natural coagulants from sources like Moringa oleifera and Benincasa hispida seeds. These show promise as low-cost, biodegradable alternatives to chemical coagulants, with lab tests of M. oleifera extract achieving about 94% removal of suspended microplastics (Agarwal, Prakash, and Saini, 2025). On the other hand, the discovery of bacteria like Ideonella sakaiensis, which produces enzymes to break down polyethylene terephthalate (PET), has opened a new avenue for bio-remediation, though it faces significant challenges with slow degradation rates and scalability for real-world application (Yoshida et al., 2016). Similarly, techniques such as using ferrofluids to magnetise microplastics for efficient removal are under development but require more research to become practical for large-scale operations (Hamzah et al., 2021).

Downstream solutions: sustainable sludge management

The success of advanced midstream technologies presents a serious downstream challenge: the concentration of collected microplastics in sewage sludge. A common disposal method involves processing sludge to form biosolids, which are then distributed to agricultural land as fertiliser. This approach is a key fault in the capture strategy, as it reintroduces collected microplastics directly into terrestrial and agricultural environments, where they can accumulate in soil and enter the food chain (Nizzetto, Futter, and Langaas, 2016). Without a sustainable management plan for this sludge, the WWTP essentially transfers pollution from water to land.

Thermal processes such as pyrolysis and gasification offer a solution in treating the sludge contaminated with microplastics. By heating sludge in low-oxygen environments, these methods break down the plastic polymers into valuable byproducts like synthetic gas (syngas) and bio-oil, which can be used for energy generation (Hu and Chen, 2025). This offers a circular economy approach, transforming a waste problem into an energy resource

The success of these measures depends on a foundation of robust policy and sustained capacity building. Adopting standardised methods, such as harmonised protocols for monitoring microplastics and practical guides for wastewater management, is essential for generating reliable and comparable data (Pham et al., 2024). To ensure new strategies are deployed effectively, such guidance must be paired with training programmes that enhance the technical expertise of local stakeholders. Continuous monitoring then serves as a critical feedback loop, validating the impact of interventions and identifying where further improvements are needed.

The interconnection of various solutions is a vital concern, as no single countermeasure is sufficient on its own. Consequently, addressing microplastic pollution in wastewater is a systemic concern that deserves a systemic solution.

3. Conclusion

While there are various kinds of plastic pollution sources other than the waste management sector, the research and policy actions for those sectors are limited, especially in the ASEAN region. As for agriculture and fishery, research findings are available mainly in Europe and the US. FAO released a comprehensive analysis report for the status quo and guidelines for countermeasures, with limited contributions from Asia. Nevertheless, assessment of agricultural and fishery plastic pollution and its economic and environmental impacts is emerging in this region. Countermeasures including the collection and recycling of agricultural and fishery plastic waste are considered and implemented in some ASEAN+3 countries, although those are mainly conducted by private companies or NGOs. Some government intervention may be necessary to enhance and scale up the countermeasures.

As for wastewater, several performance analyses of WWTPs have been conducted in some ASEAN+3 countries. WWTP systems in those countries have proven their efficiency to remove microplastics from effluent, when the system functions properly. This indicates the importance of establishing WWTP systems and carrying out appropriate maintenance of such systems. But the 'volume paradox' anecdote shows that the WWTP approach is not sufficient. No single countermeasure is sufficient on its own. Systematic solutions – from upstream to downstream – for plastic products are necessary.

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Chapter 10

Global and Regional Initiatives: Pathways to a Plastics Pollution Convention

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1. Introduction

In recent years, the urgency to address plastic pollution has grown significantly across Asia, particularly in Southeast and East Asia. International support has also intensified, with official development assistance (ODA) for plastic pollution mitigation reaching US$1.46 billion in 2022 – double the amount recorded in 2019. Asia has been the primary recipient of this aid, receiving an annual average of US$497 million, followed by the Americas and Africa (OECD, 2025). At the national level, countries in Southeast and East Asia have also developed a range of policies aimed at tackling plastic pollution (Akenji et al., 2019; 2020).

Despite growing demand for effective solutions, there remains a lack of comprehensive mapping of existing initiatives led by international and regional bodies. As the forthcoming global plastics treaty is expected to become the cornerstone of global plastic governance (Mendenhall, 2023), it is essential to identify and analyse existing legal instruments and institutional frameworks – highlighting overlaps and interfaces. This approach is equally important for regional initiatives, whether legally binding or voluntary.

Against this backdrop, this chapter explores the rising global and regional momentum to combat plastic pollution in the region. It provides an overview of key international and regional initiatives, programmes, and projects, with a focus on Southeast and East Asia. By comparing global and regional efforts (sections 2–4), this chapter aims to demonstrate that the region is not merely following global trends but is actively contributing to the advancement of plastic pollution countermeasures.

2. Global Initiatives

This section illustrates global initiatives addressing plastic pollution prior to the Intergovernmental Negotiating Committee on Plastic Pollution (INC) negotiations, including efforts by the Group of Seven (G7), the Group of Twenty (G20), the Basel Convention, and the United Nations Environment Assembly (UNEA). These initiatives played significant roles in building consensus towards the establishment of the INC, such as G7 Ocean Plastics Charter in 2018, the G20 Osaka Blue Ocean Vision in 2019, the amendment of the Basel Convention in 2019, and the UNEA 5.2 resolutions in 2022. These international and intergovernmental conferences are thematically interlinked through their focus on plastic pollution as a key component of marine litter, emphasising the need to address plastic pollution across its entire life cycle and contributing to the growing importance of mitigation efforts against plastic pollution.

2.1 Group of 7 (G7)

The G7 has increasingly recognised marine litter, including plastic pollution, as a pressing global challenge. This issue gained significant attention starting with the G7 Elmau Summit in 2015, and since then, the G7 has published several key endorsements and initiatives aimed at combating marine litter and plastic pollution.

At the G7 Elmau Summit, the issue of marine litter was recognised for the first time as a global challenge in the leaders' declaration (Tsuruta, 2025). For example, the leaders' declaration acknowledged that marine litter, especially plastics, is a global issue threatening marine ecosystems and human health (G7 Germany, 2015). In the leaders' declaration from the G7 Ise-Shima Summit in 2016, under the theme of resource efficiency and the 3Rs (reduce, reuse, recycle), the commitment to addressing marine litter was reaffirmed. The declaration recognised that efforts to promote resource efficiency and the 3Rs also contribute to the prevention and reduction of marine litter, particularly plastic, from land-based sources (G7 Ise-Shima, 2016).

The G7 Taormina Leaders' Communiqué in 2017 does not mention 'marine litter' or 'plastic pollution', nor do any related statements or annexes (G7 Taormina, 2017). However, at the G7 Bologna Environment Ministers' Meeting, the communiqué reaffirmed the commitment to addressing marine litter, including plastics and microplastics, by supporting international efforts such as the UNEA resolutions and the Global Partnership for Marine Litter, and by promoting circular economy solutions (G7 Environment Ministers, 2017).

Since 2018, references to 'plastic pollution' and 'marine plastics' seem to have increasingly appeared in G7 leaders' declarations, extending beyond ministerial-level meetings, including the Ocean Plastics Charter (2018, Canada); the 2030 Nature Compact (2021, United Kingdom); the G7 Climate, Energy and Environment Ministers' declaration (2022, Germany); the G7 Climate, Energy and Environment Ministerial Meeting (2023, Japan); and the G7 Leaders' Summit (2023, Japan). These highlight the growing political commitment of G7 nations to address plastic pollution and marine litter.

First, at the Charlevoix Summit in June 2018, G7 leaders recognised that 'current approaches to the production, use, management, and disposal of plastics pose significant threats to marine environments, human health, and livelihoods' (Tsuruta, 2025: 3). The Ocean Plastics Charter was signed in 2018 as an outcome of the Charlevoix Summit, led by the Ministry of Environment and Climate Change in Canada. This charter was endorsed by Canada, France, Germany, Italy, the United Kingdom (UK), and the European Union after the summit (Environment and Climate Change Canada, n.d.-a). Currently, 28 countries, 9 global partners, 17 Canadian partners, and 49 regional partners have endorsed the charter. This aims to address plastic pollution through a resource-efficient, life-cycle approach that reduces waste, supports innovation, and protects the environment. The charter outlines five key elements: (i) sustainable design, production, and after-use markets; (ii) collection, management, and other systems and infrastructure; (iii) sustainable lifestyles and education; (iv) research, innovation, and new technologies; and (v) coastal and shoreline action (Environment and Climate Change Canada, n.d.-b).

Second, during the 2021 G7 Summit in Cornwall, UK, leaders adopted the 2030 Nature Compact, committing to halt and reverse biodiversity loss by 2030 (Department for Environment, Food & Rural Affairs, 2021). The compact mainly focused on biodiversity; however, it clearly incorporates plastic litter as a marine environmental thread. This aligns with the earlier G7 and G20 initiatives, including the Osaka Blue Ocean Vision. The agreement also expresses support for the efforts of UNEA-5 and the Global Ghost Gear Initiative (G7, 2021).

Following the UNEA 5.2 resolutions in March 2022, the first G7 Climate, Energy and Environment Ministers' declaration in May 2022 reaffirmed strong support for UNEA 5.2. Emphasising a holistic, life-cycle approach, the declaration highlighted the importance of adequate technical and financial resources and encouraged partner countries to pursue environmentally and socio-economically beneficial actions. These include reducing single-use and non-recyclable plastics, as well as eliminating harmful additives used in plastic production. Furthermore, the G7 committed to stakeholder engagement, transparency, and traceability across the plastic value chain, and enhanced efforts to address marine litter, particularly from abandoned fishing gear (G7 Germany, 2022a). The G7 Ocean Deal highlighted the commitment to urgent action to end plastic pollution by supporting UNEA 5.2 negotiations and promoting life-cycle approaches to plastics (G7 Germany, 2022b).

After that, the G7 Climate, Energy and Environment Ministers' Meeting was held in 2023 in Sapporo, Japan, where they clearly stated their commitment to eliminate additional plastic pollution by 2040 (Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection, 2023). In line with the G7 declaration, efforts should focus on adopting a comprehensive life-cycle approach, promoting sustainable consumption and production, enhancing circularity within the economy, and ensuring the environmentally sound management of waste (G7 Climate, Energy and Environment Ministers, 2023b). This communiqué builds on the previous international discussion, including the G7 Ocean Deal (2022), the Osaka Blue Ocean Vision (2019), the G20 Implementation Framework for Actions on Marine Plastic Litter (2019), the Ocean Plastics Charter (2018), the G20 Action Plan on Marine Litter (2017), and the G7 Action Plan to Combat Marine Litter (2017). It also welcomed the launch of negotiations under the INC to develop a legally binding international instrument on plastic pollution, including in the marine environment (G7 Climate, Energy and Environment Ministers, 2023a). Ending plastic pollution is also mentioned by the G7 Hiroshima Leaders' Communiqué (G7, 2023).

2.2 Group of 20 (G20)

G20 activities have addressed plastic pollution, especially since 2017, including the G20 Action Plan on Marine Litter (2017), the G20 Implementation Framework for Actions on Marine Plastic Litter (2019), the Osaka Blue Ocean Vision (2019), and the MARINE Initiative (2019). These initiatives demonstrate the G20's commitment to shared principles in combating marine litter.

First, at the G20 Summit in Germany in 2017, the G20 Action Plan on Marine Litter was adopted. The plan acknowledged the urgency of taking swift action to prevent and reduce marine litter to protect human health, safeguard marine and coastal ecosystems, and mitigate associated economic impacts and environmental damage. It emphasised the need to address all types of marine litter, including single-use plastics (SUPs) and microplastics (G20, 2017).

Furthermore, building on the foundation laid by the G20 Action Plan on Marine Litter (G20 Japan, 2019a), the G20 Implementation Framework for Actions on Marine Plastic Litter was adopted during the G20 Ministerial Meeting on Energy Transitions and Global Environment for Sustainable Growth in 2019, in Japan. This framework was subsequently endorsed by G20 Leaders at the G20 Osaka Summit in 2019 (IGES, n.d.-b). The G20 Implementation Framework for Actions on Marine Plastic Litter aims to promote more concrete actions in addressing marine litter, especially marine plastic and microplastic pollution, with supporting actions aligned with national policies, strategies, and contexts on a voluntary basis and intending to complement the efforts of the United Nations Environment Programme (UNEP). This framework also acknowledged that the urgent need to tackle marine plastic litter and microplastics globally supports ongoing efforts, and recognises key international actions, including UNEA resolutions 4/7 and 4/10 and the Basel Convention. As of June 2025, there have been six editions of the G20 Report on Actions against Marine Plastic Litter, published annually since 2019 (IGES, n.d.-a) to track implementation of the implementation framework.

Just after the establishment of the G20 Implementation Framework for Actions on Marine Plastic Litter, the Osaka Blue Ocean Vision was agreed, which reflects a shared global commitment to eliminate additional marine plastic pollution by 2050 (IGES, n.d.-b). The G20 members also endorsed an implementation framework for coordinated voluntary actions under this vision (G20 Japan, 2019a). To support the Osaka Blue Ocean Vision, the MARINE initiative was launched by Japan in 2019 to assist developing countries in strengthening their capacity to manage plastic waste through a comprehensive approach with four key pillars: (i) management of wastes, (ii) recovery of marine litter, (iii) innovation, and (iv) empowerment. This programme is funded and operated by Japan (MOFA Japan, 2025).

2.3 Basel Convention

The Basel Convention on the Control of Transboundary Movements of Hazardous Waste and Their Disposal entered into force in 1992 in response to growing environmental concerns over the illegal dumping of hazardous waste, particularly in developing countries (Basel Convention, n.d.-a). In response to increasing global concern and public attention surrounding marine plastic litter and microplastics, the Government of Norway proposed amendments to annexes of the Basel Convention in June 2019 to bring plastic waste under its regulatory scope (Wingfield and Lim, 2022). This amendment had a significant influence on the rules governing the cross-border movement of plastic waste (Tsuruta, 2025).

The amendment was adopted in Annexes II, VIII, and IX. Annex II, which lists wastes requiring special consideration, added plastic waste to a list of special consideration labelled Y48. All plastic waste is covered by this amendment, except waste classified under entries A3210 (Annex VIII) and B3011 (Annex IX) (Basel Convention, n.d.-b; Tsuruta, 2025). The revision of the annex was based on proposals from the governments of Norway and Japan (Tsuruta, 2025).

A3210 covers plastic waste that contains hazardous chemicals, such as lead compounds or halogenated flame retardants, and waste classified under A3210 is subject to the Prior Informed Consent (PIC) procedure.

B3011 was also added under Annex IX, replacing B3010. B3011 applies to plastic waste that is almost free of contamination and intended for environmentally sound recycling, consisting of a single non-halogenated polymer or resin, selected fluorinated polymers, or mixtures of polyethylene (PE), polypropylene (PP), and/or polyethylene terephthalate (PET) (Basel Convention, n.d.-b.). Plastic waste is not subject to the PIC procedure under entry B3011 if it is destined for environmentally sound recycling and is almost free from contamination. This includes plastic waste composed primarily of a single non-halogenated polymer (PE, PP, and PET); a single cured resin or condensation product (urea formaldehyde and epoxy); specific fluorinated polymers; and mixtures of plastic waste consisting of PE/PP/PET, if destined for recycling

The amendments expanded the range of plastic waste types that fall under the PIC procedure. This means that exporting countries are now required to obtain formal approval from importing countries before sending specific types of plastic waste and must ensure that the receiving countries have the capacity to manage the waste in an environmentally sound manner (Wingfield and Lim, 2022). However, Van Der Marel (2022) argued that the concept of environmentally sound manner (ESM) recycling remains vague, lacks clear international standards, and often permits the mismanagement or downcycling of waste abroad, even though overarching guidance is provided in the Technical Guidelines for the Identification and Environmentally Sound Management of Plastic Wastes and for Their Disposal. This may highlight the need for stronger international rules, clearer definitions of ESM, improved oversight of plastic waste exports, and greater responsibility on the part of exporting countries to ensure that plastic waste is properly managed after shipment.

2.4 United Nations Environment Assembly (UNEA)

The United Nations Environment Assembly (UNEA), which consists of 193 UN Member States, serves as the highest global authority for environmental decision-making. It plays a critical role in shaping the international environmental agenda by providing a platform for dialogue, policy review, and experience sharing, as well as setting the strategic direction for the future work of UNEP and promoting partnerships to advance environmental objectives and mobilise resources. Since the first meeting in 2014, UNEA has adopted multiple resolutions addressing marine litter and plastic pollution.

In June 2014, representatives from over 150 countries gathered for the first UNEA, where they adopted UNEA Resolution 1/6 on marine plastic debris and microplastics. The resolution expressed concern about the impacts of plastic pollution on the marine environment, fisheries, tourism, and development, and called for stronger action, particularly by addressing pollution at its source (UNEP, 2023b). It also urged participation by the secretariats of key environmental treaties, including the Basel Convention and the Convention on Biological Diversity, to examine the issue. The resolution emphasised the importance of coordination amongst existing environmental agreements to tackle marine plastic pollution effectively. UNEA Resolution 1/6 marked a turning point, elevating marine plastic pollution to a critical global issue even before the adoption of the Sustainable Development Goals (Tsuruta, 2025).

In response to the resolution, Marine Plastic Debris and Microplastics: Global Lessons and Research to Inspire Action and Guide Policy Change was published in 2016 (Carlini and Kleine, 2018; UNEP, 2016). Following that, UNEA Resolution 2/11 on Marine Plastic Litter and Microplastics was adopted in 2016, led by Norway. This resolution refers to United Nations (UN) General Assembly Resolution 70/235 on oceans and the law of the sea and the 2030 Agenda for Sustainable Development, as well as UNEA-1. The resolution emphasised the need for 'an urgent global response that considers the entire life cycle of products' and suggested that international efforts must address not only plastic waste management but also its production phase. This laid the groundwork for a more robust international framework by calling for the enhancement of measures at the national, regional, and international levels, while acknowledging other international bodies like the Food and Agriculture Organization of the United Nations (FAO) and the International Maritime Organization (IMO) (Carlini and Kleine, 2018).

UNEA Resolution 3/7 on Marine Litter and Microplastics was adopted in 2017. During UNEA-3, UNEP presented Combating Marine Plastic Litter and Microplastics: An Assessment of the Effectiveness of Relevant International, Regional and Subregional Governance Strategies and Approaches (UNEP, 2017). The report concluded with policy recommendations emphasising the importance of addressing pollution at source or upstream, as this is more cost-effective than mitigation and removal efforts downstream. It also provided a policy recommendation for UNEA-3 to adopt governance solutions based on a holistic life-cycle approach to tackle plastic pollution effectively. UNEA Resolution 3/7's primary action was to establish an ad hoc open-ended expert group, which was tasked with exploring the barriers to and potential solutions for addressing marine plastic litter and microplastics from all sources, with emphasis on land-based sources (Carlini and Kleine, 2018).

UNEA Resolution 4/6 on Marine Plastic Litter and Microplastics was adopted in 2019. This resolution extended the mandate of the ad hoc open-ended expert group on marine litter and microplastics until UNEA-5. A key feature of this resolution is that it was the first to introduce the circular economy as a potential solution to marine plastic pollution. Although the circular economy is mentioned alongside other concepts, including environmentally sound waste management, resource efficiency, the 3Rs, sustainable materials management, innovation in related technologies, the environmentally sound clean-up of marine plastic litter, and international cooperation, the introduction of the circular economy can be considered as a notable shift in UNEA's approach to tackling plastic pollution.

Most recently, UNEA Resolution 5/14 to End Plastic Pollution: Towards an International Legally Binding Instrument was adopted in 2022. One of the key features of this resolution is its call for the development of an international legally binding instrument on plastic pollution. This instrument is intended to address the entire life cycle of plastics, allowing for both mandatory and voluntary measures, and aims to fill gaps in existing international agreements, such as the Basel Convention, the Stockholm Convention on Persistent Organic Pollutants, and the International Convention for the Prevention of Pollution from Ships (MARPOL). To support this process, UNEA also requested the UNEP Executive Director to convene an ad hoc open-ended working group in the first half of 2022. This group was tasked with preparing for the work of the INC by discussing the timetable and organisational structure for the negotiations, based on elements outlined in the resolution.

2.5 Summary

Table 10.1 summarises the responses of the G7, G20, Basel Convention, and UNEA to marine litter and plastic pollution. This section highlights the rise of marine litter-related endorsements since 2014 from various forums. These documents identify plastic litter as a major contributor to marine pollution and emphasise the importance of addressing plastic pollution across its entire life cycle, including land-based sources. The decision to establish an international treaty was not made in isolation; rather, it emerged through a complex process of navigating various international initiatives, each with its own perspectives and priorities. The convergence of ideas and efforts ultimately culminated in the resolution adopted at UNEA, marking a significant milestone in global plastic governance.

Table 10.1. Responses from the G7, G20, Basel Convention, and United Nations Environment Assembly on Marine Litter and Plastic Pollution

Year	Institutional/ intergovernmental body	Conference	Summary
2014	UNEA	UNEA-1	UNEA Resolution 1/6 recognised marine plastic pollution as a critical issue, urging coordinated international action and treaty involvement to address its sources and impacts.
2015	G7	G7 Elmau Summit	The leaders' declaration acknowledged that marine litter, especially plastics, poses a serious global threat.
2016	UNEA	UNEA-2	UNEA Resolution 2/11 called for an urgent global response to plastic litter and microplastics by addressing the full life cycle of products and strengthening global, regional, and national measures.
2016	G7	G7 Ise-Shima Summit	The commitment to addressing marine litter was reaffirmed in the leaders' declaration. The declaration noted the role of resource efficiency and the 3Rs (reduce, reuse, and recycle) in reducing land-based plastic marine litter.
2017	G7	G7 Taromina Summit	There was no mention of marine litter or plastic pollution, nor were there any related statements or annexes in the Taormina Leaders' Communiqué. However, the G7 Bologna Environment Ministers' Meeting communiqué reaffirmed the commitment to addressing marine litter, including plastics and microplastics.
2017	G20	G20 Action Plan on Marine Litter	The plan acknowledged the urgency of taking swift action to prevent and reduce marine litter.
2017	UNEA	UNEA-3	Resolution 3/7 on marine litter and microplastics emphasised the importance of addressing plastic pollution at source and agreed to establish an ad hoc open-ended expert group.
2018	G7	Charlevoix Summit	The Ocean Plastics Charter was signed. It aims to address plastic pollution through a resource-efficient, life-cycle approach that reduces waste, supports innovation, and protects the environment.
2019	Basel Convention	Basel Convention COP-14	Amendments to annexes of the Basel Convention in June 2019 brought plastic waste under its regulatory scope.
2019	UNEA	UNEA-4	Resolution 4/6 on marine plastic litter and microplastics was adopted and led to the extension of the ad hoc open-ended expert group mandate.

Year	Institutional/ intergovernmental body	Conference	Summary
2019	G7	G7 Cornwall Summit	The 2030 Nature Compact clearly incorporated plastic litter as a marine environmental thread.
2019	G20	G20 Implementation Framework for Actions on Marine Plastic Litter	This aimed to promote more concrete actions in addressing marine litter, especially marine plastic and microplastic pollution, with supporting actions aligned with national policies, strategies, and contexts on a voluntary basis and intending to complement the efforts of UNEP.
2019	G20	Osaka Blue Ocean Vision	This reflected a shared global commitment to eliminate additional marine plastic pollution by 2050.
2022	UNEA	UNEA-5	Resolution 5/14 to End Plastic Pollution: Towards an International Legally Binding Instrument was adopted, calling for the development of an international legally binding instrument on plastic pollution.
2022	G7	G7 Elmau Summit	The G7 Climate, Energy and Environment Ministers' declaration and the G7 Ocean Deal reaffirmed strong support for UNEA 5.2, advocating a holistic life-cycle approach to plastic pollution.
2023	G7	G7 Hiroshima summit	The G7 Climate, Energy and Environment Ministers' Meeting in Sapporo stated their commitment to eliminate additional plastic pollution by 2040.

COP = Conference of the Parties, G7 = Group of Seven, G20 = Group of Twenty, UNEA = United Nations Environment Assembly, UNEP = United Nations Environment Programme.

Source: Authors.

3. Regional Initiatives: Focus on Southeast and East Asia

This section provides a brief overview of key regional initiatives in ASEAN and East Asian countries. Regional bodies have increasingly prioritised activities against plastic pollution in response to growing global momentum. For example, some organisations, including the Coordinating Body on the Seas of East Asia (COBSEA), the Northwest Pacific Action Plan (NOWPAP), and Partnerships in Environmental Management for the Seas of East Asia (PEMSEA) were characterised as entities that were established as regional initiatives to address marine pollution issues in general. Over time, these entities have expanded their scope to place greater emphasis on marine litter-related activities, with a strong focus on plastic pollution. Also, several regional organisations have initiated projects about plastic pollution following the rising demand for plastic pollution-related interventions, like the Association of Southeast Asian Nations (ASEAN), Asia-Pacific Economic Cooperation (APEC), and the Economic Research Institute for ASEAN and East Asia (ERIA).

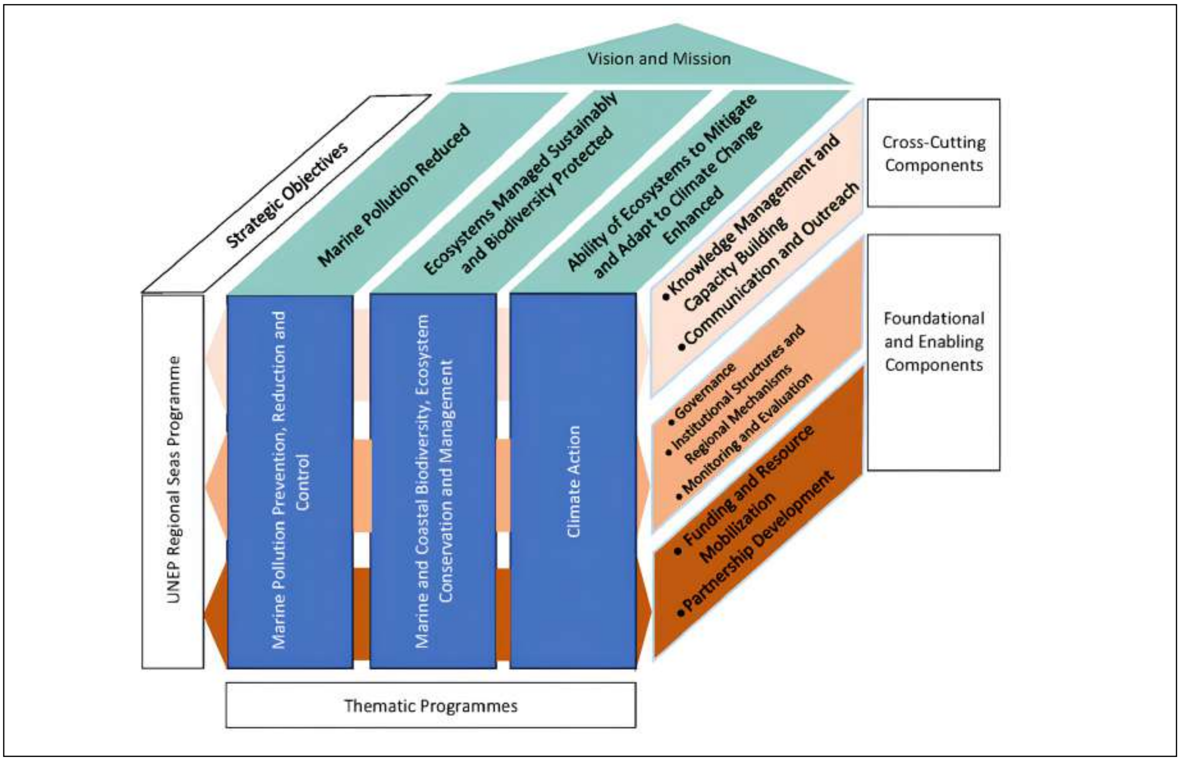
3.1 Coordinating Body on the Seas of East Asia (COBSEA)

Under UNEP, 18 regional marine initiatives have been established under the Regional Seas Programme (UNEP, 2025a). Amongst them, COBSEA and NOWPAP operate in Southeast and East Asia. COBSEA is responsible for guiding the implementation of the East Asian Seas Action Plan, adopted in April 1981 and revised in 1994 (COBSEA, n.d.). The action plan was adopted by five countries: Indonesia, Malaysia, the Philippines, Singapore, and Thailand (COBSEA, 2018). The action plan, which is formally known as the Action Plan for the Protection and Development of the Marine Environment and Coastal Areas of the East Asian Seas Region, seeks to safeguard the region's marine and coastal ecosystems to ensure the health and well-being of both current and future generations. In response to requests from participating governments, a Regional Coordinating Unit was established in 1993 to serve as COBSEA (COBSEA, n.d.). The action plan was subsequently revised in 1994, expanding COBSEA's membership to include five additional countries[1] (COBSEA, 2018). Table 10.2 (at the end of section 3) shows the current nine member countries.

COBSEA promotes regional cooperation amongst its nine member countries – Cambodia, China, Indonesia, the Republic of Korea, Malaysia, the Philippines, Thailand, Singapore, and Viet Nam – to promote the sustainable management and protection of marine coastal environments (COBSEA, n.d.). The COBSEA Strategic Directions, 2023–2027 has three focused efforts: marine pollution prevention, marine and coastal biodiversity ecosystem conservation and management, and climate action (COBSEA, 2023). Plastic pollution appears to be treated as part of marine pollution prevention amongst the three focused efforts (Figure 10.1).

[1] Australia, Cambodia, China, the Republic of Korea, and Viet Nam.

Figure 10.1. Thematic and Support Components Underpinning the COBSEA Strategic Directions, 2023–2027



COBSEA = Coordinating Body on the Seas of East Asia, UNEP = United Nations Environment Programme.
Source: Adapted from COBSEA (2018).

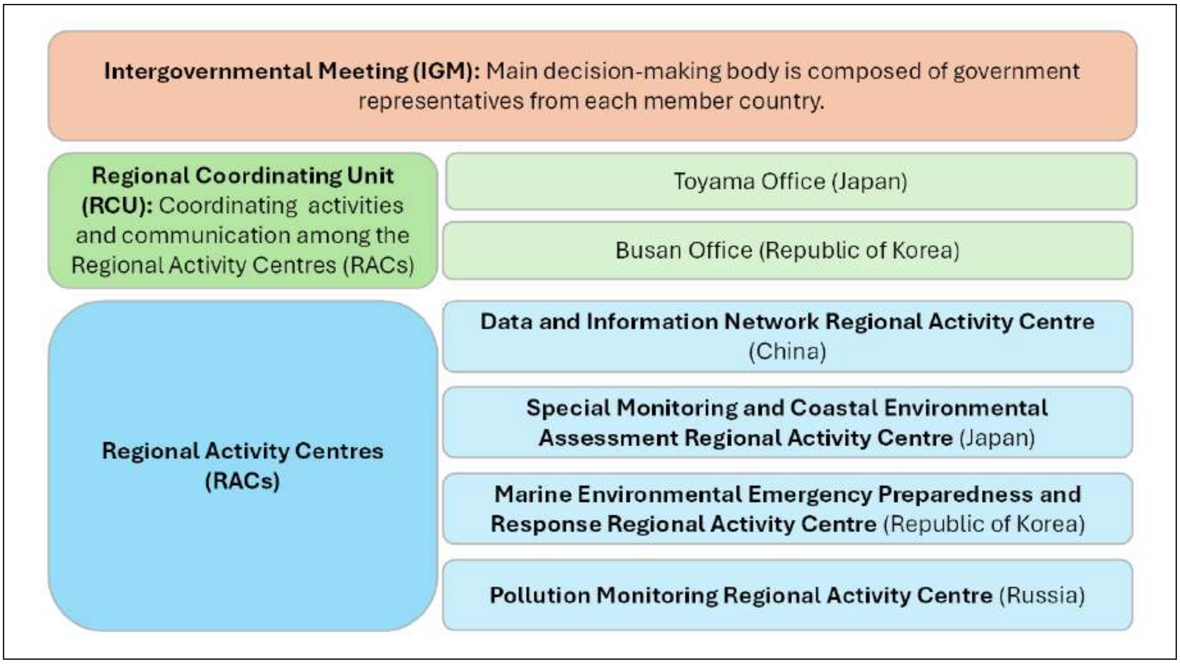
Specific to plastic waste, a key initiative is the COBSEA Regional Action Plan on Marine Litter 2019. As plastics are a significant source of marine litter, the action plan supports countries in adopting legal and economic tools to manage land-based marine litter and promote a circular economy; to advance reduction, reuse, recycling, and product replacement; to develop regional guidance for national marine litter and microplastic monitoring, aligned with established guidelines; to create regional guidelines for reducing marine litter from waste management, tourism, and plastic manufacturing; and to encourage analysis of plastic flows into the region and their contribution to marine litter generation (COBSEA, 2019). With this background, COBSEA has undertaken various activities to address plastic pollution. These include the development of a publication on waste management and plastic pollution reduction (Battelle, the Coordinating Body on the Seas of East Asia, and United States Environmental Protection Agency, 2022); a study on plastic waste leakage to identify plastic leakage hotspots (UNEP, COBSEA, Government of Sweden, and UN-Habitat, 2022); workshops on data collection and monitoring of plastic pollution such as Bangkok Plastics Week (UNEP, 2023a); and efforts to mobilise public and private finance for plastic circularity through a workshop on Accelerating Investments for Plastic Circularity (UNEP, 2024). Furthermore, COBSEA participates in the INC negotiations and provides statements as one of the country groups.

3.2 Northwest Pacific Action Plan (NOWPAP)

NOWPAP was founded in 1994 at the joint request of the four member countries listed in Table 10.2. NOWPAP focuses on the marine and coastal areas spanning from about 121°E to 143°E longitude and 33°N to 52°N latitude (UNEP, 2025b).

The Intergovernmental Meeting, the main decision-making body of NOWPAP, is responsible for setting policy directions, approving work plans, and monitoring progress. The Regional Coordinating Unit, with offices in Japan and the Republic of Korea, serves as the central hub for coordinating programme activities. It was approved in 2000 and became operational in 2004 (UNEP, 2025b). Implementation is supported by four Regional Activity Centres, each hosted by a member country. Figure 10.2 illustrates the institutional structure of the Intergovernmental Meeting, the Regional Coordinating Unit, and the Regional Activity Centres (Northwest Pacific Region Environmental Cooperation Center, n.d.).

Figure 10.2. Institutional Structure of NOWPAP



NOWPAP = Northwest Pacific Action Plan.

Source: Adapted from Northwest Pacific Region Environmental Cooperation Center (n.d.).

The NOWPAP Regional Action Plan on Marine Litter was adopted in 2008 as a coordinated response to growing marine litter in the region. The plan builds on NOWPAP's earlier work on marine litter and monitoring. Under the plan, plastic pollution is addressed comprehensively as a major component of marine litter (UNEP, n.d.-b).

While several NOWPAP publications have addressed marine litter, two specifically focus on plastic pollution. The first, 'National Actions on Marine Microplastics in the NOWPAP Region', published in 2020 by the Special Monitoring and Coastal Environmental Assessment Regional Activity Centre (CEARAC), analyses national and stakeholder responses to marine microplastics in the region. It categorises efforts into legislative measures; national strategies; monitoring activities; and initiatives for prevention, removal, and awareness-raising (NOWPAP CEARAC, 2020). The second publication, 'Recycling Plastic Marine Litter', published in 2007, examines the potential for applying plastic recycling technologies to marine litter in the Northwest Pacific, where plastics constitute about 95% of coastal debris. It outlines three main recycling methods – material, chemical, and thermal – and presents case studies for each. While recycling offers an environmentally sound alternative to landfilling and incineration, the report highlights key challenges such as contamination, material degradation, high costs, and limited infrastructure. Despite these barriers, the publication emphasised the importance of promoting recycling (NOWPAP CEARAC, 2007).

3.3 Partnerships in Environmental Management for the Seas of East Asia (PEMSEA)

PEMSEA serves as a regional coordination platform promoting the sustainable development of coastal and marine environments across the East Asian Seas (PEMSEA, n.d.-h). It collaborates with 11 Country Partners (Table 10.2) and 21 Non-Country Partners to advance the implementation of the Sustainable Development Strategy for the Seas of East Asia (PEMSEA, n.d.-b). NOWPAP is one of its non-governmental partners (PEMSEA, n.d.-f).

PEMSEA was launched in 1993 with support from the Global Environment Facility (GEF) to address marine pollution in the East Asian seas. In its early phase, PEMSEA focused on several key activities. These included the establishment of integrated coastal management pilot sites in China and the Philippines; the promotion of subregional collaboration amongst Indonesia, Malaysia, and Singapore to address pollution in the Straits of Malacca and Singapore; and capacity-building initiatives, particularly in developing countries such as Cambodia, China, North Korea, Indonesia, the Philippines, Thailand, and Viet Nam.

The initial project, titled Prevention and Management of Marine Pollution in the East Asian Seas, was led by the United Nations Development Programme (UNDP) and the IMO and hosted by the Philippines' Department of Environment and Natural Resources. The success of the pilot phase led to a second phase from 1999 to 2007, which focused on fostering intergovernmental and multisectoral partnerships, marking the formal establishment of PEMSEA (PEMSEA, n.d.-g).

PEMSEA's work is supported by two primary platforms: the East Asian Seas Congress and the East Asian Seas Partnership Council. The East Asian Seas Congress is a triennial, multi-stakeholder event that serves as a regional forum for advancing the sustainable development of oceans and coasts through knowledge exchange, policy dialogue, and partnerships. Since its inception in 2003, the Congress has brought together over 1,000 participants from governments, academia, civil society, and the private sector. Key features of the Congress include a Ministerial Forum, international conference, youth forum, exhibitions, and site visits. Over the years, its thematic focus has evolved from the blue economy and local implementation to global targets and resilience, reflecting changing regional and global priorities (PEMSEA, n.d.-c). The East Asian Seas Partnership Council provides policy and operational guidance for the implementation of the Sustainable Development Strategy for the Seas of East Asia (PEMSEA, n.d.-d).

Project ASEANO and the Marine Plastics ODA Project are noteworthy projects addressing plastic pollution. Project ASEANO, funded by the Government of Norway, is led by the Norwegian Institute for Water Research (NIVA) and the Center for Southeast Asian Studies (CSEAS) Indonesia. It is implemented in close collaboration with the PEMSEA Resource Facility and the ASEAN Secretariat, under the guidance of the ASEAN Working Group on Coastal and Marine Environment. The project's main objective is to strengthen the region's ability to address plastic pollution by improving understanding of its sources, pathways, and impacts. It promotes the development of effective and sustainable solutions to reduce plastic pollution and its effects on both the environment and socio-economic development. The project focuses on the local level, with pilot sites in the Imus River (Philippines) and the Citarum River (Indonesia) (PEMSEA, n.d.-a). The Marine Plastics ODA Project (2023–2028), funded by the Ministry of Oceans and Fisheries of the Republic of Korea, aims to mitigate marine plastic pollution in the East Asian Seas region by enhancing governance and management, showcasing exemplary practices and innovative approaches, conducting marine litter assessments, and strengthening capacity building and public awareness. The participating countries are the Philippines and Timor-Leste (PEMSEA, n.d.-e).

3.4 Association of Southeast Asian Nations (ASEAN)

ASEAN has increasingly taken action to combat plastic pollution, especially since the mid-2010s. At the 34th ASEAN Summit held in Thailand in June 2019, two significant documents addressing marine environmental protection were adopted: the Bangkok Declaration on Combating Marine Debris in the ASEAN Region and the ASEAN Framework of Action on Marine Debris (Hermawan and Astuti, 2021).

The ASEAN Framework of Action on Marine Debris was developed to implement the recommendations from the ASEAN Conference on Reducing Marine Debris in the ASEAN Region, held in Phuket, Thailand in November 2017, while considering the outcomes of the East Asia Summit Conference on Combating Marine Plastic Debris in Bali, Indonesia in September 2017. The framework outlines four priority areas – policy support and planning; research, innovation, and capacity building; public awareness, education, and outreach; and private sector engagement – with suggested actions to address marine debris (ASEAN, 2019a). In addition, the Bangkok Declaration on Combating Marine Debris in the ASEAN Region, adopted in 2019, demonstrates a collective commitment by ASEAN Member States to prevent and reduce marine debris through national actions, regional cooperation, and stakeholder engagement (ASEAN, 2019b).

Building on the 2019 declaration and framework, in May 2021, the ASEAN Regional Action Plan for Combating Marine Debris (2021–2025) was adopted to present a comprehensive, step-by-step strategy for addressing marine plastic pollution. With the support of the World Bank and technical partners, the plan outlines 14 regional actions divided into three strategic phases. It shares the same strategic pillars as the ASEAN Framework of Action on Marine Debris – policy support and planning; research, innovation, and capacity building; public awareness, education, and outreach; and private sector engagement – while providing an implementation roadmap (World Bank, 2021).

Most recently, the ASEAN Declaration on Plastic Circularity was adopted in 2024 at the 44th and 45th ASEAN Summits in Vientiane, Lao People's Democratic Republic (Lao PDR). The declaration underscores the importance of a full life-cycle approach to plastic management, focusing on eco-design, reuse, innovation in alternatives, improved waste management, pollution prevention, public–private collaboration, and alignment with global and national efforts to combat plastic pollution as well as the affirmation of support for the development of a legally binding international agreement on plastic pollution (ASEAN, 2024).

3.5 Asia-Pacific Economic Cooperation (APEC)

APEC was established in 1989 as a regional economic forum and now comprises 21 member economies (Table 10.2). Its primary goal is to promote free and open trade and investment, economic growth, and regional cooperation across the Asia-Pacific region (APEC, n.d.-a).

The APEC Roadmap on Marine Debris was endorsed in 2019 to guide APEC's work under the Oceans and Fisheries Working Group. Its vision is to encourage member economies to take voluntary and concrete actions, considering their respective domestic circumstances, to address marine debris, including plastic litter in the marine environment. These actions should be grounded in scientific evidence and informed by lessons learned from regional efforts, with a focus on policy development, research and innovation, sharing best practices, increasing access to financing, and facilitating private sector engagement. The Marine Debris Management and Innovation Sub-Fund is a dedicated APEC funding mechanism established to support projects that address marine debris, especially plastic waste, and promote sustainable development. Administered by the APEC Secretariat and guided by the Oceans and Fisheries Working Group, the Sub-Fund provides financial support for initiatives that build capacity in developing APEC economies, develop waste management infrastructure and policy, promote technical innovations that create value from plastic waste, and encourage private sector engagement (APEC, n.d.-c).

As of May 2025, five projects listed in APEC's project database include the term 'plastic' in their titles, covering topics such as waste management, bioplastics, and plastic recycling. These include the APEC Seminar on Promoting Circular Economy and Sustainable Materials Management to Effectively Address Marine Plastic Litter in the Asia-Pacific Region (2020, Viet Nam); the Workshop on Promoting Bioplastic Materials to Reduce Marine Plastic Litter in the Asia-Pacific Region (2022, Indonesia); the Workshop on International Policy Development of Marine Pollution Control, including Marine Plastic Debris and Sustainable Waste Management (2023, China); the Workshop on the Latest Plastic Recycling Technologies and Their Policy Applications (2024, Korea); and Policies, Standards, and Best Practices for Recycling of Plastic Intended to Contact with Foods to Reduce Marine Plastic Waste amongst APEC economies (2024, China).

3.6 Regional Knowledge Centre for Marine Plastic Debris (RKC-MPD) of the Economic Research Institute for ASEAN and East Asia (ERIA)

ERIA was established to positively influence relationships and policymaking within and between ASEAN and East Asian countries (ERIA, 2023). It comprises 16 member countries, as Table 10.2 shows (ERIA, 2024a).

The RKC-MPD, established in 2019 by ERIA, aims to support ASEAN Plus Three (ASEAN+3) countries[2] in enhancing plastic circularity and preventing marine plastic pollution. The centre serves as a hub for information dissemination, research support, and capacity building initiatives. Its activities include facilitating regional dialogues, promoting private sector innovations, and fostering collaborative networks to address marine plastic debris effectively (ERIA, n.d.-b). This is in line with the ASEAN+3 Marine Plastics Debris Cooperative Action Initiative in 2018.

ERIA's RKC-MPD has been dedicated to the activities of plastic pollution mitigation through conferences, working groups, and public outreach. Co-organisation of the ASEAN Conference on Combating Plastic Pollution (ACCPP), under the rotating ASEAN Chairmanship, is one of the most important regional activities held by the RKC-MPD. The ACCPP, spearheaded by Indonesia under its ASEAN Chairmanship in October 2023, is a high-level regional initiative addressing the growing plastic pollution crisis in Southeast Asia, with a strong focus on multi-stakeholder cooperation (ERIA, n.d.-a). The second ACCPP was held in October 2024 in the Lao PDR under its chairmanship of ASEAN. This conference focused on strengthening multi-stakeholder partnerships under the theme of 'Action, Innovation, and Partnership to Phase Out Plastic Pollution'. It aimed to advance a circular plastic economy by minimising waste, maximising resource efficiency, and fostering regional collaboration (Suwarno et al., 2025). Most recently, ACCPP was held in 2025 in Malaysia under the theme 'All Hands on Deck: Uniting Forces for a Sustainable Plastics Future' and highlighting strong regional progress on plastic pollution solutions, while also persistent gaps in implementation and impact (ERIA, 2025).

Further noteworthy work by ERIA's RKC-MPD is the Expert Working Group on Marine Plastic Debris, which is a collaborative initiative coordinated by ERIA in partnership with the Institute for Global Environmental Strategies (IGES). The first meeting was held in September 2021. Its goals include supporting data-driven policymaking, promoting knowledge sharing, and addressing marine plastic pollution and circular economy challenges in the ASEAN+3 region (IGES, 2021). As of July 2025, seven Expert Working Group meetings have been held (IGES, 2025).

Furthermore, the RKC-MPD has contributed to various knowledge products and projects, in addition to knowledge-sharing activities through multiple channels, including publications, webinars, and workshops. For instance, Solikhin et al. (2025) urged ASEAN Member States to integrate the One Health Framework, which links human, animal, and environmental health, into national and regional micro- and nanoplastics research. The RKC-MPD also contributes to the promotion of extended producer responsibility (EPR) in ASEAN Member States (ERIA, 2024b; ERIA RKC-MPD, 2022).

[2] The ASEAN+3 countries are the 11 ASEAN Member States (Brunei Darussalam, Cambodia, Indonesia, the Lao PDR, Malaysia, Myanmar, the Philippines, Singapore, Thailand, Timor-Leste, and Viet Nam) plus China, Japan, and the Republic of Korea.

3.7 Summary

Table 10.2 lists the member countries or economies of each body, while Table 10.3 highlights key documents and events associated with each, many of which are considered to have been endorsed by multiple member countries. The region has multilayered regional initiatives. Although some functions and activities overlap, each institution has worked closely and collaboratively with other institutions to tackle plastic pollution in the region, which is recognised as a hotspot of marine debris. These efforts have been accompanied by the continuous implementation of projects addressing plastic pollution from various angles, including pollution monitoring, public awareness, environmental impacts, socio-economic dimensions, and waste management.

Table 10.2. Member Economies of Regional Bodies

Regional body	Member economies
Association of Southeast Asian Nations (ASEAN)	Brunei Darussalam, Cambodia, Indonesia, the Lao PDR, Malaysia, Myanmar, the Philippines, Singapore, Thailand, Timor-Leste , and Viet Nam
Coordinating Body on the Seas of East Asia (COBSEA)	Cambodia, China, Indonesia, the Republic of Korea, Malaysia, the Philippines, Thailand, Singapore, and Viet Nam
Northwest Pacific Action Plan (NOWPAP)	China, Japan, the Republic of Korea, and Russia
Partnerships in Environmental Management for the Seas of East Asia (PEMSEA)	Cambodia, China, North Korea, Indonesia, Japan, the Lao PDR, the Philippines, the Republic of Korea, Singapore, Timor-Leste, and Viet Nam
Asia-Pacific Economic Cooperation (APEC)	Australia, Brunei Darussalam, Canada, Chile, China, Hong Kong, Indonesia, Japan, Republic of Korea, Malaysia, Mexico, New Zealand, Papua New Guinea, Peru, the Philippines, Russia, Singapore, Chinese Taipei, Thailand, the United States, and Viet Nam
Economic Research Institute for ASEAN and East Asia (ERIA)	Australia, Brunei Darussalam, Cambodia, China, India, Indonesia, Japan, the Lao PDR, Malaysia, Myanmar, New Zealand, the Philippines, the Republic of Korea, Singapore, Thailand, and Viet Nam

Source: Authors.

Table 10.3. Key Regional Documents and Events on Marine Debris Endorsed by Southeast and East Asian Bodies

Year	Regional body	Officially adopted document/event amongst the member countries
2008	Northwest Pacific Action Plan (NOWPAP)	NOWPAP Regional Action Plan on Marine Litter
2017	Association of Southeast Asian Nations (ASEAN)	ASEAN Framework of Action on Marine Debris
2019	Coordinating Body on the Seas of East Asia (COBSEA)	COBSEA Regional Action Plan on Marine Litter 2019
2019	ASEAN	Bangkok Declaration on Combating Marine Debris in the ASEAN Region

Year	Regional body	Officially adopted document/event amongst the member countries
2019	Asia-Pacific Economic Cooperation (APEC)	APEC Roadmap on Marine Debris
2019	Economic Research Institute for ASEAN and East Asia (ERIA)	Establishment of Regional Knowledge Centre for Marine Plastic Debris
2021	ASEAN	ASEAN Regional Action Plan for Combating Marine Debris (2021–2025)
2024	ASEAN	ASEAN Declaration on Plastic Circularity

Source: Authors.

4. Regional Projects and Programmes

This section explores plastic pollution-related projects led by international organisations such as UNEP, the World Bank, and the Asian Development Bank (ADB), highlighting how their implementation supports and complements global and regional capacity building initiatives, focusing on Southeast and East Asia. In this section, the World Bank and ADB are selected due to their high visibility in the ASEAN and East Asia regions as multilateral development banks, along with UNEP, which serves as the main international organisation addressing plastic pollution, as evidenced by its role at UNEA and as the secretariat of the INC on the global plastics treaty. The highlighted programmes in this section also work closely with the regional initiatives to catalyse support to the efforts of ASEAN and East Asia countries.

4.1 United Nations Environment Programme (UNEP)

UNEP serves as the foremost international body guiding global environmental efforts by collaborating extensively with 193 of its Member States (UNEP, 2025c). This section focuses on the CounterMEASURE project, SEA circular Project, and Global Partnership on Plastic Pollution and Marine Litter (GPML), which are related to the ASEAN and East Asia region.

The CounterMEASURE project (Phase 1), funded by the Government of Japan and officially titled the Promotion of Action against Marine Plastic Litter in Asia and the Pacific, aims to develop a region-specific model for monitoring and assessing plastic leakage and efforts to reduce plastic pollution. This focuses on plastic waste originating from land that flows into waterways like rivers, canals, and drainage systems leading to the oceans (Geoinformatics Center, n.d.). In 2019/2020, the project held technical consultations and expert meetings in Thailand and India to discuss methods for tracking plastic leakage and to share insights on linking science and policy. Surveys were also conducted in five Mekong cities and four Indian cities, and outreach activities with non-governmental organisations (NGOs) in India were conducted to raise public awareness (UNEP, 2020). Phase 2 of the CounterMEASURE project seeks to produce, share, and distribute scientific data on plastic pollution in the Mekong, Ganges, and specific rivers in Myanmar and Sri Lanka, with the goal of supporting policy and decision-making at the local, national, regional, and global levels (Convention on the Conservation of Migratory Species of Wild Animals, 2020). Building on the CounterMEASURE project, the Strengthening Plastic Pollution Management in Asia and the Pacific initiative (2023–2025) aims to improve assessment and monitoring tools and protocols, while strengthening national and local waste management systems to address plastic pollution in Asia and the Pacific Islands, with Cambodia, Thailand, and Viet Nam as focal countries in Southeast Asia (Global Plastics Hub, n.d.-c).

Another key project is the SEA circular Project, titled 'Reducing Marine Litter by Addressing the Management of the Plastic Value Chain in Southeast Asia', which aims to curb marine plastic pollution by minimising the amount of plastic that enters poorly managed solid waste systems. Led by UNEP and COBSEA, the initiative promotes market-driven solutions, supports policy development, and raises awareness amongst consumers and businesses to combat plastic pollution across Southeast Asia with the support of Sweden from 2018 to 2022. The key outcomes include promoting market-driven approaches such as EPR and plastic credits; supporting policy advancements in Malaysia, the Philippines, and Thailand to reduce plastic waste; and securing co-financing from the private sector. The project also facilitated the development of national marine litter monitoring programmes in five COBSEA member countries and established a regional research database on marine litter (UNEP, COBSEA, and Government of Sweden, 2022). After the original phase from 2018 to 2022, the project had an extension phase and has made important contributions to the INC. The extension period's outcomes include the development of a regional plastic circularity guidance framework and evidence-based recommendations for Producer Responsibility Organisations, as well as support for EPR initiatives in Cambodia, Indonesia, the Philippines, and Viet Nam in addition to several capacity building activities and regional trainings (UNEP, COBSEA, and Government of Sweden, 2023). This project focuses on Cambodia, Indonesia, Malaysia, the Philippines, China, the Republic of Korea, Singapore, Thailand, and Viet Nam (Global Plastics Hub, n.d.-b).

The GPML was launched at the United Nations Conference on Sustainable Development (Rio+20) in 2012 to respond to the request in the Manila Declaration on Furthering the Implementation of the Global Programme of Action for the Protection of the Marine Environment from Land-based Activities. The GPML is a multi-stakeholder platform for knowledge sharing and the promotion of collaboration (UNEP, n.d.-a). A major outcome of the project is the Global Plastics Hub, which comprises three key components: a knowledge hub for sharing best practices, technical resources, and delivering trainings; a data hub offering plastic life-cycle data and tracking progress of the measurement at the national level; and a community hub that facilitates stakeholder engagement and collaboration through the GPML network (Global Plastics Hub, n.d.-a)

4.2 World Bank

The World Bank also plays a pivotal role in addressing plastic pollution globally, including Southeast Asia. One of the key plastic projects is PROBLUE, which is a World Bank-managed multi-donor trust fund that supports the integrated and sustainable management of marine and coastal ecosystems to maintain ocean health (World Bank, n.d.). PROBLUE has allocated over US$50 million to more than 100 initiatives in 60 countries to date. In Southeast Asia, the World Bank has supported the governments of Thailand and Viet Nam in shaping and guiding the execution of their National Action Plans. In Cambodia, the World Bank supports clearing waste-choked waterways. Using drones and data analysis, officials identify waste types to trace sources, inform citizens, and design incentives to cut plastic use in packaging. In Malaysia, the World

Bank tested a toolbox developed based on a technical study about plastic waste management. In Indonesia, it conducted Indonesia's first nationwide study linking local waste data with environmental factors to model how plastic flows from land into the oceans. The World Bank also supports the Philippines, advancing EPR to boost recycling and waste collection (World Bank and PROBLUE, 2024).

As a regional engagement, in 2022, the Southeast Asia Regional Program on Combating Marine Plastics (SEA-MaP) was launched, which is a US$20 million grant programme to help ASEAN Member States reduce plastic use, boost recycling, and prevent marine pollution (SEA-MaP, n.d.-a). Working with the ASEAN Secretariat, the World Bank supports regional platforms for innovation, knowledge sharing, and stronger plastic regulations (World Bank and PROBLUE, 2024). SEA-MaP seeks to address marine plastic pollution in Southeast Asia by reducing plastic consumption, improving recycling systems, and minimising plastic leakage from both land and sea sources.

To achieve these objectives, the regional project focuses on two key components: strengthening regional policies and institutional frameworks to support plastics circularity; and establishing regional platforms that encourage innovation, knowledge sharing, and strategic partnerships (SEA-MaP, n.d.-a). The first component includes developing and harmonising regulations, standards, and incentives to promote recycling, alternatives to plastics, and private sector investment. Key resources include manuals and guidebooks on plastic packaging standards, responsible plastic waste trade, financial mechanisms, phasing out SUPs, and EPR. For the second component, two platforms are to be developed. The Regional Platform for Innovation and Investments (SEA-MaP IIP) is to provide technical support to innovators, establish a financing mechanism to connect them with investors, and conduct communication and outreach activities to foster collaboration across the plastics value chain. The Regional Platform for Knowledge and Partnerships (SEA-MaP KPP) is to promote engagement amongst a wide range of stakeholders, including governments, research institutions, private sector entities, NGOs, and civil society organisations throughout the ASEAN region. These platforms are to support the implementation of key actions under the ASEAN Regional Action Plan on Combating Marine Debris (SEA-MaP, n.d.-c).

Since 2023, SEA-MaP has conducted a series of technical consultations, stakeholder workshops, training sessions, site visits, and policy meetings across ASEAN Member States to advance regional collaboration, innovation, and strategic planning in marine plastic pollution management (SEA-MaP, n.d.-b).

4.3 Asian Development Bank (ADB)

ADB has launched several regional initiatives addressing plastic pollution in the context of marine environmental protection, which include both investment loans and capacity development efforts such as policy briefs and workshops. One of the key projects, called Promoting Action on Plastic Pollution from Source to Sea in Asia and the Pacific, operates in different Asian countries (Table 10.4). Under this project, the knowledge and support technical assistance cluster is designed to assist ADB's developing member countries in meeting their commitments to reduce marine plastic pollution along the entire 'source-to-sea' pathway. It supports the development of action plans, the creation of policies and regulations that encourage a circular economy, and the preparation of investments in integrated solid waste management and circular economy initiatives. In addition, the cluster aims to strengthen regional cooperation and promote the exchange of knowledge and best practices (ADB, 2019).

As another example, ADB has approved a US$500 million loan to enhance Indonesia's efforts to curb marine plastic pollution, titled Reducing Marine Debris Program, Subprogram 1. This initiative is aligned with the Indonesian government's commitment to manage 70% of marine plastic waste by 2025, as outlined in the National Action Plan for Handling Marine Debris. This commitment aims to deal with the systemic problem of marine plastic pollution and its detrimental impact on the environmental, economic, and social impacts of plastic pollution in the environment, and ADB aims to reinforce this commitment (ADB, 2024b; 2023a). The initiative is being designed as part of ADB's Blue Southeast Asia Finance Hub – ADB's first program targeting marine debris. Launched in 2021, the hub was created with backing from ADB's Action Plan for Healthy Oceans and Sustainable Blue Economies and aligns with the objectives of the Oceans Financing Initiative (ADB, n.d.). In addition, the preparation of Subprogram 2 of the Reducing Marine Debris Program is supported by technical assistance titled Toward Plastic Pollution-Free and Sustainable Marine and Coastal Ecosystems in Indonesia and the Philippines (ADB, 2024d).

In addition, in the Philippines, as part of the Marine Ecosystems for Blue Economy Development Program (Subprogram 1), the improvement of handling and circularity of plastic and solid waste is listed as one of the key objectives (ADB, 2025). The preparation of this program is also supported by regional technical assistance titled Toward Plastic Pollution-Free and Sustainable Marine and Coastal Ecosystems in Indonesia and the Philippines (ADB, 2024d).

In parallel, ADB continues to publish policy briefs, including on the adoption of economic instruments to promote plastic packaging circularity in Thailand (ADB, 2024c) and bioplastics in Thailand (ADB, 2023b). It has also organised workshops, such as the regional capacity building workshop on Accelerating Investments for Plastics Circularity held in 2024 in Indonesia (ADB, 2024a).

Table 10.4. Overview of Plastic Pollution-Related Projects by UNEP, the World Bank, and ADB

Project name	Lead organization	Focal countries
CounterMEASURE project (Phase 1 and 2)	UNEP	Cambodia, India, the Lao PDR, Myanmar, Sri Lanka, Thailand, and Viet Nam
Strengthening Plastic Pollution Management in Asia and the Pacific	UNEP	Cambodia, Thailand, and Viet Nam
SEA circular Project	UNEP	Cambodia, Indonesia, Malaysia, the Philippines, China, the Republic of Korea, Singapore, Thailand, and Viet Nam
Promoting Action on Plastic Pollution from Source to Sea in Asia and the Pacific	ADB	China, Indonesia, Myanmar, the Philippines, Sri Lanka, Thailand, and Viet Nam
Reducing Marine Debris Program, Subprograms 1 and 2	ADB	Indonesia
Marine Ecosystems for Blue Economy Development Program, Subprogram 1	ADB	Philippines
Toward Plastic Pollution-Free and Sustainable Marine and Coastal Ecosystems in Indonesia and the Philippines	ADB	Indonesia and the Philippines

Project name	Lead organization	Focal countries
Southeast Asia Regional Program on Combating Marine Plastics	ASEAN	Brunei Darussalam, Cambodia, Indonesia, the Lao PDR, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Viet Nam
PROBLUE	World Bank	More than 60 countries including Cambodia, Indonesia, Malaysia, and the Philippines

ADB = Asian Development Bank, UNEP = United Nations Environment Programme.

Source: Authors.

5. Conclusion and Summary

This chapter has provided an overview of key international and regional initiatives, with a focus on Southeast and East Asian countries. While the international plastics treaty under negotiation (INC) seeks to establish a legally binding framework that addresses the full life cycle of plastics – including identifying chemical products and reducing the consumption and production of plastics – ASEAN's regional initiatives have taken a more pragmatic and implementation-oriented approach. These efforts have focused on strengthening waste management systems, particularly in relation to marine litter and packaging waste, rather than regulating upstream activities such as polymer design or production standards which are in line with the COBSEA statement in INC meetings (see Chapter 11). This emphasis reflects the region's infrastructural realities and policy priorities, where improving collection, recycling, and leakage prevention has been both feasible and urgent.

Importantly, ASEAN's early responses – through frameworks such as the Bangkok Declaration, the ASEAN Framework of Action, the ASEAN Regional Action Plan, and the ASEAN Declaration on Plastic Circularity – demonstrate that the region has not only aligned with global momentum but in some cases preceded it. Multilayered frameworks in the region have supported ASEAN's efforts. As the INC negotiations progress, ASEAN's experience offers valuable insights into scalable, context-sensitive implementation strategies, and its existing frameworks may serve as a foundation for harmonising regional actions with the emerging global treaty. At the same time, it is important to recognise that several regional initiatives are currently being implemented, and there is a need to explore opportunities for greater synergy amongst them.

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Chapter 11

Negotiating the Global Plastics Treaty

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1. Introduction: Overview of the plastic treaty negotiation processes

In March 2022, during the resumed fifth session of the United Nations Environment Assembly (UNEA 5.2), Resolution 5/14 was adopted, initiating efforts to develop an international legally binding instrument to address plastic pollution, including pollution of the marine environment. This resolution resulted in the formation of the Intergovernmental Negotiating Committee on Plastic Pollution (INC), which was tasked with negotiating a treaty through five scheduled sessions between late 2022 and 2024. Despite this timeline, the fifth session (INC-5.1) concluded without a finalised text. To continue the process, a resumed session (INC-5.2) was convened in August, but negotiating countries failed to finalise the text due to the significant difficulty of bridging their divergent views. Table 11.1 outlines key details from each INC meeting, including their dates, venues, and major negotiation milestones.

Table 11.1. Negotiation Process

Session	Dates	Location	Key highlights
INC-1	28 November–2 December 2022	Punta del Este, Uruguay	Main points of disputes surfaced
INC-2	29 May–2 June 2023	Paris, France	Potential options or elements for the treaty introduced by the INC secretariat
INC-3	13–19 November 2023	Nairobi, Kenya	'Zero Draft' introduced
INC-4	21–29 April 2024	Ottawa, Canada	Texts streamlined based on a 'Revised Zero Draft' Rationale shared behind divergent positions
INC-5.1	25 November– 1 December 2024	Busan, Republic of Korea	Failed attempt to bridge divides and find convergence
INC-5.2	5–15 August 2025	Geneva, Switzerland	Failed attempt to bridge divides and find convergence

INC = Intergovernmental Negotiating Committee on Plastic Pollution.

Source: Authors

At INC-1, delegates shared divergent views on what the treaty should look like and what elements should be included in terms of their national interests. In response to a request from INC-1, the INC Secretariat prepared an options document for INC-2, which outlined potential components of a legally binding agreement grounded in the life-cycle approach emphasised by Resolution 5/14. This document (UNEP/PP/INC.2/4) synthesised input from governments and stakeholders, covering a broad range of elements including core obligations, voluntary measures, and implementation strategies (UNEP, 2023). It provided the basis for discussions within contact groups, and INC-2 was instructed to use it to prepare a draft for consideration at INC-3.

During INC-3, a comprehensive Zero Draft was introduced, providing delegates with a consolidated version of the potential treaty text. While the draft aimed to balance perspectives by presenting both ambitious and moderate options – such as phasing out single-use plastics with either fixed or flexible timelines – it had mixed reactions. Some delegations viewed the draft as favouring certain positions, and the subsequent addition of multiple new inputs inflated the document from 31 to over 100 pages. Ultimately, INC-3 concluded without agreement on a single negotiating text, highlighting the ongoing divergence regarding scope and depth (IISD, 2023g).[1]

At INC-4, discussions focused on refining the expanded draft into a more coherent negotiating text. Contact groups were instructed to streamline the text by consolidating similar proposals and eliminating duplication, with the aim of enabling textual negotiations. Although this process increased the number of bracketed provisions – indicating unresolved language – it also marked the first session where substantive exchanges took place between delegations, allowing countries to better understand each other's rationale (IISD, 2024i). Between INC-4 and INC-5, two ad hoc intersessional open-ended expert groups were organised to facilitate more informed discussion at INC-5.1. At these meetings, Expert Group 1 focused on financial arrangements while Expert Group 2 focused on criteria- and non-criteria-based approaches to plastic products, chemicals of concern in plastic products, and product design, especially the recyclability and reusability of plastic products. Before INC-5.1, the Chair organised meetings with the heads of delegations and circulated two iterations of a 'non-paper' that included updated treaty text to facilitate focused deliberation.

INC-5.1 featured a dynamic exchange of views around the Chair's non-paper 3, which attempted to identify possible convergence amongst the parties. However, fundamental disagreements – especially concerning the scope of the treaty – remained unresolved (IISD 2024j). The Like-Minded Group (LMG), which includes China, Russia, and Saudi Arabia, was more unified, arguing that production-related measures, especially provisions tied to trade and economic development, deepen global inequities and exceed the mandate set by UNEA-5.2 (IISD 2024j). Strongly opposing such a stance, new cross-regional alliances emerged, with over 80 ambitious countries issuing joint statements on issues such as plastic products, including chemicals of concern, supply/sustainable production, and financial resources and mechanisms. For instance, Rwanda spoke on behalf of 85 countries in support of production limits, while Mexico delivered a statement backed by 95 countries calling for the inclusion of chemicals of concern. On financing, 110 developing countries endorsed a proposal led by the African Group, whereas most developed countries leaned towards a framework backed by the United States (US) (IISD, 2024j).

At INC-5.2, based on the proposals and views presented at INC-5.1, negotiating countries attempted to bridge the critical gap and engaged in line-by-line textual negotiations. First, they added missing elements from their own national perspectives to the Chair's text, issued on the last day of INC-5.1, which unsurprisingly ballooned the text again. At the same time, countries were enthusiastic to conclude the negotiation process. Accordingly, beyond Contact Groups meetings, they frequently held 'informals', which are inclusive to all countries, 'informal informals' (i.e. member-led informal, small group discussions), and 'bilaterals', to have more substantive discussions and find areas of convergence on the main points of dispute. In the last phase on 13 August, the Chair circulated a draft text proposal with an attempt to bridge divergent views and capture elements that could lay the foundation for agreement (IISD, 2025c). At best, the text reflected the lowest common denominators, which were more favourable to the LMG. It omitted

[1] This chapter draws extensively on the Earth Negotiations Bulletin reports of the International Institute for Sustainable Development (IISD). Reports for each INC session are available at IISD (n.d.).

all the contentious provisions – including scope, production, and health – and retained only the agreeable elements in each provision. Many countries considered it to be no advancement from the current plastic cooperation, and it was strongly criticised for its lack of ambition. To gain reflections on and inputs to the text, informal and small group consultations organised by the Chair and numerous bilateral meetings were held on 13–14 August. At the same time, a small working group of 15 countries, co-chaired by Chile and Japan, worked on a package of issues, including production, finance, plastic products, and decision-making, which could serve as a consensus text (IISD, 2025c). Incorporating the outcomes of these discussions, the Chair revised the text as a potential final text, which was then circulated and considered by the Heads of Delegation Meeting on 15 August. However, due to the lack of agreement, no further action was taken on either of the Chair's draft texts, and no subsequent negotiation plan was proposed at the closure of INC-5.2. At the closing plenary, many negotiating countries expressed rejection of the revised text as a basis for the next negotiation (IISD, 2025c).

Some studies have documented the plastic treaty negotiation process, highlighting the negotiation procedure and the main progress in each session (e.g. Cowan, 2025; Cowan et al., 2024; Cowan, Tiller, and Maes, 2024; Gonçalves et al., 2024; Naštzaam, 2024; Tiller et al., 2024; Aoki-Suzuki, Hotta, and Yagasa, 2024; Dauvergne et al., 2025; Dreyer et al., 2025). However, none of these studies assessed the whole negotiation process or did it from the perspective of Asia. This chapter presents the underlying key political challenges behind the entire negotiation process by tracing the consecutive development of the discussion and related proposals on selected key disputed provisions, as well as the negotiation positions of Asian countries in the political dynamics. It proceeds as follows. Section 2 identifies a fundamental political contention that overarches different provisions of the treaty. Section 3 illustrates divergent views on what to include in each provision. Section 3.1 covers the most contentious provisions – plastic products (Article 4), supply/sustainable production (no text), and the financial resources and mechanism (Article 10) – while section 3.2 covers the rest of the key provisions. Section 4 shows the overall positions of ASEAN Plus Three (ASEAN+3) countries,[2] drawing on their statements. Section 5 concludes this chapter with prospects for global plastic governance and cooperation in Asia.

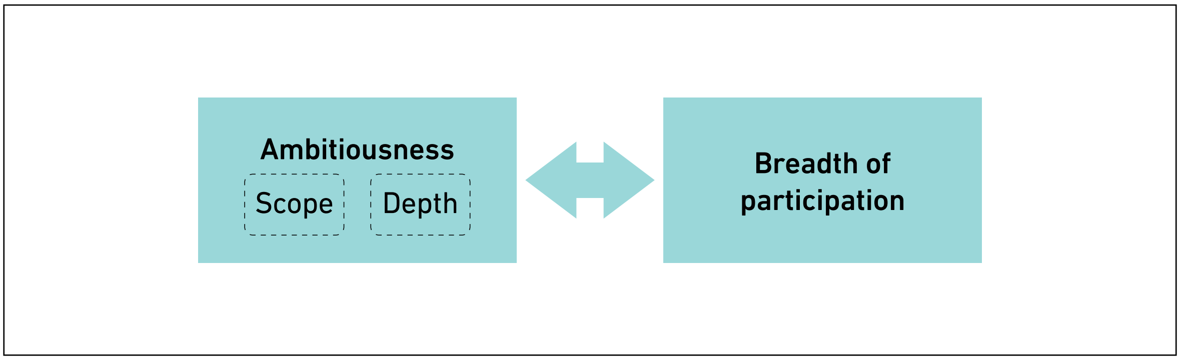
2. Overarching Confrontations over the Scope and Depth of the Treaty

From the outset at INC-1, negotiators confronted two persistent and overarching issues that would shape the entire negotiation process: the intended scope (the scope of issues covered) and the depth (the level of legal obligation it would impose) of the treaty. These issues have been the major obstacles in previous multilateral environmental treaty negotiations. Regulation on certain issues is more sensitive to some groups of countries than others, and including such issues in the treaty's scope may result in their non-participation in the treaty. In addition, even though a high level of legal obligations – common obligations regardless of national circumstances – is expected to ensure a more effective environmental treaty, it

[2] The ASEAN+3 countries are the 11 ASEAN Member States (Brunei Darussalam, Cambodia, Indonesia, the Lao People's Democratic Republic (Lao PDR), Malaysia, Myanmar, the Philippines, Singapore, Thailand, Timor-Leste, and Viet Nam) plus China, Japan, and the Republic of Korea.

entails high compliance costs for some parties and might discourage their participation (Downs, Rocke, and Barsoom, 1996). Thus, as illustrated in Figure 11.1, there is a trade-off between the ambition level of the treaty, which consists of both the scope and the depth, and the breadth of country participation (Barrett, 2008; Barrett and Stavins, 2003). Given that countries create multilateral environmental treaties as a universal cooperative framework, it is important to adjust the scope and depth so that the treaty accommodates all negotiating countries' interests. As an example, the Paris Agreement allows parties to set and achieve the reduction targets on their own according to their national circumstances. It thus compromised on high legal obligations on emissions reductions to ensure universal participation of both developed and developing countries (Keohane and Victor, 2016; Tørstad et al., 2025).

Figure 11.1. Trade-Off Between Ambitiousness and Breadth of Participation



Source: Authors.

For the plastic treaty negotiations, regarding scope, many parties supported using the framework provided by UNEA Resolution 5/14, which promoted a comprehensive life-cycle approach to managing plastic pollution. However, there were divergences in how countries interpreted the life cycle of plastics: some advocated including upstream activities like raw material extraction and polymer production, while others sought to begin at later stages, such as product design or waste management (IISD, 2022). The tension between prioritising upstream controls versus downstream interventions remained central throughout the negotiations (IISD, 2024j). A coalition of over 80 countries, known as the High Ambition Coalition (HAC), which includes the European Union (EU) and most developing nations, called for a broad and inclusive treaty addressing all stages of the plastic life cycle.[3] For example, the HAC statement at INC-4 stated: 'Stress that without this comprehensive and holistic approach, which is vital to achieving a full transition towards a safe circular economy for plastics, we will fail to end plastic pollution and not achieve our collective goal of protecting the environment and human health from the negative impacts of plastic pollution' (HAC, 2024a). In contrast, the LMG emphasised limiting the treaty to downstream measures like recycling and cleanup (IISD, 2023f; 2024i).

The discussion around depth revolved around how prescriptive the treaty should be in shaping national policies. This included questions on whether the treaty should allow countries to define their own actions through national plans, permit varying levels of commitment based on national capacity, and

[3] See HAC (n.d.) for the full list of Members and its statements at each INC session.

adopt either global standards or domestically determined targets (IISD, 2022). Countries such as China, India, and Saudi Arabia, represented by the LMG, preferred a flexible, bottom–up architecture inspired by the Paris Agreement, emphasising nationally driven commitments. Meanwhile, small island developing states and many other developing countries, mainly represented by HAC, favoured an instrument with strong regulatory provisions balanced by the principle of common but differentiated responsibilities (IISD, 2022; 2023f). For example, the HAC statement at INC-5.1 stated: 'We emphasise that effective and common legally-binding global rules are essential to address the negative economic, social, cultural, and environmental impacts of plastic pollution in all countries' (HAC, 2024b).

Put simply, HAC advocated a treaty that ensures all countries are subject to common legal obligations and standards, comprehensively covering both upstream and downstream phases, with special arrangements for developing countries in the treaty implementation. On the other hand, the LMG advocated a treaty dedicated to addressing downstream measures, particularly waste management, based on voluntary approaches with great attention to different national economic and social circumstances. Importantly, the treaty's scope and depth are interlinked in terms of the treaty's effectiveness. A treaty that includes upstream elements such as production limits but makes them voluntary would be ambitious in scope but limited in enforcement. Conversely, a narrower treaty focused only on waste management could include strict legal requirements yet fall short in addressing the full extent of the plastic crisis (IISD, 2022).

The challenge of reconciling competing national interests proved more difficult than in prior environmental treaty negotiations. From the early stages, states like India, Russia, and Saudi Arabia insisted that all decisions be adopted by consensus, reflecting deep concerns about the potential marginalisation of their positions (IISD, 2022). Rule 38 of the draft rules of procedure, which allowed for decisions by a two-thirds majority when consensus is unattainable, was hotly debated and ultimately bracketed, and remains subject to further negotiation. It thereby allowed for voting if no one opposed it, while recognising the value of consensus, suggesting that there is no agreement regarding whether member states could vote on the inclusion of articles (IISD, 2023f). Discussions on procedural fairness extended beyond voting to include transparency. Some countries, particularly India and Russia, were vocal in opposing closed-door meetings or informal discussions confined to small groups. Consequently, the process adopted a deductive negotiation style – presenting a wide range of possibilities before narrowing towards convergence. This was politically necessary but operationally complex, which made it difficult to find common ground (IISD, 2023g).

As detailed in the following sections, the whole treaty negotiation process was mainly about adjusting scope and depth to accommodate diverse interests to ensure full participation while maximising the problem-solving capacity of the treaty. Even though countries initially expected to achieve the regulation of the full plastic life cycle by compromising the level of legal obligations, by INC-5.1, it became evident that negotiators could not rely on the simple trade-off between scope and depth to achieve consensus. That is, some, mainly LMG countries, insistently oppose covering plastic production, plastic products, and chemicals, even with relaxed mandatory obligations or exemptions. At INC-5.2, there was some hope that intensive time pressure to conclude the text would encourage negotiating countries to make mutual concessions. While countries found some areas of convergence, the negotiations ended up revealing that the stances of both HAC and the LMG on key issues cannot be compromised. On the one hand, the LMG cannot accept any treaty that touches upon plastic production, chemicals, or global measures on plastic products, concerned about the potential negative impact on the domestic (oil and petrochemical) industry. On the other hand, HAC countries cannot agree with a treaty that does not cover these issues, regarding them as the core in tackling plastic pollution (IISD, 2025c).

Table 11.2. Overview of the Chair's Draft Text of 15 August 2025 at INC-5.2

Title	Content description
Article 1: Objective	Establishes the objective of the treaty: to protect human health and the environment from plastic pollution, by addressing the full life cycle of plastics through a comprehensive approach.
Article 2: Principles and approaches	Lays out guiding principles such as the Rio Declaration, common but differentiated responsibilities, and the precautionary approach.
Article 4: Plastic products	Parties reduce or restrict the production and consumption of problematic plastic products.
Article 5: Plastic product design	Parties improve the product design to support reuse and recycling and promote innovation and the use of sustainable alternatives.
Article 6: Releases and leakages	Parties assess, prevent, and reduce the release and leakage of plastics into the environment, including microplastics.
Article 7: Plastic waste management	Parties ensure plastic waste is managed in environmentally sound ways, consistent with Basel Convention standards, through plastic waste collection and recycling targets and systems, bans on open dumping and burning, and extended producer responsibility, etc.
Article 8: Existing and legacy plastic pollution	Parties identify, monitor, and remediate sites most affected by accumulated plastic pollution. Cooperation is encouraged for addressing areas beyond national jurisdiction.
Article 9: Just transition	Parties ensure that transitions away from plastic pollution are fair and inclusive. Special attention is given to workers in the plastics and waste sectors, small-scale fishers, and vulnerable communities.
Article 10: Financial resources and mechanism	Establishes financial mechanisms to support implementation, including the Global Environment Facility, a new multilateral fund, and partnerships with private finance.
Article 11: Capacity building, technical assistance and technology transfer, including international cooperation	Parties provide assistance to developing countries through training, technology transfer, and partnerships.
Article 12: Implementation and compliance	Establishes a mechanism to facilitate and promote the implementation and compliance.
Article 13: National plans	Parties create and update national plans for treaty implementation.
Article 14: Reporting	Parties submit regular reporting on national actions and progress under the treaty.
Article 15: Effectiveness evaluation	Mandates periodic reviews of the treaty's effectiveness using scientific, social, and economic data to guide improvements.
Article 16: Information exchange	Parties share scientific, technical, and policy information to support treaty implementation.
Article 17: Public information, awareness, education and research	Parties raise public awareness and support education and research related to plastic pollution.

INC = Intergovernmental Negotiating Committee on Plastic Pollution.

Notes: The table only lists the main provisions of the draft text, while provisions covered in this chapter are highlighted in grey. This table is based on the Chair's revised text of 15 August 2025 (INC Chair, 2025). The content description does not reflect the level of legal obligations in the original draft text.

Source: Authors.

3. Negotiations for Key Provisions

This section unpacks the key provisions of the Chair's revised draft text proposal of 15 August 2025 shared at the end of INC-5.2, with attention to both substantive policy obligations and mechanisms for implementation. The main operative articles are summarised in Table 11.2. Articles 1 and 2 lay the conceptual and definitional groundwork for the treaty, while Articles 3–9 outline substantive obligations across the plastic life cycle. Articles 10–17 focus on implementation tools such as financing, capacity building, compliance, and reporting. What follows is a detailed account of the position divergence on what to specify in each major provision, especially those that proved politically contentious. Amongst them, the most politically charged were plastic products (Article 4), supply/sustainable production (no text), and financial resources and mechanism (Article 10). The debate over the scope was more directly related to Article 4, while it also appeared on releases and leakages (Article 6) and reporting (Article 14). The discussion on the depth, which concerns whether policy measures should be uniform across countries or tailored to national contexts, appeared across nearly every article.

3.1 The most contentious provisions

Plastic products (Article 4). This focuses on reducing, phasing out, or restricting problematic plastic products that pose risks to health or the environment. Criteria include their likelihood to pollute, difficulty in recycling, or hazardous chemical content. Until INC-4, discussions under this provision were bifurcated into two categories – chemicals and polymers of concern, and problematic or avoidable plastic products – and this provision targeted both plastic products and chemicals at INC-5.1. The main disputes on this provision centred on the level of legal obligations – whether controls on plastic products and chemicals should be universally binding or nationally defined – and whether such controls should follow global criteria or a pre-agreed list to identify targeted plastics and chemicals (IISD, 2023c; 2023e). Relatedly, while exemptive measures were introduced to provide flexibility for this provision, consensus was not reached as intense contention persisted over whether such exemptions should be determined nationally or bound by global constraints. Furthermore, some parties insisted that no exemptions should be permitted for hazardous substances (IISD, 2024d).[4]

The issue of trade in listed chemicals, polymers, and products emerged as another flashpoint. Many countries emphasised the need to avoid redundancy with the World Trade Organization (WTO) and the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal (IISD, 2023d). Nonetheless, some parties advocated for strict global controls on transboundary trade to be extended to non-parties, a move that would surpass WTO regulations in terms of its economic and trade implications (IISD, 2024d). Others, however, warned of the risks of overreach, economic disruption, or even protectionism (IISD, 2023d; 2024d). Developing countries highlighted the need for adequate transition periods and research support to ensure that substitutes are available so as not to disadvantage economies reliant on plastic imports (IISD, 2024d).

[4] Exemptive measures had served as an independent article until the draft text issued at the end of INC5.1 but were incorporated into Article 4 in the Chair's revised text of 15 August.

By INC-5.1, negotiations on this article (plastic products and chemicals) had gained momentum relative to the provision on plastic supply (IISD, 2024j), in that several countries submitted detailed proposals (IISD, 2024g). Russia proposed a nationally flexible approach, tasking each state with identifying problematic plastics in line with domestic priorities, and grounding actions in scientific rationale. China supported national discretion in identifying target products but left space for parties to request international measures via a review body under the Conference of the Parties (COP). However, both proposals only focused on plastic products, regarding chemical regulations as out of the scope of the treaty. The US offered a hybrid model, linking nationally determined actions to annexes listing products and chemicals subject to updates. In contrast, other delegations advocated strongly for globally harmonised controls. Moldova, Norway, and the United Kingdom suggested a baseline list of plastics and measures subject to treaty-level regulation with potential exclusions or exceptions, alongside criteria for adding future products. A broader coalition, including Canada, Rwanda, Peru, and Thailand, proposed international measures for chemicals of concern, with mechanisms for exclusions and criteria to identify chemicals of concern. However, some delegations, including Saudi Arabia, rejected the inclusion of chemicals entirely, arguing that this matter should be left to existing chemical treaties, and emphasised that the INC's mandate is focused on plastic pollution, not hazardous substances. Given the strong opposition over the inclusion of chemicals of concern, since INC-5.1, the draft article is devoted solely to tackling plastic products, while it initially included a reference to 'chemicals of concern included in plastic products'. At INC-5.2, countries continued to discuss the mandatory or voluntary nature, national and/or global measures, and a global list of plastic products and chemicals of concern to be limited or phased out. While countries saw some convergence on the need for national measures, their views on other points remained divergent (IISD, 2025c).

Supply/sustainable production (No text). This focuses on measures related to the supply and sustainable production of plastics, particularly concerning primary plastic polymers. While this provision, facing the greatest hurdle, is not included in the Chair's revised draft text of INC-5.2, it has been extensively discussed throughout the INC process. From as early as INC-2, this provision became one of the most divisive, revealing fundamental disagreements over whether the treaty should mandate reductions in polymer production or instead allow for nationally determined approaches. Several LMG countries argued that limiting the availability of primary plastic would interfere with development priorities and create market disruptions, while some HAC countries underscored the necessity of addressing upstream drivers of plastic pollution to protect both environmental and human health (IISD, 2023a). Some also called for the reduction or elimination of fiscal incentives, such as subsidies for fossil fuels and plastic production (IISD, 2023a). Proposals under consideration varied widely in ambition. Some called for optional, country-led actions based on national capabilities and priorities, while others sought binding global targets. Some also suggested a combination of general global targets with more specific measures to be nationally mandated (IISD, 2023a). At INC-4, the main options on the table were no provision, a global target combined with mandatory measures, and a global target combined with voluntary nationally determined measures (IISD, 2024e). At INC-5.1, the Pacific Small Island Developing States (PSIDS), led by the Cook Islands, introduced a proposal advocating a 40% reduction in virgin plastic production by 2040 compared with the 2025 levels. This plan included a framework for data collection, reporting obligations, and a review process every 5 years to assess progress. In a separate submission, Rwanda, on behalf of 45 African countries, proposed setting a global reduction target with an assessment every 5 years, which is grounded in a circular economy model, coupled with life cycle–based measures across the plastic chain. In sharp contrast, Saudi Arabia and its allies proposed the removal of this provision altogether, asserting that regulating primary plastic production exceeded the legal scope authorised by UNEA-5.2, threatened economic resilience, and could limit innovation in sustainable alternatives (IISD, 2024g). The divergence in positions was maintained at INC-5.2, and 'informal informal' settings facilitated by Japan were repeatedly convened towards the end of the session.

Financial resources and mechanism (Article 10). This lays out the financial architecture intended to support treaty implementation, and it was amongst the most polarising issues throughout the negotiations. From the early phase of negotiations, delegates disagreed over whether the treaty should rely on the existing Global Environment Facility (GEF) or establish a new, dedicated multilateral fund tailored to plastics (IISD, 2023a; 2023b; 2024b). Developed countries favoured using the GEF, citing its institutional experience, cost-efficiency, and track record in environmental finance and leveraging the private sector. In contrast, developing countries, led by the African Group, Small Island Developing States (SIDS), and the Group of Latin America and Caribbean Countries (GRULAC), pushed for an independent, stand-alone fund that would be governed by the treaty's own COP and structured similarly to the Multilateral Fund under the Montreal Protocol (IISD, 2024c). They argued that the GEF's historical allocation patterns often disadvantaged least developed countries and SIDS and lacked the predictability and accessibility needed for equitable implementation. As a compromise, at INC-4, some parties proposed a hybrid model, in which the GEF could be used temporarily until a new fund was established. However, at INC-5.1, the camps had solidified (IISD, 2024g; 2024j). A group of developed countries – Australia, Canada, Iceland, Japan, New Zealand, Norway, the Republic of Korea, Switzerland, the United Kingdom, the US, and the EU – submitted a proposal reaffirming support for the GEF as the principal vehicle, encouraging voluntary contributions from all parties, in particular those with both the financial capacity to do so and with high levels of plastic leakage, plastic product production, or polymer production. The proposal also emphasised catalysing private finance mobilisation and private investment, encouraging the leveraging of finances from all sources. On the other side, a coalition of developing countries – the African Group, GRULAC, the Cook Islands, Fiji, and the Federated States of Micronesia – submitted a counter-proposal calling for a new fund supported by assessed contributions from developed countries and voluntary contributions from other parties. It further noted that implementation of the treaty by developing country parties 'will depend on the contribution of developed country parties related to this provision' (IISD, 2024j).

In addition, discussions on funding sources highlighted a broad range of options, including contributions from states as well as supplementary financial support from the private sector, particularly the plastics industry, and other innovative mechanisms. A number of delegations, mainly developed countries, emphasised that market-based instruments should include a financial strategy composed of the financial strategy, while others advocated for a combination of both market and non-market funding approaches to ensure flexibility and inclusivity (IISD, 2023a). Several delegations pointed to the importance of mobilising resources through public–private collaborations and highlighted extended producer responsibility (EPR) schemes as a viable funding channel (IISD, 2023a). In this context, one proposal suggested the introduction of a global fee on plastic pollution, to be levied on international producers of plastic polymers. However, many agreed that this issue should be addressed under the EPR provision of the treaty, while certain delegations emphasised that EPR frameworks should remain under the discretion of national governments and be tailored to domestic conditions (IISD, 2024d).

At INC-5.2, countries increasingly viewed a hybrid approach, which combines the GEF, a new dedicated mechanism, sub-funds, private finance, or a public–private partnership, as a landing zone for the financial mechanism, while the specific form or division of labour amongst these schemes and the categorisation of donor and recipient countries were unresolved (IISD, 2025bc).

3.2 Other provisions

Plastic product design (Article 5). This focuses on improving the design of plastic products to ensure safety, durability, reusability, recyclability, and reduced leakage, to support a transition towards a circular economy. In essence, this article introduces the concept of EPR, ensuring that manufacturers are accountable from the design to the disposal of plastic products (IISD, 2025a). Countries mainly discussed the development of criteria to guide product design for circularity; standards for how plastics are manufactured and packaged; labelling systems for plastic products and packaging; and a target for the minimum share of recycled content in products placed on the market (IISD, 2023a). They also considered the establishment of a centralised data-sharing platform to facilitate information exchange, particularly regarding the circularity of plastic products (IISD, 2023a). Relatedly, some suggested that aligning circularity criteria across countries could facilitate more efficient international recycling systems for plastics (IISD, 2023a). Some delegates also expressed concern that inaccurate or misleading product labelling could result in greenwashing (IISD, 2023a). With respect to non-plastic alternatives, numerous delegates stressed the importance of ensuring that such substitutes are genuinely sustainable and the need for thorough evaluation of their environmental, economic, social, cultural, or health-related implications, before promoting their usage (IISD 2024b). Several key points of disagreement throughout the negotiation process centred on whether the article should impose legally binding obligations or be a framework for voluntary measures, and whether the proposed requirements should be based on globally defined criteria or determined at the national level. Further contention arose over whether the article should explicitly recognise national capacities and include principles such as common but differentiated responsibilities and the precautionary approach (IISD, 2024j).

At INC-5.2, countries remained divided on whether to establish mandatory or voluntary national measures, for example, for sustainable production and consumption; reuse and recycling systems; and information on safe and sustainable use, repair, recycling, and waste management. Whether to include a provision ensuring that such measures do not constitute arbitrary trade discrimination, or whether to refer specifically to safe and sustainable chemicals and additives, also remained a highly contentious issue (IISD, 2025c).

Releases and leakages (Article 6). This focuses on addressing the prevention, reduction, and elimination of plastic releases and leakages, including microplastics, into the environment, according to national capacities and circumstances. Throughout the negotiations, divisions emerged over the extent to which national capacities should be considered in implementing obligations and the scope of the plastic life cycle that the article should cover. At INC-4, a broad group of delegations expressed support for requiring all parties to take action under this article. Several emphasised that these actions should be shaped by each country's unique circumstances and capabilities, and in some cases be nationally defined (IISD, 2024b). Regarding the scope, most delegations supported framing the article to encompass leakage sources across the full plastic life cycle – from raw material extraction and polymer production to product use and final waste management. In contrast, a number of countries preferred to narrow the scope of the article to focus only on the leakage of plastic products and waste. These delegations suggested that the article's content would be more appropriately addressed under the waste management provisions of the treaty (IISD, 2024b). Additionally, some delegations recommended a sector-specific approach that would allow differentiated treatment of emissions and leakage sources from plastic polymers, finished plastic products, and their associated uses (IISD, 2023d). It is noteworthy that while the topic had initially been framed in terms of both 'emissions' and 'releases', the Chair's draft text, since INC-5.1, adopted the term 'leakages' instead of 'emissions'. This terminology intentionally excluded greenhouse gas and other emissions associated with plastic production, narrowing the article's environmental scope (IISD, 2024j). At INC-5.2, whether to refer to the full plastics life cycle in this article remained a contentious issue.

Plastic waste management (Article 7). This focuses on environmentally sound plastic waste management, requiring the parties to implement relevant measures while considering their national circumstances and capacities. The provision includes a broad range of strategies, such as developing infrastructure for waste collection and treatment, establishing recycling targets, prohibiting open burning, and ocean dumping. It also regulates the cross-border movement of plastic waste and introduces the possibility of incorporating EPR schemes into national waste management systems. At INC-2, delegates examined various approaches to improve waste management capabilities and stimulate technological and operational innovation, potential regulatory measures of plastic waste streams, responses to illegal disposal practices, and strategies for expanding EPR programmes and market incentives for recycling (IISD, 2023a). A central issue in the debate was whether the article should contain binding obligations or serve as a voluntary framework. Delegations also deliberated over the degree to which the article should account for differing levels of national capacity and whether it should explicitly reference principles such as common but differentiated responsibilities and the waste hierarchy (IISD, 2024h). Another area of contention involved the environmental acceptability of specific waste treatment technologies. While some parties supported the regulation of some waste management options, such as incineration, chemical recycling, and refuse-derived fuel, due to environmental and health concerns, developing countries argued that these technologies currently represent their only practical options for dealing with plastic waste (IISD, 2023a).

Regarding EPR, opinions were notably divided. Some delegations supported a mandatory global requirement for parties to establish EPR systems, with flexibility for national-level design. Others preferred a non-binding approach, allowing countries to decide whether and how to develop EPR mechanisms. Divergences also arose over the scope and purpose of EPR provisions under the treaty (IISD, 2024e). These included whether responsibilities should apply narrowly to producers or more broadly across sectors and stakeholders, or the plastic value chain. Delegations also disagreed on which goals EPR schemes should prioritise, ranging from plastic reduction, recyclability, sustainable design, sound management of waste, and waste prevention and reduction. Some countries advocated for omitting any reference to EPR in the final text (IISD, 2024j). The issue of transboundary movements of plastic waste is characterised by little contention, and many countries urged alignment with the Basel Convention to prevent regulatory overlap and ensure consistency with existing international frameworks (IISD, 2024c).

At INC-5.2, countries still had divergent views on the mandatory or voluntary nature of the obligation for sound plastic waste management and the promotion of EPR, as well as on the relationship with the Basel Convention over the transboundary movement of plastic waste (IISD, 2025c).

National plans (Article 13). This focuses on formulating and periodically revising a national implementation plan that outlines countries' intended actions under the treaty, taking into account their specific national contexts. The article serves as a mechanism to translate treaty-level commitments into country-level strategies. One of the key points of contention was whether the creation and updating of national plans should be treated as a legal obligation or be left to each country's discretion. Delegates also debated whether the content of these plans should be determined by individual governments or prescribed in part by the treaty itself. At INC-3, some countries supported a more structured approach, advocating for legally binding national plans coupled with mandatory reporting obligations. Others, however, favoured a more flexible model in which the development of national plans and associated commitments would be voluntary and tailored to a country's resources and capabilities (IISD, 2023c). In discussions at INC-4, numerous delegations reaffirmed the importance of ensuring that national circumstances and varying capacities be respected when designing these plans. However, others recommended that the treaty include a standard set of elements or guidelines to facilitate monitoring and enable comparative assessment of implementation progress (IISD, 2024a). For example, some delegates advocated for including specific, measurable, achievable, relevant, and time-bound targets in national plans to ensure clarity and accountability (IISD, 2024e). At INC-5.1, several developing countries highlighted the strong linkage between the feasibility of national plan implementation by developing countries and the availability of financial and technical assistance, particularly those addressed in Article 10 (IISD, 2024j). At INC-5.2, views were divided mainly on the mandatory or voluntary nature of this article, the descriptions of the plans, and whether to link this article to financial support (IISD, 2025c).

Reporting (Article 14). This focuses on the submission of regular reports to the COP detailing the measures that countries have undertaken to fulfil their commitments under the treaty, particularly those outlined in their national plans. The core of the debate on this provision revolved around the scope of reporting obligations and whether they should apply equally to all parties, regardless of national capacity or resource availability. Several delegations expressed concern over the inclusion of sensitive information and called for flexibility in both the content and frequency of reporting. At INC-3, a number of countries supported a broad and inclusive reporting framework. At the same time, many advocated that the treaty should not impose mandatory disclosure requirements on private sector actors, and some opposed the inclusion of detailed reporting on the production, import, and export of plastic polymers and products (IISD, 2023c). Likewise, at INC-4, some delegations expressed particular concern about the publication of national reports that include quantitative data on the types and volumes of plastic materials produced, traded, consumed, and leaked throughout the value chain (IISD, 2024b). These countries questioned whether such transparency could raise confidentiality or competitiveness issues. Some participants argued for differentiated reporting schedules and expectations, allowing more flexibility for developing countries. They also emphasised that technical and financial support should be provided to ensure that all countries, regardless of capacity, could comply with reporting requirements. In contrast, some asserted that all parties, regardless of development status, should be held to the same reporting standards (IISD, 2024b; 2024f). Further discussions also addressed whether the treaty should explicitly outline separate obligations for developed countries and, as seen in Article 13, whether access to resources under the treaty's financial support should be a precondition for fulfilling reporting obligations (IISD, 2024f). At INC 5.2, countries developed discussions along with the above points.

4. ASEAN Plus Three countries in Plastic Treaty Negotiations

This section examines the characteristics and features of the negotiation stances of ASEAN+3 countries, as observed during the INC negotiation process. It focuses on the statements made by two regional groups during the INC sessions: the Asia Pacific Group (APG) and the Coordinating Body on the Seas of East Asia (COBSEA).[5] Even though both groups extensively cover ASEAN+3 members, the breadth of coverage differs between the two. All ASEAN+3 countries belong to the APG, which comprises 42 diverse nations of developed and developing countries, including South Asian countries, and nine of the ASEAN+3 countries (excluding Brunei Darussalam, Japan, the Lao People's Democratic Republic (Lao PDR), Myanmar, and Timor-Leste) are members of COBSEA. Thus, while statements made by the APG may reflect more diverse country positions across Asia and the Pacific, the analysis of COBSEA statements may offer insights into the specific features of ASEAN+3 positions.

COBSEA. The basic policy stance of the region is explicitly stated in COBSEA's statement during INC-2: 'we note that plastic pollution is primarily caused by the mismanagement and improper disposal of plastic waste. As such, we highlight the need to enhance waste management practices as a key approach to tackle plastic pollution' (COBSEA, 2023a: 1). This COBSEA statement also outlined the five key elements for INC negotiations: (i) a whole life-cycle approach; (ii) sustainable use of plastics; (iii) the adoption of safe, sustainable, and economically viable alternatives of plastics; (iv) the reporting process; and (v) harmonising monitoring and assessment, and transparent data (COBSEA, 2023a).

Furthermore, COBSEA's statement for INC-3 included the following additional parts, building upon the previous five elements: (i) product design and environmentally sound waste management; (ii) abandoned fishing gear; (iii) science-based definitions related to plastic pollution, microplastics, circularity, and substances of concern in plastics (including a scientific advisory body); (iv) EPR and national action plans; (v) effective use of existing regional mechanisms; and (vi) a reasonable transition timeline for industries and markets (COBSEA, 2023b). The statement also emphasised the stance of developing countries, which requested 'providing timely, appropriate, and adequate financial and technical assistance from developed countries through the financial mechanism' (COBSEA, 2023b: 2).

Following INC-4 in 2024, new features highlighted were the emphasis on 'Engaging all stakeholders across sectors, including governments, businesses, public and private finance institutions, investors, civil society, waste pickers, indigenous peoples and local communities, and scientific bodies is essential for collaboration and knowledge-sharing' (COBSEA, 2024a: 1).

During the process of INC5.1, the COBSEA statement again emphasised the elements of (i) national legislation to address the full life cycle of plastics, (ii) developing strong partnerships with the scientific community, (iii) a robust financial mechanism, and (iv) allowing flexible timelines for industries in transitioning to safe and sustainable alternatives (COBSEA, 2024b).

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[5] For more detail about COBSEA, see Chapter 10.

Recently, the COBSEA statement at INC5.2 called for the transition to a circular economy, a financial mechanism, as well as technical cooperation and sustained capacity building (COBSEA, 2025).

Asia Pacific Group. The APG covers a wide range of Asia-Pacific countries, including the Pacific islands and South Asian countries. The group expressed its stance on the INC negotiations with the statement at INC-2. It highlighted (i) promoting recycling and environmentally sound waste management, as well as sustainable consumption and production; (ii) financial, technical, and technological assistance and capacity building; (iii) tackling the root causes of plastic pollution, including ineffective management of waste; (iv) facilitating the full life-cycle approach, (v) being informed by the technical and scientific knowledge on sound waste management; and (vi) periodically updating national action plans as a core obligation (APG, 2023a).

At INC-3, the APG statement particularly supported the stance for the Zero Draft provided by the secretariat. The Zero Draft's emphasis on certain measures, mainly in the upstream phase, raised concerns within the APG that these may have wide and unintended socioeconomic impacts and implications. Thus, the APG noted this point and called for greater balance across different phases of the plastic life cycle in the draft text. This may also include the need for more focus on recovering and removing or remediating the legacy plastic.

Discussions. By analysing the stances of COBSEA and the APG, we find that the predominant and common regional focus is on strengthening the sound management of plastic waste, rather than imposing restrictions on plastic usage or addressing chemical concerns as a unified stance. Another recurring theme is the necessity of technical and financial support from developed countries to implement this legal instrument. Science-based approaches, including innovation and technology transfer, are also considered crucial for waste management and circularity, as emphasised by COBSEA and APG statements (e.g. Government of Malaysia (2023)). Nevertheless, ASEAN+3 country positions are not necessarily unified. For example, Japan stands out with its objective of achieving zero additional plastic pollution by 2040, a position it consistently reiterates in INC negotiations and aligns with the opinion of HAC (Government of Japan, 2023). The Philippines also proposes the phaseout of plastics through its statements, and urges 'the adoption of a globally harmonised approach to develop criteria that will identify problematic and avoidable plastic products', and 'measures to avoid health risks through the elimination of chemicals of concern in plastics through the establishment of clear criteria' (Government of the Philippines, 2024). Singapore and Thailand advocate for measures to control and limit hazardous chemicals in plastic polymers and products through their countries' opinions (Singapore, 2023; Thailand, 2024). In contrast, Malaysia opposes mere restrictions, preferring a transition towards circularity and converting waste into resources (Government of Malaysia, 2023). Even this cursory analysis suggests that, while loosely coordinated at the regional level, ASEAN+3 countries have diverse views toward plastic policy measures, depending on their national contexts.

5. Conclusion

Plastic pollution is a systemic issue deeply embedded in the modern economy. Due to the complexity of the issue, countries' views on which aspects of plastic pollution the treaty should tackle and how this should be done have never converged. In the absence of a shared understanding of the foundation of the treaty, the approaches on the table were excessively diverse, as each country advocated for solutions aligned with its own political and economic interests. As shown above, each stage of the plastic life cycle presents complex challenges, and national positions remain deeply divided across these various areas. Negotiating countries have put their best efforts into finding a viable balance between scope and depth, and one realistic political equilibrium was a low-ambition agreement based on the lowest common denominator to ensure universal participation. However, at INC-5.2, it turned out that such a resolution was not acceptable to ambitious countries. The whole negotiation process underlines the limitations of multilateralism, with countries strongly inclined to prioritise national interests over shared global challenges.

Regardless of the treaty negotiation outcome, global plastic pollution will continue to threaten humans and nature, which necessitates accelerated plastic cooperation in any form. In the absence of a treaty, one realistic way ahead is to advance regional cooperation, which could accommodate diverse national circumstances. Even though ASEAN+3 countries tend to emphasise waste management and capacity building during the negotiations, they face different challenges, depending on the developmental stages and domestic political and economic systems. In this respect, they are expected to cooperate in areas such as monitoring and reporting, technological support, and policy harmonisation, acknowledging regional commonalities and national differences. Such regional cooperation, some of which is ongoing, will help each country refine its national plans; construct data on material flows; and identify technically, politically, and economically feasible policy measures. Regional cooperation across the globe could articulate more room for formal cooperation, fostering a political momentum for a new global plastic treaty in a bottom–up manner.

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Chapter 12

Status of Plastic Waste Management and Trends in Cambodia

Yim Mongtoeun
Hoy Sereivathanak Reasey

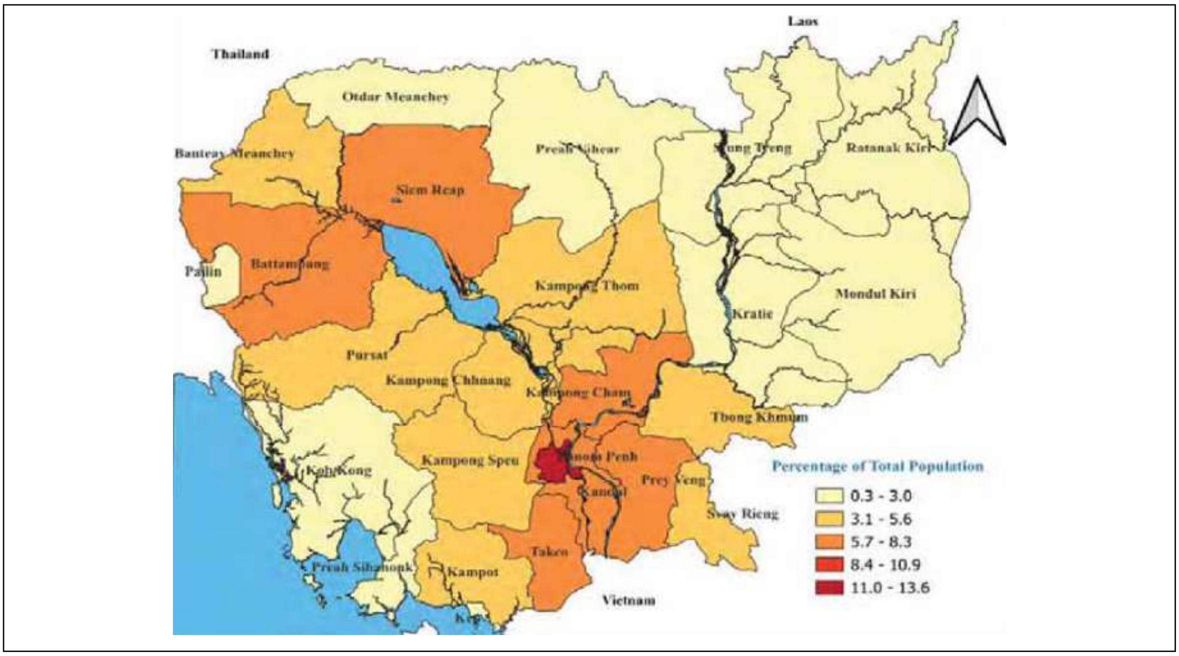
1. Introduction

1.1 Background

Cambodia, located in Southeast Asia, has a total area of 181,035 square kilometres. It is bordered by Viet Nam to the east, the Lao People's Democratic Republic (Lao PDR) to the north, and Thailand to the northwest. The coastal zone, located in the southwest, has a coastline stretching 435 kilometres that contains four coastal provinces: Koh Kong, Sihanouk, Kampot, and Kep. Cambodia has a population of about 17.28 million people as of 2024, with 3,735,659 households, of which 1,600,151 are in urban areas and 2,135,508 are in rural areas (NIS, 2025).

Phnom Penh, the capital of Cambodia, has a total area of 692.46 square kilometres and is the country's most populous city with 2,352,851 inhabitants (13.6%), followed by neighbouring Kandal with a population of 1,352,198 (7.8%); Prey Veng, 1,277,867 (7.4%); Battambang, 1,132,017 (6.6%), Siem Reap, 1,099,825 (6.4%); Takeo, 1,097,243 (6.3%); and Kampong Cham 1,062,914 (6.2%). Kep was the province with the lowest population, at 48,772 (0.3%) (Figure 12.1) (NIS, 2025). The increase in municipal solid waste (MSW) is a result of the country's rapid urbanisation, economic growth, increased consumption, and changing lifestyles, which are putting more pressure on managing MSW. Furthermore, organic waste comprises more than 50% of total waste, and open dumps are used, which are very harmful to the environment – producing greenhouse gases, water pollution, and affecting public health.

Figure 12.1. Population Distribution by Province in Cambodia



Source: NIS (2025)

1.2 Objectives of the chapter

This chapter aims to assess the status of plastic waste generation and management, identify trends and patterns of plastic use and disposal, and highlight gaps and challenges in waste management systems in Cambodia. It also evaluates current policies, regulations, and government initiatives related to plastic waste, identifying both achievements and gaps in implementation as well as infrastructure, public awareness, and related issues. By tracking recent trends and behavioural changes in plastic consumption and disposal, the study provides valuable insights into Cambodia's progress and areas needing attention, including public education and awareness campaigns to promote more sustainable practices. In addition, it evaluates the policy and legal frameworks in place, including national laws, municipal regulations, and environmental strategies related to plastic reduction and circular economy approaches. Lastly, the study aims to inform future policy development and strategic planning by offering data-driven insights and actionable recommendations.

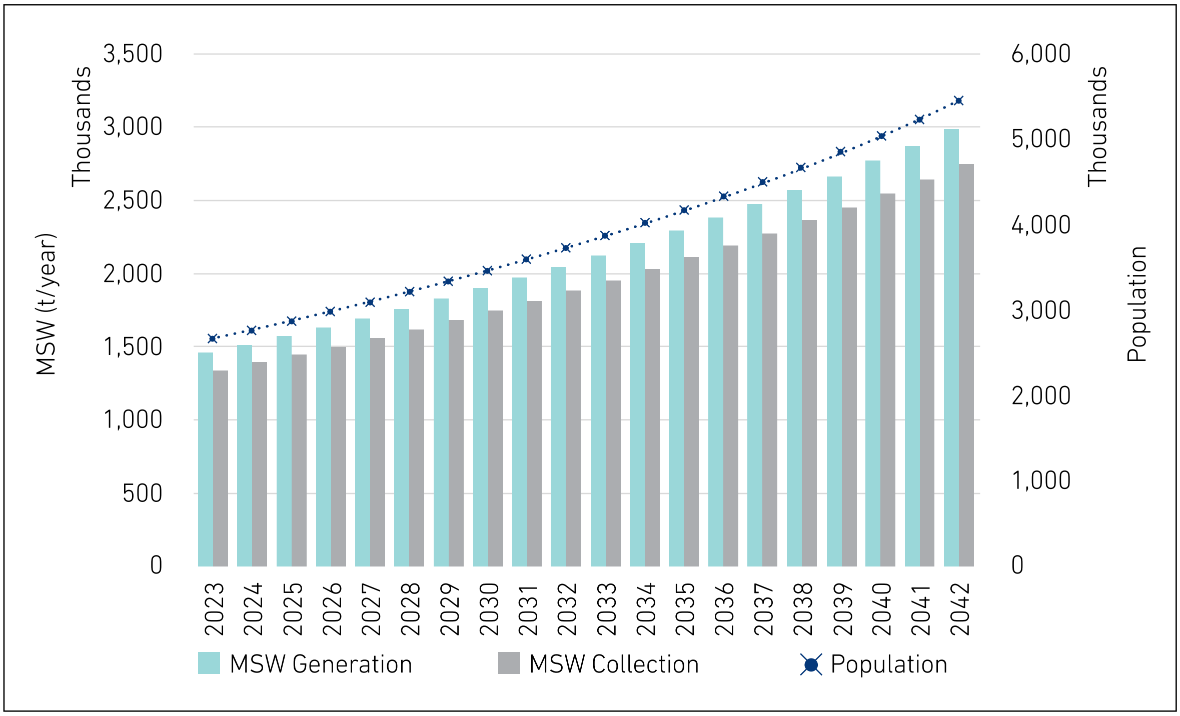
1.3 Methodology

This chapter presents the status of plastic pollution in Cambodia. It is based on a literature review of available data and information, the policy and legal framework, technical reports, and scientific papers. The data and information describing the MSW generation, composition, collection, recycling, landfilling, and incineration were obtained from various sources, including the Ministry of Environment (MOE), the United Nations Development Programme (UNDP), and Phnom Penh Capital Administration (PPCA). The Science Direct, PubMed, and Google Scholar databases were consulted using both the English and Khmer version with key terms containing plastic waste management system, waste treatment technology, recycling and disposal, challenges in plastic waste management in Cambodia, and other selected practices of developed and developing countries,

2. Status Quo of Plastic Pollution in Cambodia

In Cambodia, data on waste generation and collection vary depending on the source. The PPCA (2023) reported that up to 3,700 tonnes of waste were collected and transported to Dangkor landfill daily via registered waste collection companies – a staggering increase of 1,000 tonnes compared with 2021, with about 80% of waste collected (PPCA, 2023) (Figure 12.2). However, Pheakdey, Quan, and Xuan (2023) estimated that more waste collected (86%). Moreover, while the landfill facility was improved by changing from open dumping to sanitary landfill, especially in Phnom Penh, it still does not follow basic international standards and has already exceeded its designed capacity due to rapid urbanisation and population growth. Figure 12.2 shows the amount of waste generation, collection, and the projection from 2023 until 2042. Phnom Penh's collected waste amounted to 3,600–3,700 tonnes/day with a generation rate of 0.98 kilograms (kg)/capita/day with 1.1 kg/capita/day dumped at Dankor landfill in 2030 (Pheakdey, Quan, and Xuan, 2023; PPCA, 2023).

Figure 12.2. Phnom Penh Waste Generation, Collection, and Projection, 2023–2042



MSW = municipal solid waste, t = tonne.

Sources: Pheakdey, Quan, and Xuan (2023); and PPCA et al. (2023).

Phnom Penh's waste continued increasing (Fig 12.2) and plastic content also increased from 6% in 1999 to 21% in 2015 (Pheakdey et al., 2022). Plastics have replaced many traditional materials in our daily lives due to their light weight, durability, resistance to reactions with most chemicals, versatility of application, ease of processing, and cost-effectiveness (Chae and An, 2018). However, these advantages come with significant environmental drawbacks. In Cambodia, traditional packaging materials such as banana leaves, lotus leaves, and water hyacinth strings (Khan and Tum, 2020) have largely been replaced by plastic. Today, shoppers often go to markets without baskets and return with multiple plastic bags, and even large blocks of ice are wrapped in plastic instead of using water hyacinth strings (Khan and Tum, 2020). In addition, Single-use plastic (SUP) account for approximately 10% of the 21% plastic waste stream in Phnom Penh (UNDP Cambodia, n.d.-a; Seng, Fujiwara, and Spoann, 2018).

2.1 Plastic waste pollution in Cambodia

Plastic pollution is a global issue, and the growth of plastic waste is projected to outpace mitigation efforts in the coming decades unless immediate, coordinated, and decisive action is taken. (Borrelle et al., 2020). In addition to the visual pollution impacts of plastic waste on society and the economy, over 170 trillion plastic particles are estimated to be present in the world's oceans (Eriksen et al., 2023).

The Global Plastic Action Partnership (n.d.) reported that the issues surrounding the increase in plastic consumption in Cambodia and other Southeast Asian countries have been caused by rapid economic growth and urbanisation. UNDP Cambodia (2025) stated that plastic consumption in Cambodia is part of everyday life. In Phnom Penh alone, around 10 million plastic bags are used every day or 2,000 bags per person per year (Arduino, 2016). In addition to the service sector, plastic consumption is entrenched throughout the entire supply chain, while the lack of adequate waste management infrastructure and effective recycling mechanisms significantly amplifies its environmental impact. Tackling plastic pollution/issues will necessitate cross-sector evaluation, the creation and promotion of viable plastic alternatives, capacity building at national and sub-national levels, effective communication strategies, and better education on environmental issues (UNDP Cambodia, 2025).

Although Cambodia is not a major producer of plastic products (mostly imported), the share of plastics in the total waste at Dangkor landfill in Phnom Penh was 27%, with plastic bags comprising 15% of the plastic waste in 2015 (Koeng, 2019). In Phnom Penh, the economic impact of plastic bags on sewerage and drainage clogging causes damages exceeding US$100,000 per year (Arduino, 2016). The decomposition rate of plastics varies by material composition and structural characteristics, ranging from about 20 to 500 years and, in some cases, extending to thousands of years. For example, a single-use plastic grocery bag takes 2 decades, while polyethylene terephthalate (PET) takes about 450 years to break down (Cheariot Energy, 2024).

2.1.1 Riverine plastic pollution

Riverine plastic debris pollution is extensive and highly complex, and causes leakage. Discussions on this issue tend to focus on solid waste management (SWM), the circular economy, or the 4Rs (refuse, reduce, reuse, and recycle) principles. However, the actual problem of riverine plastic debris pollution is much broader. Estimates of the share of plastic debris carried by the 10 top-ranked rivers in the world range from 80% (Jambeck et al., 2015; Meijer et al., 2021) to 88%–95% (Schmidt, Krath, and Wagner, 2019).

Country-specific data on marine plastic leakage are not available, but a survey conducted by Fauna & Flora in Koh Rong and Koh Sdach islands revealed that plastics accounted for 80% of coastal pollution found on mainland beaches in Cambodia (Fauna & Flora, 2019). This indicated that the mainland can be considered as the main source of plastic pollution into the ocean, although the amount of plastic leaked to the sea was not specified. Haberstroh et al. (2021) estimated that 203,000 kg of plastics per day were released from Phnom Penh into the Mekong River during the rainy season. A comprehensive assessment of plastic items and hotspots across 243 coastal, river, and inland sites along Cambodia's coastline by Roman et al. (2024) revealed that there are 46,927 items in transects throughout the study area, with an average of 70 plastic items per metre of coastline. The presence of plastic in Cambodia and the Mekong Delta has not been monitored, but plastics are likely to be abundant in the region. A recent modelling study estimated that 201,122.85 tonnes of plastic entered the Tonle Sap Basin between 2000 and 2020 and projected that 256,098 ± 7,892 tonnes will enter the basin between 2021 and 2030 (Finnegan and Gouramanis, 2021).

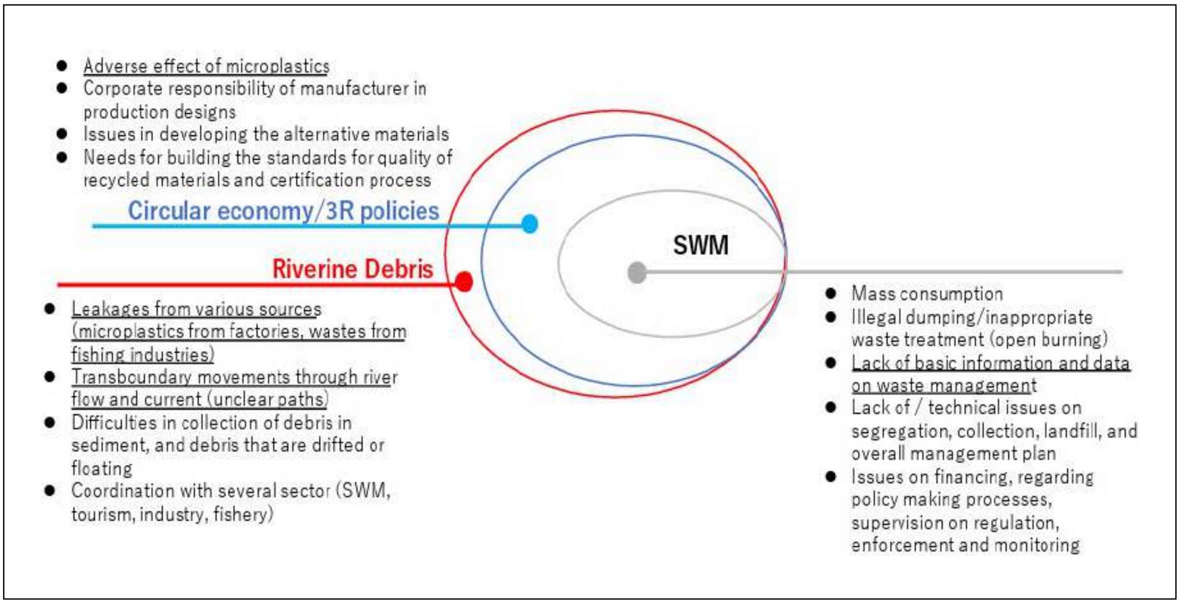
Riverine plastic debris pollution in the Mekong River presents the following three main problems (Mekong River Commission, 2022; Figure 12.3):

1. Leakage from various sources needs to be tackled in different fields, such as manufacturing, SWM, fishing, and tourism. This cannot be improved without a multisectoral approach, which means that governmental bodies, the private sector, and research institutions need to cooperate closely with each other.
2. Collecting debris is difficult once it flows into the water. The transboundary movements of such debris

through river flows and currents also make the responsibility for its management unclear.

3. Understanding and monitoring the occurrence and flowing paths of plastic debris requires an oceanographical approach.

Figure 12.3. Riverine Debris Problems and Relevant Sectors



Source: NIS (2025)

3. Plastic Waste Management in Cambodia

This section summarises the state of plastic waste management in Cambodia, where a low level of waste, which is mostly made up of plastics, can be recycled domestically. However, some local private sector initiatives involve the domestic recycling of plastics. Man Wah Cam Star Plastic Co. Ltd, a leading exporter in the staple fibre sector in Bavet city, recycles and upcycles used PET bottles into soft polyethylene staple fibre that has been exported to Viet Nam and Indonesia where it is used for industrial purposes accounted for 57% of staple fibre. Another company, Ung Sok Try Co. Ltd, processes 60 tonnes of PET bottles per day in Chbar Ampov district, Phnom Penh.

Similarly, Gomi Recycle – a joint venture between Phnom Penh Special Economic Zone and Japanese company – has collaborated with the Japan International Cooperation Agency to establish one plastic recycling company in Bavet city, Svay Rieng province, and another one in Phnom Penh Special Economic Zone. However, this joint venture focuses only on industrial plastic waste. In Phnom Penh, the joint venture turns industrial plastic waste into benches, and tiles on a small scale, and the rest is exported. Another example is a local company called Eco-Bricks, which collects 5–10 tonnes of plastic waste monthly to downcycle it into bricks for construction. Some non-governmental organisations (NGOs) such as Tonle Sap Green Bricks, My Dream Home, and TONTOTON have also transformed plastic into valuable materials. However, these are all small scale (The Asia Foundation, 2024). In 2018, the MOE introduced a charge on plastic bags and promoted the 4Rs framework – refuse, reduce, reuse, recycle (UNDP and MOE, 2021).

Cambodia does not have a framework for extended producer responsibility (EPR) or formal recycling initiatives. EPR is carried out on a voluntary basis, while plastic waste is collected by waste pickers who gather high-value recyclable materials such as steel, aluminium, PET bottles, and cardboard. As most households and businesses do not segregate their waste at source, informal waste pickers play a crucial role in reducing the amount of waste going to landfills at the beginning of the supply chain. This waste is sold to intermediaries and is mostly exported to Thailand and Viet Nam. Plastics recycling is limited in Cambodia, with PET and high-density polyethylene (HDPE) the main plastics being recycled. Other types of non-recyclable low-value plastic remain a challenge and end up in landfills, incinerated, or as litter. According to the United Nations Environment Programme (UNEP), plastic waste including PET bottles made up 21% (213,536 tonnes) of Phnom Penh's 1,015,980 tonnes of solid waste in 2019. Most of this waste is collected and disposed of at open dump sites, while the remainder is burned and disposed of on the street or into local waterways (UNEP, 2019).

3.1 Recycling activities

While most of Cambodia's recyclable plastics are exported, a few local NGOs and small businesses process waste via recycling. Private sector initiatives are sparse due to a lack of incentives. Cambodia's recycling sector is underdeveloped, with limited large-scale waste treatment facilities. Recyclable plastic is collected by about 3,000 informal waste pickers in Cambodia and sold to neighbouring countries via intermediaries. The informal sector plays an important role in waste recycling in Cambodia. In some countries, state-owned or major corporations 'manage' the recycling systems entirely or partially. By contrast, the so-called 'informal' waste economies for recyclables have been progressively organised and commercialised during the last 20 years throughout the world (Eitel, 2022). Despite the rapid economic growth, Cambodia's lax enforcement and societal readiness are barriers to transformation from traditional business models to circularity.

However, the informal sector still plays a crucial role in curbing the negative impacts of a linear economy (Valencia, 2020). Table 12.1 shows the amount of recyclable waste and the revenue from recyclables purchased by Cambodia's junk shops during 2010–2021 (Pheakdey et al., 2022). Cambodia currently exports some of its recyclable waste through intermediaries to Thailand and Viet Nam. However, Thailand banned plastic waste importation in 2020, and Viet Nam will implement a similar ban in 2025. As a result, large quantities of plastic waste will remain in Cambodia and will affect the environment if not treated appropriately domestically, where only 6.4% of waste was recycled in the country in 2022 (GIZ, 2023).

Table 12.1. Recyclable Waste Purchased by Junk Shops, 2010–2021

Year	Junkshop (number)[a]	Recyclable Waste (ton)[a]						Revenue Recovered (USD)[b]
		Paper and Cardboard	Plastic	Aluminum	Iron	Glass	Total	
2010	259	26,522	23,583	8449	63,077	1367	122,997	25,578,460
2011	313	25,340	21,689	7297	68,336	14,469	137,130	25,415,510
2012	421	14,856	13,960	9866	30,013	9083	77,777	19,556,430
2013	450	18,004	12,820	10,113	19,955	13,652	74,544	18,559,020
2014	483	22,838	15,842	15,942	29,930	14,311	98,863	27,426,040
2015	439	14,769	12, 678	100,050	17,184	9028	153,709	114,686,375
2016	445	33,857	30,907	87,741	74,328	20,134	246,967	115,820,995
2017	462	63,719	28,871	89,430	105,770	16,256	304,046	124,993,065
2018	462	36,829	23,886	26,664	45,723	7269	140,371	43,796,765
2019	498	38,180	27,208	27,973	46,282	7532	147,175	45,972,940
2020	NA	NA	NA	NA	NA	NA	NA	-
2021	692	67,701	36,389	31,120	64,348	2170	201,728	56,267,615

- = no data, NA = data not available

Source: Pheakdey et al. (2022).

3.2 Reuse and refill systems/circular economy/ zero waste approach

Population growth and changing lifestyles are resulting in an increasing amount of waste, the management of which poses a challenge for many countries, including Cambodia. The zero-waste approach is a set of practices aimed at minimising waste at source. The core principles of zero waste are waste prevention, reduction, reuse, recycling, recovery, and composting to divert materials from landfills to valuable materials towards a remarkable zero waste movement (Awasthi et al., 2021). The concepts of the zero waste approach and the circular economy system are increasingly recognised as the pathway to achieving sustainable waste management.

Reuse and refill systems are non-linear approaches that are directly linked to the zero waste approach or circular economy (closed loop) by prioritising upstream solutions to prevent waste generation at source. These initiatives also offer a promising alternative by ensuring that packaging and products are designed for longevity and eliminating waste to make it more sustainable (Iacovidou et al., 2017). This approach aligns with the principle that the best waste is the one that is not generated, positioning reuse and refill as essential strategies in the zero waste movement (Kaiser, 2025). Refill at home, refill on the go, return from home, and return on the go are four business models for this approach.

Private companies and organisations play an important role in implementing various reuse and refill systems, including the following:

(i) HEINEKEN (Cambodia) Co., Ltd. has a glass bottle return programme (not focused on plastic), which covered 1,800 bars, restaurants, and hotels across six provinces by the end of 2023.

(ii) Cambodia Beverage Company Limited (Coca-Cola) aims to achieve 100% recyclable packaging and 50% recycled content in its plastic bottles by 2025, and at least 50% recycled material in its packaging through the collection and recycling of bottles and cans by 2030, as part of its World Without Waste goals. These global targets shape expectations and sustainability practices across regional markets. The company launched the Program to Collect Plastic Shrink Film at the end of 2020, partnering with customers and recyclers and donating 850 sorting and collection bins to public schools, wet markets, and other key locations in 120 communities. It also has a partnership with PET recyclers to collect and recycle 400 tonnes of post-consumer PET bottles.

(iii) Angkor National Park and Banteay Srei collaborate with the Siem Reap Provincial Administration, the APSARA National Authority, Angkor Enterprise, and Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) under the Association of Southeast Asian Nations (ASEAN) Municipal Solid Waste Management Enhancement (AMUSE) programme to reduce plastic waste, promote sustainable tourism, and provide free access to safe drinking water at five sites within the Angkor Archaeological Park, including three water refilling stations.

(iv) Refill for a Plastic-Free Siem Reap aims to cut SUP waste. It has installed free water refill stations in Angkor Park under the Plastics in Angkor Park initiative. In addition, more than 70 businesses – such as hotels, restaurants, and cafés – offer free water refills, according to a 2023 statement by GIZ (Amarthalingam, 2025).

4. Policies and Legal Framework on Municipal Solid Waste Management and Plastic Management

National laws, policies, and regulations related to solid waste management have been formulated to protect and improve environmental quality and public health through the prevention, mitigation, and management of pollution.

4.1 Global frameworks on marine litter

Cambodia is a party to a number of conventions, treaties, and regulations related to coastal and marine environment protection, including the International Convention for the Prevention of Pollution from Ships (MARPOL) in 1997, which Cambodia has partly ratified. Annex V of MARPOL is especially relevant to plastic pollution, as it contains provisions for the prevention of pollution by rubbish including plastics from ships.

The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal and the Ban Amendment in 2001 focus on hazardous waste, but plastic waste is also covered. In 2019, Cambodia announced that it would return 1,600 tonnes of imported plastic waste to the United States and Canada.

In summary, international laws and frameworks play a crucial role in shaping national and local solid waste management policies, providing guidelines for attaining sustainability, minimising environmental impacts, and enhancing public health.

4.2 Regional frameworks on marine litter

In addition to the international frameworks listed above, Cambodia is a party to regional frameworks including the Bangkok Declaration on Combating Marine Debris in the ASEAN Region and the Framework of Action on Marine Debris in 2019, the ASEAN Framework of Action on Marine Debris in 2019, the ASEAN Regional Action Plan for Combating Marine Debris in the ASEAN Member States (2021–2025) in 2021, and the ASEAN Declaration on Plastic Circularity in 2024.

In addition to Partnerships in Environmental Management for the Seas of East Asia (PEMSEA) and the Coordinating Body on the Seas of East Asia (COBSEA), Cambodia participates in a range of regional partnerships that promote coordinated action on marine pollution control, coastal resource management, and environmental governance, such as the Regional 3R Forum in Asia in 2008, the ASEAN Circular Economy Stakeholder Platform in 2018, the Economic Research Institute for ASEAN and East Asia (ERIA) Regional Knowledge Centre for Marine Plastic Debris (RKC-MPD) in 2019, and the Regional Capacity Centre for Clean Seas (RC3S) in 2019. These partnerships support efforts to combat plastic pollution by aligning with Cambodia's needs and providing knowledge and technical guidance, policy direction, and access to funding. However, challenges lie in implementation, data and infrastructure gaps, regulatory weaknesses, resource constraints, and the need for behaviour change. With focused effort in these areas, Cambodia could leverage regional frameworks to produce visible reductions in marine litter and plastic pollution.

4.3 Cambodia legal and policy frameworks on municipal solid waste management and marine litter

Cambodia does not have comprehensive MSW policies or programmes in place. Current policies and programmes fail to address the need for substantial reductions in MSW, particularly its organic share such as food waste, and do not establish clear targets for recycling rates or other waste management indicators. However, the country has developed some regulations and is preparing an integrated SWM strategy/plan for development of the waste management sector. Various laws, regulations, and policies related to municipal solid waste management have been ratified and issued over the years. However, there are no specific frameworks on marine debris management in Cambodia.

4.3.1 Related laws and regulations on plastic management

Many laws/sub-decrees have been issued on SWM since the establishment of the MOE in 1993. Plastics are also partly covered. Plastics have also featured prominently in several national strategies, such as the National Circular Economy Strategy and Action Plan (2021), which covered promoting a reduction in the production of SUPs, as well as developing an EPR scheme and encouraging reuse, repaire, and recycling. Sub-decree No. 36 on Solid Waste Management (1999) and Sub-decree No. 113 on Urban Garbage and Solid Waste Management (2015) focus on general waste management and are not specific to plastic waste. The Phnom Penh Waste Management Strategy and Action Plan of Cambodia (2018–2035) and Sub-Decree No. 168 on the Management of Plastic Bags (2017) focus on reducing plastic bag consumption – targeting only malls/supermarkets with a charge of US$0.10 per plastic bag. Moreover, Cambodia has built a robust legal and policy foundation for tackling plastic waste, combining enforceable sub-decrees, strategic plans, and global cooperation. However, the gap between legislation and impact remains sizeable, notably in enforcement, infrastructure, and producer responsibility.

Extended Producer Responsibility (EPR) is one of the most efficient and effective policy mechanisms to support the country in reducing plastic waste and promoting sustainable waste management. The Government of Cambodia aims to transition Extended Producer Responsibility (EPR) from a voluntary scheme to a mandatory regulatory framework in order to strengthen plastic waste management and ensure greater accountability among producers, as mentioned in the National Circular Economy Strategy and Action Plan (UNDP Cambodia, n.d.-a; US–ASEAN Business Council, 2023). However, based on the national update of regulations/sub-decrees and implementation of the Basel Convention, Cambodia will develop an EPR system for electrical and electronic equipment (MOE, 2023). Table 12.2 depicts the EPR landscape of ASEAN Member States.

Table 12.2. EPR Landscape of ASEAN Member States

No.	Country	EPR Landscape for ASEAN Member States				
		1	2	3	4	5
1	Brunei	√	-	-	-	-
2	Cambodia	√	√	-	-	-
3	Indonesia	√	√	√	√	√
4	Lao PDR	√	√	-	-	-
5	Malaysia	√	√	√	-	-
6	Myanmar	√	-	-	-	-
7	Philippines	√	√	√	√	√
8	Singapore	√	√	√	√	√
9	Thailand	√	√	-	-	-
10	Viet Nam	√	√	√	√	-

ASEAN = Association of Southeast Asian Nations, EPR = enhanced producer responsibility.

Notes:

1. The country is not currently drafting or considering any EPR laws.
2. The country is exploring policy options or the framework is in the drafting stages.
3. The country has drafted an EPR framework, but it has not yet received government approval.
4. The country's EPR framework has been approved by the government but is not yet in place.
5. The country's EPR framework is currently in place.

Source: US–ASEAN Business Council (2023).

4.4 Key initiatives to mitigate plastic pollution in Cambodia

The MOE is a key policymaking body, responsible for initiating and considering solutions to SWM issues. Since plastic is a hot topic monitored by multiple stakeholders, several other entities also play a major role in plastic waste in Cambodia. This has led to the design and implementation of integrated programmes and policies in the country.

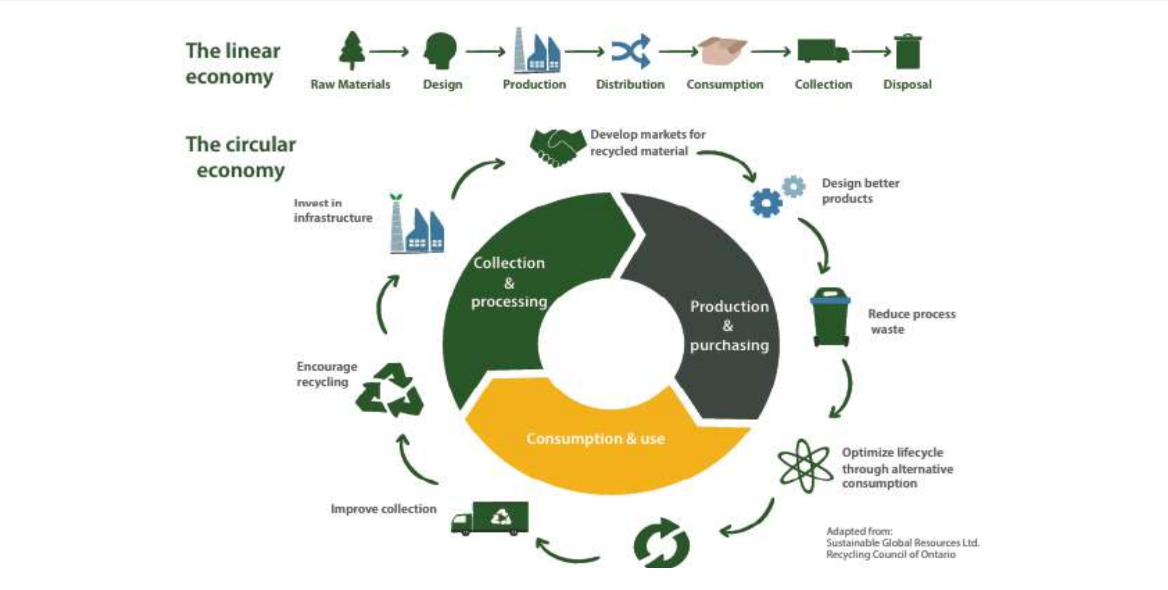
4.4.1 Circular economy policy

The National Circular Economy Strategy and Action Plan (2021) is the result of collaboration amongst the Department of Green Economy under the Secretary General for Sustainable Development of the National Council for Sustainable Development (NCSD) of the MOE, and a team of policy experts from the UNDP and the Swedish International Development Cooperation Agency (SIDA) (UNDP Cambodia, n.d.-a).

This strategy and action plan represents a high-level strategic approach to the introduction of a circular economy in Cambodia. It supports Cambodia's transition from a linear to a closed loop/circular economy as shown in Figure 12.4, by identifying priority areas to enhance economic, environmental, and social outcomes. This will not only contribute to sustainable development in Cambodia but also to global goals of reducing plastic pollution and mitigating climate change. The following guiding principles will be used throughout the transition towards a circular economy:

(i) Environmental protection and sustainability
(ii) Public health and safety
(iii) Inclusive and sustainable economic development
(iv) Non-discrimination and an intersectional approach
(v) Inclusive and effective participation
(vi) Multi-sectoral and multi-stakeholder approach

Figure 12.4. Linear Economy and Circular Economy



Source: UNDP Cambodia (n.d.-a).

The transition from a linear to a circular economy faces multiple obstacles, such as the continued preference for virgin raw materials; a lack of initiatives across design, remanufacturing, distribution, and consumption stages; limited opportunities for reuse and repair; incomplete collection service coverage; and underdeveloped recycling systems.

4.4.2 Education/campaign on plastic waste management

Plastic pollution is a growing environmental crisis, especially in developing countries like Cambodia, where infrastructure, public awareness, and behavioural change are still developing. Education and public awareness campaigns play a critical role in addressing plastic waste at source. The transition of plastic waste management in Cambodia faces a harsh reality, with complicated systemic issues that will take years and a multitude of resources to fix. Education is a crucial factor in facilitating this transition. Raising awareness about plastic use among students and within communities is indispensable. However, there is currently no official environmental course formally integrated into the school-level curriculum.

Various stakeholders, such as public–private partnerships and NGOs, contribute to plastic waste management and participate in campaigns aimed at reducing plastic pollution:

- National campaigns by the MOE
  The MOE has implemented several national plastic management campaigns, including 'Today I Will Not Use Plastic Bags' (EAC News, 2025), 'Clean Cambodia! Khmer Can Do' (MOE 2024), National Roads Without Plastic Waste (UNDP Cambodia and MOE, 2021), a waste sorting campaign (Chantha, 2025), the Supermarket Mesh Bag Initiative (MOE, 2025), the National Environment Day – 'Beat Plastic Pollution' (ODC, MOE, 2025), UNDP and international partner projects, and the UNDP–Japan 4R Project (UNDP Cambodia, 2025).

- Plastic reduction and river/beach clean-up
  Several NGOs are working on plastic reduction, including River Ocean Cleanup Cambodia (Kongnov, 2024); everwave Cambodia (in partnership with River Ocean Cleanup); Marine Conservation Cambodia (Marine Conservation Cambodia, n.d.); and One Earth – One Ocean (One Earth, 2018). Stakeholders include the BambooShoot Foundation, which works with Tonle Sap communities, as well as community- and NGO-led initiatives that organise island clean-ups in Koh Rong and Kampot (Ocean Recovery Alliance, 2023).

5. Major Challenges Affecting Plastic Waste Management

Plastic pollution is a hot topic for Cambodia, and it is facing challenges such as lack of infrastructure, low public awareness, weak law/policy enforcement, limited funding and investment, informal sector dependence, and lack of harmonised data and monitoring.

Over the past 2 decades since the early 2000s, Cambodia has introduced several regulations, guidelines, and initiatives. Nonetheless, weak monitoring and implementation, limited institutional capacity, and insufficient reliable data on plastics at national and subnational levels continue to pose major challenges. Cambodia's waste management sector also faces severely inadequate financing. Funding for waste management in Cambodia is derived from user fees, the government budget, and development partners.

6. Conclusion

Managing plastic waste in Cambodia continues to be a critical environmental issue, exacerbated by rapid urbanisation, growing consumer demand, and constrained infrastructure. Despite progress through public awareness campaigns, small-scale recycling programmes, and the development of regulatory frameworks, the country faces persistent challenges such as weak regulatory enforcement, insufficient financial and institutional support, low public awareness, and inadequate waste collection and processing capacity.

To improve plastic waste management, Cambodia must prioritise the development of sustainable waste management infrastructure, enforce stricter regulations on plastic production and use, and encourage public–private partnerships. Additionally, education campaigns aimed at reducing plastic consumption and promoting recycling are essential. With coordinated efforts from the government, private sector, and civil society, Cambodia can transition towards a more sustainable and circular waste economy, ultimately reducing the environmental and public health impacts of plastic pollution.

Insufficient recycling infrastructure and limited public awareness of regulations remain major barriers to effective plastic waste management. Promoting alternatives to conventional plastics – including bioplastics, stainless steel, glass, platinum silicone, wood, bamboo, cardboard, paper, cotton, pottery, and ceramics – offers a viable pathway toward reducing plastic use and improving waste management practices.

7. Recommendations

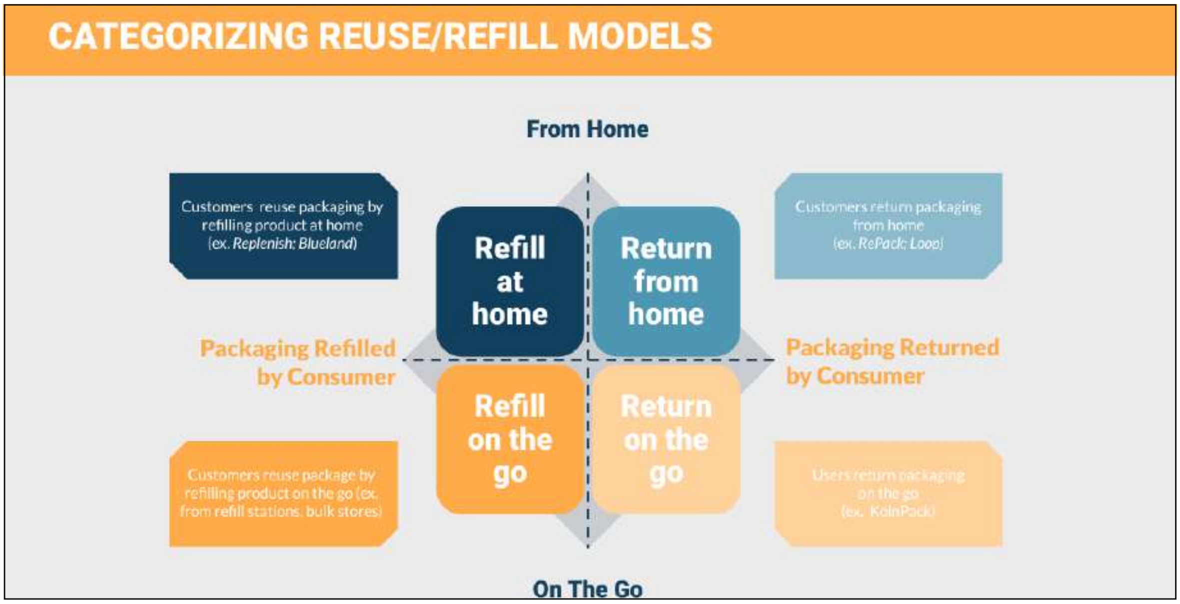
To strengthen Cambodia's solid waste management system, systemic reforms are needed to address the complexity and scale of current challenges. Addressing plastic waste will require coordinated cross-sector efforts, including the promotion of sustainable plastic alternatives, capacity building at national and sub-national levels, strategic communication, and environmental education. Planned actions should be prioritised for implementation in the short, medium, and long term to achieve measurable and sustainable results.

The following policy recommendations are proposed to address solid waste management (SWM) and plastic pollution:

- Strengthen institutional capacity, including coordination issues.
- Implement various sub-decrees on waste management.
- Promote engagement from all stakeholders, with financial support.
- Invest in waste management facilities, recycling infrastructure/equipment, and locally led innovations.
- Transition from a voluntary EPR approach to a mandatory EPR system
- Foster and empower local leadership, collaboration, and planning amongst local leadership and formal private sector collection services.

Figures 12.5 and 12.6 summarise important concepts that should be included in future policymaking for reducing plastic generation in Cambodia.

Figure 12.5. Reuse/Refill Models



Source: Circularity Concepts (2022).

Figure 12.6. Alternatives to Single-Use Plastics

Source: Hall, Thomas, and Williams (2006).

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Chapter 13

Ensuring Infrastructure and Policy Implementation to Drive Better Plastic Waste Management in Indonesia

Muhammad Reza Cordova
Attar Hikmahtiar Ramadan

1. Introduction

1.1 Status quo of plastic pollution in Indonesia

Indonesia is recognised as one of the largest archipelagic nations globally, with a population exceeding 275 million population. This Southeast Asian country, which encompasses over 17,000 islands, is distinguished by its complex maritime ecosystem and significant biodiversity (Allen, 2008; Unsworth et al., 2018). Together with 11 other Southeast Asian countries, Indonesia has one of the largest economies in Southeast Asia, with a gross domestic product of about US$1.4 trillion in 2024 (Statista, 2024). Since it acceded to the Group of Twenty (G20) in 1999, Indonesia has undergone rapid demographic expansion and industrial growth (Hermawan et al., 2011).

Nevertheless, effective environmental stewardship has not matched this economic progression, particularly in plastic waste management. Several global assessments suggest that Indonesia consistently ranks amongst the top contributors to marine plastic pollution, primarily driven by mismanaged plastic waste from land-based human activities (Cordova and Nurhati, 2019; Iskandar et al., 2021; Meijer et al., 2021; Nurhati and Cordova, 2020). Recent studies have estimated that Indonesia generates about 7.8 million tons (Mt) of plastic waste annually, of which around 4.9 Mt are classified as mismanaged or inadequately treated (Cordova et al., 2019; Cottom, Cook, and Velis, 2024; Indonesia National Plastic Action Partnership, World Bank, and Indonesian Institute of Sciences, 2019; Jambeck et al., 2015; Lebreton et al., 2017; Lebreton and Andrady, 2019; Meijer et al., 2021; World Bank, 2021). Poorly managed waste refers to uncollected litter, refuse disposed of in open dumps, and leakage from inadequately supervised landfills (Meidiana and Gamse, 2010; Nurhasanah, Cordova, and Riani, 2021). Waste management practices in Indonesia predominantly occur at the municipal level, yet average waste collection coverage across the 514 regencies and cities remains below 60% (Cordova, 2024). Furthermore, the fiscal allocation for waste management at the local government level averages 0.7%–0.8% of the regional budget (Cordova et al., 2022), which is substantially lower than the recommended 3%–4% (Cordova et al., 2024; Wardhana, 2020).

According to data from the National Waste Management Information System (SIPSN), organic waste constitutes most of the waste stream at 63.06%, while plastic waste comprises 19.74%. Food waste represents the largest segment of organic materials at 39.31%, followed by wood/twigs at 12.54% and paper/cardboard at 11.21% (Ministry of Environment and Forestry, 2024b). The heterogeneous mixture of waste deposited in landfills or the environment compromises the potential for effective resource recovery and poses significant environmental threats, which could be alleviated by implementing appropriate management strategies (Damanhuri, 2017; Damanhuri and Padmi, 2009; Honingh, 2018).

1.2 Key initiatives against plastic pollution

In response to the plastic pollution crisis, Indonesia is committed to addressing the ecological and economic impacts of plastic pollution. The foundation of this commitment lies in the National Waste Management Policy and Strategy, which advocates for a proactive approach to sustainable waste management. The National Waste Management Policy and Strategy sets ambitious targets to reduce waste generation by 30% and to manage 70% of waste by 2025. As of 2022, Indonesia has achieved a 25.3% reduction in waste and managed 49.2% of its waste (Ministry of Environment and Forestry, 2024b). While these figures indicate meaningful progress, they fall short of the established targets. Therefore, it is crucial to maintain and intensify efforts to meet the 2025 goals and future targets.

By early 2025, the Indonesian government had successfully instituted regulations that partly address plastic waste, including Law No. 18 of 2008 on Waste Management and Government Regulation No. 81 of 2012 on Household Waste and Waste-Like Waste Management. Indonesia's policy response to plastic waste is formalised in the National Action Plan for Marine Debris Management, as stipulated under Presidential Regulation No. 83 of 2018. In total, at least 17 national regulations have been enacted to strengthen waste management governance (Table 13.1). These include two key acts that form the legal foundation for compliance, four government regulations that outline operational guidelines, four presidential regulations that specify national priorities, one presidential decree that mandates particular actions, and seven ministerial regulations detailing implementation procedures (Table 13.1). The regulations focus on preventing waste production, developing and improving waste management infrastructure, and executing public awareness campaigns to educate citizens on sustainable practices. This multifaceted approach seeks to diminish waste at the origin, fosters proactive community engagement, and encourages responsible waste behaviours amongst individuals and businesses alike.

Table 13.1. Indonesian Regulations to Enhance Waste Management Practices

National law	Government regulation	Presidential regulation	Presidential decree	Ministerial regulation
Act No. 18/2008 on Solid Waste Management	Government Regulation No. 81/2012 on Waste Management of Household Waste and Household Like Waste	Presidential Regulation No. 18/2015 on Income Tax Facilities for Investment in Certain Business Fields and/or in Certain Regions	Presidential Decree 47/2005 on Ratification of the Amendment of Basel Convention on the Control of Transboundary Movements of Hazardous Wastes	Minister of Public Works Regulation No. 3/2013 on The Provision of Facilities and Infrastructure to Handle Domestic Waste and Domestic Waste Equivalents
Act No. 32/2009 on Environmental Protection and Management	Government Regulation No. 101/2014 on Hazardous Waste Management	Presidential Regulation No. 97/2017 on National Policy & Strategy on Management of Household Waste and Household-Like Waste		Minister of Trade Regulation No. 48/2015 on General Provisions in the Import Sector
	Government Regulation No. 27/2020 on Specific Waste Management	Presidential Regulation No. 35/2018 on Acceleration of Development of Waste-to-Energy Installation using Environmentally-Sound Technology		Minister of Trade Regulation No. 70/2015 on Importer Identification Number

National law	Government regulation	Presidential regulation	Presidential decree	Ministerial regulation
	Government Regulation No. 22/2021 on Environmental Protection, Organisation and Management	Presidential Regulation No. 83/2018 on Marine Debris Management (National Plan of Action on Marine Plastic Debris)		Minister of Industry Regulation No. 48/2015 on General Provisions for the Verification or Technical Tracing in the Import Sector
	Draft Government Regulation on Excise on Plastic	Draft Presidential Regulation on National Waste Management		Minister of Trade Regulation No. 31/2016 on Provisions for Importing Non-Hazardous and Toxic Waste
				Minister of Environment and Forestry Regulation No. P.75/2019 on Roadmap for Waste Reduction by Producers
				Minister of Environment and Forestry No. 9/2024 Concerning the Management of Waste Containing Hazardous and Toxic Materials and Hazardous and Toxic Waste

Source: Authors' analysis.

1.3 Challenges and opportunities to improve plastic waste management in Indonesia

Indonesia makes a significant contribution to marine plastic pollution (Cottom, Cook, and Velis, 2024; Iskandar, Cordova, and Park, 2022). Waste mismanagement is primarily driven by the absence of systematic source segregation and inadequate waste collection infrastructure (Pramudianto, 2023). These factors, combined with limited regulatory enforcement and low levels of public awareness, constitute the principal obstacles to effective waste management (Damanhuri, 2017; Putri, Fujimori, and Takaoka, 2018; Supriyadi, Kriwoken, and Birley, 2000; Widyarsana et al., 2020). Existing infrastructure does not support management, and results in environmental degradation (Darus et al., 2020; Lestari and Trihadiningrum, 2019). This condition occurs due to rapid economic growth and urbanisation, which have led to a surge in waste production (Ramadan and Sembiring, 2023). From an environmental law perspective, all regencies and cities in Indonesia have irregular waste management, requiring an integrated management approach (Widiatmoko, Zahra, and Permana, 2024). From an economic perspective, the cost of waste management is very high (Joseph et al., 2024).

Empirical studies have indicated that a substantial share of household-level waste management in Indonesia is carried out through open burning or informal burial practices (Astuti, 2014; Cottom, Cook, and Velis, 2024; Irianti, 2013; Nurhasanah, Cordova, and Riani, 2021), with these environmentally detrimental practices accounting for 40%–60% of overall management strategies (Cottom, Cook, and Velis, 2024). The lack of public awareness and poor waste management behaviour at the sources compounds the challenge (Hayati et al., 2020; Mathis et al., 2022).

Plastic waste adversely impacts key sectors, including tourism, transportation, fisheries, and overall development (Beaumont et al., 2019; Omeyer et al., 2022, 2023). These challenges also present opportunities for improvement through a circular economy approach (Pilapitiya and Ratnayake, 2024; Subekti, 2023).

1.4 Analytical framework

This chapter employs a qualitative analysis framework to explore the complexities of plastic waste management in Indonesia, leveraging insights from pertinent scientific literature, policy documents, and case studies. Initially, it delineates the current landscape of plastic pollution, providing a baseline for understanding the gravity of the issue. The analysis subsequently identifies key challenges impeding effective w4aste management, including regulatory inadequacies that obstruct enforcement and public engagement (Table 13.2). Furthermore, it examines infrastructural deficiencies, notably the shortcomings in waste collection and recycling capabilities.

Table 13.2. Waste Management in Indonesia Gap Analysis

Aspect	Current condition	Gap/Discrepancy	Impact & challenges
Waste source management	• Waste reduction at source remains low (~1.55% nationally in 2024). • Waste segregation at household and community levels is suboptimal. • Roles of local administrative units (RT/RW/*kelurahan*)* are underutilised.	• Public awareness and participation in waste reduction and segregation are low. • Coordination and policy implementation at the community level are lacking. • COVID-19 pandemic reduced waste reduction activities.	• Organic and plastic waste mixed, complicating processing. • High volume of waste is still sent to landfills. • The national target of 30% waste reduction by 2025 is unlikely to be met.
Infrastructure and facilities	• Waste management infrastructure is limited and unevenly distributed. • Recycling centres (PDU) exist in about 40 cities/regencies. • Composting facilities exist in 70+ cities/regencies but with limited capacity. • Waste-to-energy facilities operate in only 5–7 major cities. • About 54% of landfills still operate as open dumping sites; sanitary landfills are not fully optimised.	• Processing capacity is insufficient, while its geographical distribution remains uneven. • Many sanitary landfills fail to meet environmental and operational standards. • Adequate technology and skilled human resources are lacking .	• Large amounts of waste continue to end up in open dumps. • Environmental and public health risks persist. • Processing capacity lags increasing waste generation.

Aspect	Current condition	Gap/Discrepancy	Impact & challenges
Regulation and policy	• National regulations exist. • Regulatory frameworks at the regional and governor levels vary across regions (e.g. Jakarta). • Waste management master plans and regional strategies have been formulated.	• Implementation is inconsistent at local and community levels. • The authority and capacity of local administrative units (RT/RW/kelurahan) is limited. • Inter-agency and cross-sector coordination is weak. • Funding and incentives are inadequate.	• Policies have limited effectiveness in reducing waste volume. • Discrepancies exist between regulations and on-the-ground practices. • Difficulties are present in achieving national targets for waste reduction and handling.
4. Public understanding and perception	• Public awareness is improving in some areas but remains uneven. • Cultural and regional differences affect waste management perceptions. • Community participation in segregation and reduction remains low.	• Effective education and outreach are lacking across regions. • Cultural and economic disparities influence waste behaviour. • Pandemic worsened consumption and waste management patterns.	• Establishing consistent waste segregation and reduction habits faces challenges. • Unsustainable waste management practices continue. • Challenges are experienced in mobilising collective community action.

COVID-19 = coronavirus disease, PDU = Pusat Daur Ulang (recycling centre).

* *Rukun Tetangga* (RT) and *Rukun Warga* (RW) are neighbourhood-level community organisations in Indonesia, while kelurahan refers to the lowest formal administrative unit at the urban village level, responsible for local governance and community coordination.

Source: Authors' analysis.

To contextualise these challenges, the analysis references government policies and initiatives to address plastic contamination, highlighting their implications for both urgency and scope. The framework also posits potential solutions to enhance plastic waste management practices. This includes the exploration of circular economy strategies, the reinforcement of extended producer responsibility (EPR) schemes, and the promotion of active community involvement. Ultimately, the analytical framework aspires to provide a thorough understanding of the multifaceted nature of plastic waste management in Indonesia, aiming to inform the development of effective and sustainable interventions.

2. Analysis

2.1 Data sources

This chapter conducts an in-depth analysis of the complexities surrounding plastic management in Indonesia. Using a qualitative approach, it draws from various scientific publications and academic papers, with data collected up to early 2025 to ensure the information is current. The sources for the analysis are categorised into three main areas.

First, it includes research findings from reports authored by researchers and academics, and scientific publications sourced from books, journals, and conference proceedings. A literature search utilising the Google Scholar database was conducted up until May 2025, employing keyword combinations such as 'plastic debris', 'plastic litter', 'marine litter', and 'Indonesia'. The terms EPR, circular economy, and Indonesia were also used in the search.

Second, the chapter reviews national and regional policies and regulations about waste management in Indonesia. We gathered documents from the public domain that pertain to national policies and local government regulations regarding plastic litter.

Lastly, this chapter examines case studies focusing on waste management initiatives in regions such as Java and Bali.

2.2 Methodologies

We analysed the collected findings through thematic and comparative analysis. In this study, thematic analysis was applied to systematically identify and interpret patterns within the collected data, focusing on key challenges, opportunities, and potential solutions related to plastic waste management in Indonesia (Cernasev and Axon, 2023; Herzog, Handke, and Hitters, 2018; 2019) in plastic waste management. A comparative analysis then evaluates the effectiveness of various waste management strategies implemented (Oyewale, Tartibu, and Okokpujie, 2023) in Indonesia. This analysis interprets successful initiatives to identify areas for further improvement (Müller et al., 2020). Based on the two analyses, we provide recommendations for policymakers, businesses, and the public by combining research insights with regulatory data, towards the establishment of effective and sustainable waste management practices in Indonesia.

In addition, we use a polynomial model to forecast Indonesia's marine plastic leakage through 2030. We demonstrate an optimistic scenario, as well as a business-as-usual scenario with a forecast table model. A second-degree polynomial regression model is applied to predict the plastic leakage trend from 2024 to 2030. This model accounts for the declining, yet decelerating (Maroni, 1995), impact of government interventions (Sims, 1986). The optimistic scenario assumes continued government intervention and fiscal efficiency through 2026. In contrast, the forecast table model with the business-as-usual scenario is based on a historical downward trend (Jambeck et al., 2015; Zhao et al., 2021). The forecast table model assumes that government efficiency continues until 2026 (Sukmawijaya and Gunanto, 2025), and then its impact declines naturally. Indonesia's 2025 state budget shows an increase in infrastructure spending and energy transition, but the environmental budget is relatively stagnant (Putra, 2025). The forecast table model assumes no additional injection of funds/investments after 2026. Therefore, this reflects projected outcomes based on current waste trends without aggressive intervention.

2.3 Results

2.3.1 Persistently low performance of waste management

Waste management in Indonesia faces various challenges, including low waste collection and limited processing infrastructure. This results in low recycling rates and high waste, which end up in open dumping and informal landfills. Meanwhile, existing laws and regulations related to waste management have not been implemented optimally (Table 13.3). The monitoring system has not been implemented properly either.

2.3.1.1 Regulatory gaps

The Indonesian government has established at least 17 regulations on waste management, including two acts, four government regulations, four presidential regulations, one presidential decree, and seven ministerial regulations. Collectively, these regulations outline the rules governing waste generation practices, developing waste management infrastructure, and implementing public awareness campaigns. However, a gap analysis (Tables 13.2 and 13.3) has identified shortcomings in regulation and infrastructure, as well as limited public participation. Indonesia's legal landscape for waste management is governed by a complex web of regulations, each with a specific focus area and identified gaps (Tables 13.1 and 13.3), as summarised below:

- Act No. 18/2008 on Solid Waste Management lacks integration with marine and hazardous waste management and does not emphasise circular economy principles.
- Act No. 32/2009 on Environmental Protection and Management has insufficient linkage between environmental protection and waste management, coupled with limited enforcement mechanisms.
- Government Decree No. 81/2012 on Household and Household-Like Waste primarily targets urban areas, neglecting rural waste management strategies and producer responsibility.
- Government Decree No. 101/2014 on Hazardous and Toxic Waste has inadequate provisions for emerging hazardous waste streams and suffers from limited public awareness.
- Government Regulation No. 27/2020 on Specific Waste Management faces ambiguities in defining waste types.
- Government Regulation No. 22/2021 on Environmental Protection, Organisation, and Management overlaps with existing regulations and lacks a strong focus on waste management within broader environmental frameworks.
- Presidential Regulation No. 18/2015, focused on investment, has limited direct relevance to waste management.
- Presidential Decree No. 97/2017 on National Policy & Strategy on Household Waste lacks enforceable targets.
- Presidential Regulation No. 35/2018 on Waste-to-Energy Installations narrowly focuses on energy recovery, potentially conflicting with environmental standards.

- Presidential Regulation No. 83/2018 on Marine Debris Management is not well-integrated with land-based strategies and has weak enforcement for marine pollution control.
- Minister of Public Works Regulation No. 3/2013 on Domestic Waste Facilities prioritises infrastructure over waste reduction.
- Trade regulations like No. 48/2015 and No. 70/2015, and Industry Regulation No. 48/2015, have limited impact, focusing on import procedures.
- Minister of Trade Regulation No. 31/2016 lacks clear guidelines for imported non-hazardous waste.
- Environment and Forestry Regulation No. P.75/2019 on waste reduction relies on a voluntary approach.

The ministerial-level regulation highlights EPR principles. EPR holds producers accountable for managing plastic throughout its entire life cycle. However, the implementation of EPR suffers from a fragmented approach, particularly in terms of law enforcement, which complicates the ability to hold producers accountable. The recent Minister of Environment and Forestry Regulation No. 9/2024 on Hazardous & Toxic Waste suffers from inconsistent implementation and infrastructure gaps.

In addition to overarching regulations established by the central government, provincial governments, as well as regency and city governments, have enacted local policies to tackle the growing concern of waste management, particularly concerning single-use plastics. As of August 2024, 2 provinces, 45 cities, and 67 regencies have implemented regional regulations focused on either the prohibition or restriction of single-use plastics (Ministry of Environment and Forestry, 2024a). These regulations often drill down into specific areas, addressing the use of plastic bags in modern markets with detailed guidelines. However, the landscape is less restrictive when it comes to traditional markets, with bans currently in place only in the bustling urban centres of Jakarta and Balikpapan.

This varied approach reflects the diverse strategies employed across regions to combat plastic pollution and encourage more sustainable practices. In the future, the Indonesian government is expected to consider several key policies aimed at enhancing its efforts to combat plastic pollution (Zaki, 2025). These policies may include regulations on single-use plastics, incentives for recycling, waste-to-energy (WtE) implementation, and stricter enforcement of waste management regulations (Zaki, 2025).

Table 13.3. Indonesian Waste Management Regulations Gap Analysis

Regulation	Focus area	Waste source coverage	Type of waste addressed	Policy instruments	Implementation framework	Enforcement mechanism	Funding mechanism	Monitoring & evaluation	Circular economy element	Identified gaps
Act No. 18/2008	Municipal solid waste	Households, commercial, and industrial sectors	Organic, recyclable, residual	3R principles, EPR	National and local government roles	Weak enforcement, limited penalties	Limited, primarily local budgets	Data collection and reporting	Emphasises recycling and reuse	Inadequate infrastructure, weak enforcement, limited public awareness
Act No. 32/2009	Environmental protection	All sectors	All waste types	EIA, licensing	National and local government coordination	Weak enforcement, inconsistent penalties	Limited, varies by region	Monitoring through EIA process	Supports sustainable resource use	Insufficient penalties, lack of integration with waste management
GR No. 81/2012	Household Waste	Households and similar sources	Organic, recyclable, residual	3R, TPS-3R	Local government implementation	Weak enforcement, limited penalties	Local government funding	Monitoring through local authorities	Promotes waste segregation and recycling	Inconsistent implementation, lack of infrastructure
GR No. 101/2014	Hazardous waste	Industrial and healthcare sectors	Hazardous and toxic waste	Licensing, EIA	Industry self-regulation with oversight	Weak enforcement, inconsistent penalties	Industry funding, limited government support	Monitoring through EIA process	Encourages safe handling and disposal	Limited public awareness, inadequate infrastructure
GR No. 27/2020	Specific waste	Industrial and commercial sectors	Specific waste types (e.g. mining, agriculture)	Licensing, EIA	Industry self-regulation with oversight	Weak enforcement, inconsistent penalties	Industry funding, limited government support	Monitoring through EIA process	Encourages waste minimisation and recycling	Limited public awareness, inadequate infrastructure
GR No. 22/2021	Environmental protection	All sectors	All waste types	Environmental approval, licensing	Integrated business and environmental licensing	Weak enforcement, inconsistent penalties	Varies by sector and region	Monitoring through environmental approval process	Supports sustainable development	Insufficient penalties, lack of integration with waste management
PR No. 18/2015	Investment in waste management	All sectors	All waste types	Tax incentives	National government facilitation	Limited enforcement, relies on investor compliance	National government funding	Monitoring through investment tracking	Encourages private sector involvement	Limited enforcement, lack of integration with waste management
PR No. 97/2017	Household waste	Households and similar sources	Organic, recyclable, residual	3R, waste separation	National and local government coordination	Weak enforcement, inconsistent penalties	Local government funding	Monitoring through local authorities	Promotes waste segregation and recycling	Inconsistent implementation, lack of infrastructure
PR No. 35/2018	Waste to energy	Municipal waste	Municipal solid waste	Feed-in tariffs, tipping fees	Public–private partnerships, local government facilitation	Weak enforcement, limited penalties	Government subsidies, private investment	Monitoring through project tracking	Supports renewable energy generation	Limited enforcement, lack of integration with waste management
PR No. 83/2018	Marine debris	Coastal and marine areas	Plastic and microplastic waste	National Action Plan, stakeholder engagement	National and local government coordination	Weak enforcement, inconsistent penalties	Government funding, private sector involvement	Promotes waste reduction and recycling	Limited enforcement, lack of integration with waste management	
MPW Reg. No. 3/2013	Domestic waste facilities	Households and similar sources	Domestic waste	Facility standards, infrastructure development	Local government implementation	Weak enforcement, limited penalties	Local government funding	Monitoring through local authorities	Supports waste management infrastructure	Inconsistent implementation, lack of infrastructure

Regulation	Focus area	Waste source coverage	Type of waste addressed	Policy instruments	Implementation framework	Enforcement mechanism	Funding mechanism	Monitoring & evaluation	Circular economy element	Identified gaps
MOT Reg. No. 48/2015	Import sector	Importers	All waste types	Import regulations, licensing	National government oversight	Weak enforcement, inconsistent penalties	Government funding, industry compliance	Monitoring through import tracking	Encourages responsible waste importation	Limited enforcement, lack of integration with waste management
MOT Reg. No. 70/2015	Importer identification	Importers	All waste types	Importer identification, licensing	National government oversight	Weak enforcement, inconsistent penalties	Government funding, industry compliance	Monitoring through import tracking	Ensures accountability in waste importation	Limited enforcement, lack of integration with waste management
MOI Reg. No. 48/2015	Import sector	Importers	All waste types	Import regulations, licensing	National government oversight	Weak enforcement, inconsistent penalties	Government funding, industry compliance	Monitoring through import tracking	Encourages responsible waste importation	Limited enforcement, lack of integration with waste management
MOT Reg. No. 31/2016	Non-hazardous waste import	Importers	Non-hazardous waste	Import regulations, licensing	National government oversight	Weak enforcement, inconsistent penalties	Government funding, industry compliance	Monitoring through import tracking	Ensures accountability in waste importation	Limited enforcement, lack of integration with waste management
MOEF Reg. No. P.75/2019	Producer waste reduction	Producers	All waste types	Roadmap, producer responsibility	Industry self-regulation with oversight	Weak enforcement, inconsistent penalties	Industry funding, limited government support	Monitoring through producer reports	Encourages waste reduction and recycling	Limited public awareness, inadequate infrastructure
MOEF Reg No. 9/2024	Hazardous & toxic waste	Households, commercial, and industrial sectors	Hazardous and toxic waste (B3)	Waste minimisation, producer responsibility	National and local government coordination	Weak enforcement, inconsistent penalties	Industry funding, limited government support	Monitoring through local authorities	Promotes waste segregation and recycling	Inconsistent implementation, lack of infrastructure

3R = reduce, reuse, recycle; EIA = environmental impact assessment; EPR = extended producer responsibility; MOEF = Kementerian Lingkungan Hidup dan Kehutanan (Ministry of Environment and Forestry); MOI = Kementerian Perindustrian (Ministry of Industry); MOT = Kementerian Perdagangan (Ministry of Trade); MPW = Kementerian Pekerjaan Umum (Ministry of Public Works); PR = Presidential Regulation; TPS = Tempat Penampungan Sementara (temporary disposal site).

Notes:

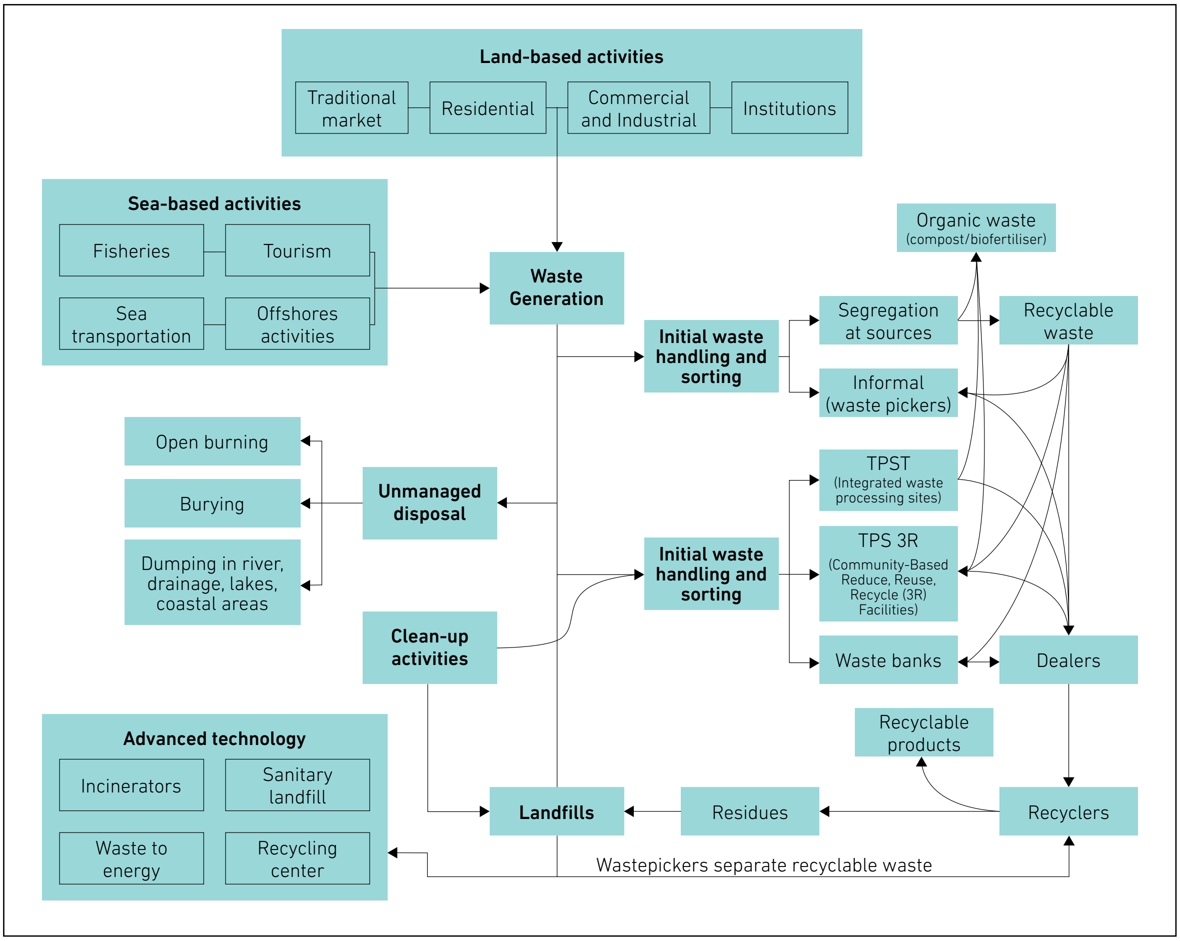
1. 3R is the core principle of waste management promoted in Indonesian regulations to minimise waste generation and maximise material recovery.
2. EIA refers to a mandatory environmental assessment process required for activities or projects that may have significant environmental impacts, regulated under Indonesian environmental law.
3. EPR is a policy approach that assigns producers responsibility for the post-consumer stage of products, particularly packaging waste, including collection, recycling, and environmentally sound disposal.
4. The MOEF is the primary national authority responsible for environmental protection, waste management policy, and enforcement in Indonesia.
5. The MOI is responsible for regulating industrial production, including aspects related to packaging, materials, and producer compliance under EPR schemes.
6. The MOT oversees trade and distribution systems, including the circulation of packaged goods relevant to plastic consumption and waste generation.
7. The MPW is responsible for the administration of public works, including the construction and maintaining large-scale waste management infrastructure.
8. Presidential Regulations are a legal instrument issued by the President of Indonesia to implement laws and define national policies, including those related to waste and marine debris management.
9. TPSs are designated facilities at the local level for temporary collection and storage of municipal solid waste before transportation to treatment or final disposal sites.

Source: Authors' analysis.

2.3.1.2 Data disparities and infrastructure limitations

Plastic waste management is likely to be more effective when interventions are implemented at the source, such as domestic activities. The process of sorting and reducing waste lightens the burden downstream (landfill). The flow of the waste management system in Indonesia is still relatively simple (Figure 13.1). In general, waste from sources from land- and sea-based activities undergoes a process that will generally end up in landfill areas.

Figure 13.1. Waste Management Flow in Indonesia



3R = reduce, reuse, recycle; TPS = Tempat Penampungan Sementara (temporary disposal site); TPST = Tempat Pengolahan Sampah Terpadu (integrated waste treatment facility).

Notes:

1. 3R is the core principle of waste management promoted in Indonesian regulations.
2. TPSs are designated facilities at the local level for temporary collection and storage of municipal solid waste before transportation to treatment or final disposal sites.
3. TPST refers to a decentralised waste management facility designed to process municipal solid waste at or near the source through activities such as sorting, recycling, composting, and other treatment methods, thereby reducing the volume of waste transported to final disposal sites.

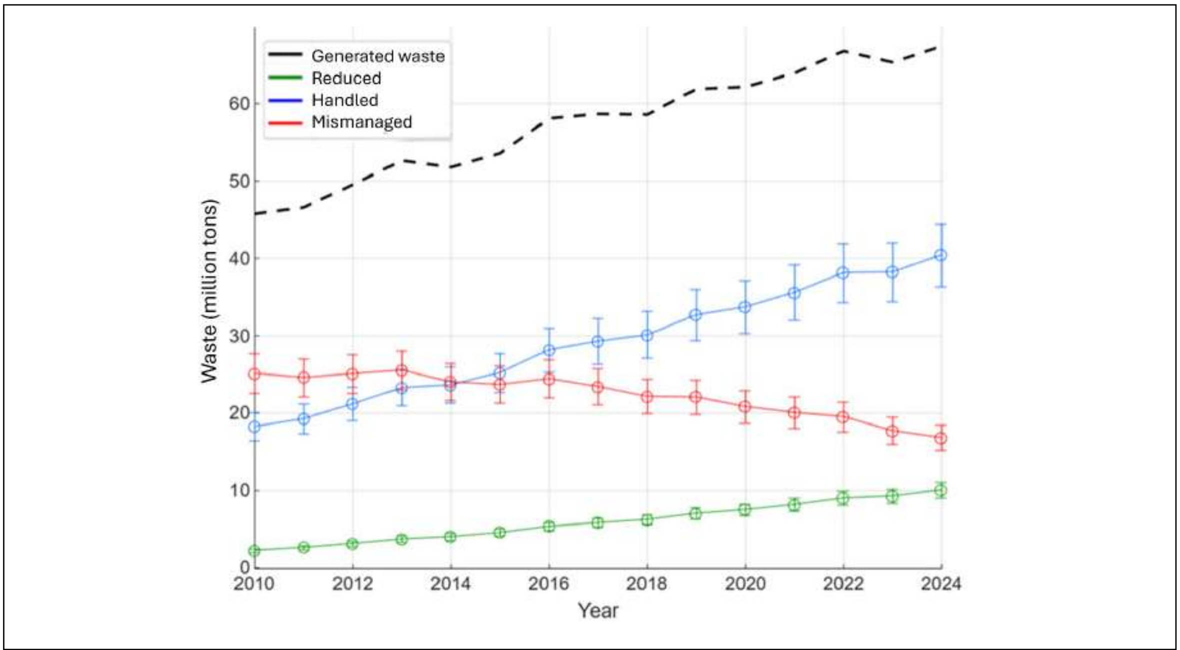
Source: Authors' analysis.

This study found disparities in the data released by several Indonesian government agencies. Data on generated, reduced, handled, and mismanaged waste vary significantly and are inconsistent, depending on the source. These include the Ministry of Environment and Forestry (Kementerian Lingkungan Hidup dan Kehutanan/KLHK), BPS-Statistics Indonesia (BPS), the Ministry of National Development Planning (Kementerian Perencanaan Pembangunan Nasional/Badan Perencanaan Pembangunan Nasional Republik Indonesia), and the Ministry of Health (Kementerian Kesehatan). Data disparities can lead to basic decision-making errors due to inaccurate data. On the one hand, data from the National Waste Management Information System (SIPSN) reported in official documents (Ministry of Environment and Forestry, 2024b; National Coordination Team on Marine Debris Management, 2024) stated that generated waste in 2023 was around 38 Mt. On the other hand, based on data from BPS-Statistics Indonesia (2024), the World Bank (2021), and global studies (Cottom, Cook, and Velis, 2024; Jambeck et al., 2015; Lebreton et al., 2017; Lebreton and Andrady, 2019), generated waste in 2023 was around 70 Mt.

This data disparity is largely attributable to differences in primary data sources and reporting mechanisms. The SIPSN relies on bottom–up data and reporting submitted by regencies and cities, while BPS-Statistics Indonesia calculates top–down data by estimating per capita waste generation. The problem with the SIPSN data is that not all regencies and cities report data completely or consistently every year, so the figures are thought to be underestimated. Moreover, in the SIPSN, data from regency-level authorities are obtained through three different methods. Amongst the three methods used at the regency level, only one method relies on primary sampling data, while the other two use estimation regulated in the SIPSN. The estimations are typically based on the type of city, ranging from small cities to metropolitan areas. Official data from BPS-Statistics Indonesia use a macro-scale approach, calculating per capita waste generation data of 0.7–0.8 kilograms (kg) per day.

In this study, we use data from BPS-Statistics Indonesia's survey calculations that match the context of population and consumption. The data results can be seen in Figure 13.2. We included a 10% standard deviation of the data to reflect the data variation mentioned in BPS-Statistics Indonesia (2024). By 2024, the proportion of municipal solid waste that was formally managed increased to 61.62% of total waste generation (Figure 13.2). The proportion of mismanaged waste declined to 38.38%. This reduction is associated with a decrease in estimated plastic waste leakage into the marine environment, which fell to about 41.97% of total plastic waste in 2023 (Table 13.4).

Figure 13.2. Solid Waste Management Performance in Indonesia, 2010–2024



Note: The dotted black line represents generated waste (Mt); the blue line represents handled waste (Mt); the red line represents mismanaged waste (Mt); and the green line represents reduced waste (Mt).

Sources: Authors' analysis based on Badan Kebijakan Pembangunan Kesehatan (2024); Badan Penelitian dan Pengembangan Kesehatan (2019); BPS-Statistics Indonesia (2024); Indonesia National Plastic Action Partnership, World Bank, and Indonesian Institute of Sciences (2019); Ministry of Environment and Forestry (2024b); World Bank (2021); Shuker and Cadman (2018).

Table 13.4. Solid Waste Composition and Plastic Waste Management in Indonesia, 2010–2023

Year	Solid waste composition (%)									Plastic waste management (million tons)						
	Food waste	Plastic	Green/ Yard	Paper	Textile	Glass	Metals	Leather & rubber	Others	Total plastic waste	Burned	Buried	Disposed to water bodies	Marine plastic leakage	Leakage reduction (%)	Leakage reduction accumu-lation (%)
2010	50.00	12.00	10.00	10.00	4.00	2.00	2.00	2.00	8.00	4.56	1.14	2.28	-	-	-	-
2011	50.50	12.50	10.00	9.50	4.00	2.00	1.80	1.80	7.90	4.94	1.19	2.52	-	-	-	-
2012	51.00	13.00	10.00	9.00	4.00	2.00	1.70	1.70	7.60	5.46	1.26	2.84	-	-	-	-
2013	51.50	13.50	10.00	9.00	4.00	2.00	1.60	1.60	6.80	5.94	1.31	3.09	-	-	-	-
2014	52.00	14.00	10.00	9.00	3.80	1.90	1.50	1.50	6.30	6.44	1.35	3.41	-	-	-	-
2015	53.00	14.50	10.00	9.00	3.80	1.80	1.50	1.40	5.00	6.96	1.39	3.76	-	-	-	-
2016	54.00	15.00	10.00	9.00	3.60	1.80	1.40	1.30	3.90	7.50	1.43	4.05	-	-	-	-
2017	55.00	15.50	9.50	8.50	3.40	1.80	1.30	1.20	3.80	8.14	1.47	4.48	-	-	-	-
2018*	56.00	16.00	9.50	8.00	3.20	1.70	1.20	1.10	3.30	8.80	1.50	4.93	1.06	0.62	-	-
2019	57.00	16.50	9.00	8.00	3.00	1.70	1.10	1.00	2.70	9.57	1.53	5.45	1.05	0.57	8.06	8.06
2020	58.00	16.00	9.00	8.00	2.50	1.50	1.00	1.00	3.00	9.60	1.44	5.57	0.96	0.52	8.06	16.13
2021	50.50	15.00	10.00	10.00	4.00	2.00	1.00	1.00	6.50	9.82	1.37	5.79	0.88	0.44	12.9	29.03
2022	41.60	18.50	11.00	10.00	5.00	2.50	2.10	1.80	7.50	12.16	1.58	7.30	0.97	0.40	6.45	35.48
2023	41.60	18.50	11.00	10.00	5.00	2.50	2.10	1.80	7.50	13.08	1.57	7.85	1.05	0.36	6.45	41.94

* National Coordination Team on Marine Debris Management (TKN PSL) started to estimate the leakage.

Sources: Authors' analysis based on Badan Kebijakan Pembangunan Kesehatan (2024); Badan Penelitian dan Pengembangan Kesehatan (2019); BPS-Statistics Indonesia (2024); Cordova et al. (2023); Indonesia National Plastic Action Partnership, World Bank, and Indonesian Institute of Sciences (2019); Kementerian Lingkungan Hidup dan Kehutanan (2024b); World Bank (2021); National Coordination Team on Marine Debris Management (2022; 2024); Shuker and Cadman (2018).

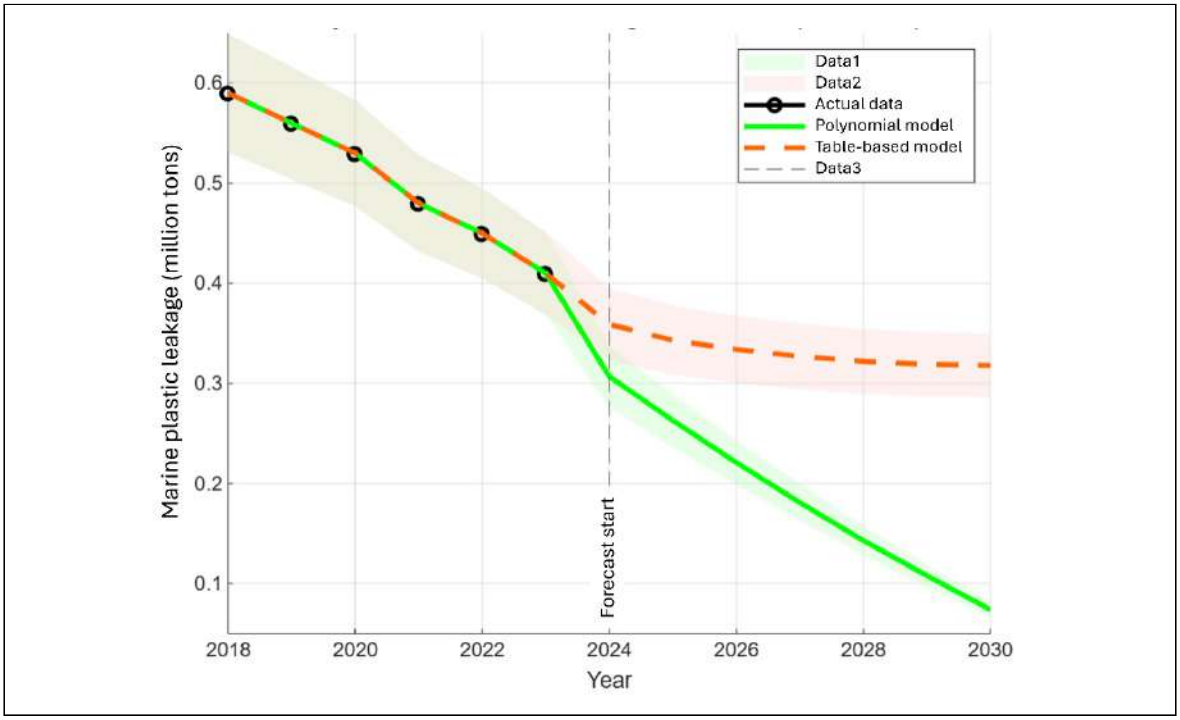
However, the management is not optimal due to the lack of segregation from the source and low waste collection. Waste management infrastructure in Indonesia is insufficient and inequitable. In major cities like Jakarta, waste collection rates are relatively high (96.5%). But in one agglomeration area of Greater Jakarta, rubbish collection rates remain low. Bogor Regency's rubbish collection rate is 41.40%, while Depok's is only 56.22% (Cordova et al., 2024). Indonesia's waste collection rate generally remains between 40% and 60% (Cordova, 2024).

Furthermore, rubbish that reaches landfills is not managed optimally. Empirical data indicate that only 110 out of 550 landfills in Indonesia operate with a sanitary landfill system (Cordova, 2024), with merely around 10% having explicit plans to fully adopt such systems (Cordova, 2024). Meanwhile, overall waste volume reduction remains minimal, at about 1.5% per year (BPS-Statistics Indonesia, 2024), suggesting that landfill improvements have yet to significantly impact national waste reduction efforts (Cordova, 2024).

Another challenge is that the intermediate facilities are not optimal because they still depend on the informal sector, causing a large amount of waste entering landfills.
On the one hand, the informal sector plays a role in collecting, sorting, and selling plastic waste (and other types of waste) that can be recycled and has high value. The contribution of the informal sector is vital to the recycling chain and circular economy. It is estimated that 3.70–5.00 million people work in the informal sector in Indonesia, including waste pickers, collectors, and peddlers. On average, one waste picker can collect 0.5–1.0 kg of recyclable material daily (BPS-Statistics Indonesia, 2024). Recycled products recovered through the informal sector are estimated at 15–16 Mt annually, equivalent to 22% of total national waste (Ministry of Environment and Forestry, 2024b; National Coordination Team on Marine Debris Management, 2024).

On the other hand, the informal sector only collects high-value waste, while the formal sector's capacity to recover low-value waste has not yet developed. This dependence on the informal sector reduces the effectiveness of intermediate processing. As a result, the volume of unsorted waste entering final disposal sites increases. This impacts the estimated leakage of plastic waste entering the sea. The difference is quite significant based on forecasting using a polynomial model (for the optimistic scenario) and a table model (for the business-as-usual scenario). In 2030, the amount of leakage in the business-as-usual scenario will be 76.70% higher than the optimal scenario implementing a progressive policy with fiscal intervention and large-scale policies by the government and international donors (Figure 13.3).

Figure 13.3. Forecast of Plastic Leakage to Indonesian Seas, 2024–2030 Using Polynomial Model (Optimistic Scenario) and Table Model (Business-as-Usual Scenario) (million tons)



Source: Authors' analysis.

2.3.2 Opportunities in waste management

At this critical point to overcome the plastic waste problem in Indonesia, there are various opportunities for improvement. Although several opportunities for improving plastic waste management exist, these have not yet been fully optimised due to fragmented governance and inconsistent implementation strategies. There are at least five significant opportunities: circular economy approaches, public–private partnerships (PPPs), EPR schemes, the role of local communities, and rising social awareness.

2.3.2.1 Circular economy, PPPs, and EPR

As pointed out in Section 1.1, municipal waste in Indonesia is dominated by organic waste (food waste and green waste) and plastic waste. The dominance of these two types of waste can be an opportunity for a circular economy approach.

As an example of a strategy for a circular economy approach to plastic waste, an ongoing initiative is being implemented by PT Perusahaan Listrik Negara (PT PLN), which collaborates with Waste Bank for 'Pay Electricity with Waste' (PT PLN, 2017). This programme aims to encourage waste sorting at the source. Once sorted, the waste is collected and handed over to designated collectors. The programme was initiated with the establishment of the PLN Waste Bank, which allows residents living near local offices to exchange sorted recyclable waste for electricity credits or bill reductions. PT PLN reported that the programme has been conducted since 2017 in cooperation with more than 1,000 waste banks and more than 53,550 customers (PT PLN, 2023). On a larger scale, PT PLN is working with several provinces, cities, and regencies, such as in Bali, East Java, Cilacap, and Jakarta, to develop refuse-derived fuel (RDF) for steam power plants (Rachman and Jelita, 2024; Widyarsana and Saraswati, 2022; Wiharja et al., 2024 However, since the electricity price is cheaper than the economic cost, this programme faces challenges in broadening its coverage (Azis, Kristanto, and Purnomo, 2021; Romaulina and Faturohman, 2024).

PPPs for waste management in Indonesia have significant potential. Despite regulatory, operational, and social challenges, PPPs have made incremental progress despite initial limitations (Amirudin, Inoue, and Grause, 2023; Pahripi and Mahyuni, 2025). The PPP programme in Makassar City has succeeded in addressing odour issues at Tamangapa Landfill (Nahruddin, 2016). The local government implemented the Clean Development Mechanism framework in partnership with Gikoko Kogyo Indonesia. This initiative involves capturing and combusting methane landfill gas from the Tamangapa Landfill. As a result, it positively addresses odour problems and enhances air quality in the surrounding area (Nahruddin, 2016). However, the PPP programmes under way in Pekanbaru and Bandung are still ineffective (Haqq and Gultom, 2022; Harirah, Isril, and Febrina, 2020). If sufficient information about the business cost is disclosed, coordination between the local government and the private sector can be improved.

EPR is a policy approach to hold producers accountable for the entire life cycle of products that can end up as waste, particularly e-waste and plastic waste (Sulami, Murayama, and Nishikizawa, 2018) (see also Chapter 6). EPR can also shift responsibility to producers for the end-of-life management of their products (Sulami, Murayama, and Nishikizawa, 2018). The government needs to support EPR by providing incentives for more sustainable designs and reducing waste generation (Cordova, 2024; Joseph et al., 2024; Ono, Hewage, and Visvanathan, 2023). EPR can thereby force post-consumer product waste management (Ardi and Purwojatmiko, 2019; Simon et al., 2021).

EPR in Indonesia is stipulated in Government Regulation No. 81/2012 and Minister of Environment and Forestry Regulation No. P.75/2019 (Sulami, Murayama, and Nishikizawa, 2023). Both regulations mention the obligation of producers to take responsibility for waste reduction and recycling (Destyanto, Kirana, and Ardi, 2019). However, implementation of the obligation still needs to be developed. PPPs have a role in EPR. EPR combined with community participation can be the key to improving waste management in Indonesia (Budihardjo, Ardiansyah, and Ramadan, 2022; Sulami, Murayama, and Nishikizawa, 2018). A community-based circular economy can encourage initiatives to reduce plastic waste from the source, reuse products, and recycle (Budihardjo, Ardiansyah, and Ramadan, 2022; Pandebesie et al., 2019). An example of refined implementation is the EPR of retail shops, hotels, and restaurants in Bandung City, which have adopted initial steps such as providing non-plastic shopping bags and bioplastic packaging (Arisman et al., 2023).

If EPR is integrated in the national legislative framework, it will be a great opportunity to pursue the circular economy through environmentally friendly design of plastic products (Cottom, Cook, and Velis, 2024; Filella and Turner, 2023). Incorporating EPR into regulations can unify similar programmes at the regional level, facilitating their replication in other areas. This approach also aligns with national objectives concerning eco-design. Furthermore, the successful integration of locally institutionalised EPR within national regulations can yield significant advantages for industry. By adopting environmentally friendly design standards throughout the product life cycle, industry can effectively bridge local practices with national policies, supporting the transition to a circular economy.

2.3.2.2 Social awareness and public understanding

Without active involvement from households, neighbourhoods, and local organisations in activities such as waste reduction, segregation at source, recycling, and monitoring, even the most advanced waste management systems struggle to function optimally (Frigo et al., 2025). In other words, the success of waste infrastructure depends heavily on whether communities are willing and able to adopt responsible waste practices in their daily lives.

One of the most persistent problems in Indonesia lies in insufficient community participation and entrenched behaviours that hinder progress towards sustainable waste solutions. Such behavioural patterns are closely linked to socio-economic conditions. In lower-income communities with limited access to information and lack of environmental education, daily economic pressures often take priority over concerns about waste. As a result, improper disposal practices such as open dumping, open burning, and non-separation of waste remain common (Botelho, 2012; Wilkerson et al., 2018). Furthermore, long-standing habits have been inherited from previous generations whose waste was biodegradable. Their habits are continued despite the significant shift in waste composition towards non-degradable materials such as plastics. Addressing this issue requires not only technical interventions but also targeted efforts to raise public awareness, build community ownership of waste solutions, and design programmes that are sensitive to socio-economic realities.

However, people's willingness to take action, exemplified in the willingness to pay (WTP) for waste management, is uneven due to different economic standards and educational factors. Studies in various regions of Indonesia reveal that the WTP ranges from Rp14,542 to Rp37,800 per month (Table 13.5). In Meureudu City, the estimated WTP for waste management service is less than Rp10,000 (US$0.50) per month (Muhshanati, Azizah, and Abbas, 2023), indicating limited household capacity to financially support formal waste management services. National policies need to be added to increase WTP, e.g. raising public awareness and increasing investment in local infrastructure.

Table 13.5. Willingness to Pay for Waste Management in Indonesia

Location / Population	Average WTP (Rp per month)	Key factors influencing WTP	Socio-economic considerations	Notes	Source
Cikarang Residential	37,800	Awareness, perception, and preferences regarding waste management	Focus on housewives, implying a range of educational levels and household income within the residential area	No significant difference between WTP and the current fee paid (Rp37,350). This suggests the current pricing is aligned with residents' WTP.	(Ismail, 2021)
West Aceh Regency	14,542	Income and public perception of waste management	Lower income may correlate with lower WTP.	No relationship between education and WTP for household waste retribution. There is a relationship between family income and WTP for household waste retribution.	(Amanda, Ichwansyah, and Saputra, 2023)

Location / Population	Average WTP (Rp per month)	Key factors influencing WTP	Socio-economic considerations	Notes	Source
Semarang City	16,838	Education level and length of residency	Higher education leads to increased WTP, suggesting a link between awareness and socio-economic status.	Higher WTP should be accompanied by improved waste management services.	(Bakara and Bowo, 2019)
Meureudu City, Aceh	24,286 (offered), 9,218 (ability)	Education, family size, income, waste management knowledge	Lower income may correlate with lower WTP.	The level of education, number of family members, income, and knowledge of respondents regarding waste management all significantly influence WTP.	(Muhshanati, Azizah, and Abbas, 2023)
Bekasi and Tangerang	33,814 (Bekasi), 34,117 (Tangerang)	Rapid urbanisation and population growth	High population density affects waste generation and management capacity.	Bekasi and Tangerang face challenges due to rapid population growth, increasing consumption, and strain on waste management infrastructure.	(Ismail, Juwono, and Hadikusuma, 2022)

WTP = willingness to pay.

Source: Authors' analysis.

Table 13.6 shows quantitative studies illustrating variances in community involvement in waste management. In Greater Jakarta, while 98% of residents were highly aware of the importance of waste management, only 14% of households sorted waste. The ratio is comparable to the national level: 11%–13% sorted waste for reuse or dispose. If Greater Jakarta, the capital city, has poor public awareness and limited community participation, the situation in small neighbouring cities is likely to be much worse.

Table 13.6. Study of Public Awareness and Participation in Waste Management in Indonesia

City	Province	Year	Aspect	Quantitative indicator	Source
Greater Jakarta	Greater Jakarta	2020	Awareness of importance	98% highly aware	(LIPI, 2020)
Greater Jakarta	Greater Jakarta	2020	Households sorting plastic waste	14% of households sorting plastic waste at home	(LIPI, 2020)
Greater Jakarta	Greater Jakarta	2020	Participation in waste sorting	50% of households dump plastic waste without sorting	(LIPI, 2020)
Gresik	East Java	2020	Participation in waste bank programme	57.5% of waste bank members actively involved	(Rachmah and Purwandari, 2024)

City	Province	Year	Aspect	Quantitative indicator	Source
Bekasi	West Java	2022	Community participation in waste bank management	75% community participation rate in waste bank programme	(Salsabila, Linda, and A'yunin, 2023)
Bekasi	West Java	2022	Low participation despite good knowledge and attitude	96.9% low participation; 50.9% good knowledge and attitude	(Salsabila, Linda, and A'yunin, 2023)
Tanah Putih	Riau	2023	Community willingness to provide waste bins	94% of households willing to provide waste containers	(Fitriani, Windusari, and Putri, 2024)
National	National	2023	Waste sorted and reused	11% nationally	(BPS-Statistics Indonesia, 2024)
National	National	2023	Waste sorted and disposed	13% nationally	(BPS-Statistics Indonesia, 2024)
National	National	2023	Waste disposed without sorting	76% nationally	(BPS-Statistics Indonesia, 2024)
Jakarta	Jakarta	2024	Urban public awareness and participation	Low public awareness and limited community participation	(Safri, 2024)
Bukittinggi	West Sumatra	2025	Impact of employee and community participation on waste management effectiveness	Significant positive influence	(Lanin and Mulya, 2025)

Source: Authors' analysis.

One of the schemes that supports increasing community participation in waste segregation from the source and increasing the collection rate is the waste bank. In Bekasi, Gresik, and Bukittinggi, where waste banks are active, 50%–75% of community members participated in managing waste at the source (Table 13.6). This is because members of the waste bank engage in effective in-home waste segregation practices and facilitate the deposit of recyclable materials, which reduces plastic waste leakage and significantly enhances collection rates from the waste bank. However, this achievement is generally limited to specific areas that receive proper support and governance. National figures show that as the population grows, community involvement decreases. Expanding and enhancing community-based programmes must be linked to government policies to encourage public participation in regional waste management.

3. Discussion

3.1 Rectification of regulatory gaps in waste management

Waste management in Indonesia faces many challenges and opportunities in seeking to preserve Indonesia's natural environment. The key aspect that can be improved is plastic waste management, which is supported by all sectors, from upstream to downstream, under the umbrella of a circular economy (Jang et al., 2020; Kumar et al., 2021; Nyika and Dinka, 2024; UNEP, 2023). Economically, plastic waste management must be supported to eliminate inequality in terms of infrastructure and inconsistent implementation of regulations that the government has designed (Widagdo and Anggoro, 2022; Widyarsana and Saraswati, 2022). National environmental governance regulations need to be integrated into local regulations. The process must involve all stakeholders, including the government, industry, and local communities. Thus, there is a need to strengthen governance frameworks, as existing circular economy regulations often remain fragmented and insufficiently translated into effective implementation. This includes securing the active involvement of all relevant stakeholders across the waste management chain.

The legal framework for waste management needs to support environmental governance. Despite the existence of 17 national and ministerial regulations, more than 100 regional regulations (which were primarily issued at the provincial and municipal levels) have yet to adequately address key challenges in national waste management (Hardi, Senastri, and Wiryani, 2024; Listiningrum et al., 2023; Maskun et al., 2023). Based on the gap analysis in Table 13.3, the main problems are (i) ambiguous, overlapping regulations; and (ii) weak inter-agency coordination in regulatory formulation and implementation.. The ambiguity of regulatory provisions has contributed to low levels of implementation and compliance across multiple administrative levels. An ego-sectoral approach amongst various ministries, agencies, and local governments mars the current regulatory framework surrounding waste management (Ridho et al., 2023). These conditions lead to fragmented and inconsistent policy implementation (Hidayatullah and Sofro, 2024).

One of the consequences is the disparity of waste data in Indonesia (Hidayatullah and Sofro, 2024; Figure 13.2). As mentioned above, official data are not consistent across ministries and agencies (see subsection 2.3.1.2). Regulatory frameworks intended to provide a legal basis for waste management, including EPR and circular economy initiatives, have not clearly specified criteria, delineated obligations, or defined the division of roles amongst stakeholders (Hardi, Senastri, and Wiryani, 2024; Listiningrum et al., 2023; Maskun et al., 2023). Regulations should clarify the roles of the central and local governments or small- or large-scale industries. Even within single agglomerations or provinces, regulatory discrepancies persist. For instance, while the provinces of Bali and Jakarta, alongside over 100 regencies and cities, have enacted bans on single-use plastics in modern markets, traditional markets remain largely unregulated (Cordova, 2024). A lack of stringent sanctions and ineffective oversight from governmental regulators compounds this inconsistency (Arisman and Fatimah, 2023).

Consequently, waste management in Indonesia relies heavily on the efforts of volunteers and communities rather than robust institutional frameworks (Hardi, Senastri, and Wiryani, 2024). Several measures are essential to address these regulatory challenges. Firstly, harmonising and simplifying existing regulations will delineate responsibilities and streamline bureaucratic processes (Kamaruddin et al., 2022; Maskun et al., 2023). Achieving this requires strengthening institutions and enhancing coordination amongst all stakeholders involved in waste management (Amirudin, Inoue, and Grause, 2023; Maskun et al., 2023). Given that local governments serve as the primary agents for waste management, it is crucial to establish Regional Public Service Agency Technical Implementation Units (Unit Pelaksana Teknis Dinas, Badan Layanan Umum Daerah (UPTD BLUD)) that can flexibly manage budgets to address each region's unique characteristics (Purba and Erliyana, 2020).

Secondly, there is a pressing need for stringent law enforcement and consistent oversight (Hardi, Senastri, and Wiryani, 2024; Purba and Erliyana, 2020; Sulistyowati et al., 2023). Implementing effective incentive and disincentive mechanisms across all involved sectors warrants attention (Bachtiar and Andriana, 2024; Purwoko and Wibowo, 2018). For instance, the central government should incentivise regions that successfully innovate in waste management (Budihardjo, Ardiansyah, and Ramadan, 2022; Gall et al., 2020). Similarly, local governments could incentivise producers or industrial consortia to engage in EPR initiatives (Ardi and Purwojatmiko, 2019). The informal sector should also be considered for incentives when it enhances waste collection rates for recycling (Gall et al., 2020). Additionally, imposing strict sanctions on non-compliant regions, producers, or communities will reinforce regulatory adherence (Hardi, Senastri, and Wiryani, 2024).

Effective law enforcement necessitates bolstering technical capacity and funding at the regional level and amongst producers and industry consortia that meet regulatory requirements for EPR and plastic waste management (Cordova, 2020; Hardi, Senastri, and Wiryani, 2024; Purba and Erliyana, 2020). Clarity and consistency in technical guidelines, supplemented by regular training, are imperative for the efficient implementation of regulations (Hidayati et al., 2023; Maskun et al., 2023; Suryani et al., 2023; Taryono and Wulandari, 2021).

Lastly, it is crucial to foster data transparency (Rodríguez-Martín et al., 2020) and public participation (Hinojosa and Thiel, 2009; Rodríguez-Martín, Palomo-Zurdo, and González-Sánchez, 2020; Safri, 2024). Regulatory bodies must publicly disclose comprehensive data regarding implementing incentives, disincentives, and law enforcement activities (Foulon, Lanoie, and Laplante, 2000; Vadlamannati and Cooray, 2015). This level of transparency is vital for evidence-based policymaking (Foulon, Lanoie, and Laplante, 2000). Furthermore, engaging the public in policy monitoring, evaluation, and planning processes will ensure that policies are responsive to genuine community needs (Finnveden et al., 2013; Velichko, Tshovrebov, and Niyazgulov, 2020).

Ultimately, improving waste management in Indonesia requires an integrated and collaborative approach (Frost and Sullivan, 2021). The Indonesian government could focus on cohesive national policies, strong law enforcement, and data-driven decision-making. The industrial sector could reduce its plastic footprint through sustainable practices and investment in recycling infrastructure. Communities could contribute through wise and responsible consumption and waste segregation at the source.

3.2 Bridging the data disparities and infrastructure in waste management

The disparity between the data from the SIPSN and BPS-Statistics Indonesia, apart from being caused by different methods, is also a result of inconsistent data sources (Hidayatullah and Sofro, 2024; Indonesia National Plastic Action Partnership, World Bank, and Indonesian Institute of Sciences, 2019; World Bank, 2021). Data sources involve many stakeholders – from the household and informal sectors to the final facility (Cordova et al., 2019; Ministry of Environment and Forestry, 2024b; National Coordination Team on Marine Debris Management, 2024). As a result, comprehensive monitoring of data flow is challenging.

Because infrastructure and technology are still limited, the data obtained must be improved (Gurney and Shepson, 2021). This would reduce the significant difference between official data and real data in the field. Several strategies are needed to minimise the disparity of waste data in Indonesia. Coordination must be strengthened between government agencies, followed by standardisation of data collection (Han, 2023). All institutions involved in waste management must have clear roles and share data through an integrated system (Han, 2023). The uniformity of methods will prevent duplication or inconsistency of data between agencies. Integrated waste data should be made transparent through a real-time digital reporting platform that enables timely submission, verification, and aggregation of data at the local, regional, and national levels. Such real-time data digitisation can improve the accuracy, consistency, and timeliness of waste data reporting for policy planning and monitoring (Wahyuni et al., 2024). In addition to platforms and integration, high human resources capacity and public involvement are needed for evaluation and audit (Shalash et al., 2022). These efficient and practical steps are expected to minimise the disparity of waste data, with the goal of developing data background for more targeted policy formulation.

The activities of Indonesia's population generate considerable waste but are not accompanied by adequate infrastructure facilities. This variation stems from a shortage of operational funds, which hampers the effective execution of sanitary landfill practices (Wikurendra, Abdeljawad, and Nagy, 2023). Consequently, support from various stakeholders is essential, including significant investments in waste treatment infrastructure, landfill upgrading, and operational capacity at the local level. The opportunity to improve waste management infrastructure requires a holistic approach.

The first step is to obtain accurate data so that the planning is mature and can anticipate the increase in waste volume. The next step is to improve the physical infrastructure. Improving the quality and capacity of infrastructure must be a top priority. The construction of modern landfills that prioritise the implementation of sanitary landfills must be rolled out nationally, accompanied by an increase in the budget. Infrastructure must also start from the source, such as sorting facilities, recycling, and organic waste processing with bioconversion, which must exist at the village or kelurahan (urban village-level administrative unit) level. Waste collection rates must be aligned at every level of regencies and cities to ensure that no waste is left behind. At the final disposal facility, technologies such as waste-to-energy (WtE) and refuse-derived fuel (RDF) should be encouraged to reduce waste volume while generating renewable energy. Based on the data summarised in Table 13.7, we project the requisite waste management facilities required, encompassing waste banks, reduce–reuse–recycle facilities (TPS 3R), integrated waste processing facilities (TPST), sanitary landfills of varying capacities, WtE or incineration plants, RDF production, and recycling facilities.

The estimated waste management aligns with the average operational performance observed across Indonesia. Numerous factors influence investment and operational costs; however, it is critical to assume optimal operational efficiency across all facilities to meet the 100% waste management target, aiming towards Indonesia's zero waste goal by 2040 and zero emissions by 2050. This calls for the expansion and modernisation of extensive waste management infrastructure. Operational efficiency can be enhanced in several ways, including the implementation of the internet of things within smart waste management systems and the improvement of human resources capabilities. Comprehensive standard operating procedures should support this effort. Data collected from smart systems should be overseen by a single agency using a data-sharing platform. Furthermore, smart waste collection systems should engage various stakeholders, including government entities, industry representatives, scientific organisations, and community members. On the other hand, infrastructure for waste management systems that can shift the paradigm from open dumping to sanitary landfills, including WtE, incineration, RDF, and optimal recycling operations, needs to be implemented as soon as possible.

The projected investment required for these initiatives is substantial. According to estimates in Table 13.7, alongside data from the Indonesia National Plastic Action Partnership (NPAP) in 2021, the investment is anticipated to be in the range of US$18 billion–US$20 billion from 2025 through 2044, with annual operational costs estimated at US$1 billion starting in 2040. This initial financial outlay may appear daunting; however, it is a strategically critical investment to mitigate greater economic losses in the future. Based on analyses by Beaumont et al. (2019) and Cordier et al. (2024), the economic repercussions of plastic waste entering oceanic ecosystems range from US$3,300–US$39,753 per ton. Given that Indonesia's average plastic waste leakage into the ocean from 2018 to 2023 is about 484,000 tons, the estimated potential economic loss amounts to US$1.6 billion–US$19.0 billion annually. Although the annual investment required for waste management infrastructure is significant (US$18 billion–US$20 billion), the projected avoided costs (US$1.6 billion–US$19.0 billion annually) indicate that improved systems can deliver meaningful long-term value, both economically and environmentally. Thus, to foster national economic growth, it is imperative to prioritise and not postpone investments that could exacerbate existing waste management challenges and lead to greater losses in the future.

Table 13.7. Facility Needs and Estimated Investment for Waste Management Infrastructure in Indonesia

Facility	Current condition	Estimated number needed	Estimated waste managed (per unit)	Investment value (US$/unit)	Estimated total cost (US$/year/unit)
Waste bank	About 13,000 units	50,000	0.1–0.5 tons/day	1,000	500
Reduce–reuse–recycle facilities (TPS 3R)	Around 2,000 active units	5,000	1–5 tons/day	10,000	5,000
Integrated waste processing facilities (TPST)	Less than 100 large-scale units	5,000	1–5 tons/day	10,000	5,000
Sanitary landfill small	In progress in several locations	250	100–500 tons/day	500,000	50,000
Sanitary landfill medium	In progress in several locations	100	500–2,000 tons/day	1 million	100,000

Facility	Current condition	Estimated number needed	Estimated waste managed (per unit)	Investment value (US$/unit)	Estimated total cost (US$/year/ unit)
Sanitary landfill large	In progress in several locations	50	2,000 tons/ day	5 million	250,000
Waste-to-energy/ Incineration plant	5–7 pilot and planned units (mainly in major cities)	50	1,000–5,000 tons/day	10 million	1 million
Refuse-derived fuel	5–6 operational out of 34 targeted facilities	50	500–2,000 tons/ day	10 million–20 million	1 million
Recycling facility	40+	250	10–100+ tons/ day	1 million	500,000

Sources: Authors' analysis based on Badan Kebijakan Pembangunan Kesehatan (2024); Badan Penelitian dan Pengembangan Kesehatan (2019); BPS-Statistics Indonesia (2024); Cordova et al. (2023); Indonesia National Plastic Action Partnership, World Bank, and Indonesian Institute of Sciences (2019); Ministry of Environment and Forestry (2024b); World Bank (2021); National Coordination Team on Marine Debris Management (2022; 2024); Shuker and Cadman (2018).

It should be noted that the substantial investment required poses a significant challenge, particularly given that WTP amongst the Indonesian population remains relatively low, ranging from Rp14,542 to Rp37,800 per month (Table 13.5). To achieve optimal waste management through enhanced services and infrastructure modernisation, WTP needs to increase to Rp98,971–Rp123,382 per month (Suryani, 2022).

However, this increase to the optimal level cannot be achieved overnight. It is projected to take 5–10 years, contingent upon several factors. These include robust economic growth and tangible improvements in waste management quality during the first 3 years. During this period, it is also crucial to enhance the foundational quality of waste management and strengthen waste banks, TPST, and TPS3R. In years 3–5, a flexible payment system should be implemented alongside transparency in the utilisation of retribution funds. Community involvement is also essential, emphasising mutual education and a widespread public awareness campaign. In the fifth year, it is expected that WTP will increase to around Rp50,000–Rp60,000 per month. In years 6–10, the focus should be on consolidating regulatory enforcement while optimising technology-based services and diversifying waste management solutions. By the tenth year, it is expected that WTP will have increased to around Rp100,000–Rp125,000 per month. Throughout the entire decade, it has been vital to conduct periodic evaluations of tariffs and services, adjusting them to be in line with economic conditions, WTP, and public satisfaction levels.

3.3 The role of community behaviour and non-technical aspects in sustaining waste management infrastructure

Sustainable waste management infrastructure in Indonesia is shaped not only by technical innovations and physical systems, but also by the behaviour of communities and various non-technical factors (Ratnasari et al., 2023). While engineered solutions, such as sanitary landfills, material recovery facilities, and WtE plants, are critical, their effectiveness is deeply influenced by how communities interact with these systems. Community behaviour, public awareness, institutional capacity, regulatory frameworks, and financial willingness all play vital roles in determining whether waste infrastructure can function sustainably over time (Mukhtar, Williams, and Shaw, 2018). In a country as diverse and complex as Indonesia, where geographical, cultural, and economic conditions vary widely, these non-technical elements are especially important in shaping outcomes and achieving national targets such as zero waste by 2040 and zero emissions by 2050.

Indonesia currently faces a range of challenges that reflect this dynamic. In many parts of the country, communities continue to practice open dumping, open burning, and indiscriminate waste disposal. These habits often stem from traditions passed down through generations, when most household waste was organic and could decompose harmlessly (Suwarno and Nurhayati, 2021). Today, with the rise of plastic and other non-biodegradable materials, these inherited practices contribute significantly to environmental pollution and strain existing waste infrastructure. Waste separation at source remains uncommon, and even where formal collection systems exist, public participation is often weak. Non-technical factors such as limited funding for community outreach, weak enforcement of regulations, poor institutional coordination, and minimal integration of the informal sector further undermine efforts to improve waste management. As a result, many disposal facilities across Indonesia operate beyond capacity, with limited maintenance and inadequate community support. At the same time, the informal sector, despite playing a critical role in recycling and resource recovery, remains undervalued and poorly integrated into formal waste management strategies, resulting in inefficiencies and lost opportunities for sustainable resource use (Aprilia, 2021).

In the short term, Indonesia can take several steps to address these issues. Public education campaigns should be intensified, focusing on culturally appropriate messaging that resonates with local communities and emphasises waste reduction, segregation, and responsible disposal. Community-based pilot programmes, such as waste banks, TPS3R, TPST initiatives, and local composting schemes, can build local ownership and demonstrate good practices at the grassroots level (Zhang et al., 2024). Local governments need to strengthen enforcement of existing regulations by combining penalties for illegal dumping with incentives for sustainable community practices. Quick upgrades to existing infrastructure, such as converting uncontrolled dumpsites into controlled or sanitary landfills, can provide immediate improvements while paving the way for larger-scale investments.

For long-term sustainability, Indonesia must pursue deeper systemic changes. Waste education should be embedded within school curricula to shape the attitudes of future generations and encourage lifelong sustainable behaviours. Governance frameworks that integrate national, provincial, and local levels of government are essential to ensure consistency in policy, effective coordination, and community engagement (Suryawan and Lee, 2023). Formalising and supporting the role of the informal sector, through training, protections, and inclusion in municipal waste strategies, can improve recycling rates and create better livelihoods. Investments in institutional capacity – such as government staff training, long-term funding mechanisms for community programs, and private sector partnerships – are equally critical. Research and innovation should also be encouraged to better understand socio-cultural drivers of waste behaviour and to pilot test technologies tailored to Indonesia's diverse conditions.

3.4 Closing the waste management loop in Indonesia

The plastic waste management challenge in Indonesia is multifaceted, extending beyond overlapping regulations and infrastructure shortcomings. A robust solution necessitates cross-sectoral collaboration that effectively integrates environmental goals with public health initiatives (Safri, 2024). The government must lead in spearheading efforts to mitigate plastic pollution, thereby safeguarding both ecosystems and community health.

As Indonesia progresses towards developed status, adopting blended finance mechanisms is critical for enhancing the flexibility of funding inclusive programmes (Clark, Toftner, and Bendixen, 1971; Iacovidou et al., 2025). Such a financial strategy could effectively intertwine EPR frameworks with PPPs to facilitate the transition to a circular economy in a holistic manner (Iqbal et al., 2023). This type of transition is inherently capital-intensive and relies on collaborative engagements across various sectors and stakeholders (Ezeudu and Bristow, 2025). Through collaborative investment approaches, PPPs can significantly contribute to blended finance, enabling co-investment models that amplify resource mobilisation (Ezeudu and Bristow, 2025; Iqbal et al., 2023). Conversely, EPR regulations can be implemented by industries or producers, as evidenced by successful initiatives in countries like Russia (Gubernatorov, Tutukina, and Stepanova, 2021). In these systems, tariffs and budget allocations are complemented by private sector investments, showcasing the efficacy of the PPP model (Arbulú, Lozano, and Rey-Maquieira, 2016; Gubernatorov, Tutukina, and Stepanova, 2021; Haqq and Gultom, 2022).

Indonesia could draw lessons from Tanzania, a developing nation that has successfully leveraged blended finance mechanisms (Ilomo and Charles, 2025). Globally, financing models that incorporate income recycling, composting, and private investment often surpass government funding in effectiveness (Ilomo and Charles, 2025). However, it remains crucial to acknowledge that government financing is still the predominant model employed across developed and developing nations (Addo et al., 2020; Ilomo and Charles, 2025). In Indonesia, waste management responsibilities are primarily decentralised to regencies and municipalities, often leading to budgetary constraints (Aprilia, Tezuka, and Spaargaren, 2011; Cordova, 2024; Damanhuri, 2008; Listiningrum et al., 2023). A blended finance approach has the potential to address these local challenges effectively. It can help to fund WtE projects (Yong et al., 2019), waste banks, and TPS3R (Hakim and Hidayati, 2023; Rahmadhani, Aziz, and Indah, 2024), thereby enhancing investments in sustainable waste management technologies. Moreover, blended finance can play a pivotal role in integrating renewable energy systems within waste management operations, yielding economic and environmental benefits. Waste banks and TPS3R initiatives supported by this financing model could empower local communities while promoting more sustainable waste management practices.

Despite the potential of blended finance, its successful implementation must carefully consider regulatory frameworks that align with stakeholder needs and technology integration within existing systems (Ezeudu and Bristow, 2025; Faiz et al., 2024; Amalin and Rachman, 2019). Equally important is the need to address socio-cultural dynamics and enhance the knowledge base of local communities (Saravani et al., 2021). There exists a degree of resistance to adopting improved waste management practices (Chandrappa and Das, 2024). This underscores the necessity for adequate socialisation and education strategies that can overcome cultural barriers (Chandrappa and Das, 2024). In summary, any advancement in waste management in Indonesia requires a comprehensive strategy encompassing the reinforcement of the institutional framework, infrastructure development, and heightened public education and engagement initiatives.

4. Conclusion

Reviewing and managing plastic waste in Indonesia is a crucial undertaking that requires a holistic approach. It is essential to recognise that the mixed waste produced by the Indonesian population has not yet been effectively managed. The challenges of waste management in Indonesia complicate governance, with overlapping regulations, poorly recorded data, unintegrated industries, and general resistance to changing habits.

Indonesia has initiated efforts to reduce waste leakage and combat environmental pollution. While dozens of national regulations and numerous local laws exist, they are not yet fully leveraged to enhance waste management on a national scale. Community involvement remains a significant hurdle, as waste sorting is not performed at the source, and collection rates at local levels are still lacking. Moreover, waste management is not recognised as a basic service in existing regulations, and local governments face budgetary constraints while the community's willingness to invest in solutions falls short. The complexity of managing waste is exacerbated by the lack of environmentally friendly technological innovations, with much of the waste ending up in landfills through open dumping and inadequate infrastructure, leading to improper disposal.

Despite these challenges, efforts are ongoing to transform waste management in Indonesia. The path forward lies in policy reform, technological innovation, and community engagement, all supported by blended finance for inclusive waste management. A holistic approach is vital, integrating measurable policies and strengthening institutions between national and local governments. Policy reform could become the cornerstone for financing circular economy initiatives. Engaging the community and industry through PPPs and EPR will help distribute waste management infrastructure evenly throughout the country. A comprehensive waste management strategy requires active community involvement to ensure transparency and accountability while respecting regional social and cultural values.

The journey towards improving waste management will not be easy, but we can create a sustainable future with commitment and a long-term vision. The time for progress is now. By acting decisively and optimally, we can secure a better and cleaner environment for future generations.

Terms

- Circular economy: An economic system aimed at minimising waste and making the most of resources. In the context of plastics, this involves reducing plastic consumption, reusing plastic products, recycling plastic waste, and recovering energy from non-recyclable plastics.
- Extended producer responsibility: A policy approach where producers are given significant responsibility, financial and/or organisational, for the treatment or disposal of post-consumer products.
- Mismanaged waste: Waste that is improperly managed or disposed of, increasing the risk of leakage into oceans, rivers, and land ecosystems (e.g. uncollected waste, open dumping, and leakage from landfills).
- Marine plastic pollution: The accumulation of plastic waste in oceans and coastal areas, where it harms marine ecosystems, wildlife, and human health through physical damage and chemical contamination.
- Plastic pollution: The accumulation of plastic waste in the environment (land, water, and air), which has adverse effects on wildlife, habitats, and human health.
- Waste management hierarchy: The prioritisation of waste management practices, typically in the order of prevention, minimisation, reuse, recycling, energy recovery, and disposal.
- Willingness to pay: The maximum price paid for a service, service, or product. In this case, payment for services in waste management sector.

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Chapter 14

People-Led Plastic Reduction in a Landlocked Nation: Drivers of Waste Management in the Lao PDR

Valy Phommachak

1. Introduction

1.1 Economic structure and plastic pollution in the Lao PDR

The Lao People's Democratic Republic (Lao PDR) is the only landlocked country amongst the Member States of the Association of Southeast Asian Nations (ASEAN), bordered by five nations and traversed by the Mekong River (UNIDO, 2020). With a total land area of 236,800 square kilometres, it is classified as a lower-middle income country and a least developed country, with graduation expected in 2026 (Government of the Lao PDR, Ministry of Foreign Affairs, and LDC Secretariat, 2024).

According to the World Bank's Lao PDR Economic Monitor, published in May 2025, the nation's economy is primarily driven by sturdy achievement in the services sector, followed by electricity generation, mining, agriculture, and some manufacturing (World Bank, 2025). Within these sectors, micro, small, and medium-sized enterprises are the dominant enterprises in the Lao PDR.

In recent years, the Lao PDR's economy has expanded moderately, with a reported growth rate of about 4.1% in 2024, supported by strong contributions from the services, mining, agriculture, and manufacturing sectors, including rising tourism and infrastructure investment, which is contributing to changing consumption patterns and increased waste generation in the country (World Bank, 2025). As a result of changing lifestyles over the past 2 decades, household waste generation has nearly doubled and plastic accounts for about a quarter of the total waste (World Bank, 2022c). In 2022, the Global Green Growth Institute (GGGI) and the Government of the Lao PDR reported that plastic waste was the second largest of all wastes collected in Vientiane, the capital city of the Lao PDR. This reflects the urgent need to address plastic pollution (Government of the Lao PDR, 2022).

While plastic waste in the Lao PDR has increased alongside economic growth (Noudeng et al., 2024), the country continues to face major challenges in managing this issue. Key challenges are the limited waste management infrastructure, as only 40%–60% of waste is normally collected (Vongthavilay, Rawlins, and Sattler, 2022); the financial and technical constraints that lead to an under-regulated and underdeveloped waste management system (WWF, 2024a); heavy reliance on the informal sector; and gaps in public awareness and policy enforcement (Bengtsson and Long, 2022).

1.2 From a landlocked country to Sea: the Lao PDR's Plastic Pollution Contribution via the Mekong

Although the Lao PDR is a non-coastal country, its extensive 1,900-kilometre stretch of the Mekong River connects the nation directly to marine ecosystems. This vital waterway flows through six countries before emptying into the South China Sea, making the Lao PDR an important contributor to transboundary plastic pollution. Meijer et al. (2021) identified the Mekong River as one of the world's most significant plastic-emitting rivers. Their research showed that a relatively small group of rivers, including the Mekong, are collectively responsible for most of the plastic transported into the ocean. Moreover, according to Schmidt, Krauth, and Wagner (2017), the Mekong River ranked amongst the world's top 10 plastic-emitting rivers, with an estimated annual load of around 33,000 tonnes of microplastics and over 3,300 tonnes of microplastics entering the ocean each year. In the Lao PDR, due to the limited and underdeveloped solid waste management infrastructure, substantial amounts of plastic waste enter the river system on a regular basis, contributing to the issue of marine debris in the region (Noudeng et al., 2024). This highlights that, despite being a landlocked country, the Lao PDR's waste leakage into the Mekong River contributes to transboundary marine plastic pollution.

Furthermore, Nguyen et al. (2023) highlighted that Southeast Asia is one of the largest contributors of plastic waste entering the ocean, with river systems such as the Mekong River playing a significant role in transporting land-based plastic pollution into marine environments. The study used ocean current modelling to trace the movement of plastic waste discharged from the Mekong River, revealing that the coastlines of Indonesia and the Philippines are amongst the most heavily affected due to the influence of seasonal drift patterns. These findings highlight the complex and far-reaching nature of plastic pollution, where waste generated in one country can travel across vast distances and impact ecosystems and communities in other nations. In this context, plastic waste originating in the Lao PDR and other upstream countries not only causes environmental harm within their national boundaries but also contributes to a larger transboundary crisis that affects regional marine biodiversity, fisheries, tourism, and coastal livelihoods.

To corroborate the statement that the Lao PDR is one of the main contributors of plastic waste to the Mekong River, and eventually to the oceans, the World Bank has reported that plastic waste is scattered across the country (World Bank, 2022c). The World Bank also found that in six cities in the Lao PDR, 95% of the waste consists of single-use plastic (SUPs), with the tourism and hospitality sectors identified as key contributors. By 2035, it is projected that 1.4 million tons of waste will be generated per year, up from about 910,000 per year in 2020 (World Bank, 2022b). This dataset illustrates how plastic pollution plays a major role in environmental issues in the Lao PDR and is likely to increase in the future if current patterns of plastic use and disposal continue.

The most recent data from an interview with Vientiane City Office for Management and Service, reported in a Facebook news article by Lao Youth Radio on 11 July 2025 (Lao Youth Radio FM 90.0 Mhz, 2025), revealed that the city alone generates 711 tons of household waste per day, with only 450–500 tons being collected and transported to the landfill located 32 kilometres from the city centre. Based on a 2020 study by GGGI, which found that plastic waste accounts for about 27% of the total wastes in the landfill, it can be estimated that up to 135 tons of plastic waste per day are disposed of in the landfill (Government of the Lao PDR, 2022).

To address these issues, the Lao PDR has committed to and participated in various international cooperation efforts in the Mekong River region, aiming to tackle environmental challenges, including plastic pollution in the river. These collaborations include the following:

(i) The Lao PDR has engaged in regional efforts to combat plastic debris issues, such as (a) a memorandum of understanding with Cambodia in September 2024 to address plastic pollution in the Mekong River, focusing on reducing cross-border waste and enhancing environmental cooperation; and (b) the CounterMEASURE Project, where the country collaborates with the United Nations Environment Programme (UNEP) and other Mekong countries, aiming to identify and manage plastic pollution sources in the river (Ousa, 2024).

(ii) The Mekong River Commission (MRC), comprising the Lao PDR, Cambodia, Thailand, and Viet Nam, has led coordinated efforts in monitoring and managing plastic pollution across the basin. In 2022, the MRC adopted and pilot tested three standardised monitoring protocols under its Riverine Plastic Monitoring Programme, which are now being integrated into its Water Quality Monitoring Network. These protocols cover (a) riverine macroplastic monitoring, which tracks larger plastic debris using nets and traps; (b) riverine microplastic monitoring, which analyses water samples for small plastic particles (< 5 millimetres), and (c) microplastic ingestion in fish, which assesses microplastic contamination in aquatic species as indicators of ecosystem and food chain impacts. These protocols are implemented by national agencies across member countries, with support from regional and international partners, to ensure consistent, comparable data for long-term plastic pollution monitoring and policy development (International Network of Basin Organizations, 2024).

(iii) The Lao PDR is a member of the Mekong Plastics Innovation Alliance, which is part of the larger Indo-Pacific Plastics Innovation Network (IPPIN). This platform connects innovators, researchers, and entrepreneurs across Mekong countries to co-develop scalable solutions for plastic waste reduction through technology, design, and policy innovation.

1.3 Key policy instruments for solid waste management in the Lao PDR

This chapter first explores the Lao PDR's policy development at the national level, highlighting the legal and institutional frameworks guiding waste management and plastic waste reduction. It then turns to the critical role of local initiatives, which demonstrate how community-based action, innovation, and partnerships are shaping practical approaches to sustainable waste management in a landlocked context. It highlights initiatives spearheaded by local non-governmental organisations, grassroots foundations, social enterprises, and international organisations working closely with communities across the country. By focusing on these actors, the chapter aims to illustrate how localised leadership, community engagement, and innovative partnerships are shaping more sustainable approaches to plastic reduction and waste management in a landlocked, resource-constrained context like the Lao PDR.

A national solid waste management law has not yet been enacted. Acting like an umbrella to control all actions that might affect the environment, Environmental Protection Law No. 29/NA 2013 requires individuals or organisations that potentially emit pollutants to undertake measures to prevent environmental degradation resulting from the emission of pollutants, including waste (Article 25). Other guidelines include the Guideline on Solid Waste Management and Elimination (No. 0233 dated 20 January 2020) from the Ministry of Natural Resources and Environment (MONRE), renamed the Ministry of Agriculture and Environment (MAE), which provides a comprehensive framework for implementing recommended practices in all sorts of solid waste management, including plastic wastes; the Guideline for Plastic-Free Meeting(UNDP, 2024a); and the Guideline for Waste Banks, which is being developed. These guidelines represent proactive policy tools that lay the groundwork for future national legislation and help build a culture of responsible waste management across the Lao PDR.

Despite the absence of a waste management law, progress has been made at the sub-national level. In 2021, the Sustainable Solid Waste Management Strategy and Action Plan for Vientiane 2021–2030, developed by the Vientiane Capital government with technical support from GGGI, was officially endorsed by the Vientiane Capital government (Government of the Lao PDR, 2022). The strategic plan includes the following:

(i) A section outlining the current situation and knowledge related to solid waste management in Vientiane Capital, such as the types and sources of solid waste, waste collection rates and service areas, waste management facilities, methods and vehicles used, solid waste from medical settings, waste management fees, and challenges in management.
(ii) Vision and strategy for sustainable waste management until 2023 defined by six strategic outcomes, including full-access waste collection, waste-to-resource practices, reduced generation, operational efficiency, and decent informal sector jobs.
(iii) Work plan and activities from 2021 to 2030, with medium- and long-term targets to support continuous progress.
(iv) Implementation mechanism.

This action plan focuses on the leading role of Vientiane as a capital city and the Vientiane City Office for Management and Service, working collaboratively with district and village administration. The aim is to ensure sustainable public services to achieve the goal of being a clean, green, and liveable city.

Furthermore, in August 2024, MAE officially endorsed the National Plastics Action Plan for Lao PDR 2024–2030 (NPAP), which is aligned with the 9th Five-Year National Socio-Economic Development Plan (2021–2025) and places high priority on controlling plastic pollution. The plan was developed with the support of the World Bank, which has also played a leading role in conducting studies and producing reports on waste management and plastic pollution in the Lao PDR. It also contributes to the broader goals of the National Green Growth Strategy through 2030 and the Natural Resources and Environment Strategy (2016–2025), reflecting the country's firm commitment to sustainable environmental practices. From the international perspective, the NPAP aims to support international sustainability efforts by contributing to Sustainable Development Goal (SDG) 12 (responsible consumption and production) and SDG 14 (life below water). It also aligns with the Bangkok Declaration on Combating Marine Debris in ASEAN, adopted by all ASEAN Member States at the 34th ASEAN Summit on 22 June 2019, which requires no separate ratification procedure.

The NPAP consists of four work plans:

(i) Work plan 1: create and improve regulations, rules, policies, and guidelines to manage and reduce plastics, including encouraging businesses and producers to be more responsible.
(ii) Work plan 2: encourage awareness raising for people and businesses in reducing the use of plastics, reuse, and segregation of plastic wastes.
(iii) Work plan 3: encourage and support the reduction of SUP usage as much as possible by improving plastic waste collection, segregation, and transportation systems; by increasing the recycling rate; and by encouraging the use of alternative items.
(iv) Work plan 4: create management, monitoring, and assessment systems to implement the work plans.

The NPAP has three expected outputs: (i) an improved plastic management system and reduced pollution, (ii) a clean and sustainable environment through improved resource use, and (iii) a low-carbon community based on a circular economy.

Several international organisations have supported policymaking for plastic pollution countermeasures in the Lao PDR. Since 2021, the World Bank has published nine reports focusing on the analysis of solid waste management in the country. The World Bank is one of the leading organisations paving the way to tackling plastic pollution in the Lao PDR. Its publications include assessments of waste management infrastructure, collection practices, financing mechanisms, plastic flow analysis, stakeholder mapping, policy evaluations, and the environmental and social impacts of landfills (Table 14.1). Many of these studies also contributed to the development of the NPAP.

Table 14.1. World Bank Studies and Reports Related to Waste Management and Plastic Pollution

Title of the study/report	Year published	Focus of the study/report
Supporting the Lao PDR to Improve Solid and Plastic Waste Management	2021	Infrastructure, waste collection practices, financing
Plastic Diagnostics (Plastic Action Plan support)	2021	Analysis of plastic flow, items, stakeholder roles
Plastic Policy Report (Plastic Action Plan support)	2021	Evaluates policy options for NPAP
Get Clean and Green – Solid & Plastic Waste Management in Lao PDR	2022	National diagnostic, recommendations on how to better control solid waste, and actionable roadmap
Pre-Feasibility Study: Waste Management Infrastructure	2022	System design and engineering investment options
Plastic Waste Environmental & Health Impacts – Press Coverage	2022	Summarises major findings on plastic pollution in Lao cities
Behavioral Insights to Reduce Open Waste Burning in Lao PDR Behavioral Insights and Policy Options	2022	Uses the behavioural method to assess open burning in the Lao PDR
The Lao PDR Pollution and Waste Management Project Pre-ESIA/Feasibility Report	2023	Detailed environmental and social impact study of Vientiane landfill
World Bank Press Release: Pollution and Waste Management Project Approval	2025	Announces project and its scope in the Lao PDR

Lao PDR = Lao People's Democratic Republic; NPAP = National Action Plan on Plastic Management for Lao PDR, 2024–2030;PWMP = Lao Pollution and Waste Management Project; Pre-ESIA = preliminary environmental and social impact assessment.

Source: Author's compilation based on World Bank publications and press releases, 2021–2025.

The United Nations Development Programme (UNDP) supported the Department of Environmental Promotion under MAE in developing and publishing the Plastic-Free Meeting Guideline in 2021, which aims to guide offices across all sectors, government, state enterprises, and private organisations in reducing the use of SUPs during meetings and daily operations. It provides practical recommendations, including a list of SUPs commonly used in meetings, along with suggested sustainable alternatives; recommended actions to minimise SUP use in office settings, promoting more sustainable practices; and waste segregation practices, encouraging proper sorting and management of waste to support recycling and reduction efforts (UNDP, 2022).

In addition, in December 2025, the Department of Environment and Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), in collaboration with the Department of Environment (DOE), MAE, and a technical team from Econox Laos, developed the Guideline for Establishing Recycle Waste Banks in Lao PDR. This national guideline aims to provide a standardised framework for all sectors, particularly local communities and schools, to establish and manage their own waste banks. The initiative supports sustainable waste management by equipping the DOE with practical tools and training modules to build the capacity of target groups – local communities and offices in all sectors – enabling them to implement and sustain community-based waste bank systems effectively (Ministry of Agriculture and Environment, 2025).

1.4 Local and national challenges

The major challenge the Lao PDR is facing is the nationwide inefficient solid waste management system, especially in rural areas where infrastructure is lacking. This inadequacy includes a shortage of service providers, insufficient waste management facilities such as sustainable landfills, limited knowledge and awareness about solid waste management, and financial constraints (Tomio et al., 2023).

In the Lao PDR, especially in rural areas, the absence of formal waste collection services compels local people to resort to open dumping and burning of waste. A World Bank study in 2022 on 1,900 Lao citizens indicated that about one-third of Lao households lack access to waste collection services, leading to widespread open burning practices, as 53% of respondents who did not have waste collection services were found to depend on open burning methods. This study also showed that 18% of the people who burn their waste attributed this behaviour to a lack of knowledge, reporting that they did not know how to access services, did not believe they needed them, or were unaware of the harmful effects of burning waste. Importantly, this group was predominantly composed of young, less educated individuals living in rural areas, indicating that public awareness is notably low in those regions (World Bank, 2022a).

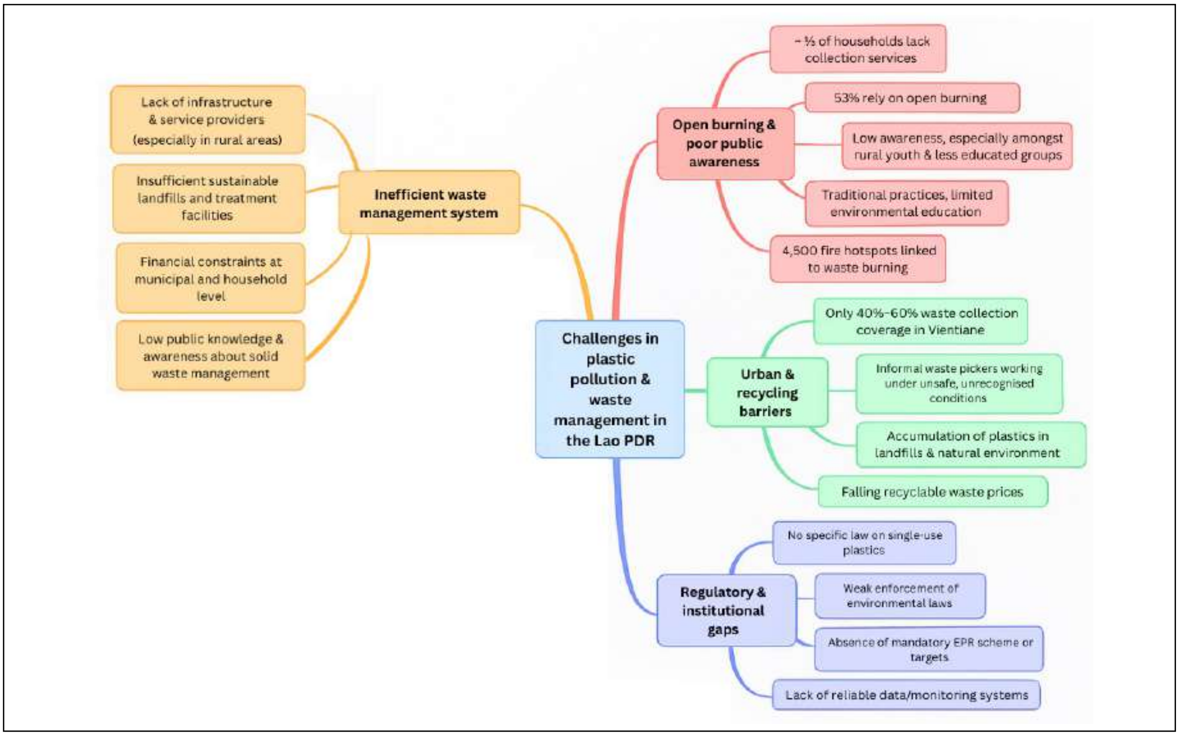
A UNDP report in 2020 found that up to 4,500 fire hotspots were recorded towards the end of 2020, many of which were strongly linked to the open burning of solid waste by local villagers in Vientiane Capital (UNDP, 2020). These reports indicated that public awareness of proper waste management practices is generally low, particularly in rural areas. Traditional practices and limited environmental education contribute to behaviours such as littering and open burning (Tomio et al., 2023). The urgent need to strengthen law enforcement and regulatory frameworks, awareness campaigns, and community engagement are important to shift these behaviours towards more sustainable practices.

Urban areas, while better served, still face challenges that hinder effective actions on waste collection, household-level waste segregation, and recycling. For instance, in Vientiane Capital, waste collection coverage is estimated at 40%–60%, leaving a significant portion of waste uncollected (Vongthavilay, Rawlins, and Sattler, 2022). Although junk shops in Vientiane continue to purchase recyclable materials, a local non-governmental organisation has reported that they are facing declining prices, particularly for plastic waste, because some factories in neighbouring countries have stopped accepting these materials (Green Vientiane, 2025a). As a result of new restrictions on exporting waste to Thailand and Viet Nam, less recyclable material is being collected and sent to sustainable destinations, leaving tons of plastic waste piling up in landfills and scattered in the natural environment (Green Vientiane, 2025a).

Landfills in the Lao PDR are typically open, unsustainably managed sites, lacking proper lining, leachate collection, or treatment systems. It is common to see informal waste pickers living and working within these landfills, often under unsafe, unsanitary conditions and without adequate protection – posing risks to their health and safety (Tasaki, Rawlins, and Vongthavilay, 2024). Consequently, much of the solid waste in the Lao PDR ends up scattered across natural landscapes, farmlands, and roadsides, posing threats to public health (World Health Organization, 2024). This leads to soil and water contamination, as well as air pollution from uncontrolled fires. In addition, municipalities often lack the financial resources to invest in necessary waste management infrastructure and services. The cost of waste collection services can be a burden for local villagers, leading to low participation rates. Innovative financing mechanisms and increased investment are needed to expand and improve waste management systems (Environment Protection Fund, 2025).

Another challenge closely linked to waste management and plastic pollution is the informal waste picker sector, which is the main driver of the flow of recyclable waste in the Lao PDR. According to a World Bank study (Tasaki, Rawlins, and Vongthavilay, 2024), informal waste pickers in Vientiane capital play a vital role in recycling, recovering plastics, and reducing landfill waste, yet they remain largely informal, without legal recognition or safe working conditions. Globally, informal pickers account for up to 95% of plastics recovered in some urban settings, despite facing precarious health risks and lacking policy inclusion. Experts emphasise that integrating them through cooperatives or extended producer responsibility (EPR) schemes could enhance the efficiency of waste management systems and improve livelihoods (UNDP, 2023). Hence, in the Lao PDR, there is an urgent need to improve the working conditions of informal waste pickers, as well as to create legislation that recognises and supports them.

Figure 14.1. Challenges in Plastic Pollution and Waste Management in the Lao PDR



EPR = extended producer responsibility.

Source: Authors, based on Sections 1–4.

The lack of specific laws and regulations to control the import and use of SUPs allows businesses and consumers to use them freely without restriction (Bengtsson and Long, 2022). Although the business sector is the main contributor to SUP pollution (Swisscontact, 2024), the Lao PDR does not yet have formal EPR legislation, and no mandatory obligations or targets are in place for producers of packaging or plastic products. While the NPAP currently promotes EPR as a voluntary initiative and encourages businesses to engage in collection and reuse schemes, it lacks a clear regulatory framework and market-based incentives to drive systematic participation. Moreover, the Lao PDR faces an influx of low-quality imported plastic products, particularly multilayered packaging, which cannot be managed or recycled by the technology currently available in the Lao PDR. These plastic wastes end up accumulating in landfills or the environment, contributing significantly to long-term pollution and microplastic contamination (UNEP, 2018).

Another major challenge reported by GIZ in 2022 is the lack of reliable data and monitoring systems to track plastic waste generation, disposal, and leakage into the environment (Collard, Galtung, and Mosberg, 2024). Without robust baseline data on such information, it is difficult to set realistic reduction targets, design evidence-based policies, or evaluate programme effectiveness for single-use plastic reduction and sustainable plastic waste management in the Lao PDR (Ibid.) (Figure 14.1).

Amidst the ongoing development of legislation and incentives by the government for plastic reduction and waste management, but without a specific law and legislation regarding SUP reduction and waste management, local projects have emerged as outstanding examples of community-led initiatives. These will be detailed in the next section, highlighting efforts by youth, villages, businesses, and institutions across sectors.

2. The Lao PDR's Emerging Local Efforts

2.1. Initiatives in the hospitality sector

Across the Lao PDR, local campaigns have become a key part of efforts to tackle plastic waste. Since the hospitality sector plays an important role in economic development and is one of the top contributors to municipal solid waste, particularly SUP waste such as PET bottles, plastic packaging, and food containers (World Bank, 2022b), many outstanding initiatives have been focused on the hospitality sector (e.g. hotels, restaurants, cafés, apartments for both short-term and long-term stays, tourism sites, and tour operators).

An early initiative was implemented in tourism hotspots across the country from Luang Prabang to the southern Lao PDR to reduce the use of SUPs, especially plastic water bottles. Through the 'Refill Not Landfill' movement, hotels, cafés, tour operators, and attractions like museums offer free or cheap water refills and encourage visitors to use reusable bottles. Some businesses have fully phased out selling plastic water bottles, helping tourists become part of the effort to reduce plastic waste when travelling (Figure 14.2).

Figure 14.2. Refill Not Landfill Project

Source: Brian G Atkinson.

Since around 2016, when the initiative was launched by Easia Travel in Luang Prabang, the project has expanded to about 100 refill stations by 2023 in Luang Prabang and the southern provinces. These refill points offer tourists accessible water refilling options and promote the use of reusable bottles, contributing to helping avoid the use of around 30,360 plastic bottles in the Lao PDR (ASEAN–Japan Centre, 2023). As of 2025, the Refill Not Landfill initiative continues its commitment to expanding water stations at multiple locations.

At the national level, broader support for reducing plastic waste in the hospitality sector has started to become tangible. A notable initiative is the Plastic Free Laos Label (PFLL), which was created in 2018 under the Regional Economic Integration of Laos into ASEAN project by GIZ and the SME Service Center, under the National Chamber of Commerce and Industry. The PFLL helps hospitality businesses reduce the use of SUPs by offering support such as connecting businesses to eco-friendly suppliers. Since 2019, Econox Laos has taken over the management of the PFLL and has been training 112 businesses across the country, particularly in Vientiane Capital, Vang Vieng, and Luang Prabang, to help them achieve their goal of becoming green businesses with SUP-free services and operations (Figure 14.3).

Figure 14.3. Plastic Free Laos Certificate and Trophy of a Champion in Reducing SUPs

SUP = single-use plastic.

Source: Plastic Free Laos.

As of 2025, the PFLL has 16 active members, including 7 Plastic-Free Laos Champions with gold labels and 3 with green labels. These efforts are estimated to help members to avoid generating up to 25 tons of plastic waste per month.

Since 2021, the PFLL has worked in collaboration with Swisscontact, under the Waste to Value (W2V) project, to reach out to businesses to increase its members. Currently, it is working in collaboration with the Luxembourg Development Agency (LuxDev), under its Skills for Tourism, Agriculture and Forestry (STAF) programme, to train up to 50 businesses on green skills, focusing on the reduction of SUPs in seven major cities – Vientiane, Khammouane, Bolikhamxay, Bokeo, Luang Prabang, Savannakhet, and Champasak. The PFLL also partners with alternative product producers and distributors, as well as green start-ups, to connect them with PFLL members through an initiative called the 'Green Map'. This initiative aims to help businesses find sustainable packaging solutions at discounted rates and replace SUPs.[1]

A key initiative supporting plastic reduction and circular economy efforts in the Lao PDR is Swisscontact's W2V project, funded by the European Union. According to Swisscontact (2024), the project focuses on promoting a sustainable approach to plastic waste by improving collection, sorting, and recycling systems, while encouraging businesses to move away from SUPs. It operates in Vientiane Capital, Vientiane Province, and Luang Prabang (Swisscontact, 2024).

[1] Communication with Econox Laos, June 2025.

The W2V project takes a multi-stakeholder approach by working with small businesses, local governments, waste pickers, and communities. According to Swisscontact (n.d.), by 2028, the project is expected to train 300 informal waste workers, with at least 40% increasing their annual income by SwF500, and to support 16 recollection businesses to raise efficiency and increase income by up to SwF2,000 per year. In addition, W2V aims to provide 40 green businesses with access to finance information and to engage 500 small and medium-sized enterprises (SMEs) in the hospitality and tourism sector (50% women-led) through e-learning on green practices. These combined efforts promote behavioural change, encourage sustainable alternatives to SUPs, and reduce plastic leakage into the Mekong River. The project also collaborates with the PFLL as one of its main local partners.

2.2. Start-ups and local green alternative business

One of the most innovative green start-ups emerging in the Lao PDR's hospitality sector is 'Rent Your Cup', an initiative under the PFLL implemented by Econox Laos. Rent Your Cup was launched in May 2025 in response to the increasing volume of SUP waste generated at cafés, events, and tourist sites (footnote 2). The service offers a circular, shared-cup system that allows customers to rent reusable cups for their drinks at participating cafés, resorts, and festivals instead of using disposable ones. The primary aim is to eliminate the need for SUP cups, lids, and straws by making reuse more convenient, accessible, and appealing for both businesses and consumers. The initiative operates with a straightforward return system whereby customers can return their cups to any participating site (Plastic Free Laos Label, n.d.).

Rent Your Cup was pilot tested at select hospitality venues and public events in Vientiane Capital, Vang Vieng, and Luang Prabang, focusing on raising awareness amongst middle- and high-income customers, tourists, and young people attending festivals under the support of the 'Lasting Laos' project of Plan International Laos. It is supported under Phase II of the Breaking Plastic Habit in ASEAN Countries project by the Institute for Global Environmental Strategies (IGES) and the Economic Research Institute for ASEAN and East Asia (ERIA) (Institute for Global Environmental Strategies, 2024). The project has also partnered with member businesses of the PFLL and is closely linked with behavioural change efforts and green business training. Looking ahead, Rent Your Cup plans to expand its network across key cities and tourist hotspots, helping businesses cut down on waste while encouraging consumers to take part in a more sustainable lifestyle. As of September 2025, 12 businesses in Vientiane and Luang Prabang have enrolled in and launched Rent Your Cup services, aiming to help their customers reduce SUPs by avoiding disposable cups when purchasing drinks (Plastic Free Laos Label, n.d.) (Figure 14.4).

Figure 14.4. Rent Your Cup Service Poster

Source: Plastic Free Laos Label.

Figure 14.5. Waste Pick-Up Truck of Go2Green Service

Source: Go2Green.

Another standout example in the growing landscape of Lao green start-ups that contribute to tackling plastic pollution is Go2Green. It is a Vientiane-based green tech start-up that uses a mobile application to connect households and businesses with waste collectors, enabling scheduled pick-ups and promoting proper waste sorting. The initiative was launched in 2023 by a former software developer who saw the potential for digital tools to address the Lao PDR's growing waste management challenges.[2] The app streamlines logistics, tracks environmental impact, and helps turn recyclable materials into revenue, while creating livelihood opportunities for informal waste workers. Go2Green has partnered with local recyclers, businesses, and communities to build a circular waste economy in the capital. The platform is expanding its network through awareness campaigns on its online platform, public clean-up events, and word-of-mouth referrals from satisfied users. By mid-2025, Go2Green had serviced hundreds of households and small businesses across Vientiane, with plans to scale its operations and introduce data-driven waste monitoring to support policy development and urban sustainability goals (footnote 3) (Figure 14.5).

[2] Communication with Go2Green owner, June 2025.

Nature Ware by Nikola is a social enterprise that specialises in producing eco-friendly, biodegradable tableware and packaging alternatives made primarily from areca palm leaves, cornstarch, and bamboo. The initiative aims to provide sustainable options to replace SUPs, particularly in the food and hospitality sectors. Nature Ware partners with local farmers to source raw materials and supports community-based production models that empower rural women through income-generating opportunities. Recognised as a finalist in the Ending Plastic Pollution Innovation Challenge (EPPIC) 2023, the enterprise has gained visibility for its sustainable solutions in the Lao PDR and across ASEAN (UNDP, 2024b). As of 2025, Nature Ware products are being used by cafés, hotels, and event organisers in Vientiane and Luang Prabang, contributing to efforts to reduce plastic waste in daily business operations (UNDP, n.d.).

Low-value plastic (LVP) wastes are types of plastic whose cost of collection and processing exceeds the revenue generated from their recycled materials, often including hard-to-recycle items. To address the technical and economic challenges of recycling LVP, PatiHoub, a community-driven recycling initiative based in Luang Prabang, focuses on turning LVP waste into premium recycled products, mainly hardboard sheets as materials for construction and furniture (PatiHoub, n.d.). Founded with a commitment to both environmental sustainability and social inclusion, PatiHoub aims to reduce plastic pollution by creating a value chain where plastic is not discarded but reimagined. The organisation collects hard-to-recycle plastic waste such as snack wrappers and multilayer packaging, which are typically excluded from conventional recycling systems, and transforms them into handcrafted tiles, furniture, and decorative items, using low-emission and locally adapted technology. It also works with schools, communities, and the hospitality sector to raise awareness about plastic waste and promote circular practices. As of 2025, one of PatiHoub's most notable contributions was its collaboration with youth volunteer groups such as Precious Plastic Vientiane and Green Luang Prabang in campaigns to collect high-density polyethylene (HDPE) waste. These efforts led to the recycling of about 575 kilograms of plastic bottle caps, which were turned into school tables (Precious Plastic Vientiane, 2024; PatiHoub, 2024) (Figure 14.6).

Figure 14.6. School Tables Made from LVP (HDPE Caps)

HDPE = high-density polyethylene, LVP = low-value plastic.

Note: Made by Patihoub in collaboration with Precious Plastic Vientiane.

Source: PatiHoub.

2.3. Civil society organisations and youth-led initiatives

Civil society groups and youth-led initiatives have made important contributions to plastic reduction efforts in the Lao PDR. One example is Green Vientiane, a Lao-based initiative dedicated to addressing plastic pollution through a multifaceted, evidence-driven approach. Initiated under the research group Sustainable Environment Research Centre (SERC) Asia, the project emphasises rigorous research, fact-checking, and awareness raising. It has conducted value chain surveys, collaborated with the Global Plastic Action Partnership, and worked with Lao media to prevent the spread of misinformation. Green Vientiane also documents the stories of people on the frontlines and promotes solutions that safeguard both communities and the environment. Its outreach includes social and mass media campaigns, community clean-ups, and impactful partnerships. Notably, the initiative has sensitised over 1.2 million individuals during the That Luang Festival and installed waste bins in Sokxay Marts, a minimart chain in Vientiane Capital, to improve plastic waste management. In 2024, Green Vientiane also collaborated with the World Health Organization to strengthen sustainable waste practices in four hospitals in Vientiane (Green Vientiane, 2025b).

Another outstanding civil society organisation in the Lao PDR working towards adopting zero waste practices and tackling plastic waste issues is Zero Waste Laos, a dynamic volunteer-led initiative focusing on plastic pollution, waste reduction, and climate action across the country (Zero Waste Laos, n.d.). In addition to planting over 5,200 trees at more than 260 schools, the group has launched numerous awareness campaigns targeting both students and communities, aiming to install long-term environmental consciousness. One of its key approaches is promoting zero waste lifestyles and responsible plastic use by encouraging reuse, recycling, and the reduction of SUPs. Through educational workshops, community clean-up drives, and collaboration with schools and civil society groups, Zero Waste Laos empowers youth and local leaders to become environmental champions in their own communities. It also organises eco-events and social media campaigns to spotlight sustainable alternatives and to shift public behaviour towards more responsible consumption patterns. While its operations are largely volunteer-based, the initiative has made a noticeable impact on public awareness and behaviour regarding plastic waste and sustainable living throughout the country.[3]

Figure 14.7. Clean-Up Activity Organised by Trash Idol Luang Prabang

Note: Hospitality businesses in the province collaborated in this activity.

Source: TRASH idol, Luang Prabang.

[3] Communication with Zero Waste Laos, July 2025.

In a World Heritage city like Luang Prabang, which is also a tourism hotspot, youth are motivated to conserve the city from littering and waste pollution, especially from plastic waste. Trash Idol Luang Prabang, founded in 2014, organises regular clean-up events after major festivals, raising public awareness about the impact of litter, partnering with the local authorities, including the Urban Development and Administration Authority (We Are Lao, n.d.). The group organises regular community clean-up events in the city centre of the province, such as the night market and touristic areas, bringing together volunteers, local residents, school students, hotel staff, and tour operators – especially in the aftermath of major festivals such as the Lao New Year and the Boat Racing Festival. Monthly clean-ups are held on the last Sunday of every month, targeting busy public spaces and riverbanks around the city (Discover Laos Today, n.d.). The initiative underscores how consistently held local clean-ups, combined with public awareness (businesses and the people)

outreach, can be an essential part of a sustainable urban solution (Figure 14.7). Leading international conservation organisation WWF has been playing a key role in addressing solid waste management challenges in the Lao PDR, especially through its collaborative, locally driven approach. Under the Consolidating Municipal Solid Waste Management Profiles for Vientiane, Luang Prabang, and Vang Vieng project, WWF worked closely with government bodies such as MONRE and sub-national authorities, while strengthening partnerships with local civil society organisations and community-based actors (WWF, 2024a). One of WWF's core strategies was to conduct community consultations, participatory surveys, and capacity-building workshops to ensure that voices from the ground, especially those from informal waste pickers and women-led households, were reflected in the baseline assessments and planning processes. In Luang Prabang and Vang Vieng, WWF collaborated with local organisations and local authorities to collect data and co-develop municipal solid waste management profiles, which now serve as evidence-based planning tools for future investment and interventions. Moreover, WWF supported initiatives to improve data collection methods, raise public awareness about SUP reduction, and promote sustainable alternatives through stakeholder dialogues and media engagement. Looking ahead, WWF plans to expand its technical assistance to other municipalities and deepen its collaboration with grassroots movements, green businesses, and local innovators. This includes advocating for extended producer responsibility (EPR) frameworks, integrating gender-sensitive approaches, and continuing its work with local governments to operationalise waste management plans that are both inclusive and climate resilient.

Taken together, these efforts demonstrate that while the Lao PDR continues to face significant challenges, local organisations and youth-led movements are at the forefront of pioneering practical solutions to reduce plastic waste. Their actions are increasingly complemented by the government's gradual progress in developing policies and regulations, such as the NPAP and city-level solid waste strategies. This collaboration between grassroots leadership and emerging policy frameworks is helping the country forge its path towards a cleaner and more sustainable future.

3. Discussion: Reflections on Successes, Challenges, and the Role of Policy

The initiatives presented in this chapter reveal a dynamic and evolving landscape of local responses to plastic pollution in the Lao PDR, alongside the efforts of the government and support from international organisations. Many have achieved notable success through strong community engagement; partnerships with local people, local businesses, and educational institutes; and an emphasis on awareness raising and behavioural change. These efforts are often led by passionate youth groups or local organisations that understand the context on the ground and are committed to long-term change. Their ability to creatively adapt circular solutions, such as converting plastic waste into reusable products or rental schemes, demonstrates the potential for localised innovation to make tangible environmental impacts.

However, these successes are not without challenges. A recurring limitation lies in the sustainability of donor-driven or pilot initiatives. While external funding has been instrumental in launching many of these projects, their continuation often depends on the presence of long-term support structures, which are currently lacking, such as supporting the ecosystem for green businesses (e.g. government incentives) or developing a high level of public awareness. Once the initial funding period ends, several projects struggle to maintain momentum and sustain their efforts, especially when there is no clear strategy for transitioning ownership to local actors or institutions. This raises important questions about dependency and the need for exit strategies that include capacity development and system integration from the outset.

Another key barrier is the difficulty of scaling up small, localised initiatives into broader and more systemic solutions. Without formal recognition or integration into national frameworks, many pilot projects remain confined to their original scope. Even well-designed and impactful projects cannot achieve long-term influence if they are not aligned with or supported by national policies, regulations, and financing mechanisms. In this regard, government leadership plays a pivotal role. National policies, such as the upcoming Waste Bank Guideline or EPR mechanisms, can provide the enabling environment needed for these local solutions to grow and be replicated elsewhere.

To address these challenges, it is essential to view these initiatives not just as isolated success stories, but as testing grounds for what might work at scale. Their impact should inform policymaking and investment decisions. At the same time, government and development actors must ensure that structures are in place to absorb and institutionalise promising practices. This includes building local capacity, developing appropriate incentives, and ensuring that technical guidelines and support systems are accessible and responsive to community needs. Only through this kind of coordinated approach and multi-sectoral collaboration can the promise of these grassroots innovations be fully realised.

4. Conclusion

This chapter has highlighted a growing ecosystem of community-led initiatives tackling plastic pollution in the Lao PDR alongside the efforts of the government. They often adopt a bottom–up approach, rooted in local knowledge, creativity, and determination to make a change. These efforts represent important steps towards a more circular and sustainable future, not only by addressing environmental issues but also by fostering civic responsibility and social cohesion. Nevertheless, they also expose critical gaps in long-term support, policy integration, and system-wide coordination.

As the Lao PDR continues to shape its national response to plastic pollution, there is an urgent need to bridge the gap between local innovations and national policies. Pilot projects and small-scale models, no matter how successful, cannot deliver sustainable changes without being supported by government frameworks and multi-stakeholder collaboration. The path forward must therefore include a deliberate strategy for sustaining, scaling, and institutionalising effective practices. With the right investment and political will, the country can build on the existing foundation to develop a coherent, inclusive, and impactful approach to plastic waste management that reflects the realities and potential of Lao society.

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Chapter 15

Addressing Marine Plastic Pollution: The Malaysian Scenario

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1. Introduction

With an extensive coastline spanning about 4,800 kilometres, Malaysia boasts a rich tapestry of flora and fauna, constituting some of the world's most exquisite and diverse ecosystems. The marine biodiversity within Malaysian waters hosts a plethora of species, with at least 700 marine species documented. This diversity underscores Malaysia's significance within the Southeast Asian region. Of notable interest is the presence of 11 species of marine mammals within Malaysian waters (Abdul Hamid and Che Din, 2022). Moreover, Malaysia's reliance on marine fisheries resources is pivotal for national food security, serving as a crucial protein source (Mohamad, Rahmat, and Mohd, 2022; Saadon et al., 2020), while contributing significantly to the nation's economic growth (Kurniawan et al., 2021). Amongst the key ecosystems driving these benefits are coral reefs, which play a fundamental role in providing ecological services to marine organisms and humans alike (Burke et al., 2011).

Praveena, Shaifuddin, and Akizuki (2018) highlighted that personal care and cosmetic products are amongst the primary contributors to marine plastic pollution in Malaysia. Ranked as the 28th largest plastic polluter globally (Lim et al., 2023), the nation is implicated in the annual release of over 0.073 million metric tonnes of plastic waste into the oceans, earning the designation of the third-highest polluter in this regard. Jambeck et al. (2015) noted that Malaysia was identified as the eighth highest contributor of plastic marine debris globally. This stark reality translates to a distressing statistic of 2.29 kilograms (kg) of plastic waste discarded per person annually, underscoring the profound environmental challenges faced by Malaysia's marine ecosystems.

For Malaysian islands, high microplastic abundance has been recorded on Pulau Gazumbo and Pulau Songsong, with 7.32 grams per square metre (g/m^2) and 9.77 g/m^2, respectively (Lim et al., 2023). Based on the study by Lim et al. (2023), these pollutants come from packaging and household goods, discarded fishing gear or ghost gear, the shipping industry, etc., and are mostly constituted by mainly identified polymer materials such as high-density polyethylene (HDPE), polyethersulfone (PES), polypropylene (PP), and polystyrene (PS). Santodomingo et al. (2021) observed that these pollutants eventually reach and settle in critical ecological areas in the ocean, where an average of 10.7 items per 100 m2 of marine litter, comprised mainly of plastics (91%), was found in the coral reef areas of Sabah, Malaysia. Islam et al. (2013) added that discarded fishing gear or ghost nets entangled in the reef structures also promote coral reef degradation in Malaysia.

According to the United Nations Environment Programme's Coordinating Body on the Seas of East Asia (COBSEA, n.d.), 80% of marine debris originates from land. This is due to the disposal of waste in rivers and streams, which eventually flows to the ocean. In Malaysia, the Klang River, Selangor River, and Sungai Satu Village have been identified as the highest land-based contributors to marine plastic pollution (Chen et al., 2021). As many as 15.3 million kg of plastic waste were dumped into the open ocean through the Klang River – the highest on record around Peninsular Malaysia (Zaki et al., 2021). During the Malaysian Plastics Manufacturers Association (MPMA)–Scientex Sustainability Project on Pulau Ketam, 9,860 kg of waste were collected from Sungai Satu Village (Chin, 2019). Despite the staggering amount of plastic waste produced by Malaysia, its waste management systems are considered inadequate (Kaza et al., 2018) as it relies heavily on landfilling and domestic burning (Moh and Manaf, 2014). This was acknowledged by Malaysia during the third session of the Intergovernmental Negotiating Committee on Plastic Pollution (INC-3).

2. Impacts of Plastic Pollution on the Malaysian Marine Environment

Malaysia's marine environment is drowning in plastic pollution, with a staggering 73,000 tonnes of plastic waste dumped into its waters annually. This alarming statistic ranks Malaysia amongst the top 10 worst plastic polluters globally, causing widespread ecological and economic devastation. Plastic is particularly harmful because of its durability; it takes from 500 to 1,000 years to degrade. According to Tan et al. (2022), a study conducted by the Centre for Marine and Coastal Studies of Universiti Sains Malaysia found that Malaysia has the highest rate of plastic consumption in Asia – 62 kg per capita annually – and ranks eighth in the world for plastic pollution.

Chan (2006) documented the tragic fate of sea turtles in Malaysia ensnared by discarded fishing gear, highlighting the lethal consequences of plastic pollution. Such incidents not only cause injuries but can also lead to agonising deaths. The delicate balance of the ocean is thrown into chaos, jeopardising the entire marine food web. The economic repercussions are equally alarming. Plastic pollution deters tourists, inflicting harm on an industry crucial to Malaysia's economy.

The fishing industry is also impacted, with plastic harming marine life and disrupting fishing activities, compromising food security. Furthermore, the cost of cleaning up this plastic mess is significant, diverting resources away from other essential areas. Recent studies highlight the severity of this problem. A recent study revealed the alarming accumulation of microplastics in Malaysia's marine environment, posing a serious threat to marine life and potentially human health (Raja Sulaiman et al., 2023). Additionally, a 2021 World Bank report exposed the stark reality of Malaysia's plastic waste management, with only 24% of plastic recycled in 2019 (World Bank, 2021), making the national target of 40% by 2025 appear increasingly out of reach.

Studies have found that most marine plastic pollution originates from land-based sources. In Malaysia, plastic waste mismanagement is a major contributor, with inadequate waste collection and disposal systems leading to plastic debris entering waterways and ultimately reaching the ocean. Single-use plastic items, such as plastic bags, bottles, and straws, are particularly problematic due to their abundance and low recycling rates (Jambeck et al., 2015). Additionally, Malaysia is a major importer of plastic waste, with reports of illegal dumping contributing to the problem.

2.1 Marine plastic debris in Malaysia

Marine plastic debris is a significant environmental threat impacting ecosystems around the world, including Malaysia. It refers to plastic materials that either end up in or enter the ocean or other marine environments and persist there as waste – whether it is discarded intentionally or accidentally. Unlike marine plastic litter, which refers to larger plastic items visibly discarded in the ocean, marine plastic debris encompasses a wide range of plastic items, fragments, and particles found in the marine environment, including beaches, water columns, and sediments (COBSEA, n.d.). It basically includes any persistent solid plastic material found in the marine and coastal environment, regardless of origin, encompassing a broader range of materials classified into size-based types – mega, macro, meso, micro, and nano (Idrus, Roslan, and Harith, 2022). Marine plastic debris poses a serious threat to marine life, ecosystems, and human health, as it takes a devastating toll on marine life by causing entanglement and injury for marine animals, suffocating coral reefs, and disrupting delicate marine ecosystems.

Malaysia is reported to rank amongst the top 5 countries globally for plastic waste mismanagement, with each Malaysian contributing about 2.4 kg annually that often ends up in oceans or rivers (Ramendran, 2025). According to Martinus (2020), Malaysia had the highest annual per capita plastic use of 16.78 kg per person in the region, making it a bigger plastic consumer in Southeast Asia than other economies like China, Indonesia, the Philippines, Thailand, and Viet Nam. The main cause of environmental plastic waste leakage has been identified as the lack of sound waste management systems (Chen et al., 2021). Another study reported that Malaysian plastic mismanagement was 25.49 kg annually, ranking the country 10th in the Plastic Polluters report (Kabilan, 2024). In terms of marine plastic debris, Malaysia ranked 5th, with each Malaysian littering 2.29 kg of plastic waste annually.

Marine plastic debris poses problems for coral reef ecosystems near urban areas, particularly in coastal waters, which are often regarded as some of the most significantly affected by plastic pollution (Heery et al., 2018). Studies have found plastic debris in various coastal areas. For instance, at Pasir Pandak Beach, Sarawak, Malaysia, concentrations of 101.70 items/m^2 of macroplastics and 1,084.00 items/m^2 of microplastics were observed (Idrus, Roslan, and Harith, 2022). In estuarine waters, the mean abundance is 2.47 particles per litre (L) in the Klang River Estuary (Zaki et al., 2021). Fauziah et al. (2021) noted that past studies indicate that plastic debris on Malaysian beaches ranges from 64 items/m2 to 1,930 items/m2, with plastic film being the most dominant type.

According to Fauziah et al. (2021), the plastic film mainly originated from packaging materials. This is corroborated by the International Coastal Cleanup, which collected 41,015 kg of rubbish consisting of 388,730 items, with the most common being plastic bottles at 50,785 bottles, followed by cigarette butts at 39,584 pieces, and plastic/foam pieces at 38,801 pieces (Reef Check Malaysia, 2024). Past studies have also demonstrated a growing awareness of the marine plastic debris issue amongst fishing communities. They recognise the detrimental impacts of plastic pollution on marine life, fishing gear, and the overall health of the marine environment. However, their perceptions of marine plastic debris are often shaped by cultural values, traditional practices, and limited access to information. This is evidenced by a study conducted on Malaysian beaches, which found that fish-landing sites tend to accumulate plastic debris – particularly fishing lines and foamed plastics from the fishing gear – highlighting the connection between fishing activities and marine plastic debris (Fauziah, Liyana, and Agamuthu, 2015).

2.2 Microplastic pollution in Malaysia

The consequences of plastic pollution are far-reaching and devastating, with microplastics posing a particularly serious threat. These tiny plastic fragments – less than 5 millimetres (mm) in size – persist in the environment for long periods and are easily ingested by marine organisms. Once inside their bodies, microplastics can induce toxicity, cause biodiversity loss, harm marine health, and potentially threaten our health through contaminated seafood (Azmi, Nor, and Abdullah, 2018). These nearly invisible fragments, which are often smaller than a grain of rice, have invaded every corner of our oceans, creating a silent yet significant threat to marine life. In Malaysia, the full extent of this contamination is unclear, but the picture emerging from recent studies paints a grim portrait.

Ibrahim et al. (2016; 2017) found microplastics in both wild and farmed fish, underscoring the pervasive nature of this issue. Jaafar et al. (2021) stated that commercial marine fish from Malaysian coastal waters contained microplastics (about 86% in fish gastrointestinal tracts and 92% in gills) across multiple species, proving the widespread ingestion of microplastics by fish in Malaysian waters. Physical damage, blocked digestive tracts, and reduced nutrient uptake are just some of the ways microplastics can silently affect individuals and potentially impact entire populations.

Praveena, Shaifuddin, and Akizuki (2018) found that emissions of microplastics from personal care products and cosmetics contribute to microplastic contamination in the marine environment. Once personal care products and cosmetics are used, microplastics travel from wastewater systems and escape into the marine environment. Fendall and Sewell (2009) had earlier warned that microplastics would eventually pervade the bigger mesh size of wastewater plant screens and enter the marine environment. In Malaysia, most wastewater treatment types are preliminary (rags, rubbish, grit, oil, and grease removal), primary treatment (settleable and floatable material removal), and secondary treatment (biological treatment to remove organic and suspended solids).

A review by Choong, Hadibarata, and Tang (2021) showed that microplastic contamination can be found in the freshwater and marine environment of Malaysia. For instance, an average of 179.6 items/L and 1,464.8 items/L of microplastics was reported in the Kelantan and Langat rivers in Malaysia, respectively (Anuar et al., 2023). Their distribution in the surface water around the four marine park islands (Perhentian, Redang, Kapas, and Tenggol) in the state of Terengganu, Malaysia during the coronavirus disease (COVID-19) pandemic showed that Pulau Perhentian recorded the greatest abundance of microplastics (588.33 ± 111.77 items/L), followed by Pulau Redang (314.67 ± 58.08 items/L), Pulau Kapas (359.8 ± 87.70 items/L), and Pulau Tenggol (294.33 ± 101.64 items/L) (Yusof et al., 2023). The emergence of microplastics is known to have a significant impact on marine organisms. One of the earlier studies in Malaysia found ingestion of microplastic in a filament form and various colours and sizes inside a tissue of bivalve, Scapharca cornea, in Setiu Wetland, Terengganu, Malaysia (Ibrahim et al., 2016).

Recently, more microplastic ingestion has been found in various marine organisms such as zooplankton in the estuary and offshore water of Terengganu (Taha et al., 2021) and the polychaete *Namalycastis* sp. in Setiu Wetland (Hamzah et al., 2021). Evidence also shows that microplastic ingestion was found in aquaculture organisms such as in the tissue of cage-cultured Asian sea bass, *Lates calcarifer* (Ibrahim et al., 2017), and mud crab, *Scylla* sp. (Hossain et al., 2023), in Terengganu. This indicates that microplastic pollution in seawater has the possibility of transmission through the food web (Taha et al., 2021), affecting the diet of the marine organisms, which will subsequently be consumed by humans.

2.3 Ghost net problems in Malaysia

Ghost nets – derelict fishing gear abandoned or lost at sea – are a chilling manifestation of plastic pollution's insidious grip on our oceans. These remnants, woven from synthetic fibres, drift for years, silently capturing and killing marine life. In Malaysia, where vibrant coral reefs and diverse ecosystems teem with life, ghost nets pose a significant threat, entangling, injuring, and ultimately killing countless creatures.

The true extent of ghost nets' presence in Malaysian waters remains unclear. Chelliah et al. (2024) discovered the incidence of ghost nets around Tioman Island Marine Park, where repeated retrievals from coral reef habitats highlighted the widespread presence of discarded fishing gear in sensitive ecosystems. The lack of comprehensive data, however, hinders our understanding of the full scale of ghost net pollution and its overall impact on marine life. The most immediate and visible impact of ghost nets is entanglement. Turtles, dolphins, dugongs, and countless fish species become ensnared in their mesh, unable to escape. Hamzah et al. (2020) documented the entanglement of sea turtles in Terengganu, Malaysia, showcasing the agonising reality these creatures face. Entanglement can lead to severe injuries, starvation, and ultimately death (Duncan et al., 2017).

The impacts of ghost nets extend beyond ecological damage. Entangled marine life translates to lost income for fishing communities that rely on healthy populations for their livelihoods (Do & Armstrong, 2023). Additionally, ghost nets harm and entangle corals and reef-associated organisms and can negatively affect fisheries by damaging habitat quality and catch potential (Chelliah et al., 2024).

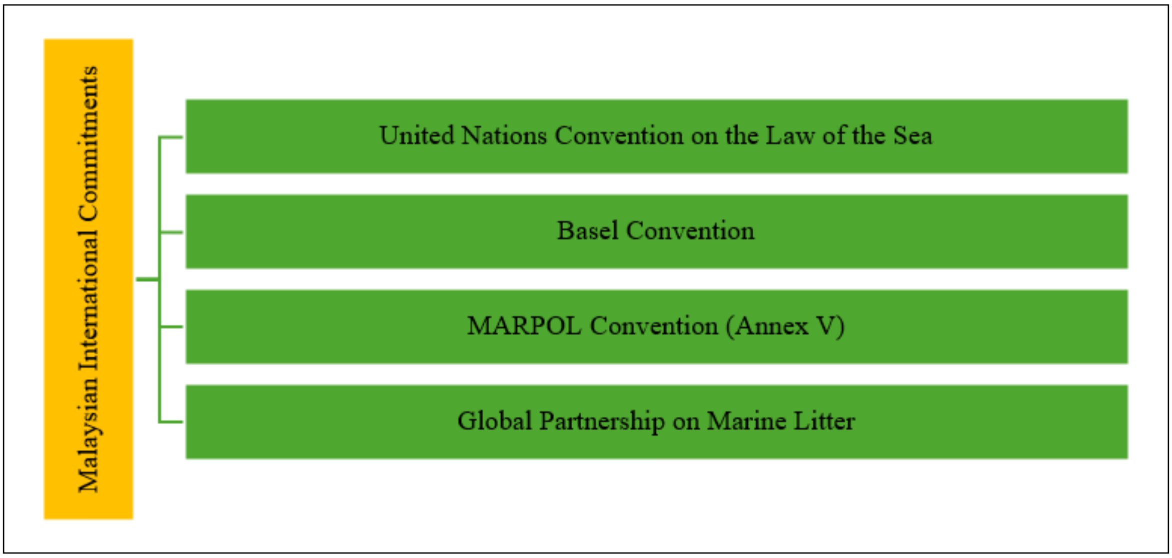
3. Malaysia's International and Regional Commitment to Address Marine Plastic Pollution

In addressing marine plastic pollution, as a sovereign coastal state, Malaysia has international commitments at the global level as well as regional commitments as a coastal state within the seas of East Asia and as an Association of Southeast Asian Nations (ASEAN) Member State.

3.1 International commitments

Malaysia's international commitments in addressing marine, including plastic, pollution are evident from its ratification of the United Nations Convention on the Law of the Sea (UNCLOS), the Basel Convention, and the International Convention for the Prevention of Pollution from Ships (MARPOL), as well as its participation in the Global Partnership on Plastic Pollution and Marine Litter (GPML).

Figure 15.1. Malaysia's international commitments: Malaysia's International Commitments Related to Plastic Pollution



MARPOL = International Convention for the Prevention of Pollution from Ships

Source: Authors

The 1982 UNCLOS is an international convention that defines a nation's rights, duties, and use of the worldwide oceans. It is often dubbed as the Constitution of the Seas, which specifies the legal foundation for managing marine activities. Malaysia ratified UNCLOS on 14 October 1996, affirming its right over a vast marine area and continental shelf. As a consequence of this ratification, Malaysia has strengthened its claims over its maritime zone in the South China Sea and the Straits of Malacca, the main shipping routes. Basically, a coastal state like Malaysia acts as a 'resource manager' in its Exclusive Economic Zone (EEZ) and is responsible for protecting its marine environment, including preventing pollution from both point and non-point sources. The preamble of UNCLOS clearly states that 'the problems of ocean space are closely interrelated and need to be considered as a whole' (United Nations Convention on the Law of the Sea, 1982, Preamble, p. 25) insinuating that Malaysia is duty-bound to protect both its marine environment and the bordering seas. In addition to that, Malaysia's commitment under UNCLOS is reflected in its domestic legal framework, most prominently the EEZ Act, 1984; the Merchant Shipping Ordinance (1952); the Environmental Quality Act (EQA), 1974; and the Customs Act, 1967.

Beyond inspiring its national legislation, Malaysia's achievement under UNCLOS includes its advocacy in the international treaty framework and ocean governance. Malaysia periodically supports efforts complementing UNCLOS, such as the High Seas Treaty (Biodiversity Beyond National Jurisdiction), and has proven its tenacity to extend the UNCLOS spirit into emerging areas of global dispute. This allows a higher chance for global collaboration and capacity building in ocean governance and sustainability (Bernama, 2025). Malaysia's activities in marine biodiversity, climate resilience, and sustainable resource use, which included participation in United Nations (UN) fora, ASEAN platforms, and dialogues on marine environmental conservation, are a form of multilateralism. Through these efforts, Malaysia has situated itself as a responsible coastal state that actively supports the development of the international maritime order while safeguarding its maritime interests.

Malaysia has also been a state party to the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal (1989) since 1993. The main purpose of Basel Convention is to regulate the transboundary transfer and disposal of wastes. Malaysia has embedded the provisions of the convention into the national legal framework through the Environmental Quality Act, 1974 (EQA) and the Customs Act, 1967. The emergence of new waste streams, specifically electronic waste (e-waste) in the early 2000s, prompted Malaysia to introduce the Environmental Quality (Scheduled Wastes) Regulations 2005, as subsidiary legislation under the EQA. These regulations categorised hazardous waste into five major categories and 77 subcategories, thereby strengthening national enforcement and compliance with Basel standards.

Malaysia became a major destination for global waste flows when China's National Sword Policy (2018) banned the import of 24 types of solid waste, including plastic waste. Nevertheless, under the Basel Convention, Malaysia intercepted and repatriated 267 containers of illegal plastic waste, and another 81 were being returned to their origin countries between 2019 and 2021, supporting the 2019 Basel Amendment on plastic waste (Basel Action Network, 2021). A transition from vulnerability to assertive leadership can be seen in Malaysia's Basel Convention participation, as it inspired its national legislation and positioned it as a regional advocator and frontline enforcer.

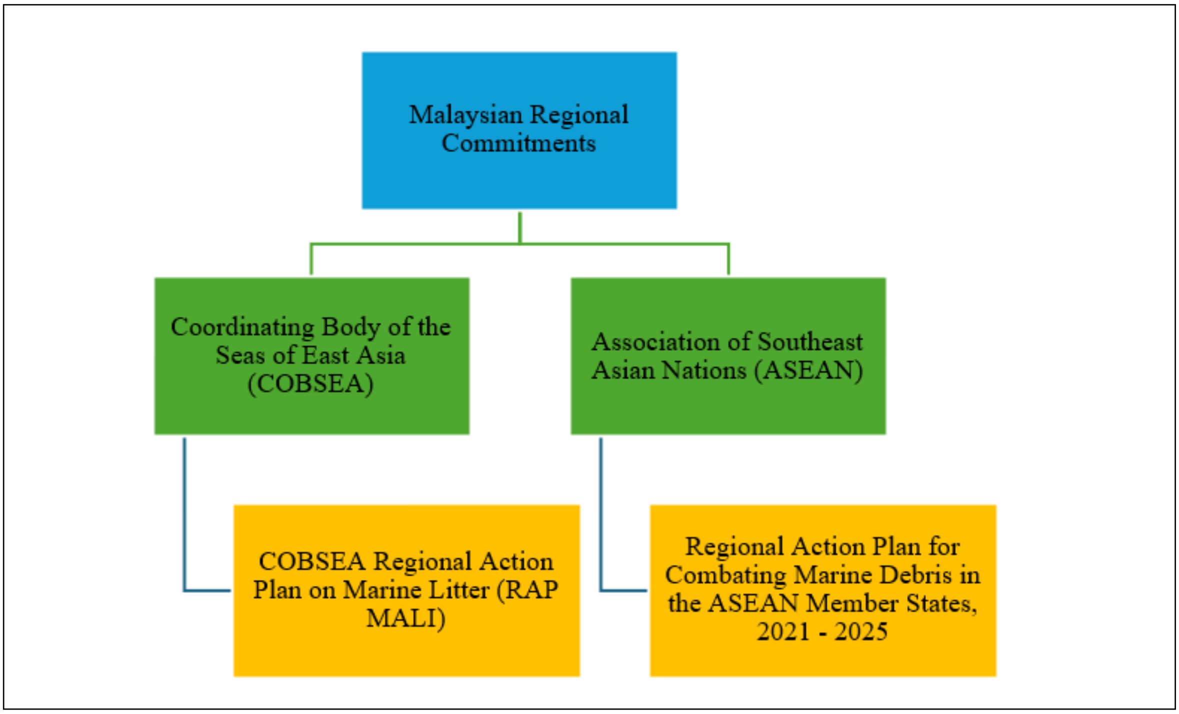
As a State Party to the International Maritime Organization (IMO), Malaysia also has obligations under IMO MARPOL Annex V, which serves as an international regulation designed to prevent and reduce pollution from rubbish discharged into the sea by ships. MARPOL Annex V prohibits the dumping of all rubbish at sea, with a complete ban on plastics, and sets specific rules for the management, separation, and disposal of different waste types, such as food waste and operational waste. The annex emphasises prevention, accountability, and meticulous record-keeping to protect marine life and the ocean environment from the dangers of ship-generated waste.

Apart from these international commitments, as a state party to UNCLOS, Malaysia may also be involved in committing to the GPML. This initiative, launched at the UN Conference on Sustainable Development (Rio+20) conference in 2012 and hosted by UNEP, is a voluntary partnership for coordination and knowledge-sharing amongst stakeholders to prevent and reduce marine plastic pollution. Malaysia's participation in the GPML is reflected in its membership in regional seas coordinating bodies governed by UNEP as well as the development of its own national policies that align with GPML goals.

3.2 Regional commitments

On the regional front, two main platforms address marine plastic pollution (Malaysian regional commitments). In 1981, UNEP established the Coordinating Body of the Seas of East Asia (COBSEA), a regional multilateral mechanism. This organisation comprises nine member states of the regional seas of East Asia: Cambodia, China, Indonesia, Malaysia, the Philippines, the Republic of Korea, Singapore, Thailand, and Viet Nam. It provides the members with a platform for partnerships, policy development, and regional efforts in coastal and marine environmental conservation. COBSEA focuses on three main areas to assist in coordinating regional action: marine pollution, ecosystem management, and governance.

Figure 15.2. Malaysian regional commitments: Malaysia's Regional Commitments Related to Plastic Pollution



Source: Authors

COBSEA has developed a framework known as the Regional Action Plan on Marine Litter (RAP MALI) to address plastic pollution by guiding its member states to create a standardised system for surveillance, increase capacity, and promote policies to reduce plastic leakage into the ocean. The framework was developed in 2008 and amended in 2019 to enhance regional and national efforts to bring them into line with global commitments on marine litter and microplastics like the United Nations Sustainable Development Goals (SDGs) and the United Nations Environment Assembly. As a littoral state to the seas of East Asia, Malaysia is committed to COBSEA RAP MALI, which aims to deliver Target 14.1 of SDG 14 (by 2025, prevent and significantly reduce marine pollution of all kinds, particularly from land-based activities, including marine debris and nutrient pollution) and contribute to the achievement of other SDGs and associated targets.

Malaysia has been an active participant, adopting COBSEA's regional priorities on marine litter into its national policies through the implementation of the Regional Action Plan on Marine Litter (RAP MALI). This integration has strengthened Malaysia's national marine litter policy framework, such as the Roadmap Towards Zero Single-Use Plastics, 2018 - 2030 and the Plastics Sustainability Roadmap, 2021 - 2030, by incorporating key regional priorities, including centralised regulation, extended producer responsibility (EPR), policy alignment, and the abolition of harmful single-use plastics. According to the Environmental Investigation Agency (2025), Malaysia has implemented stricter control on plastic waste imports (effective on 1 July 2025) through Customs Order 2025 (Prohibition of Imports), which requires pre-approval for shipments under specific Harmonised System (HS) codes, contamination thresholds, and Basel Convention adherence. These measures align with RAP MALI's objectives by addressing plastic waste leakage at border points and within domestic waste management system.

Another regional intergovernmental organisation is ASEAN, which was developed to promote regional peace and stability, improve economic growth, encourage social progress and cultural development, and allow cooperation amongst its Member States. It is also a channel for Southeast Asian countries to exchange knowledge and strive collectively to encounter regional and global issues. Malaysia has a regional commitment under ASEAN, which is the Regional Action Plan for Combating Marine Debris in the ASEAN Member States 2021–2025. This introduces the phased implementation of a systematic and integrated response to guide regional actions in addressing the issue of marine plastic pollution, highlights the status of and challenges faced by ASEAN Member States (AMS), and identifies potential solutions along the value chain to overcome unsustainable plastic consumption, waste management, and marine debris pollution.

Achievements under the Regional Action Plan for Combating Marine Debris in AMS are hard to document, as they are recent or ongoing, but some can be reasonably tied to Malaysia's contribution. These are its leadership in regional standards and collaboration, as well as its engagement with private sector innovation platforms to encourage research, capacity building, and knowledge trading. For example, Malaysia's ASEAN Chairmanship in 2025 strongly emphasised reducing plastic waste imports or waste colonisation by insisting on stricter enforcement or regulation on transboundary issues. According to Bernama (2024), Malaysia will lead the implementation of more stringent measures to resolve these issues also faced by other AMS. Furthermore, Malaysia has also embarked on private sector innovation platforms to foster research, capacity building, and knowledge exchange in addressing marine plastic pollution. For example, Malaysia's Private Sector - Innovation as a Driver to Tackle Marine Plastics, is a webinar platform to raise awareness on the marine plastic debris issue in the ASEAN context, specifically in Malaysia, while showcasing innovative business practices demonstrated by leading Malaysian private companies and relevant business associations. These efforts contribute significantly to Malaysia's regional commitment as an AMS to minimise plastic leakage into the marine environment.

3.3 Malaysian domestic policy and legal framework addressing marine plastic pollution

On the national front, the Prime Minister's Office of Malaysia declared in 2019 that Malaysia had acknowledged the severity of marine plastic pollution by implementing various initiatives. The government has established a national roadmap for phasing out single-use plastics by 2030. Additionally, several states have implemented bans on plastic bags and other single-use items. Public awareness campaigns and educational programmes are also being implemented to encourage responsible plastic consumption and waste management practices.

3.4 Policies

Malaysia has launched a series of policies and action plans to combat plastic pollution, steadily progressing from green technology adoption to a full circular economy approach (Malaysian policies). The Green Technology Master Plan, 2017–2030 was an early framework to encourage eco-friendly product design and sustainable manufacturing, paving the groundwork for greener alternatives to plastics. Following this, the Roadmap Towards Zero Single-Use Plastics, 2018–2030 set forth a phased strategy to reduce single-use plastics through bans, levies, and the promotion of biodegradable substitutes, constituting Malaysia's most direct commitment to overcome plastic waste. In 2019, the National Policy on Sustainable Consumption and Production solidified this effort by emphasising resource efficiency, waste diminution, and sustainable consumer practices. Meanwhile, Strategy 2.3 of the National Cleanliness Policy, 2020–2030 aims to improve solid waste management and advocate waste segregation, including plastics. Strategy 2.3 of the National Cleanliness Policy's Environmental Sustainability Cluster advocates improved solid waste management mechanisms, while its Circular Economy Cluster promotes the transformation from a linear economy to a circular economy based on the principles of reduce, reuse, and recycle (3Rs), which must be extended to all industrial sectors.

Figure 15.3. Malaysian policies: Malaysian Plastic Pollution Policies

Source: Authors

Strategy A2 of the Twelfth Malaysia Plan, 2021–2025 is an extended attempt to gradually resolve the harmful plastic issue. It stresses environmental resilience and an introduction to the principles of the circular economy. If Malaysia embraces the circular economy, it will promote the adoption of the entire country approach and integration of the SDGs and environment, sustainability, and governance (ESG) principles in decision-making. The transformation entails creating an enabling ecosystem, improving product and service design and procedures, increasing EPR, and refining waste management – proving Malaysia's efforts to eliminate plastic pollution that is harmful to the marine ecosystem as well as human health.

The National Marine Litter Policy and Action Plan, 2021–2030 was launched in 2021 by the Ministry of Natural Resources and Environmental Sustainability, formerly known as the Ministry of Environment and Water (KASA), recognising the gravity of marine plastic pollution. This policy and action plan highlighted crucial areas and actions to address marine litter pollution in Malaysia. The National Roadmap Towards Zero Single-Use Plastics, 2018–2030 and the Plastic Sustainability Roadmap, 2021–2030 were subsequently launched. The Plastics Sustainability Roadmap intends to identify and eradicate problematic and unnecessary single-use plastics by 2030 through redesign, innovation, and reuse models by proposing five strategies to shift to a sustainable plastics industry, such as the implementation of an EPR scheme. Through this roadmap, the Ministry of Natural Resources and Environmental Sustainability aims to achieve a 25% recycling rate for plastic packaging by 2025 and 100% by 2050 and to implement an EPR scheme. The implementation of an EPR initiative is amongst the core strategies identified as part of the country's effort to find a solution to post-consumer waste, including plastics. EPR for packaging was designed to reduce the environmental and economic burdens of plastic waste management for municipalities by EPR to the end-of-life stage (World Bank, 2022).

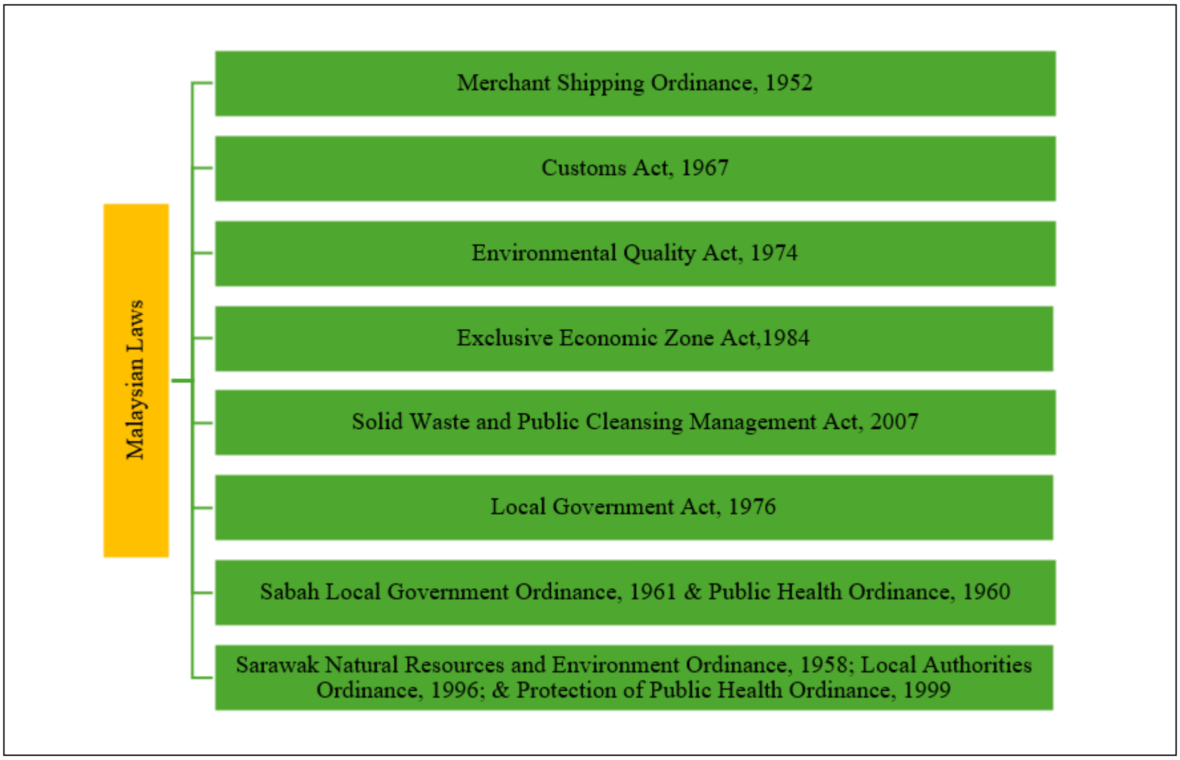
EPR implementation began with a voluntary scheme before transitioning to a mandatory scheme. This took into consideration the readiness and capacity of industry players, especially small and medium-sized enterprises. In the first 2 years (2021–2022) during the inception phase, the government, together with industry associations and relevant organisations, advocated for EPR adoption and readiness of the industry through various EPR capacity-building programmes, as well as the implementation of the INSPiRE programme, which began in 2022. The voluntary EPR phase has been implemented nationwide between 2023 and 2025, with the scheme scheduled to become mandatory in 2026.

The Circular Economy Policy Framework for Manufacturing was initiated to reduce plastic waste in manufacturing processes and advance resource efficiency. It is a comprehensive guide for all stakeholders to drive the nation towards long-term sustainability goals. The blueprint was designed to catalyse the adoption of circular economy practices, hinting at the participation and collaboration of all stakeholders to drive initiatives that enhance climate action and reduce environmental impact. Finally, the most recent Circular Economy for Solid Waste Blueprint (Blueprint Ekonomi Kitaran bagi Sisa Pepejal), 2025–2035 was launched by the Ministry of Housing and Local Government, better known as KPKT. As a circular economy roadmap that focuses specifically on solid waste management, this initiative offers a long-term plan to revolutionise solid waste management through recycling markets, waste-to-resource programmes, and EPR systems.

3.5 The Laws

Malaysia has integrated its obligations under UNCLOS (specifically Part XII: Protection and Preservation of the Marine Environment), the Basel Convention, and MARPOL Annex V into its domestic legal framework to address marine plastic pollution (Malaysian laws). An example is the Merchant Shipping Ordinance, 1952, which is one of the fundamental Malaysian maritime legislations. The ordinance has measures to regulate ship-based pollution, including the discharge of waste into Malaysian waterways, despite its main concentration on maritime registration, safety, and navigation. This prevents ships from contaminating the marine environment with waste and debris that often contains plastics, eventually addressing marine plastic pollution.

Figure 15.4. Malaysian laws: Malaysian Legal Framework Related to Plastic Pollution



Source: Authors

The Customs Act, 1967 was enacted to control Malaysia's trading activities. This law is significant, as it allows authorities to limit the entry of plastic waste into Malaysia. To prevent Malaysia becoming a landfill for foreign plastic pollution, this law restricts or bans the import of non-recyclable plastics and illicit shipments of plastic rubbish. The EQA, which is the primary environmental law in Malaysia, offers extensive procedures for preventing, reducing, and managing pollution. This act empowers the government to regulate solid waste handling, including plastic, industrial discharges, and waste management. Specifically, the EQA allows the licensing of waste treatment, recovery, and disposal facilities, including facilities managing scheduled and non-scheduled wastes; enforces laws against illegal disposal methods that contribute to pollution; and imposes controls on scheduled waste.

The EEZ Act broadens Malaysia's authority over resources and activities within the nation's EEZ, which covers up to 200 nautical miles from its coastline. This act incorporates provisions that are consistent with international maritime laws, which include the prevention and control of marine pollution. The EEZ Act enhances Malaysia's capacity to control marine waste and pollution in coastal areas to ensure that plastic debris does not harm marine ecosystems or fisheries within the EEZ.

The Solid Waste and Public Cleansing Management Act, 2007 sets out regulations for managing controlled solid waste and public cleansing to ensure sanitation and promote sustainability across Peninsular Malaysia and the Federal Territories. The act established the Solid Waste Management and Public Cleansing Corporation (SWCorp) as the regulatory authority and requires licences for waste management services and facilities. Key provisions include mandatory waste separation at source, and the act promotes waste reduction, reuse, and recycling. Although this act does not specifically provide clear prohibition and measures to curb plastic pollution in the country, it contains provisions for initiatives like EPR and the Deposit Refund System (DRS). Nonetheless, as noted by the Malaysian Green Tech & Climate Change Corporation (MGTC), the act falls under the Federal Constitution's Concurrent List, allowing states the discretion to opt out. It should be noted that, by virtue of the Local Government Act, 1976, the management of solid waste is delegated to local authorities as governed by their respective by-laws. For states that have yet to adopt the Solid Waste and Public Cleansing Management Act, 2007 – Kelantan, Terengganu, Perak, Selangor, and Penang – the Local Government Act, 1976 and subsidiary local authority by-laws enacted thereunder remain the primary legal framework governing solid waste management.

Due to the special distribution of powers allocated to Sabah and Sarawak under the Federal Constitution of Malaysia, the laws relating to solid waste in these two Borneo states are distinct. In Sabah, the laws on waste management are the Local Government Ordinance, 1961; the Public Health Ordinance, 1960; and by-laws, including Uniform (Anti-Litter) By-laws 2010, the Uniform (Beauty and Health Care Centre) By-laws 2014, Uniform (Compounding Offences) By-laws 2013, and the Conservancy and Hygiene By-laws. The relevant laws on waste management in Sarawak are the Natural Resources and Environment Ordinance 1958; the Local Authorities Ordinance, 1996; and the Protection of Public Health Ordinance, 1999.

4. Conclusion

Plastic pollution is one of Malaysia's most significant environmental issues due to its large coastline and rich marine biodiversity. Malaysia faces a severe marine plastic pollution problem and ranks as a significant global contributor, with millions of tonnes of plastic entering its oceans annually. This is driven by rapid economic development, which has led to increased waste, a robust plastic manufacturing sector, and an increase in single-use plastics. These have made Malaysia one of the top global polluters due to inadequate waste management, high plastic consumption, and significant contributions to marine plastic debris – jeopardising marine life and ecosystems, as well as human health.

Recognising that marine plastic pollution is not a single-nation issue, the global community has undertaken multifaceted efforts to prevent, reduce, and manage marine plastic pollution, including land-based and sea-based plastic waste leakage through international treaties, regional agreements, and collaborative initiatives. Malaysia has committed to global legal frameworks – UNCLOS, the Basel Convention, and IMO MARPOL Annex V – as well as the voluntary UN GPML. It has also joined regional efforts to address marine plastic pollution, notably the COBSEA and ASEAN initiatives. The regulations under these international legal frameworks have been embedded into Malaysia's domestic laws, including the Merchant Shipping Ordinance, the Customs Act, the EQA, and the EEZ Act. Working in tandem are Malaysian national policies, from the Green Technology Master Plan, 2017–2030 to the most recent Circular Economy for Solid Waste Blueprint, 2025–2035, which have all manifested Malaysia's dedication to addressing marine plastic pollution.

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Chapter 16

Myanmar's Resource-Restricted Society Strengthens Non-plastic Products and Systems

Friedor Jeske

1. Introduction

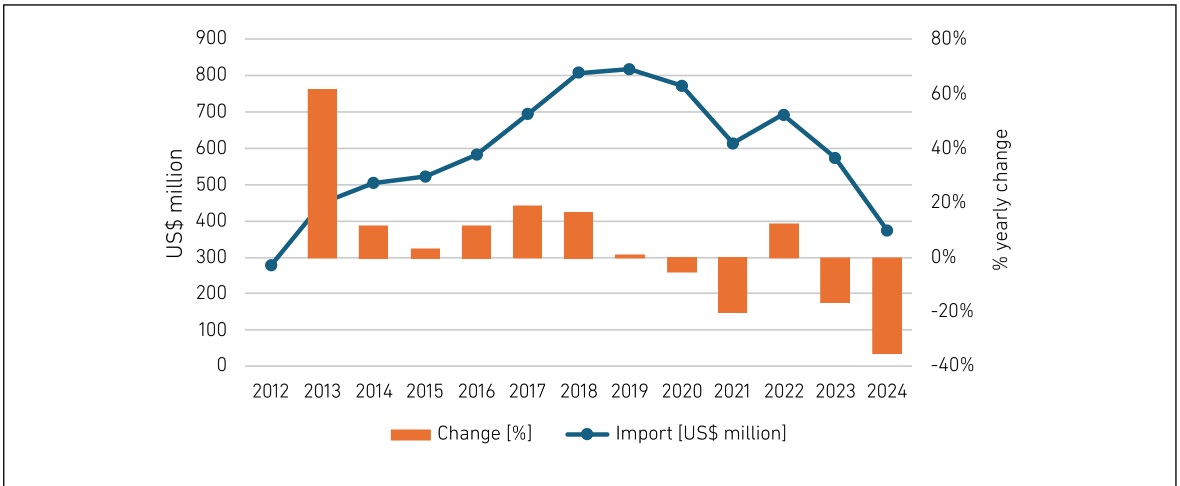
Myanmar was highly isolated until 2011, and goods entered the country subject to many restrictions. This scarcity in products encouraged an economical model built around local production and consumption as well as reuse and repair. During a brief opening to imports from 2011 until 2021, this model was partly replaced by a more linear consumption model allowing the import of cheap consumer goods and virgin plastics for single-use plastics (SUPs), mainly from neighbouring China and Thailand. The result was a strong increase in plastic pollution as municipalities were not equipped with facilities to handle the amount of waste contaminated with plastic. After the coup d'état in 2021, trade again became more challenging and the economy partially returned to proven resource-efficient practices from the past.

1.1 Status quo of plastic pollution in Myanmar

Myanmar, with over 670,000 square kilometres, is one of the largest countries in Southeast Asia. The 2024 census estimated the population at around 51 million people (Department of Population, 2024). Some 31% of them live in urban areas, while 69% live in rural areas, with per capita gross domestic product (GDP) of US$1,233 for 2023 (World Bank, n.d.).

Waste generation in general and plastic waste generation in particular in Myanmar are amongst the lowest in the world, at 0.37 kilograms (kg) per capita per day and 0.04 kg/capita/day, respectively, in 2019 (Thant Myanmar, 2022). This was the peak of plastic consumption, with imports worth around US$800 million in plastic related goods compared with less than US$300 million in 2012 (Figure 16.1). Since 2019, the import of plastics has decreased by 77%, reflecting a significant movement towards alternative or package-free consumption practices within community economies. This also indicates a shift towards circular systems such as refill and repair.

Figure 16.1. Import of Plastics and Related Products to Myanmar, 2012–2024



Source: TrendEconomy (n.d.).

Waste generation data are not well recorded, with the best documented data from Mandalay showing a near doubling of waste collection between 2012 and 2019 (reflecting increased generation as well as higher collection rates by the municipality) (Thant Myanmar, 2022). A reduction in plastic waste generation after the coup could not be assessed because no studies have been conducted measuring the plastic component inside solid waste during this period. Although plastic waste generation is very low, plastic waste disposal shows significant challenges, with 30% of urban and 82% of rural plastic leaking to water, soil, or air via open burning. The remaining plastic is recycled (12%) or disposed of in open dumpsites managed by large city councils (Thant Myanmar, 2022).

1.2 Key initiatives against plastic pollution

In response to the economic crisis, the current administration follows an import-restrictive policy through import licence restrictions and quotas requiring importers to export goods of the same value (USDA Foreign Agricultural Service, 2024). This affects all goods, including plastics, aiming to reduce Myanmar's trade deficit and maintain foreign currency reserves. In addition to the official restrictions, a disruption in supply chains due to transport challenges, as well as periodic border closures by the main trading partner China, further reduces the influx of foreign goods in general and plastic items in specific.

The resulting impacts for the private sector are higher prices for plastic products and material, which encourages a reduction in plastic use (Figure 16.1) and a shift to local and reusable packaging, favouring small-scale producers who rely on natural or reusable packaging. It also strengthens market systems and production methods that require no, limited, or reusable packaging and energy, such as wet markets, street vendors, and cottage industries. An additional factor is the limited availability of electricity, which further discourages industrial production lines using SUPs as the main packaging material (Min, 2025). The result is the revival of two historically strong systems: (i) local production and consumption (the 'community economy'); and (ii) a circular economy built around reuse (of packaging and consumer goods), repair, and waste picker–led recycling. Yangon, with its 5.5 million citizens, hosts 44,000 reuse and repair workers (seven times more than Bangkok) (Win et al., 2023) and 24,000 waste pickers, while one in 10 families works in local production and retail.

1.3 Key issue: alternative products vs alternative systems

It is widely accepted that product design plays a key role in reducing plastic pollution. In the global plastic treaty negotiations, this is reflected in a dedicated article that is split into (i) a measure on reuse and recycling of plastic products, and (ii) technological advancements in alternatives to plastic products. In the current form of the article, this approach overlooks the system-level strategies naturally adopted in low-income countries like Myanmar, where limited access to virgin plastic drives more sustainable solutions.

Instead of investing in new materials or technologies to replace plastic packaging, Myanmar shifts towards low-tech systems that reduce the need for packaging. These changes do not involve altering the product itself but transforming the consumption context. For example, during economic growth, takeaway food – and therefore plastic use – increased. Since the economic downturn in 2021, vendors have responded to plastic scarcity by adding seating, encouraging dine-in consumption, and eliminating the need for disposable containers.

This illustrates that sustainable product design often starts with sustainable systems. In Myanmar – and many countries across the Global South – such systems still exist and operate effectively at scale. This study highlights three common ones:

(i) reuse and repair of consumer goods;
(ii) local community-based production and consumption; and
(iii) open-loop reuse, such as returnable glass bottles collected via informal networks.

These models reduce plastic use, support local economies, and offer a systems-based foundation for low-waste product design, without relying on advanced technologies or large investments.

1.4 Analytical framework

This analysis is grounded in the understanding that system-level approaches, rather than solely product-level interventions, are key to addressing plastic pollution in low- and lower middle-income countries. In contexts such as Myanmar, sustainable practices are often embedded in traditional systems that emphasise resource efficiency, reuse, and localised production. Three recent studies are analysed, which cover a different angle of circularity and are traditional with the potential to be a future solution: (i) circular consumer practices (Win et al., 2023); (ii) community-based local economies (Thant Myanmar, 2025b); and (iii) open-loop reuse infrastructure (Thant Myanmar, 2025a). These systems illustrate how upstream restrictions on plastic availability can drive innovation in design and function – not by replacing plastic with another material, but by shifting the systems of consumption.

2. Analysis

This paper looks at three different aspects of the implications resulting from reduced import of plastics. The analysis combines quantitative and qualitative data from different reports, exemplifying the contribution of alternative system approaches to plastic reduction.

2.1 Explanation of the data

During Myanmar's period of economic liberalisation, the country experienced a sharp rise in plastic-related products, which increasingly replaced traditional modes of production and consumption. This shift led to an almost threefold increase in the import of plastic products, peaking in 2019. However, since 2021, a sustained decline has been observed – driven by stricter import policies, border disruptions due to conflict, and reduced consumer purchasing power. As a result, spending on plastic-related imports dropped by 77% from the 2019 peak (TrendEconomy, n.d.).

This chapter explores three systems that faced setbacks during the liberalisation period, when they were partially displaced by linear, resource-inefficient models heavily reliant on plastic. However, following the 2021 coup d'état, these traditional systems – long proven resilient in the face of resource scarcity, limited consumer spending, disrupted supply chains, and fragile energy infrastructure – have seen a resurgence:

(i) circularity in consumer goods through reuse and repair;
(ii) local production and consumption, also referred to as the 'community economy'; and
(iii) the reuse system for glass bottles, supported by widespread waste picker infrastructure.

A recent comparative study between Yangon and Bangkok (Win et al., 2023) highlighted Yangon's strong reliance on circular economy practices in the consumption of everyday consumer products. The research focused on common product categories such as clothing (Figure 16.2), electronics, and bicycles, examining how these items are reused, repaired, or recycled in both cities.

Figure 16.2. Countrywide Availability of Second-Hand Clothing, Mainly from Japan and the Republic of Korea

Source: Thant Myanmar.

The aim was to assess the degree of 'circularity' in urban consumption systems and to understand the broader value generated by these practices. The methodology involved mapping and analysing the reuse (second-hand markets) and repair infrastructure in each city. To capture the multi-dimensional benefits of circularity, the study applied three key lenses:

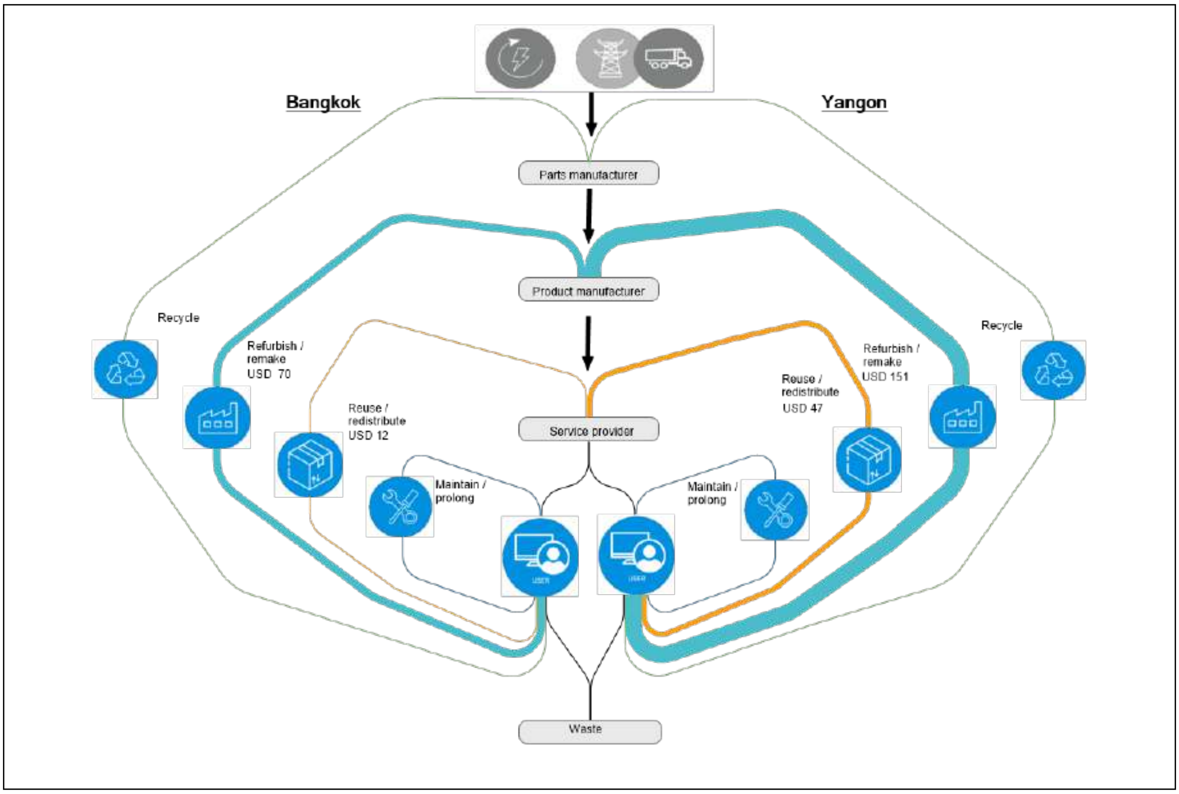
(i) **Material dimension (environmental value)**: This perspective focused on how much material is diverted from the waste stream through reuse and repair. While recycling plays a dominant role in this dimension, reuse and repair still contribute meaningfully. The findings showed that circular practices (including recycling) in Yangon led to a 23% reduction in waste, compared with 18% in Bangkok.

(ii) **Value dimension (economic savings)**: This dimension assessed how much money individuals save through access to cheaper second-hand goods and by extending the life of products through repair. In Yangon, these practices result in estimated annual savings of US$198 per person – more than double the savings observed in Bangkok. Notably, repair activities contribute more to this value than reuse, whereas recycling offers minimal direct economic benefit to consumers.

(iii) **Item dimension (socio-economic access)**: This perspective considered the number of products kept in circulation, especially items that are otherwise expensive or unavailable. Yangon stands out significantly in this area, with an average of nearly five items per person per year staying in use via reuse or repair. In contrast, Bangkok records less than 40% of this volume. The high level of repair engagement in Yangon plays a key role here – residents are more likely to repair even low-value items, and repair services are more widespread and accessible than in Bangkok.

Overall, the study underscored the importance of circular systems in contexts where financial constraints, limited product availability, and infrastructure disruptions shape consumer behaviour. In Yangon, reuse and repair are not just environmental or economic strategies – they also serve as crucial mechanisms for maintaining access to goods in a resource-constrained environment. The findings suggest that strengthening repair and second-hand networks can play a central role in sustainable urban consumption, particularly in cities facing similar structural limitations.

Figure 16.3. Quantitative Butterfly Flow Diagram for Inorganic Materials, Comparing Bangkok with Yangon



Source: Win et al. (2023).

In Figure 16.3, the strength of the loops indicates their contribution to the value generated for each citizen. Each loop shows the economic benefit one citizen receives as a result of the system maintaining that loop. As an example, Yangon residents have an annual cost saving of US$151 per person due to access to repair their goods in contrast to purchasing new ones. The US$198 total cost reduction from reuse and repair is equivalent to a monthly salary for skilled labour and therefore significantly contributes to a family's living standard.

In addition to the circular economy, local production and consumption or the 'community economy' plays a significant role in reducing plastic consumption in Myanmar. Often referred to as the traditional system of production and consumption, the community economy is deeply embedded in daily life – particularly in food and beverage provisioning – and is characterised by decentralised, small-scale operations rooted in local relationships and practices.

Data from the Organisation for Economic Co-operation and Development (OECD) *Regional Plastics Outlook for Southeast and East Asia* (OECD, 2025) highlighted that the amount of plastic usage for some Association of Southeast Asian Nations (ASEAN) low- and middle-income countries averaged 26 kg per capita per year (in comparison, Myanmar uses 14 kg per capita per year as a least developed country (Thant Myanmar, 2022)). All the low- and middle-income countries (e.g. Cambodia, Indonesia, and the Lao People's Democratic Republic (Lao PDR)) still rely significantly on the community economy, while others like China and Thailand already exceed 70 kg per capita per year and the Republic of Korea and Japan have surpassed 100 kg per capita per year, which is nearly 10 times higher than Myanmar.

A strong argument for this link between the use of plastic packaging and the system in which food is consumed was made by Chakori (2022), which linked the increase in food packaging to three subsystems that define modern production and consumption: (i) globalisation (requiring long supply chains), (ii) supermarkets (increasing shelf life and using packaging as a marketing tool for competing brands), and (iii) time poverty of households (reduced time to cook). The three subsystems have 'reinforcing feedback loops', leading to a continuously self-strengthening system with increased packaging.

In Myanmar, the opposite trend is visible. Thant Myanmar (2025b) examined how local production and consumption is strengthening as a coping mechanism to the socio-economic downturn resulting from the coup d'état. Broken supply chains, challenges in managing large operations and businesses, and the increased amount of free time by households due to less work opportunities enforce an opposing system as described by Chakori. The macroeconomic factors lead to a highly localised, fractured informal system, with short supply chains relying on minimal non-local inputs (including packaging). This system revolves around a network of wet markets, street vendors, tea shops, food stalls, cottage industries, and short supply chains that connect urban consumers to rural and peri-urban agriculture. These elements form a historically evolved web of mutual dependency, shaped by cultural practices, economic necessity, and the geography of Myanmar's cities and villages.

One of the most notable environmental contributions of the community economy is its low reliance on plastic, especially compared with the more centralised and industrialised food systems found in supermarkets and large food companies. This is largely because the underlying mechanics of the system predate the widespread use of plastic – and in many cases, have continued unchanged.

Plastic, where used, typically plays a lesser and non-essential role as products come mostly in loose form. Packaging is mainly employed for on-the-go convenience, such as plastic bags, expanded polystyrene (EPS) takeaway containers, or polypropylene (PP) drink cups. However, traditional, low-waste practices remain widespread:

- Wet markets are the backbone of daily consumables, with 90% of citizens relying on them – often bringing their own baskets to markets (Figure 16.4).
- On-site consumption is common, especially at tea shops and food stalls, reducing the need for disposable packaging (Figure 16.5).
- Business-to-business packaging often uses organic, biodegradable materials – such as banana leaves, bamboo trays, or woven straw – readily available near rural production areas.

These practices contribute to a structural reduced requirement for SUPs, not through policy or technological innovation, but through continuity of tradition.

Figure 16.4. Wet Market in Yangon

Source: Thant Myanmar.

Figure 16.5. On-Street Restaurants

Source: Thant Myanmar.

The scale of the community economy (Thant Myanmar, 2025b) in urban areas like Yangon is substantial, with an estimated 90% of urban residents relying on it for their daily needs and an average of 50% of household income spent on products sourced from this system. Beyond its environmental benefits, the community economy delivers broad socio-economic advantages, challenging the dominant development narrative, which favours automation, centralisation, and plastic-intensive packaging:

- It provides employment for about 10% of the local population.
- It offers low-barrier job entry for individuals, especially in informal settings – over 60% of vendors operate informally, often using public space to sell or produce goods.
- It supports marginalised groups, particularly women (who own over 70% of local shops) and older persons, who benefit from the flexibility to work from home or set their own hours.
- It contributes to urban social cohesion – places like tea shops and food stalls function as daily gathering spaces, reducing isolation.
- The system aligns well with sustainable urban planning models such as the '15-minute city', where all basic needs are accessible within a short walking distance.

While it is difficult to quantify the community economy's contribution to plastic reduction, the country's low levels of plastic waste generation (OECD, 2025) – combined with its high degree of consumer reliance on the community economy – indicate a strong correlation between this system and reduced plastic consumption as opposed by a system with global supply chains and large supermarkets relying heavily on packaging (Chakori, 2022). This suggests that supporting and preserving the community economy – through inclusive policies, accessible public space, and local economic development – can be a powerful strategy not only for social resilience and economic inclusion, but also for environmental sustainability, particularly in reducing the dependency on SUPs (Box 15).

Box 16.1. The Noodle Soup System – A Tale of Two Models

Noodle soup is one of the most common fast foods accessible in Myanmar. Its widespread popularity makes it a powerful example for understanding how different systems of food production and distribution influence environmental impact, plastic usage, and local economic development. In Myanmar, noodle soup is primarily accessed through two contrasting systems: the linear (industrial) model and the community economy.

1. The linear system: instant noodles
In the linear, industrial model, consumers typically purchase instant noodles (packed in multiple layers of plastic) from retail shops or supermarkets. This model heavily contributes to plastic pollution and resource-intensive consumption, offering minimal economic return to local communities.

2. The community economy: fresh noodle soup vendors
In contrast, the traditional or community-based model offers a markedly different experience. In this system, noodle soup is prepared and sold by local street vendors, tea shops, or small eateries, typically within walking distance of where customers live or work. This system distributes economic value within the local community, enabling small vendors, fresh noodle producers, family-run stalls, and market traders to sustain livelihoods. Moreover, it supports informal employment and inclusive economic participation, especially amongst women and older persons who can work from home.
Source: Author.

Returnable glass bottles (RGBs) are a widely used reuse solution globally. A study by Thant Myanmar (2025a) explored the system in Myanmar, focusing on how bottles are recovered and reintegrated into circulation despite the lack of a regulatory framework. Recent research has categorised this as an open-loop reuse system – meaning that bottles are not exclusively returned to the original producer but remain in circulation, available for purchase by any producer or business in the reverse supply chain.

RGBs are primarily collected by waste pickers, who treat them like any other recyclable material. The bottles pass through the informal recycling logistics chain – from waste pickers to junk shops to aggregators – until they reach washing facilities. These facilities clean the bottles and sell them to producers, which can be any company in need of containers (Figure 16.6). Workers can clean up to 1,000 containers per day. Large-scale washing facilities have a daily flow of 250,000 bottles per day, relying mainly on manual labour.

Figure 16.6. Manual Washing Facility in Yangon

Source: Thant Myanmar.

Since ownership of RGBs transfers with the bottle, there is no fixed loop; instead, a flexible network of producers – primarily large-scale beer and whisky companies – rely on a shared system to return their bottles (Figure 16.7). The current system has the following characteristics:

- About 3.5 million RGBs are circulating in Myanmar – roughly 40% less than polyethylene terephthalate (PET) bottles and nearly double the number of aluminium cans.
- Some 40%–60% of RGBs are reused by their original producer.
- Some 20%–30% are reused by different producers, mostly local small-scale producers.
- Around 15% are lost, either due to breakage or lack of a return market, and end up in waste disposal.

Figure 16.7. Repurposed Beer Bottles

Source: Thant Myanmar.

Producers reliant on RGBs face significant challenges: elevated import costs for new containers generally disincentivise producers to use glass, while frequent supply chain disruptions due to road blockages makes return more costly. Nevertheless, glass offers several advantages; the process of reusing bottles through washing is low-tech, requires no electricity, and can be carried out locally. Reuse also diminishes reliance on imports of new bottles, and consumers often perceive glass packaging as indicative of higher quality. As a result, many producers are choosing to recover more RGBs through reuse, reducing dependency on imported glass (see below).

According to local washing facility operators, the RGB system is growing organically, largely driven by the informal sector. One washer describes the process:

> Waste pickers and junk shops don't always know which containers are reusable, so they collect any glass bottles and pass them up the chain, even at low prices. Over time, washers accumulate these bottles at their facilities. Once enough are collected, they reach out to producers to buy them back. Producers usually agree, since reused bottles cost only a fraction of new ones. After that, the return system increases the RGBs by increasing the prize of the container and therefore incentivising waste pickers to collect more.[1]

On the other hand, in price negotiations on RGBs, producers threaten switching to plastic packaging to reduce prices:

> Producers lower the return price for RGBs by threatening to switch to plastic containers, making margins so slim that transporting RGBs from distant locations is no longer viable, causing these RGB to drop out of the return system.[2]

This informal yet functional process supports the reuse economy and ensures a steady flow of bottles, even without formal coordination.

2.2 Methodologies

In Myanmar, limited research has been conducted on the circular economy – particularly in the areas of reuse systems and non-plastic alternatives. While formal data sources are scarce, these systems are deeply rooted in local traditions and widely practised. As a result, this study draws on a small number of recent research reports, primarily three key studies that form the analytical foundation. To supplement these, it also references international trade data to illustrate trends in formal imports of plastic products.

2.3 Result

Import restrictions lead to product and system innovation in the midstream, strengthening the circular economy: The three systems analysed here all experienced a revival following the imposition of upstream restrictions on plastic product imports. They either utilise traditional mechanisms developed under previous economic hardships to expand their operations or they innovate by using new technologies. It is crucial for policymakers in low-income countries that upstream restrictions on plastic can be seen as a chance to leapfrog the linear economy models of middle- and high-income countries simply by investing in tradition and local systems.

1 Interview with Ko Khant Maung, 14/02/2025
2 Ibid.

The circular and community economy reduces the cost of living while creating local jobs in a low-income country like Myanmar: Countries facing high rates of unemployment and low-paid jobs can benefit significantly from circular systems. On the one hand, the circular economy creates jobs in reuse and repair as well as local production and retail, which leads to circular money flow inside the communities. On the other hand, high-quality reuse and repair products as well as locally produced products greatly reduce the cost of living while maintaining decent living conditions. The result is a win-win for communities, and governments should prioritise the interests of communities over those of large industries and corporations.

3. Discussion

This analysis connects to the ongoing global debate on midstream measures in the international plastic treaty negotiations – particularly the emphasis on product design that reduces reliance on virgin plastics. Increasingly, there is a recognition that solving the plastic crisis demands systemic change, not just better-designed individual products. The African Group's Conference Room Paper for the Intergovernmental Negotiating Committee on Plastic Pollution (INC-5) highlighted this systemic focus (African Group, 2024). Its proposal on product design stresses the following needs:

> Systemic requirements include infrastructure alignment, standardized reuse systems, and Extended Producer Responsibility (EPR) schemes. Infrastructure alignment ensures systems are in place to support the lifecycle of products from design through end-of-life management
> (African Group, 2024).

This approach prioritises systems over single-product fixes, advocating for reuse and repair as the default practice – an important departure from the widely held belief that plastic is necessary for development in low-income countries. The African Group, composed primarily of low- and lower middle-income nations, argues the opposite: development is better supported by systems that reduce material input and maintain product value over time.

This perspective aligns strongly with Myanmar's reality. As a local glass washer noted, cheap plastic threatens traditional circular systems, including reuse of bottles and natural packaging industries. Until around 2010, Myanmar widely used leaves, bamboo, and other biodegradable materials for packaging. Meals were often consumed at roadside stalls with reusable tableware, deeply embedding non-plastic systems into everyday life.

In high-income countries – especially within the European Union (EU) – regulatory tools like the 2024 EU Directive on the Right to Repair are shaping the transition to circular systems. However, since these tools require a high level of regulatory enforcement capacity, they are often ill-suited to low-income contexts where informal and traditional practices are embedded in local, traditional practices and generate far less plastic waste without the backing of formal laws. These systems are frequently overlooked in global policy discussions because they are not the result of formal institutions or modern innovation. As a result, they are often mischaracterised as underdeveloped, rather than being recognised as efficient, resilient, and contextually appropriate solutions. This perception has led to under-representation of Global South countries in international negotiations, despite their practical, long-standing experience with reuse, repair, and waste reduction.

South and Southeast Asian countries are particularly well positioned to lead in systemic and product innovation because of the following reasons:

(i) Their circular systems are already active, often rooted in tradition, and widely practised.
(ii) These systems support local economies, gender equality, and social inclusion (e.g. over 70% of Myanmar's small food vendors are women-owned, and older persons often participate in home-based production).
(iii) Informal reuse and repair systems offer people access to high-quality goods at a low cost, while profits stay within the community.
(iv) Open-loop reuse, such as Myanmar's returnable glass bottle network, outperforms recycling by providing more income opportunities across the value chain – especially for waste pickers.

Despite their effectiveness, these systems often lack support from national governments. Informal recyclers, like waste pickers, continue to face legal and institutional barriers, even after decades of advocacy. Reuse and repair sectors have even less formal representation and capacity to shape policy.

In that regard, countries like Myanmar, which face economic and resource constraints, are not lagging – they are already practising many core principles of the circular economy. What is needed now is for these governments to embrace and elevate their own solutions, and for international frameworks to recognise and integrate these practices into the global response to the plastic crisis.

4. Conclusion: Myanmar as a Case Study for System-Based Midstream Solutions

The case of Myanmar illustrates how a system-based approach in the midstream of the plastic life cycle can meaningfully reduce plastic reliance and help tackle plastic pollution. These systems do not depend on advanced technology or large-scale investments. Instead, they are rooted in traditional knowledge and localised practices that sustain and strengthen community-based economies.

Similar models – anchored in reuse, repair, and local production – exist to varying extents across all ASEAN Member States. This offers a shared foundation for locally adapted, low-cost solutions that provide both environmental and socio-economic benefits.

In Myanmar, these midstream systems evolved out of tradition and necessity, shaped by long-standing resource scarcity and economic constraints. However, their continued relevance depends on transforming them into intentional, forward-looking models – not just coping mechanisms.

During Myanmar's political opening in 2011, these traditional systems were challenged by an influx of linear, industrialised structures: centralised manufacturing, large retail chains promoting long-shelf-life products, and international brands introducing disposable packaging. This shift represented a broader tension between two competing development paths:

- On one side, the modern, linear model – often associated with high-income countries like the United States – emphasises convenience, scale, and consumption. This model was often viewed as a benchmark for development and has only recently been challenged by the ideal of circularity.
- On the other side, traditional systems – which are decentralised, resource-efficient, and low-waste – offer a more sustainable model, though often undervalued in policy and public perception.

For Myanmar and other countries with similar experiences, the question is one of values and direction: whether to pursue a model of development that replicates the environmental pitfalls of the Global North, or to recognise, protect, and invest in home-grown systems that are already aligned with the circular economy.

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Chapter 17

Plastic Waste Management in the 'Middle Island Regions' of the Philippines

Melissa May F. Cardenas

1. Introduction

The Philippines, as a tropical archipelagic country, faces unique challenges in plastic waste management due to its geography, which includes long coastlines, mountainous terrain, and an increasing number of people living in coastal areas. This makes the country highly susceptible to plastic leakage into the marine environment and positions it as a major contributor to global marine plastic pollution.

This report, which focuses on the 'middle island regions' of the Philippines, highlights that these areas have some of the highest percentages of 'residual' waste, which is mostly composed of single-use plastics and sachets. This contrasts with the more urbanised regions of Luzon, where most of the country's recyclable plastic waste is generated. The high cost of logistics and a lack of recycling facilities outside urban Luzon make it difficult to collect and transport plastics for recycling in the middle island regions, leading to lower collection rates. The report suggests that interventions in these areas are crucial to reducing plastic pollution.

This introductory section provides an overview of the solid waste management situation in the Philippines, with a focus on plastic waste. National government policies and programmes will also be discussed, as well as some local government and private sector initiatives. We expound on the rationale for focusing on medium-sized and small islands in the Philippines, as well as looking at areas with varying levels of urbanisation and access to solid waste management technologies.

1.1 Marine plastic pollution in the Philippines

The Philippines, with a land area of 300,000 square kilometres and a population estimated at over 114 million in 2024 (ranking 12th globally), faces significant challenges in waste management, exacerbated by its 48.3% urbanised population. It is estimated that cumulative waste generation from 2000 to 2030 will exceed 70 million tons (Mt) (ADB, 2004). The nation's waste generation rate for 2025 is projected at 62.8 kilotons per day, with the National Capital Region alone contributing 9.4 kilotons per day (DENR EMB, 2025). Plastic waste constitutes a substantial portion of the municipal solid waste stream, ranging nationally from 12% to 24% (DENR, 2025).

Adding to the plastic burden, the country imported an average of 2 Mt of plastics and plastic products annually between 2021 and 2023 (Environweave Integrative Environmental Research, 2025a). A deeper dive into importation data from 2012 until 2024 also revealed that 180 kilotons of plastic goods that were described as 'scrap', 'used', or 'second-hand' entered the Philippines during this 13-year period, averaging about 7.7 kilotons per year until 2017, but jumping to 19 kilotons per year afterward, coinciding with the implementation of stricter waste importation into China through its Operation National Sword (Environweave Integrative Environmental Research, 2025b).

A landmark study estimated the amount of plastic leakage to the marine environment for 192 countries, using a model that considered factors such as coastline length, coastal population, waste generation, plastic waste percentage, and mismanaged waste (Jambeck et al., 2015). For the Philippines, the model estimated 0.28–0.75 Mt of plastic marine debris leakage annually. This extensive plastic waste generation and mismanagement have positioned the Philippines as a major contributor to global marine plastic litter, ranking third out of 192 countries. In addition, a 2021 model on riverine plastic contributions to the ocean ranked the Philippines highest, with 4,820 rivers collectively emitting over 350,000 Mt of plastic per year (Meijer et al., 2021).

Aside from plastic pollution leakage to the environment, the economic impact of this primarily linear plastic economy is significant: 78% of the material value for major resins like polyethylene terephthalate (PET), polypropylene (PP), and polyethylene (PE) is lost due to low collected-for-recycling rates (World Bank, 2021).

1.2 Efforts to address plastic pollution in the Philippines

The Philippines has implemented several key legislative and strategic initiatives to address its solid waste and plastic pollution crisis. The foundational law, the Ecological Solid Waste Management Act of 2000, places the primary responsibility for managing waste from residential and commercial sources on local government units.[1] This act notably set an ambitious target for local governments to divert at least 25% of waste through reduction, reuse, recycling, and composting by 2005.[2] Building on this, the Extended Producer Responsibility Act was enacted in 2022, mandating that major producers of plastic packaging, termed 'Obliged Enterprises', establish extended producer responsibility (EPR) programmes to recover a specific percentage of their previous year's plastic packaging footprint. The law sets a progressive recovery target, aiming for 80% by 2028.[3] Initial efforts under the EPR Act show promise; as of audited reports submitted for 2025, recovery rates reached 55.60% for rigid plastics, and 56.33% for flexible plastics, both exceeding the mandated recovery target of 40% of the 2024 plastic footprint (DENR, 2026).

Beyond legislation, the National Plan of Action on the Prevention, Reduction, and Management of Marine Litter outlines six programmatic actions, including marine litter baseline studies, promoting a circular economy, and addressing existing river and marine litter (DENR, 2021). It also details four enabling and cross-cutting actions, such as policy support, enforcement, financing, and capacity building.

Reinforcing these efforts, the National Plastic Action Partnership (NPAP) was launched in January 2025 (Moaje, 2025). This initiative is led by the Department of Environment and Natural Resources (DENR), with support from the Global Plastic Action Partnership under the World Economic Forum, and includes vital representation from the private sector.

[1] Republic Act No. 9003, Chapter II, Article 1, Section 10.

[2] Republic Act No. 9003, Chapter III, Article 1, Section 20

[3] Republic Act No. 11898, Chapter III-A, Article 2, Section 44-F.

1.3 Plastic waste management challenges in archipelagic Philippines

The Philippines, a nation of 7,641 islands clustered into Luzon, Visayas, and Mindanao, presents unique challenges for plastic waste management. The country has 82 provinces, which are administratively divided into 18 regions. This study focuses on five regions located in its geographical 'middle', which are uniquely defined by their composition of medium-sized and small islands disconnected from the larger landmasses of Luzon and Mindanao: Southwestern Tagalog (MIMAROPA), Western Visayas, Central Visayas, Eastern Visayas, and the newly formed Negros Island Region (Figure 17.1).

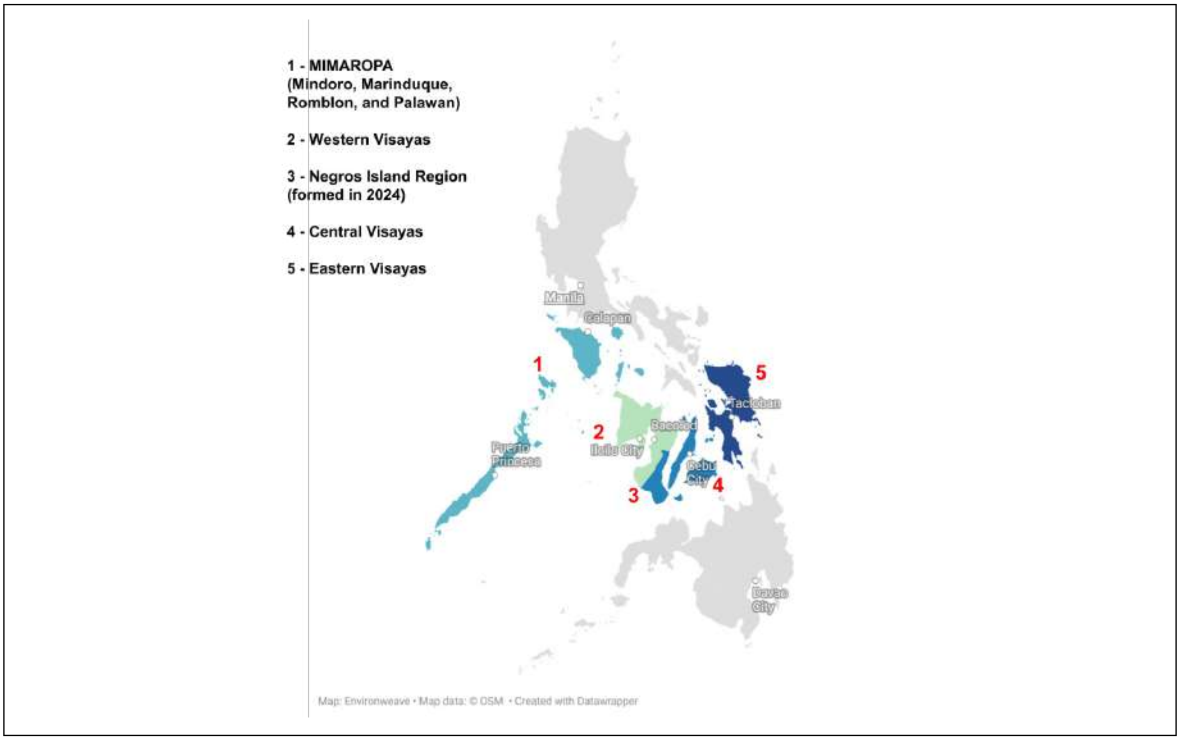
The waste management challenge is particularly acute in these ecologically sensitive middle island regions. Their unique geography, characterised by narrow coastal strips between shorelines and mountains, concentrates human settlements along the coast. This high coastal population density is a key factor in plastic leakage models, such as the one by Jambeck et al. (2015), which estimated that 15%–40% of plastic waste generated in coastal areas reaches the ocean. While studies on large river basins like the Mekong suggest that a smaller percentage of plastic (less than 2%) ultimately reaches the marine environment, archipelagic countries like the Philippines and Indonesia face higher leakage rates. This is attributed to their shorter river lengths and the proximity of dense populations to coastal areas (Meijer et al., 2021). A caveat is that the plastic reservoirs captured along the riverbanks would become remobilised during high wind speeds, heavy rainfall, flooding, and river discharge (van Emmerik et al., 2022). This is troubling given that extreme weather events are occurring more frequently in the Philippines, with the country having ranked first in the World Risk Index for several years (Bündnis Entwicklung Hilft/IFHV, 2024).

Adding to the complexity, these middle islands are home to many of the Philippines' most popular tourist destinations and 'resort islands'. For instance, Boracay Island, famous for its white sand beaches, experiences the highest daily per capita waste generation rates in the country, reaching 1.46 kilograms (kg) per person per day. This rate contrasts sharply with the island's waste generation of only 0.30 kg/person/day during its temporary closure for 6 months in 2018 to tourism, as surveyed by the National Solid Waste Management Commission (NSWMC) Technical Working Group. In fact, tourist waste generation rates can go as high as 4.88 kg/person/day, effectively 10 times that of residents, which is computed at 0.41 kg/person/day (Razon, 2019). Other tourist hubs, such as the municipalities of El Nido and Coron in Palawan, also have elevated waste generation rates of around 0.60 kg/person/day (DENR EMB, 2025a), a figure comparable to those of highly urbanised cities in the Philippines (Environweave Integrative Environmental Research, 2023).

An additional layer of urgency is that many of these islands, including Coron, Palawan, Mindoro, Sibuyan, and Verde Island, are critical hubs for terrestrial and marine biodiversity. These biodiversity hotspots host a high concentration of endemic flora and fauna. In particular, the Verde Island Passage has been identified as having the world's highest index of marine shore fish biodiversity (Carpenter and Springer, 2005). Similarly, Sibuyan Island is referred to as the 'Galapagos of Asia' due to its geological isolation and high number of endemic mammals, trees, and vascular plants (Heaney, 1993; Goodman and Ingle, 1993; Esselstyn and Goodman, 2010).

Given that the middle island regions of the Philippines are both economically vital tourist destinations and globally significant biodiversity hotspots, their potential as sources of marine pollution is a critical concern. Therefore, it is essential to closely examine plastic waste generation in their coastal cities and municipalities and to support their localised waste reduction and management efforts.

Figure 17.1. Five 'Middle Island Regions' in the Philippines



Source: Map created by Environweave Integrative Environmental Research for this report using the Datawrapper app.

1.4 Regional waste generation patterns in the Philippines

The waste management situation across the five island regions included in this study varies widely, depending on the level of urbanisation and economic activity. On one hand, there are cities and metropolitan areas that are considered highly urbanised and host special/industrial economic zones. At the other extreme are remote islands that do not have running water and have limited access to electricity, becoming reliant on packaged food and water, thus generating plastic packaging waste with uncertain methods of disposal.

It is often challenging to find sub-national waste generation data, let alone estimates of plastic waste generation in specific regions of the Philippines. While the DENR Environmental Management Bureau (EMB) website provides the projected amount of solid waste generated daily with granularity up to the city/municipality level, these estimates are primarily based on demographic data, and most likely based on assumed waste generation rates of 0.5 kg/person/day for urban populations and 0.3 kg/person/day for rural populations from more than 2 decades ago (World Bank, 2001; NSWMC, 2004). Thus, a more accurate albeit tedious method is a bottom–up approach using local solid waste management data.

2. Determining the Rate of Plastic Waste Generation in the Philippines

As mentioned in Section 1, there are varying estimations of the amount of plastic waste generated in the Philippines at the national level. These may have been generated through computational models in relation to more available data from other countries or may have been based on local studies mainly done in Metro Manila and projected nationally. Neither methodology would provide the granularity needed to understand the complexity of plastic waste generation and management in other parts of the Philippines. This section proposes a methodology for consolidating representative municipal-level data and provides the result of this analysis towards more detailed estimations of waste generation, with a focus on plastic-related waste in the middle island regions of the Philippines.

2.1 Regional waste generation patterns in the Philippines

Each municipality, city, and province in the Philippines is required to submit a Solid Waste Management Plan (SWMP) that covers a period of 10 years.[4] This SWMP contains data on waste generation rates, municipal waste composition, and budget allocation, as well as local government plans and programmes on the diversion of waste from final disposal in landfills.

All SWMPs contain the results of a waste analysis characterisation study (WACS), providing municipal waste composition based on four categories outlined by the Ecological Solid Waste Management Act: biodegradable waste, recyclables, residual waste, and special waste (e.g. hazardous waste and bulky waste). This waste characterisation identifies 'the constituent materials which comprise the solid waste generated within the jurisdiction of the LGU'.[5] Essentially, WACS data submitted by Local Government Units (LGUs) were based on waste generated at the source and often do not contain analysis of waste at the 'end of pipe', i.e. at the final disposal site, where it is expected to be primarily residual waste.

To encourage increased diversion rates, updated guidelines for conducting WACS include identifying the fraction of 'residual waste with potential for recycling'. This includes low-value plastics or sachets that can be processed as refuse-derived fuel (RDF) for cement kiln co-processing or infused as composite material for plastic pallets and other methods of mechanical recycling.[6] Figure 17A in the supplementary material shows these waste categories as shown in the NSWMC WACS Manual (NSWMC et al., 2020).

[4] Republic Act No. 9003, Chapter III, Article 1, Section 16. Local Government Solid Waste Management Plans.

[5] Republic Act No. 9003, Chapter III, Article 1, Section 17b, Components of the Local Government Solid Waste Management Plan - waste characterisation.

[6] NSWMC Resolution No. 1380, Series of 2020. Adopting the Guidelines on the Waste Analysis and Characterization Study and Its Related Manual.

2.2 Deriving regional plastic waste composition and generation rates in the Philippines

An analysis of local government 10-year SWMPs was conducted by Environweave for the Economic Research Institute for ASEAN and East Asia (ERIA) (Environweave Integrative Environmental Research, 2023), based on data from 742 SWMPs provided by the NSWMC Secretariat. This chapter incorporates data from 15 additional LGUs from the MIMAROPA region that were previously not available. Grouped by administrative region, weighted averages of the waste composition reported in SWMPs were calculated in relation to the population of that municipality or city. This provided a region-specific breakdown of the four major categories of waste.

However, it is very rare to find detailed information specifically on the plastics component of the generated waste from submitted SWMPs. Globally, plastics range from 8% to 12% of municipal solid waste (Kaza et al., 2018). DENR estimates range from 12% to 24%, likely compiled from various studies, although it was difficult to find the specific sources of these estimates, therefore it is unclear how these estimates were derived. A summary of these plastic composition estimates is provided in Table 17A in the supplementary material.

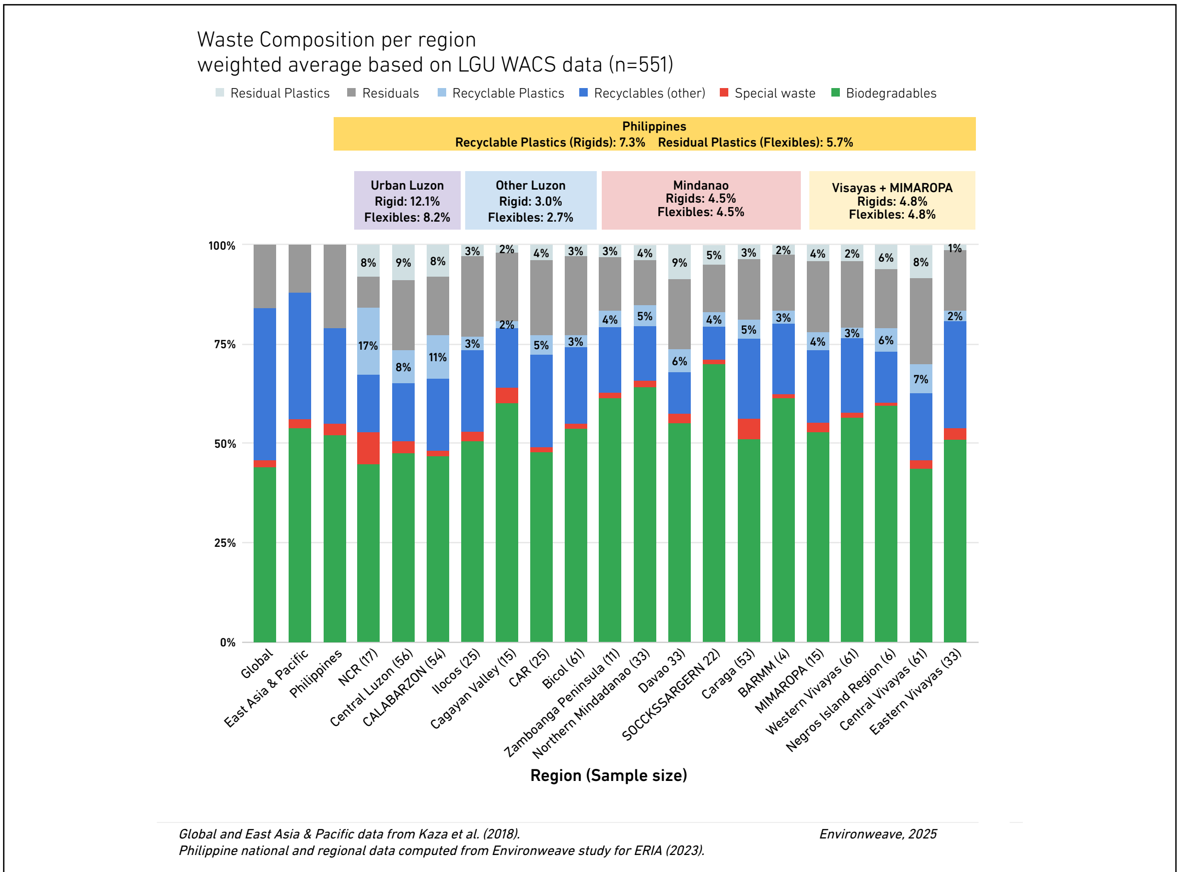
Meanwhile, an analysis of the SWMPs of Metro Manila showed that plastics comprise 54% of the recyclables fraction, or about 20% of the total waste generated (World Bank, 2022a). Using the regional weighted average of the recyclables fraction obtained from the SWMP dataset, 54% of this value is used to calculate the plastic component as a first step, assuming that the entirety of the regional population is urbanised. Furthermore, this study assumes that half of the residual waste fraction is composed of flexible plastic waste in Metro Manila households, adopting estimates used in the Waste Management Infrastructure Gap report under the Healthy Oceans and Clean Cities Initiative project (World Bank, as cited in Mogol et al., 2022). Since these fraction values are based on studies done in Metro Manila with a 100% urbanisation rate, these results are then adjusted based on the urbanisation rate for each region based on the 2020 Census of Population and Housing (Philippine Statistics Authority, 2022).

The LGU SWMP dataset from 2023 also contained per capita daily waste generation rates from 476 cities and municipalities. This study adds 14 more values from the MIMAROPA region that were previously unavailable. These values were then grouped according to the 18 Philippine regions, and weighted averages were computed in consideration of the populations of the contributing LGUs. Most of these values were from waste analysis and characterization studies conducted around 2015, so these were adjusted to 2025 values based on a 1.2% annual increase estimated by a joint study by the NSWMC, DENR and IGES (2019). The amount of waste generated daily at the regional level was then computed by multiplying the 2025 projected population of each corresponding region. Then, the fractions of the corresponding waste types (plastic recyclables and residuals, other recyclables, other residuals, special waste, and biodegradables) were used to compute the amount of each waste type generated daily for each region. The results of these computations are provided in Tables 17B–17D in the Supplementary Material.

2.3 Estimating plastic composition and volume of Philippine municipal waste

Figure 17.2 shows the waste composition profile across the different regions of the Philippines computed for this study based on the methodology outlined in Section 2.2. Based on WACSs from 551 cities and municipalities, rigid plastics that are collected for recycling comprise an estimated 7.3% of the municipal waste in the Philippines. This average is weighted with consideration to population distribution across the 18 regions. Meanwhile, the national weighted average for the plastics fraction of residual waste (primarily composed of flexible plastics and laminates) is about 5.7% of total municipal solid waste. Together, plastics make up 13% of municipal waste in the Philippines. The waste composition distribution of biodegradables, special waste, and other recyclables is also available in the supplementary material.

Figure 17.2: Waste Composition Across Philippine Regions

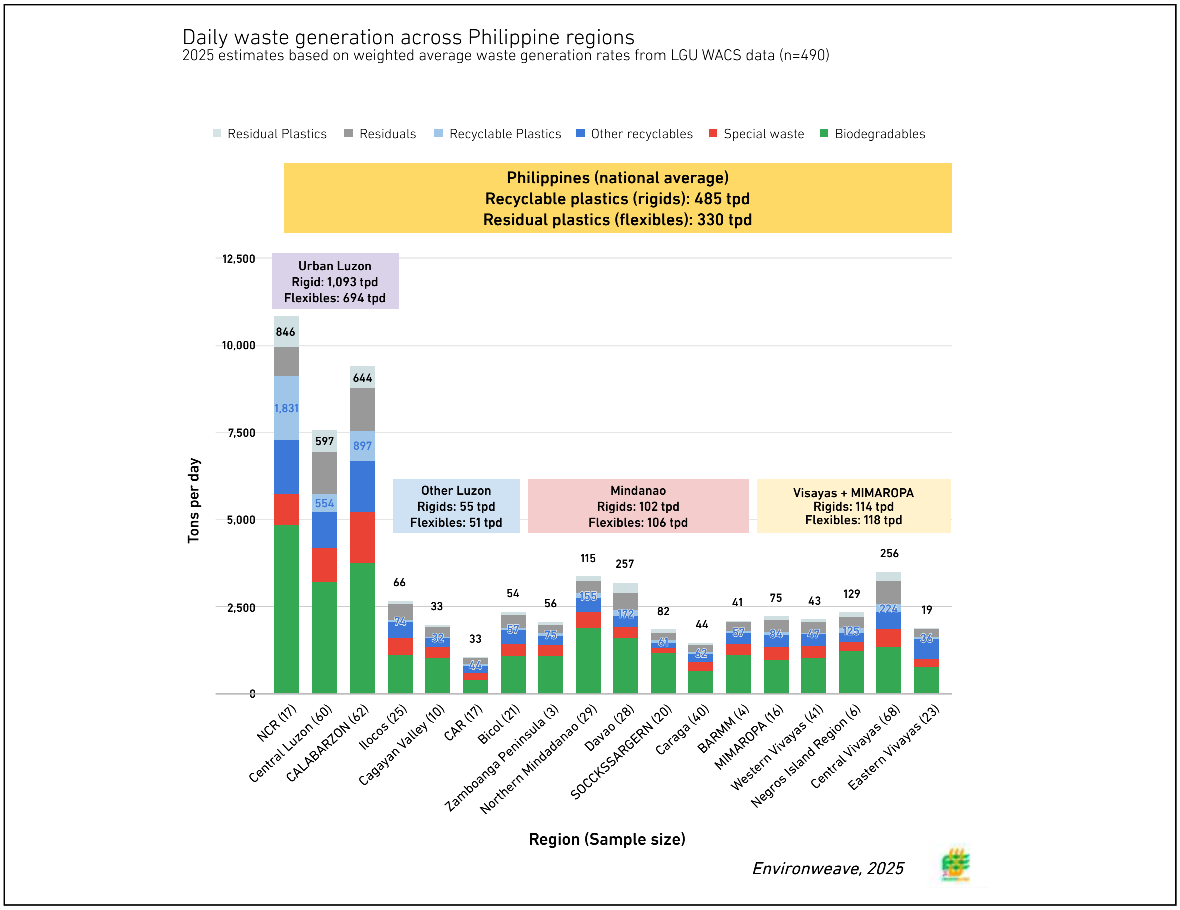


BARMM = Bangsamoro Autonomous Region in Muslim Mindanao; CALABARZON = Cavite, Laguna, Batangas, Rizal and Quezon; CAR = Cordillera Administrative Region; LGU = local government unit; MIMAROPA = Mindoro, Marinduque, Romblon, and Palawan; NCR = National Capital Region; SOCCSKSARGEN = South Cotabato, Cotabato (North Cotabato), Sultan Kudarat, Sarangani, and General Santos City; WACS = waste analysis characterisation study

Sources: Compiled by Environweave. Global and East Asia & Pacific data from Kaza et al. (2018); Philippine national and regional data from Environweave Integrative Environmental Research (2023); and plastics fraction estimated based on the methodology described in Section 2.2 of this report. Details provided in Table 17B, Supplementary Material.

Meanwhile, Figure 17.3 shows daily waste generation rates in the 18 regions for 2025, highlighting the portions for plastics and residual waste. The estimated amounts of plastics, other recyclables, and residual waste generated daily according to the major island groupings are shown, with Metro Manila and the two highly urbanised regions surrounding it shown separately from the rest of Luzon. As expected, these urbanised regions in the Philippines have the highest waste generation rates, generating more than 70% of recyclable (rigid) plastics and more than 60% of the residual (flexible) plastic waste in the Philippines (Figure 17.4).

Figure 17.3: Plastic Daily Waste Generation Across Philippine Regions

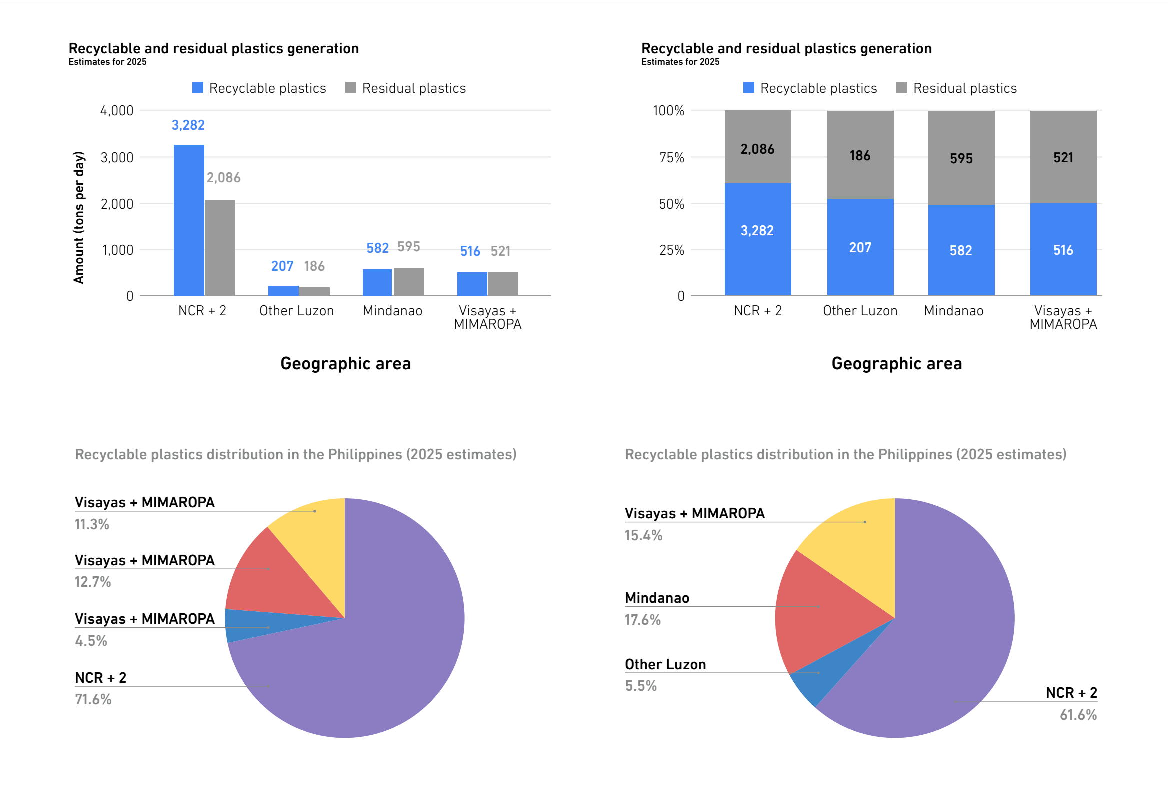


BARMM = Bangsamoro Autonomous Region in Muslim Mindanao; CALABARZON = Cavite, Laguna, Batangas, Rizal and Quezon; CAR = Cordillera Administrative Region; LGU = local government unit; MIMAROPA = Mindoro, Marinduque, Romblon, and Palawan; NCR = National Capital Region; SOCCSKSARGEN = South Cotabato, Cotabato (North Cotabato), Sultan Kudarat, Sarangani, and General Santos City; tpd = tons per day; WACS = waste analysis characterisation study.

Notes: Rigid and flexible plastics daily generation rates are shown per region, estimated based on methodology described in Section 2.2 of this report. Regional data are based on the results of 490 daily waste generation rates (kilograms/person/day) as reported in LGU 10-year Solid Waste Management Plans (Environweave, 2023).

Sources: Compiled by Environweave. Regional data computed from Environweave Integrative Environmental Research (2023). Details provided in Table 17C, Supplementary Material.

Figure 17.4: Plastic Waste Distribution Across Philippine Regions



LGU = local government unit; MIMAROPA = Mindoro, Marinduque, Romblon, and Palawan; NCR = National Capital Region

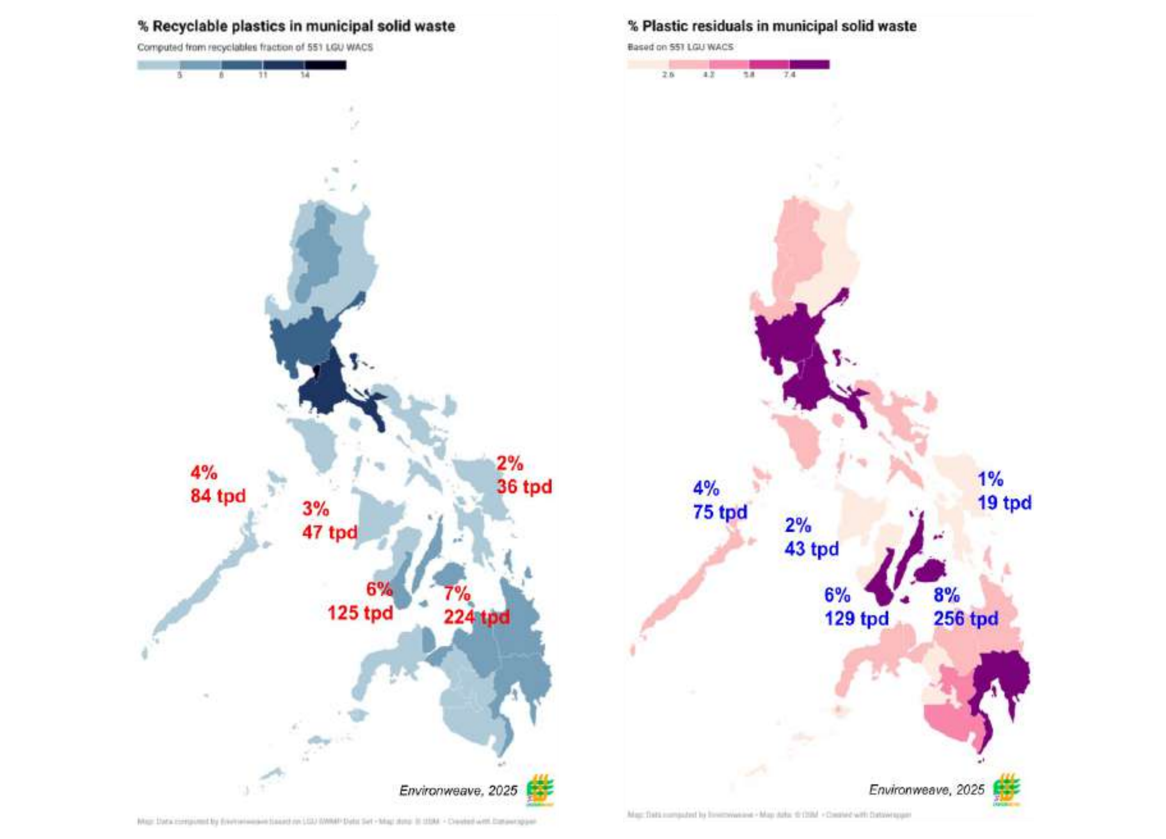
Notes: Plastics fractions are estimated based on methodology described in Section 2.2 of this report. Regional data are based on the results of composition analysis of 551 waste analysis and characterisation studies conducted at the city or municipal level and waste generation rates reported by 490 LGUs.

Sources: Compiled by Environweave. Regional data computed from Environweave Integrative Environmental Research (2023). Details provided in Table 17C, Supplementary Material.

2.4 Estimating plastic waste composition in the middle island regions

Looking at waste composition profiles in the middle island regions of the Philippines, the portion of plastics that are often collected for recycling is 2%–7%, while the residual plastic waste (i.e. single-use plastics and sachets), is 1%–8% (Figure 17.5). Outside the three highly urbanised regions of Luzon, the ratio of rigid and flexible plastics is nearly 1:1 in terms of weight. It is worth noting that the Central Visayas region and the Davao region where Metropolitan Cebu and Metropolitan Davao are located, respectively, reflect the highest residual plastic fractions of all the regions in the Philippines – higher than even the National Capital Region. The implications of these will be discussed further in Section 3.

Figure 17.5. Recyclable and Residual Plastic Fractions In The Middle Island Regions



tpd = tons per day, LGU = local government unit, WACS = waste analysis and characterisation study

Notes: Regional data are based on the results of 551 waste analysis and characterisation studies conducted at the city or municipal level. Recyclable and residual plastic fractions and the generated amount is estimated based on the methodology described in Section 2.2 of this report.

Sources: Chart created by Environweave using the Datawrapper app. Regional data computed from Environweave Integrative Environmental Research (2023). Details provided in Table 17C, Supplementary Material.

2.5 Estimating Philippine per capita plastic waste generation rate

Using per capita daily waste generation rates from WACS results from 490 cities and municipalities, each Filipino generates 0.49 kg of solid waste per day. Using the national values of the recyclable and residual plastic waste fractions, each Filipino generates about 70 grams of recyclable plastic and residual waste daily – equivalent to the weight of a small banana. In 1 month, this would accumulate to about 2 kg of plastic waste per Filipino.

Extrapolating this on a national scale with the projected population in 2025, the Philippines is expected to generate 1.7 Mt of recyclable plastic waste and 1.2 Mt of residual plastic waste this year, totalling 2.9 Mt of plastic-related waste.

The national plastic roadmap being finalised under the NPAP provides an estimate of 1.8 Mt of plastic to be generated annually based on 2020 baseline data (National Plastic Action Partnership, 2025), close to this study's estimate for recyclable plastic waste generation of 1.7 Mt.

Meanwhile, the DENR lower limit estimate for plastic waste generation is at 2.7 Mt of plastic (DENR, 2025), which is close to the combined values of the recyclables and residuals plastic fractions computed in this study, at 2.9 Mt.

Note that all these computed plastic generational values are two to three times less than the projected plastic waste generation estimates of the Jambeck study, at 6.1 Mt by 2025 (Jambeck et al., 2015). The estimates of plastic waste generation in the Philippines from studies done over the past decade are available in Table 17E.

3. Implications of Regional Variation in Plastic Waste Generation

By using a bottom–up approach in estimating the amount of plastic-related waste that is being generated in the different geographical regions of the Philippines, this section discusses the results from Section 2 and their implications in designing waste management strategies and supporting infrastructure. By identifying areas that are potential plastic pollution hotspots given their high waste generation rates, proximity to the sea, and limited access to material recovery facilities, recycling facilities, and final disposal sites, interventions in these areas would have highly positive impacts on reducing plastic leakage to the environment.

This section also includes photos from site visits and insights from key informant interviews with local government representatives, junk shop operators, and sanitary landfill managers conducted from March 2019 up to March 2025. Some of these visits to island-based cities and towns were conducted for the 2023 ERIA report (Environweave Integrative Environmental Research, 2023), while other visits were independently funded by Environweave as part of continuing research on waste management issues in different parts of the country. This section highlights some creative initiatives to minimise plastic waste pollution in the middle island regions.

3.1 Significant regional variation in plastic waste generation

Some interesting patterns can be identified regarding plastic and residual waste generation in relation to the major island groupings, based on the results of the WACS data analysis:

1. **More than 70% of recyclable plastic waste in the Philippines is generated in the three highly urbanised regions of Luzon**. More than 3,000 tons of recyclable plastic waste in the Philippines is generated daily by just the three highly urbanised regions found in the Luzon Island group: the National Capital Region (NCR); Central Luzon; and Cavite, Laguna, Batangas, Rizal, and Quezon (CALABARZON). This makes them the primary hubs for large-volume waste trade and recycling. This has an implication on the distribution of waste collection and material recovery activities in other parts of the country.

2. **More than 60% of residual plastic waste in the Philippines is generated in the three highly urbanised regions of Luzon**. The residual plastic waste (which can be considered 'flexible' plastics and laminates) generated in Metro Manila, Central Luzon, and CALABARZON amounts to more than 2,000 tons per day. This implies that diversion of these low-value plastics is crucial in these areas, so collection hubs for processing RDF or mechanical integration into plastic-based construction materials would make more business sense in these areas.

   Urbanised areas reflect residual plastic waste fractions of 8%–9%. Five highly urbanised regions show residual plastic waste fractions of at least 8%. Outside the Greater Metro Manila area, values are exhibited by Central Visayas and the Davao region. This may be attributed to a high level of urbanisation and a large commuter population in cities like Cebu, Lapu-Lapu, and Mandaue, comprising Metropolitan Cebu, as well as Davao City and its surrounding urban areas. These urban areas may have greater reliance on necessities that are packaged in sachets so that these can be bought inexpensively in small quantities (locally called 'tingî'). Even popular beverages are sold in 190-millilitre bottles, designed for distribution in areas with lower incomes.

3. **In Mindanao, the Davao Region has the highest percentage of recyclable and residual plastic waste**. Collectively, plastic-related waste generation in the Davao Region at 429 tons per day accounts for more than one- third of the municipal waste generated in Mindanao. It is also worth noting that the residual plastic waste generated at 257 tons per day exceeds that of recyclable plastic waste at 172 tons per day. In Mindanao, materials that are typically classified as 'recyclables' in other areas may not be reaching waste trade networks and instead end up in landfills. This is particularly notable given that weekly coastal clean-ups in Davao City have shown that 24% of the collected waste consists of PET bottles, which are commonly recycled elsewhere in the country (Environweave Integrative Environmental Research, Ridge to Reef, and Davao City ENRO, 2022).

4. **In the middle island regions, Central Visayas has the highest percentage of recyclable and residual plastic waste**. For Visayas and MIMAROPA, nearly 50% of plastic-related waste is generated in Central Visayas, at an estimated 480 tons per day. The amount of residual plastic waste in this region (256 tons per day) also exceeds that of recyclable plastic (224 tons per day), though not as significantly as the Davao region. Given that several cement factories are on the island of Cebu, this makes it convenient for flexible plastics to be processed as RDF. However, this option is a challenge for other middle island regions, given the high cost of inter-island transportation.

3.2 Limited regional recycling and waste treatment

Since larger volumes of recyclable materials – and by extension, recyclable plastics – are generated in the urban regions of Luzon, most recycling and waste treatment facilities are located there. In the inventory of junk shops and recycling facilities provided by the NSWMC, numerous junk shops are found all over the country; however, most recycling plants are in NCR, Central Luzon, or CALABARZON. Only three recycling facilities are found elsewhere, specifically in Mindanao, and none in the middle island regions (NSWMC, 2023).

This implies that there would be lower collection-for-recycling rates in the rest of Luzon, especially in Mindanao and the middle island regions, since a larger distance must be covered to bring enough waste to consolidators and recycling centres. This would require a large investment in logistics given the need for sea transport, as well as a large area for local consolidation to amass sufficient volume for cost-efficient operations. It does not make business sense to operate large-scale materials recovery or recycling facilities outside the Greater Manila area, unless there are strategic clustering and consolidation of sufficient volumes to maximise hauling and other operational costs.

As mentioned briefly in Section 2.1, there have been some shifts in allowing for more nuanced classifications of what post-consumer waste types are considered 'recyclable' or 'residual'. In a resolution by the NSWMC adopting the updated Guidelines on the Waste Analysis and Characterisation Study, there is a new subcategory for waste classification for 'residuals with recycling potential'.[7] This pertains mostly to low-value plastic films and laminates that are dried and shredded for integration into rigid plastic lumber, or RDF for cement kiln co-processing. It may be beneficial for new guidelines to include the accessibility of a trade network as a defining criterion for classifying post-consumer waste as 'recyclable', aside from its material composition.

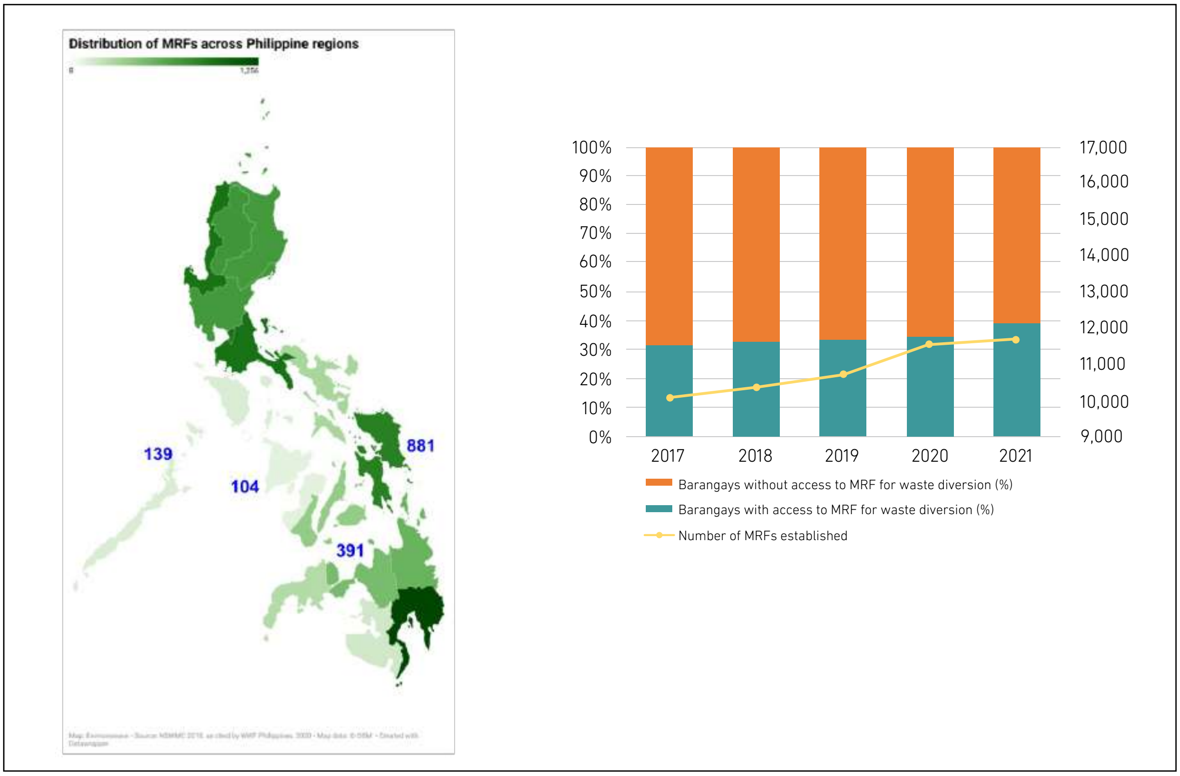
3.3 Limited materials recovery in middle island regions

Under Republic Act No. 9003, each barangay (the smallest level of local governance) should either have a materials recovery facility (MRF) or be connected to a materials recovery system (MRS). However, as of 2021, only 39% of the more than 42,000 barangays nationwide are serviced by an MRF or MRS (Commission on Audit, 2023), as shown in Figure 17.6, which also provides a distribution map of MRFs across the Philippines. This map is based on the number of MRFs as of 2018, highlighting the counts for the middle island regions. In these same regions, there are more municipalities that are classified under lower income brackets compared with other parts of the Philippines.[8] This means that they also have less internal revenue allotment, and less fiscal flexibility to improve waste management infrastructure or assign personnel as municipal or barangay environment officers.

[7] NSWMC Resolution No. 1380, Series of 2020. Adopting the Guidelines on the Waste Analysis and Characterization Study and Its Related Manual.

[8] Department of Finance DAO 074 Series of 2024, 'Schedule of income classification for the first general income reclassification of provinces, cities, and municipalities based on the income ranges' under Republic Act No. 11964.

Figure 17.6. Availability of Material Recovery Facilities Across the Philippine Regions



DENR EMB = Department of Environment and Natural Resources Environmental Management Bureau, MRF = material recovery facility, NSWMC = National Solid Waste Management Commission.

Notes: MRF distribution map (left) developed by Environweave for this report using the Datawrapper app, adapted from World Wide Fund for Nature Philippines (2020) citing 2018 data from the National Solid Waste Management Commission. The Negros Island Region was still part of the Western Visayas and Central Visayas Regions.

Graph showing establishment rate of MRFs (right) published by the Commission on Audit (2023) based on data from National Solid Waste Management Commission and DENR EMB.

Sources: Compiled by Environweave based on World Wide Fund for Nature Philippines (2020) and Commission on Audit (2023).

Highly urbanised cities in the middle island regions would have more financial resources to construct centralised MRFs with larger storage areas as well as space for sorting and further processing of recyclable materials. However, many barangay MRFs in the island municipalities are low-cost 'cage-type' structures that serve as temporary storage for recyclables, pending collection and transfer to the centralised MRF managed by the municipality. Others developed a mobile MRF that can go around smaller roads to collect recyclables from households. One island barangay has an informal agreement with fishing vessels that regularly pass through their village to bring the collected recyclables and unload them when they get to the fish ports in Metro Manila.[9] Some of these MRFs are shown in Figure 17.7.

[9] Environweave field interview, Busuanga, 2019.

Figure 17.7. MRFs in the Middle Island Regions of the Philippines

Left: A concrete centralised MRF in Calapan City, Mindoro Island. Photo: Seph Baluyot, Nov 2018. Right: A simple *purok* MRF in Palawan island. Photo: Mel Cardenas, April 2019

Above: A mobile MRF of Barangay Tabing Dagat, Odiongan, Tablas Island Romblon.
Below, left: Collection cages for PET bottles and other plastics; right: murals near the community baywalk to increase environmental awareness to reduce plastic pollution, Odiongan, Romblon.
Photos: Mel Cardenas, June 2024.

Left: A cage-type MRF in the island barangay of Panlaitan, Busuanga. Some of the recyclables are collected by fishing vessels that dock on the island on their way back to the Navotas fish port in Metro Manila. Right: Location of Panlaitan Island. 12°07'15.0"N 119°50'56.0"E Photos: Mel Cardenas, April 2019

MRF = material recovery facility, PET = polyethylene terephthalate.

Source: Environweave.

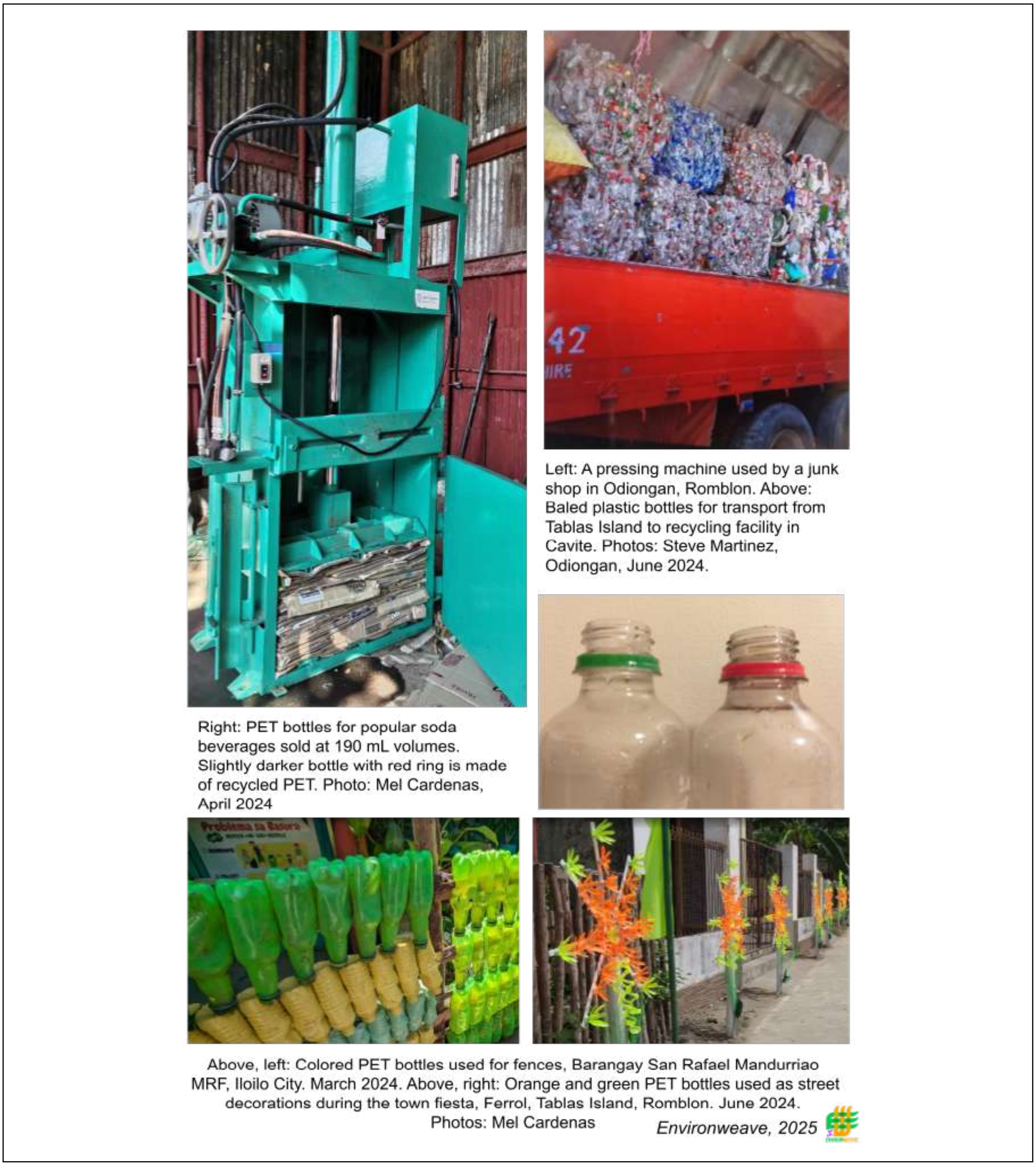
The high cost of logistics, relative to other countries in Southeast Asia, is one of the main reasons that only about 28% of polyolefin-based plastics are collected for recycling in the Philippines. In addition, the informal recycling industry, operating without costs of taxation and compliance with environmental and occupational health and safety laws, dominates and inevitably distorts market prices (World Bank, 2021). Supported by a network of junk shops found all over the country, this also plays a role in the informal dismantling of other post-consumer waste, such as household appliances. Junk shops in Metro Manila can send a team of two or three people with a small truck to board a ferry to the island of Mindoro and finance their stay for 1 month to harvest plastics and metals from e-waste, while leaving hazardous waste materials exposed to the environment after clandestine dismantling on-site.[10]

There are efforts of 'obliged enterprises' under EPR programs for plastic packaging to increase collection by tapping their distribution channels to serve as collection points for retrieved plastic packaging. Another strategy for collection is through partnerships with local governments during their festival season, when tourists significantly increase waste generation, such as when the City of Bacolod partnered with a beverage company to collect PET bottles after use (Guadalquiver, 2025). Some island-based junk shops have also been tapped by plastic packaging producers to supply recovered rigid plastics to their partner recycling facility and deployed a pressing machine for proper baling of plastics and other recyclables prior to shipping to Luzon.[11] With the establishment of the PETValue bottle-to-bottle recycling facility in 2022, located in General Trias, Cavite, some beverage bottles sold in the Philippines are now using recycled PET (rPET). Design-for-recycling initiatives are also practised by some brands through the shift to clear PET bottles that were previously packaged in green bottles; however, other brands continue to use coloured PET. Since these coloured bottles cannot be traded as recyclables, some island communities resort to reusing these as makeshift flowerpots, for their backyard fences, or even repurpose them for decorations for the town fiesta. Figure 17.8 shows some images of these repurposing or recovery efforts.

[10] Environweave field interview, Caloocan City, 2025

[11] Environweave field interview, Odiongan, 2024.

Figure 17.8. PET Bottle Waste Diversion in the Middle Island Regions



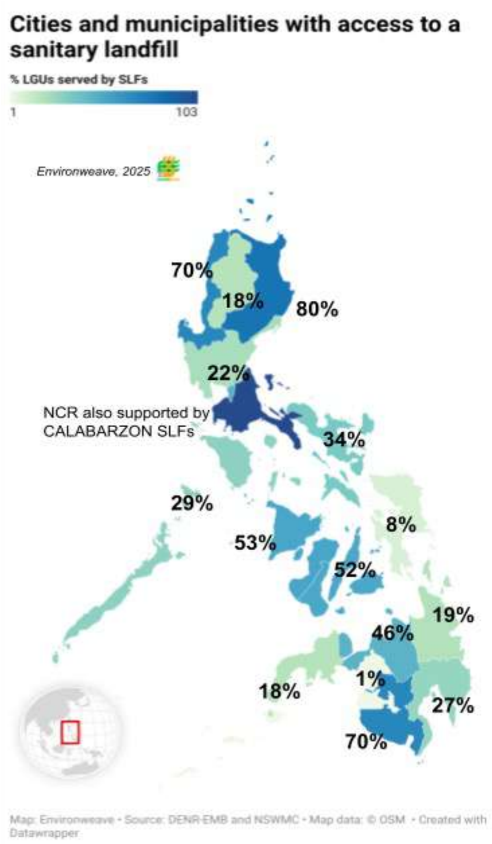
mL = millilitre, PET = polyethylene terephthalate

Source: Environweave.

3.4 Limited sites for sanitary landfills in middle island regions

In the Philippines, the current practice of residual waste management is disposal in sanitary landfills. As of June 2025, there are 373 sanitary landfill facilities (SLFs) in the Philippines servicing 680 cities and municipalities (DENR EMB, 2025a), tripling from the 101 SLFs recorded a decade ago. This welcome development was accompanied by the closure or rehabilitation of more than 900 illegal dumpsites that were operating in the early 2010s. Despite this, only 42% of the LGUs in the country are being serviced by sanitary landfills. In the middle island regions, this access rate goes down to 29% in MIMAROPA and 8% in Eastern Visayas (Figure 17.9).

Figure 17.9. Distribution of Sanitary Landfills in the Philippines



LGU = local government unit; NCR = National Capital Region; CALABARZON = Cavite, Laguna, Batangas, Rizal, and Quezon; SLF = sanitary landfill facility

Source: Environweave using the Datawrapper app, based on Department of Environment and Natural Resources and National Solid Waste Management Commission data, August 2025.

One of the major reasons for the low number of operating SLFs is the difficulty of identifying a suitable site that meets the 13 criteria for selection,[12] which includes proximity to groundwater sources, perennial surface waters, underlying rock formations, proximity to faults, suitable availability of soil cover, avoidance of slopes, vulnerability to flooding, and proximity to ecologically sensitive areas, amongst others (Commission on Audit, 2023). For instance, SLF sites should not be located in areas with fractures or fissures, or which are composed of carbonate, karst, or other porous rock formations – but this would be a challenge for most of the municipalities in a volcanic, archipelagic country like the Philippines, and specifically for smaller islands due to their geology and topography.

Competing land use allocations also play a part in the SLF site selection dilemma. In one Palawan municipality, the existing municipal dumpsite was continuously used despite being about 50 metres away from the shore of an inland bay because the proposed SLF site is within a protected area as well as on indigenous ancestral land.[13] To date, this municipality does not have a recognised landfill listed in the DENR EMB database. Meanwhile, an SLF that is situated in an old cinnabar pit mine has challenges with using the surrounding soil for cover, with the possibility of making mercury more bioavailable through bacterial interactions with organic contaminants in the residual waste.[14]

There have been interventions in improving final disposal sites in the island regions. The sanitary landfill in Malay, Aklan was upgraded to a Category 3 SLF with the installation of a plastic lining protective barrier, with assistance from the Department of Science and Technology. This was part of the rehabilitation plan for Boracay Island in 2018, when the island resort was temporarily closed to tourists for 6 months to address sanitation and other environmental issues, including solid waste.[15]

In other municipalities that have smaller budgets, the focus has been to convert open dumpsites into controlled dumps with sufficient soil cover over the residual waste. Frequently, the requirement for soil cover is not met because of the breakdown of heavy construction equipment like backhoes and excavators, often imported as 'surplus' or used old models with limited after-sales support. One municipality received technical assistance from a landfill management engineer, deployed by the United States Peace Corps, for rehabilitation of its dumpsite. The final disposal site was inspected recently by the EMB Regional Office and deemed compliant.[16] Figure 17.10 shows some images of final disposal sites in the island regions.

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[12] NSWMC Resolution No. 64, Series of 2013. Adoption of modified guidelines on site identification criteria and suitability assessment procedure for sanitary landfills.

[13] Environweave field visit, 2019.

[14] Environweave field visits, 2019, 2025, and 2026.

[15] Environweave field visit, 2018

[16] Environweave field visits, 2019 and 2024.

Figure 17.10. Some Final Disposal Sites in the Middle Island Regions of the Philippines

DENR = Department of Environment and Natural Resources, EMB = Environmental Management Bureau, SLF = sanitary landfill facility.

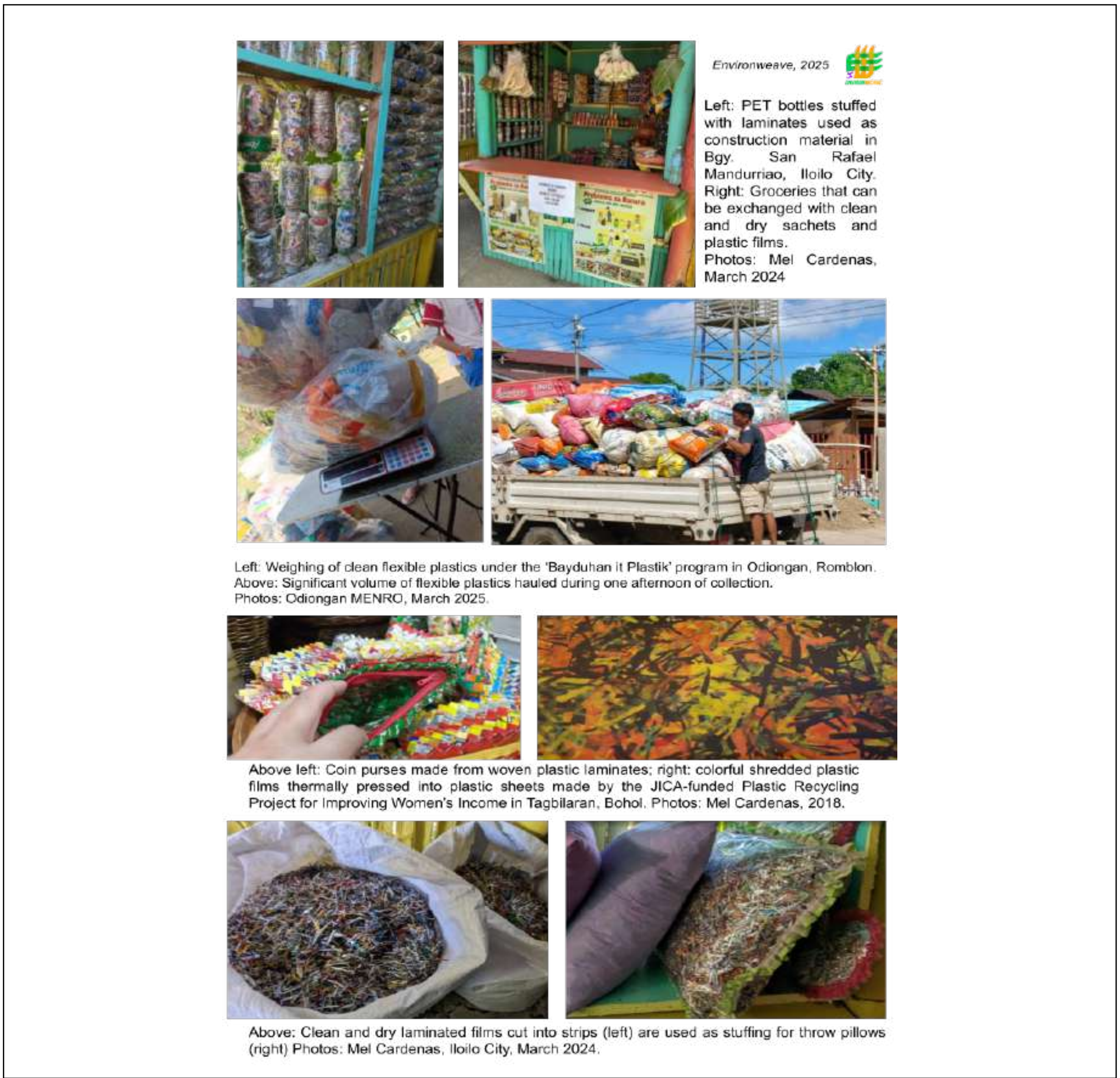
Sources: Specified in the figure.

3.5 Addressing plastic waste in islands

Island cities and municipalities are employing creative strategies to reduce the volume of residual waste for final disposal, given the limited landfill space. A widespread strategy employed by many LGUs is incentivising the collection of single-use plastics and laminated sachet packaging, in exchange for rice or grocery items. In the municipality of Odiongan in Tablas Island, Romblon, the Bayduhan it Plastik (roughly translated as 'plastic exchange') programme increased waste diversion from 10 kg to 25 kg for each of the barangays in the town (Fos, 2023).

In the past, it was common practice to stuff flexible plastics and sachets into PET bottles, which were then used as alternative bricks for plant boxes, fences, or low walls. While this serves to contain these low-value flexible plastics and prevent litter, it also prevents the recovery of the more valuable PET for possible recycling, so alternative uses for these collected films and laminates were developed. Now these flexible plastics are used as raw material for upcycled products sold by local women's cooperatives, often with training and funding support from international foundations and non-governmental organisations. Products include purses or bags woven out of laminates, or throw pillows stuffed with shredded plastics. Some photos of these containment, collection, and upcycling strategies are shown in Figure 17.11.

Figure 17.11. Diverting Low-Value Plastics in the Middle Island Regions of the Philippines



Environweave, 2025

Left: PET bottles stuffed with laminates used as construction material in Bgy. San Rafael Mandurriao, Iloilo City. Right: Groceries that can be exchanged with clean and dry sachets and plastic films. Photos: Mel Cardenas, March 2024

Left: Weighing of clean flexible plastics under the 'Bayduhan it Plastik' program in Odiongan, Romblon. Above: Significant volume of flexible plastics hauled during one afternoon of collection. Photos: Odiongan MENRO, March 2025.

Above left: Coin purses made from woven plastic laminates; right: colorful shredded plastic films thermally pressed into plastic sheets made by the JICA-funded Plastic Recycling Project for Improving Women's Income in Tagbilaran, Bohol. Photos: Mel Cardenas, 2018.

Above: Clean and dry laminated films cut into strips (left) are used as stuffing for throw pillows (right) Photos: Mel Cardenas, Iloilo City, March 2024.

JICA = Japan International Cooperation Agency, MENRO = Municipal Environment Office and Natural Resources, PET = polyethylene terephthalate.

Sources: Specified in the figure.

Many of the final disposal sites in the islands still receive a significant amount of waste that is composed of recyclable material (such as PET bottles) but is not harvested due to limited trade. Aside from rigid plastics, these include clear and coloured glass bottles used for gin, beer, and wine, with high generation rates in tourism areas. To reduce the space taken up by these bulky items in their disposal sites, municipalities purchase plastic shredders and glass pulverisers and make 'eco-bricks' by incorporating glass and plastic into hollow blocks or paver tiles.

The use of treatment technologies to reduce the amount of residual waste for final disposal is still limited in the Philippines. While the DENR has released guidelines for waste-to-energy (WtE) facilities for municipal solid waste,[17] adoption of this technology is still low given high capital investment costs and uncertainties in feedstock sourcing, as well as resistance from civil society organisations. Consultations are being conducted by the DENR EMB and NSWMC to develop guidelines for clustering LGUs for more cost-efficient recyclables collection, residual waste treatment, and final disposal. Meanwhile, the use of waste materials as alternative fuel (i.e. RDF) for cement kilns is possible if it follows the guidelines stipulated in DENR's Guidelines on the Use of Alternative Fuels and Raw Materials in Cement Kilns.[18]

In the island province of Cebu, cement factories provide an opportunity for co-processing of plastic films and laminates in their kilns. In 2015, as part of the closure of the Inayawan landfill that serviced the cities of Metropolitan Cebu, a facility to produce RDF from residual waste was set up as a pilot project supported by the Japan International Cooperation Agency (JICA), Japan's Ministry of the Environment, and the City of Yokohama. The facility, located in Consolacion, Cebu, has been operated by Guun Co. Ltd. since its inauguration in 2017, and can process 50–75 tons of low-value plastics and contaminated paper daily. With the recent joint venture with SM Prime, the facility is now receiving waste from residential areas, offices, and commercial establishments to produce RDF and even compost from kitchen and restaurant food waste.[19]

RDF is also being sourced from across the sea, from the island of Panay. Iloilo City partnered with Evergreen Lab for plastic credits accounting under EPR programmes. Flexible plastics, processed into fluff fuel at the Central MRF beside the Calahunan Landfill, are bought by Cemex for use in its cement plant in Naga City, Cebu. With their landfill already at 70% capacity, this partnership increases waste diversion while providing additional funds for solid waste management. Transportation is shouldered by the cement company through reverse logistics – after it delivers bags of cement from Naga to Iloilo, the backload is tonner bags full of RDF.[20] Figure 17.12 shows some photos of these efforts to increase waste diversion from final disposal sites.

[17] DENR Department Administrative Order 2019-21. Guidelines governing waste-to-energy (WtE) facilities for the integrated management of municipal solid wastes.

[18] DENR Department Administrative Order 2010-06. Guidelines on the use of alternative fuels and raw materials in cement kilns.

[19] Environweave field visits, January and March 2025..

[20] Environweave field visit with ERIA and 3RproMar, March 2024.

Figure 17.12. Waste Diversion of Flexible Plastics in the Middle Island Regions of the Philippines

MRF = materials recovery facility, RDF = refuse-derived fuel.

Source: Environweave.

4. No Island Is an Island

Addressing the Philippines' complex plastic waste crisis requires a multifaceted approach, with promising solutions emerging from local, national, and international collaborations. In the middle island regions, initiatives are beginning to provide concrete, on-the-ground strategies. For example, under the Healthy Oceans and Clean Cities Initiative (HOCCI), funded by the people of Japan and implemented by UN-Habitat Philippines, two of the six partner cities were from the middle island regions – Calapan City in Mindoro Oriental and Ormoc City in Leyte. Under the HOCCI, these cities developed localised action plans to address plastic waste and reduce leakage to the environment. Calapan City's plan focuses on improving its readiness for the new EPR law by organising waste collectors into a registered cooperative and establishing better data collection systems to accurately track plastic waste diversion (Magcale-Macandog et al., 2023). Other international partnerships are also fostering solutions in the island regions, such as the Plastic Smart Cities programme of the World Wide Fund for Nature (WWF) with the municipality of Taytay, Palawan, and the 3RproMar programme of Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), which includes Iloilo City and the province of Guimaras (World Wide Fund for Nature, 2023).

Beyond formal government and international programmes, creative community-based solutions are also gaining traction. Greenpeace Philippines' Kuha sa Tingi campaign, for example, directly tackles the sachet problem by promoting a refill-and-reuse system. While the pilot programmes were launched in Metro Manila with suppliers based there, the success of this model presents a clear challenge and opportunity for expansion into the island regions. This would require identifying local suppliers of consumer goods or developing new social entrepreneurship programmes to support a distributed refill system (Ledesma et al., 2024).

Furthermore, a growing body of scholarly research is providing a critical evidence base for these efforts. In July 2025, the University of the Philippines Marine Science Institute hosted PlastiCon, the first national conference on plastics, which brought together international and local experts from academia, industry, and public interest groups (PlastiCon, 2025). The event fostered a crucial exchange of information on topics ranging from riverine plastics and microplastics to the public health risks of pollution and the practical implementation of EPR. Several sessions featured grassroots efforts by farmer's groups, village leaders, and women's cooperatives. These scientific cross-sectional dialogues are essential for developing data-driven policies and strategies while being grounded by community wisdom.

In conclusion, the Philippines is confronting the threats of marine plastic pollution through a concerted, whole-of-nation effort. Successfully managing waste in the island regions which form the country's 'geographic middle' require creative solutions that are tailored to the unique needs and logistical constraints of their communities. These local solutions must be strategically linked to the broader circular economy initiatives and waste management infrastructure that are currently concentrated in the mainland urban areas. This integrated approach, which leverages the joint efforts of national and local governments, the private sector, public interest groups, researchers, and citizens, is the key to building a more sustainable and resilient future for the Philippines and its invaluable island ecosystems.

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Chapter 18

Singapore: A City-State's Comprehensive Approach to Plastic Pollution Management

Liu Yulu

1. Introduction

As a city-state with limited land mass and high population density, Singapore faces the challenge of managing plastic pollution against the background of its strategic planning as a global shipping hub, financial hotspot, and technology cluster. Challenges for Singapore in the management of plastics include land and resource constraints, infrastructure for sustainability, and consumer behaviours.

Plastics are ubiquitous in Singaporean daily life – used in packaging, containers, industrial applications, and more. Singapore generated 1,001,000 tonnes of plastic waste in 2022, with a 6% recycling rate, and 957,000 tonnes in 2023, with a 5% recycling rate (NEA, 2023b), and the majority of non-recycled plastic was incinerated. Meanwhile, as an island state with an interconnected coastline and waterways, Singapore is particularly vulnerable to marine plastic pollution. A study on marine litter and plastic waste by the National Environment Agency (NEA) highlighted that both macroplastics and microplastics are found in Singapore waterways, reservoirs, and coastal zones (NEA, 2025h). The identified sources of pollution are land-based and sea-based (NEA, 2025h). The presence of microplastics in local waters also raises concerns about water quality and food safety (NEA, 2025h).

In response to these challenges, Singapore has developed a comprehensive and innovative approach to waste management, emphasising efficiency and urban sustainability. This chapter explores Singapore's countermeasures against plastic pollution, highlighting key strategies including incineration, recycling initiatives and mechanisms, policy frameworks, and regional collaboration. By examining these initiatives, policies, and mechanisms, the chapter aims to provide valuable insights into how Singapore addresses plastic pollution through integrated urban planning and sustainable practices, offering lessons that can inform regional environmental policies and urban development across Southeast Asia and beyond.

2. Key Initiatives Against Plastic Pollution in Singapore

Singapore's key initiatives on combating plastic pollution include the 2019 Zero Waste Masterplan, launching a deposit-refund scheme for plastic bottles, and various public awareness campaigns. In addition, Singapore has invested in advanced recycling technologies and enforced strict anti-littering regulations. Regionally, Singapore collaborates through the platform of the Association of Southeast Asian Nations (ASEAN), as well as collaborative partnerships with neighbours, to improve waste management practices and share sustainable solutions, aiming to reduce plastic waste and promote a circular economy in the region (see Chapter 10).

2.1 The 2019 Zero Waste Master Plan

Singapore's Zero Waste Masterplan, launched in 2019 by the Ministry of the Environment and Water Resources (now the Ministry of Sustainability and the Environment) and the NEA, is a comprehensive strategy designed to transform Singapore into a sustainable and resource-efficient country (Ministry of the Environment and Water Resources and NEA, 2019). Singapore's waste management sector has long relied on incineration and landfill, causing critical pressures on the only landfill in Singapore, the Semakau Landfill. As the Semakau Landfill is projected to be fully utilised by 2035, it is imperative for Singapore to have a comprehensive waste management plan. The 2019 Zero Waste Masterplan takes a whole-of-nation approach to facilitate a circular economy that features reducing, reusing, and recycling, aiming at extending the lifespan of the Semakau Landfill and reducing the waste impact on the environment (Ministry of the Environment and Water Resources and NEA, 2019).

The 2019 Zero Waste Masterplan sets out regulatory frameworks and ambitious targets for both the public and private sectors, and calls for community action. The core goal is to reduce the per capita amount of waste sent to the Semakau Landfill per day by 30% by 2030, decreasing the 0.36 kilogram (kg) per capita in 2018 to 0.25 kg per capita in 2030. At the same time, the goal for the national recycling rate is 70% by 2030. To incentivise the drive towards a more circular economy, Singapore adopted the Resource Sustainability Act in 2019, providing enforcement tools for key waste streams, including e-waste, food waste, and plastic packaging waste.

The master plan also introduced mandatory packaging reporting in 2020, requiring producers to declare the types and amounts of packaging they supply annually, thereby encouraging reduction and innovation in the design of packaging. Producers under this reporting scheme include manufacturers, importers, and retailers, and the goods that are regulated include packaged food, beverages, household cleaning products, and others (NEA, 2025g). As an extension of the reporting scheme, extended producer responsibility (EPR) for electronic waste, introduced in 2021, requires the producers of certain products to ensure the products are collected and recycled, fostering sustainable use of electronic appliances (NEA, 2025c). For food waste, which is a robust industry in Singapore that is closely linked to residents' daily lives, the master plan mandates segregation and on-site treatment for large food waste (NEA, 2025d).

2.2 Deposit-refund scheme for plastic bottles

Singapore is introducing its first domestic deposit refund scheme (DRS) for plastic beverage bottles in the ASEAN region, scheduled to take effect in April 2026, fitting into its broader aim of tackling single-use plastic waste and achieving a circular economy (NEA, 2025a). The scheme was announced in 2023 and has gone through a series of public consultations and stakeholder engagements.

The method of the DRS is straightforward – as its name denotes, consumers will pay a small deposit when purchasing drinks in eligible plastic bottles, and the deposit is expected to be S$0.10–S$0.20. The deposit is fully refundable when the empty bottles are returned to designated collection points, including collection machines close to supermarkets, convenience stores, and community centres.

The DRS builds upon existing waste management mechanisms, including the mandatory packaging reporting (introduced in Section 2.1) and the 'Say YES to Waste Less' campaign (in Section 2.3), while closing the gap between recycling business and consumers by offering direct economic incentives. The scheme aims to reduce littering, improve the quality of recyclables collection, and raise public awareness. The NEA is working with beverage producers and importers, retailers, and communities to set up an island-wide network of return points.

The first phase of the DRS will focus on single-use plastic bottles, with potential expansion to metal cans and glass bottles. The collected plastic bottles will be processed at dedicated recycling facilities, to be converted into new packaging or products, closing the plastic resource loop. It is hoped this policy milestone in waste management will significantly contribute to a higher recycling rate in Singapore and to achieving the zero waste goal.

2.3 Public awareness campaigns

As mentioned in Section 2.1, the 2019 Zero Waste Masterplan emphasises public awareness and consumer behavioural change, recognising the importance of consumers, households, and businesses. Singapore therefore has put forward public awareness campaigns including the 'Say YES to Waste Less' to engage residents directly in reducing waste (NEA, 2024a; Singapore Association of Trade and Commerce, 2025).

This campaign aims to encourage residents to make small changes to create huge impacts on the amount of waste they generate in their daily lives, including bringing shopping bags, containers, and cutlery. It involves outreach efforts, public advertisements on public transportation, and collaboration with shops and community centres. For instance, educational posters will be placed at dining areas and convenience stores, and workshops will be organised for residents on ways to reduce waste in daily grocery runs (Teo, 2020; Clean and Green Singapore, 2025).

Other public awareness raising campaigns include the '#RecycleRight Campaign' on good waste sorting habits; the 'Bring Your Own (BYO)' Campaign encouraging customers to bring their own bags, bottles, and containers; 'Let's Recycle Together' promoting recycling; and the 'Plastic-Lite Singapore' Movement for reducing plastic waste, championed by the NEA (Ong, 2020).

3. Incineration as a Primary Waste Management Strategy

As a densely populated island with limited land area, the development of a distinctive approach to municipal solid waste management is therefore significant in suiting its unique geographical constraints. As introduced earlier, the only landfill, Semakau Landfill, is projected to reach full capacity by 2035. At current disposal rates, Singapore faces the task of reducing the landfill rate and adapting to a more circular economy. As a result, Singapore has adopted incineration as the primary method for solid waste treatment, aiming to reduce reliance on landfill space and to convert waste into energy through incineration.

Singapore's waste management infrastructure is operated at four waste-to-energy (WtE) incineration plants: Tuas, Tuas South, Senoko, and Keppel Seghers Tuas (NEA, 2024c). Singapore's growing population and booming economy have contributed to a sevenfold increase in the amount of solid waste disposed, from 1,260 tonnes a day in 1970 to a peak of 8,741 tonnes a day in 2021 (NEA, 2024c).
The incineration process combusts waste at high temperatures, reducing the volume by up to 90% (NEA, 2024c). The incineration bottom ash and a small amount of fly ash are disposed of at the Semakau Landfill. The incineration, as a WtE process, generates electricity for national needs (NEA, 2024e). The energy transition enhances Singapore's energy resilience and adheres to the goal of promoting resource efficiency in the 2019 Zero Waste Masterplan.

One of the main concerns regarding Singapore's incineration approach is its threat to air quality, through the possible release of toxic pollutants. Singapore has therefore invested in leading emission control technologies for the four incineration plants, which remove dust and pollutants from the flue gas. NEA has reported consistent good operation of incineration plants to guarantee that the emissions are within regulatory limits, as provided by relevant legislation and guidelines, including the Environmental Protection and Management (Air Impurities) Regulations (2008) and Guidelines for a Special Waste Incinerator (2009). The pollutants regulated include smoke, particulates, and sulphur dioxide (NEA, 2024e).

Another ongoing challenge for the incineration approach is the low resource recovery efficiency. While incineration reduces waste volume and landfill needs drastically, the low resource recovery efficiency could be a missed opportunity for Singapore. Valuable materials, including metals, glass, as well as recyclable plastics, are often combusted alongside general waste, losing resources that could have been recycled or reused. The reliance on incineration also discourages the formation of good recycling habits amongst the public, as there is less motivation for them to recycle. This topic will be elaborated on in the following sections.

4. Challenges in Recycling Market Development

To solve the plastic pollution issue that Singapore is facing, a persistent challenge is the development of a robust and self-sufficient domestic recycling market. This multifaceted challenge involves economic, social, as well as technological factors that both reflect Singapore's own conditions, and a broader global perception of recycling.

With a population of about 5.9 million and a small industry on the island, there is not enough local demand for products made from recyclables, nor is there enough supply of recycling materials. Recycling businesses in Singapore therefore face difficulties in securing consistent sources of funding, or affordable costs for collecting, processing, or marketing products made from recycled materials. For this reason, the Singaporean market is not large enough for such products made from recycled materials, and it is challenging for recycling business owners to sustain operations, investment in technologies, or competitive pricing. In addition, due to the incineration approach mentioned above, there is a lack of domestic supply of recycled materials to establish a local circular economy where waste is expected to be collected, processed, and reused locally (Banerjee and Tan, 2024).

Another consideration in the domestic recycling market is high land and labour costs. Recycling facilities, including collection, sorting, and processing, require huge space, which is a permanent challenge for Singapore. In urban planning, industrial land is often prioritised for higher value activities including electronics or biomedical manufacturing, and waste recycling and processing is commonly seen as less economically viable and critical (Urban Redevelopment Authority, 2025). Singapore has a tight labour market, which relies heavily on foreign labour for labour-intensive sectors (Ministry of Manpower, 2025). This adds to the operational costs and the loss of competitiveness to countries with bigger land masses and lower labour costs. These factors affect local businesses and investors when making business decisions.

Singapore has therefore turned to exports of recyclables to larger markets, which exposes Singapore to changes in the global market. For instance, China banned the import of most contaminated recyclables in 2017 and introduced a complete ban in 2021 (Ministry of Ecology and Environment, China, 2021). Another challenge in exporting recycled materials is the actual recycling rates achieved in recipient countries, raising questions about the efficiency and legitimacy of the export approach (Ministry of Sustainability and the Environment, Singapore, 2020).

The quality of domestically collected recyclables in Singapore poses difficulties. Recycling in Singapore is predominantly operated through blue bins in residential areas (NEA, 2024c). The placement of blue bins in residential areas makes it convenient for people to participate in recycling, yet this can lead to contamination of recyclables, such as packaging with food scraps, non-recyclable items, or white waste (Ang, 2025). Such contaminated collected materials are costly to sort or clean, and might end up being incinerated but not recycled.

5. Limited Landfill Capacity

Singapore's only landfill, Semakau Landfill, has been in operation since 1999. It is located off the southern coast of Singapore. The landfill was built by enclosing part of the ocean with a rock bund and surrounding it with an impermeable membrane and clay. This design prevents leachate from contaminating the adjacent waters or destroying marine biodiversity in the locality (NEA, 2024d).

In addition to the public awareness campaigns and zero waste initiative, Singapore is also working on innovative waste treatment as well as usage of the incineration ash. The government strongly supports advanced recycling technologies, biological treatment of organic waste, and upcycling of incineration ash. For instance, the NEA launched a 'Closing the Waste Loop' research and development initiative to fund projects and studies that offer scalable solutions for resource recovery, alternative materials, and waste valorisation (NEA, 2025b). Projects under the initiative are extracting construction aggregates and metals from incineration bottom ash to be diverted from landfill. The Tuas Nexus Integrated Waste Management Facility, planned for completion in the late 2020s, will further integrate waste management and resource recovery, contributing to a circular economy (NEA, 2025e). Urban mining of incineration ash for metals and minerals is also taking place, as well as using biotechnological processes to convert food and organic waste into biogas or compost, reducing the pressure on incinerators and the landfill (Tan, 2024; NUS CDE, 2022).

6. Waste Trade Dynamics Within ASEAN

Singapore has adopted a combined approach of domestic waste treatment and the export of recyclables to regional and global markets. This approach responds to Singapore's limited domestic market, restricted land space, and high costs mentioned in previous sections. Yet, waste trade within ASEAN, especially the tightening of waste import regulations and bans by other countries in the region, has emerged as a challenge for Singapore, calling for reassessment of this paradigm.

The global movement of waste has long been a critical issue in the recycling industry. In Southeast Asia, Indonesia, Malaysia, the Philippines, Thailand, and Viet Nam have been major importers of recyclable materials (Fernandes, 2023), as alternatives for countries with limited domestic recycling capacity or high costs of processing, including Singapore. Such arrangements have led to environmental and social risks and concerns in importing countries, due to illegal dumping, insufficient processing infrastructure, or inadequate regulation. Following the 2018 Chinese ban on importing waste, other Southeast Asian countries tightened their regulations on contaminated waste and electronic waste. These policies signal a broader shift amongst ASEAN Member States towards a greater sense of responsibility regarding sustainability and environmental protection. These changes in policies in neighbouring countries affect Singapore's export approach, adding pressure on waste management, incineration, and landfill systems, while pushing Singapore to make changes in its waste management approach.

ASEAN, as a regional intergovernmental body, has also adopted relevant policies on waste trade issues, including developing regional frameworks to promote environmental sustainability, responsible waste management, and circular economy initiatives. The ASEAN Framework of Action on Marine Debris in 2019 and the ASEAN Regional Action Plan for Combating Marine Debris in the ASEAN Member States (2021–2025) call for closer scrutiny of transboundary waste flows, waste collection, and recycling enhancement, and the reduction of single-use plastics (ASEAN, 2019; 2021). These regional instruments and initiatives reflect a regional aspiration to combat unregulated waste trade and protect the environment. Singapore therefore must align its future management approach with regional instruments.

The changing landscape of waste trade in ASEAN is compelling Singapore to accelerate the development of its domestic recycling capabilities. The government recognises that reliance on exports is no longer viable and has initiated a range of policies and investments to build local processing capacity.

At the regional level, Singapore is responding to ASEAN's broader environmental vision, including working with the Coordinating Body on the Seas of East Asia (COBSEA), ASEAN Working Group on Chemicals and Waste, and bilateral initiatives to develop best practices on waste management, marine debris, and circular economy.

7. Update on the 2019 Zero Waste Masterplan and 2030 Green Plan

As mentioned in the introduction, Singapore launched the Zero Waste Masterplan in 2019, with the aim to reduce the amount of waste sent to Semakau Landfill by 30% by 2030. This goal is a key part of the wider Singapore Green Plan 2030 under the 'sustainable living' and 'resource circularity' pillars, charting a sustainable future over the next decade for Singapore. Under this initiative, Singapore has made efforts to meet the goal, and this section will give an overview of the relevant approaches (Green Plan, 2025).

The EPR scheme was introduced to the e-waste stream in July 2021, requiring producers to manage the collection and recycling of products at the end of their lives (NEA, 2025i). Plans are ongoing to extend EPR to plastic packaging, including the forthcoming DRS in April 2026.

For food waste, which accounts for around 11% of total waste, Singapore has experimented with the separation of food waste collection in participating hawker centres and food manufacturing sites.[1] The Resource Sustainability Act, 2019 requires large food waste generators to segregate and handle food waste on-site, instead of transporting it. With the deployment of on-site food waste digesters at hawker centres and coffee shops, the amount of food recycled has increased.

[1] Hawker centres are open-air complexes in Singapore that offer communal dining spaces and affordable food options. They are typically maintained by the NEA.

In addition to the mandatory reporting framework for packaging, there is ongoing development of alternative packaging, as well as innovation in sustainable packaging, including converting incineration ash into construction materials (NEWSand) (NEA, 2020a). At one of the incineration sites, Tuas Nexus, Singapore introduced its first integrated water and solid waste treatment facility, and it will be constructed in phases, and the first phase is expected to be progressively completed from 2027 onwards. This integrated facility is designed to maximise energy efficiency and resource recovery. (NEA, 2020b; NEA, 2025e) With more than 500 e-waste recycling bins around the island, it is more convenient for residents to dispose of old electronic devices in a more sustainable and responsible way.

Public engagement and education is a central piece of the Zero Waste Masterplan and Green Plan implementation. Large supermarkets introduced charges for disposable plastic shopping bags in 2023, aiming to instil sustainable consumer behaviour. These initiatives have witnessed progress, including a drop in plastic bag use at supermarket outlets (CNA, 2024). The reported domestic recycling rate increased from 13% in 2019 to 17% in 2022, and non-domestic recycling rates (in industrial and commercial sectors) continue to surpass 70% (NEA, 2025f).

Singapore's Zero Waste Masterplan, as an integral part of the Singapore Green Plan 2030, demonstrates a comprehensive approach to waste management and sustainability (Green Plan, 2025). With clear targets, regulations, and an all-hands-on-deck approach, the country is making steady progress towards achieving resource circularity by 2030. With the ongoing journey, Singapore is maximising its adaptability and innovation capacity to build a sustainable future.

8. Deposit and Refund Policy for Plastic Bottles

As mentioned in previous sections, the DRS will leverage behavioural changes by setting a tangible value on empty bottles, and it is hoped to serve as a nudge to consumers to return bottles, avoiding loss in daily expenses. This approach also shifts residents' perceptions of plastic bottles as a resource – not waste or a burden. This scheme will be supported by public education campaigns and convenient return machines, boosting recycling rates for consumer plastics in Singapore.

The deposit and refund process is expected to be digitalised, aligning with Singapore's existing 'Smart Nation' infrastructure. The reverse vending machines will play a central role in the recycling process and will be placed at high-traffic areas including supermarkets, public housing blocks, and metro stations. An app marking nearby machines is expected, and e-payment systems may be used to streamline the refund process. The returned bottles will be digitally tracked, providing data for back-end monitoring, policy, and business decision-making. Data analysis will optimise the collection hotspots and refunding approach. Data may also help in expanding the scheme to other recyclables, as well as upgrading packaging designs.

For the recycling industry, this policy creates new and more consistent opportunities for bulk collection, sorting, logistics, recycling, and other phases involved in the recycling process. For instance, producers are incentivised to put forward new designs that are easier and more economical to collect and recycle, riding the wave of eco-design. This also fits well within Singapore's EPR framework, which now only applies to e-waste but may be extended to other types of waste with a possibility of extension, contributing to policy integration and scale expansion (Woo, 2022). For informal waste collectors in Singapore, this scheme might provide a more formalised income stream.

With this promising step towards zero waste and a circular economy, Singapore is considering the integration of technology, social equality, stakeholder engagement, and continuous adjustment, ultimately turning plastic waste into positive change for Singapore's sustainability (NEA, 2022b).

9. Enforcement of Anti-Littering Measures

Singapore's international reputation as a clean city is more than efficient cleaning services or comprehensive government initiatives. It also has strict anti-littering laws, strong enforcement, and a combined mechanism of both education and deterrence. This section looks into the regulation of littering, as well as the enforcement of regulations, the balance between punishment and education, and the ongoing challenge of keeping this high standard in a changing global environment.

Singapore's anti-littering rule is provided in the Environmental Public Health Act, 1987, granting authorities the right to penalise individuals for a range of offences against public cleanliness, including discarding cigarette ends, food packaging, tissues, or drink containers in public spaces. A first-time offender can be fined up to S$2,000, and a repeat offender can be requested to pay up to S$4,000 for a second conviction and up to S$10,000 for the third and subsequent convictions. A corrective work order might also be invoked for offenders, with the requirement to clean public spaces, wearing distinctive fluorescent vests. The corrective work order is often carried out in public, as a deterrence to the offender (NEA, 2023a). These heavy fines and corrective work orders are designed to send a message to residents: littering is not accepted socially in Singapore, and actions will be taken against it.

The strict legislative framework is backed by robust enforcement. The NEA is the primary authority responsible for enforcement. NEA officers, both uniformed and in plain clothes, are dispatched for monitoring and enforcement across the islands, with focused patrols at community centres, food courts, and public transportation interchanges. CCTV footage capturing littering behaviour is admissible in court. The NEA, in addition to its deployment of officers, encourages the public to report littering via hotlines and digital platforms, sending the message that the city's cleanliness is a public asset that is owned by the whole community. In 2021, the NEA issued more than 19,000 tickets for littering and related offences, with media coverage (NEA, 2022a).

In addition to regulative and enforcement sectors, Singapore carries out public education projects to cultivate such recognition amongst residents to promote civic responsibility. As early as the 1960s, Singapore introduced the 'Keep Singapore Clean' campaign, laying the foundation for environmental stewardships, communal ownership, and national identity (Chia, Jia, and Lim, 2025). Environmental education is part of the school curriculum at all levels, teaching the younger generation about the importance of good habits and a clean environment. At the general public level, movements include 'Clean and Green Singapore', mobilising the public to participate in clean-up activities, recycling, and public awareness raising (Clean and Green Singapore, 2025). Posters, social media, and public announcements are used to raise the visibility of this issue. The cultivation of civic responsibility is possible by combining laws, enforcement, and education in Singapore, where the sense of sustaining a clean environment is embedded in social life and everyone is expected to contribute to it, rather than it solely being imposed by the law or the government. For instance, residents understand that a clean environment also reduces pest infestations, the transmission of diseases, and environmental hazards. As a popular destination for global tourists, a clean environment is also the key to attracting both tourists and investment.

10. Bilateral and Regional Initiatives

In the context of transboundary pollution, floating plastic pollution poses a threat to Singapore's marine environments, impacting biodiversity and water quality (Wong, 2025). It has implemented measures to tackle this issue, featuring regular clean-up operations and installing floating barriers to intercept floating debris in transboundary waterways (Ministry of Sustainability and the Environment, Singapore, 2025).

Singapore is involved in the ASEAN Smart Cities Network, which aims to promote cooperation in sustainable urban development. The network's initiatives leverage technological developments in innovative waste management systems and facilitate knowledge exchange amongst member cities. Singapore's leadership role in this network demonstrates its commitment to regional collaboration and urban sustainability (ASEAN, 2025).

11. Conclusion

Singapore's multi-pronged approach to managing plastic pollution reflects its commitment to environmental sustainability. Through incineration, recycling, policy innovation, and regional cooperation, Singapore aspires to mitigate the impacts of plastic waste and transition to a circular economy. Drawing on these efforts, it has contributed lessons for urban waste management and sustainable urban design. Continuous innovation and improvement will remain essential as Singapore navigates complex management of plastics in a rapidly changing environment.

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Chapter 19

Plastic Waste Management in Thailand – Policy Challenges and Lessons from Voluntary Initiatives to Reduce Single-Use Plastics

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1. Introduction

One of Thailand's most urgent environmental issues is managing municipal solid waste. It is anticipated that the nation's municipal solid waste generation will continue to rise. According to the Pollution Control Department (2025a), Thailand's municipal solid waste rose slightly from 26.95 million tons (Mt) in 2023 to 27.20 Mt in 2024. Since plastic waste makes up a significant portion of all solid waste, the government decided to make it a national priority in 2018. In response, the Prime Minister directed the Ministry of Natural Resources and Environment to work with multiple sectors on urgent measures against plastic pollution. As a result, Thailand introduced the Plastic Waste Management Roadmap and the Phase I Plastic Waste Management Action Plan (2020–2022) (Pollution Control Department, 2020a). These policies and plans emphasise cooperation between the public, private, and public sectors to manage plastic waste throughout its life cycle – production, distribution, consumption, and end-of-life management – to achieve tangible results. Currently, Thailand is working on Phase 2 of the Plastic Waste Management Action Plan (2023–2027), which focuses on reducing and getting rid of specific plastics, particularly single-use plastics (SUPs) (Pollution Control Department, 2023b).

The 2024 Thailand Pollution Situation Report indicated that Thailand generated about 2.88 Mt of SUP waste, down from 3.03 Mt in 2023, or 11.25% of total municipal solid waste that year (Pollution Control Department, 2025a). However, only 0.72 Mt (25%) was recycled or recovered. The remaining 2.16 Mt or 75% of SUP waste was disposed of by local administrative organisations (LAOs), with a portion ultimately into the environment. Plastic shopping bags (thin and thick), plastic bags used for containing hot and cold products, plastic straws, plastic cups, and polystyrene foam food containers were also listed as the most prevalent types of plastic waste in the report. There are the low proper management and recovery rates of plastic waste, compared with the actual plastic volumes generated. This chapter analyses Thailand's plastic pollution situation, policy framework, and challenges, focusing on how to reduce the use of SUPs and promote sustainable plastic waste management.

However, production-related agencies have yet to assume a definitive role in Thailand's plastic management system, leaving much of the responsibility to LAOs. These LAOs – tasked with waste collection, transportation, and disposal – continue to face financial, personnel, and technological limitations that constrain their ability to implement circular economy principles effectively (Klinjan and Sukmaitree, 2025; Phavatvekin, Thummanitchayuth, and Noochaikaew, 2025).

2. Analysis

This section uses a Timeline Narrative Method and a qualitative data analysis approach to explain and examine the development of Thailand's plastic waste management policies and initiatives.

2.1 Analysis of key waste management initiatives in Thailand

Government structure

The LAOs are primarily responsible for municipal solid waste management in Thailand. Their mandate covers the entire process from upstream to downstream management. Their authority is defined by laws related to local government functions, decentralisation, public health, and the maintenance of public order and cleanliness (Jaiching and Wongwisetthorn, 2025). LAOs and related agencies are also required to translate national policies and plans into practice for the transition towards a circular economy and a low-carbon society, as specified in the 13th National Economic and Social Development Plan (2023–2027). This is one of the key initiatives of the 13 key milestones in the plan (Office of the National Economic and Social Development Council, 2023).

In addition, Thailand has developed the Plastic Waste Management Roadmap 2018–2030, which is divided into two key action plan phases. Phase 1 (2018–2022) focused on phasing out certain SUPs, improving recycling systems, and building public–private partnerships to strengthen waste management. Phase 2 (2022–2027) emphasises increasing recycling rates, expanding SUP reduction measures, and ensuring that post-consumer plastics are effectively brought back into recycling processes.

Phase 2 of the action plan is driven by the Bio-Circular-Green (BCG) Economy Model, which was approved by the Cabinet in 2021 as a framework for sustainable development, as part of a national agenda. This led to the formulation of the BCG Action Plan (2021–2027), in which plastic waste management is highlighted as a critical priority (National Science and Technology Development Agency, 2022). However, the BCG plan does not clearly define the roles and responsibilities of LGOs. As a result, Unrot and Wasinadamrongdee (2022) stated that each locality must define its own approach to waste management, something some localities may lack the capacity to do, especially when it comes to encouraging citizens to reduce and sort waste at the source.

Overall, the Government of Thailand has continuously enacted a number of policies and initiatives to support plastic waste management (Table 19.1). The most fundamental one is the 3Rs principle (reduce, reuse, recycle), along with appropriate end-of-pipe disposal techniques. Award schemes have been used to encourage better 3R practices, such as the Zero Waste School Award, the Zero Waste Community Award, and the Clean Province Award (Kraichakr, Yanakitti, and Yanasitthi, 2023). Furthermore, BCG policies supporting the circular economy have been promoted to ensure efficient resource use and maximise waste recovery, which will reduce the amount that needs to be disposed of in landfills (National Science and Technology Development Agency, 2022). To better reflect actual costs, regulations have also been issued to support the adjustment of waste management fees.

Table 19.1. Timeline of Plastic Waste Management Policies Initiated in Thailand

Year	Policy/Plan/Measure	Key details
2015	Zero Waste School	Promotes and awards schools that demonstrate effective and innovative waste management.
2016	Zero Waste Community	Encourages communities to reduce and sort waste at source and undertake systematic waste management.
2016	Clean Province	Evaluated and motivated provinces to improve waste management systems.
2018	Roadmap on Plastic Waste Management (2018–2030) and Action Plan Phase 1 (2018–2020)	Phase 1 focused on phasing out key SUPs and ensuring that designated plastics are recyclable.
2021	BCG Economy Model and BCG Action Plan (2021–2027)	Plastic waste was designated as a national priority, with a focus on the circular economy.
2022	Plastic Waste Management Action Plan Phase 2 (2022–2027)	Focuses on boosting recycling rates and reusable systems, further reducing SUPs, and achieving full plastic waste recycling.
2023	13th National Economic and Social Development Plan (2023–2027)	Prioritises the transition to a circular economy and low-carbon society.
2023	Draft EPR legislation	Developing a legal framework towards mandatory producer responsibility.

BCG = Bio-Circular-Green, EPR = extended producer responsibility, SUP = single-use plastic.

Source: Authors.

Based on the domestic effort, Thailand called for regional action on plastic pollution countermeasures, focusing on SUPs. At the Special ASEAN Ministerial Meeting on Marine Debris in 2019, Thailand suggested and pushed for the adoption of the ASEAN Framework of Action on Marine Debris. Its Framework I: Policy Support and Planning includes two suggested actions for SUPs. Action B-3 encourages national authorities to develop and promote product sustainability and circularity criteria against the unsustainable use and disposal of SUP products. B-4 calls for the development and/or strengthening of upstream policies for land-based leakage, which includes SUPs (ASEAN, 2019). The framework paved the way for the creation of the ASEAN Regional Action Plan for Combating Marine Debris in the ASEAN Member States (2021–2025). This plan calls for the development of guiding principles for phasing out select SUPs, pointing out the necessity of policy efforts to address the issue of SUPs, including root causes such as the culture and habits of using disposable items (ASEAN, 2021). The action plan highlighted that most of the marine plastic pollution comes from SUPs, marking this as the regional action plan to address this issue.

Performance and challenges

According to the Pollution Control Department (2025a), amongst 27.20 Mt of total municipal solid waste, about 10.51 Mt (38%) in 2024 were recovered and recycled, which increased by 2.19 Mt from the previous year. Proper disposal of municipal solid waste amounted to 10.42 Mt, showing a slight improvement from 2023; however, 4.73 Mt (17%) of the municipal solid waste was still improperly open dumped to landfill.

Currently, Thailand has 7,845 LAOs. A study by Klinjan and Sukmaitree (2025) indicated that the majority of LAOs are still unable to manage end-of-pipe waste effectively, even though some have adopted cluster-based approaches to jointly transport and dispose of waste. These challenges are particularly prevalent amongst smaller LAOs, which often lack sufficient capacity. In contrast, Dhanapañño et al. (2024) emphasised that larger municipalities have more sophisticated and intricate waste management systems, backed by better infrastructure and cutting-edge technologies for recycling and waste sorting. These factors enable more efficient management of larger volumes and a wider range of waste types, in contrast to areas where small-scale LAOs play a predominant role.

Large LAOs, such as Bangkok Metropolitan Administration, have implemented SUP reduction measures through the 'Greener Bangkok' handbook, bans in government agencies, public campaigns, and international cooperation. These efforts have also been pilot tested in Bangkok Metropolitan Administration schools and street food markets. Tourist provinces like Phuket have served as pilot areas for phasing out SUPs in collaboration with international partners (Bangkok Metropolitan Administration, n.d.; Thai-German Cooperation, 2025; Mekong Institute, 2025).

From a legal perspective, problems persist regarding the determination of waste collection and disposal fees by LAOs. Each LAO has the autonomy to set its own fee rates, but in most cases, the fees collected remain insufficient to cover the actual costs of waste management (Phavatvekin, Thummanitchayuth, and Noochaikaew, 2025).

Upcoming EPR scheme

In 2023, the Government of Thailand drafted the Sustainable Packaging Management Act, spearheaded by the Pollution Control Department, which is based on the principle of extended producer responsibility (EPR). The draft act specifies that manufacturers and importers are accountable for packaging throughout its life cycle. Additionally, it outlines the responsibilities of distributors in setting up return points where consumers can minimise and return packaging, as well as the responsibilities of LAOs in collecting packaging apart from other waste. The draft act also provides for the establishment of a Producer Responsibility Organisation (PRO) to assist and coordinate systems for collecting packaging for reuse or recycling. Depending on how much packaging is put on the market, the PRO is to charge producers an EPR fee. This new draft act is in line with Thailand's context and the principles to pursue the circular economy; however, it is still imperative to determine appropriate PRO and fee rates and guarantee multi-stakeholder participation. The draft act remains in the legislative process, with ongoing discussions and reviews to clarify its details (Pollution Control Department, 2024).

2.2 Analysis of voluntary initiatives to reduce SUPs

As noted above, Thailand developed the Roadmap and Action Plan on Plastic Waste Management in 2018, which prioritised the reduction and phase-out of SUPs. The government's efforts in driving this issue have been clearly supported by the private sector, as evidenced by the establishment of the Public–Private Partnership for Sustainable Plastics and Waste Management (PPP Plastics) in 2018, which brought together more than 30 organisations to collectively promote solutions and raise public awareness on SUPs (PPP Plastics, 2021). The campaigns worked effectively by using emotional appeals, celebrity endorsements, and simple consumer challenges to connect with people's sense of ethics and responsibility (Sedtha et al., 2023).

At that time, the government, in collaboration with the Thai Retailers Association and private sector partners, launched the 'No Plastic Bag Campaign' in major department stores, supermarkets, and convenience stores. Plastic bags for small purchases were discontinued, a charge of 1 baht was imposed per plastic bag, and employees were encouraged to reduce plastic use (Boonbandit, 2019a; 2019b). This initiative, which was a significant voluntary measure to reduce SUP consumption, led to a nationwide ban on the distribution of free plastic bags in retail establishments, which went into effect on 1 January 2020 (Boonbandit, 2019a). But during the coronavirus disease (COVID-19) pandemic (2020–2021), plastic consumption rose again, primarily due to food delivery and e-commerce services and the expanding use of plastic packaging for hygienic and safety reasons. Consequently, the amount of plastic waste was higher than usual (Wongprapinkul and Sujira, 2021; Mangmeechai, 2022). In response, the government, private sector, and academia signed a memorandum of understanding (MOU) in 2020 to voluntarily reduce SUPs in food delivery services (Pollution Control Department, 2020b).

The ban on SUP bags in outpatient departments was first implemented in 2018 in hospitals under the Department of Medical Services, Ministry of Public Health (Hfocus, 2018). Initially introduced as an organisational policy within hospitals under the Department of Medical Services, it was later expanded to over 1,000 hospitals across the country, involving multiple government agencies, and it is still in place today (Sedtha et al., 2023).

According to a study by Oludoye et al. (2024), urban dwellers generally tend to reduce their use of SUPs because they believe it is 'the right thing to do' to preserve ecosystems and the environment. In contrast, rural residents are more likely to consider the direct benefits they receive, such as the costs of alternative products. In a similar vein, a study by Thailand Environment Institute Foundation (2024) on the marketing of bio-based SUP substitutes found that usability is still a concern for consumers. Strength, flexibility, durability, and resistance to moisture or leakage are key concern areas where bio-based products still fall short of conventional plastics. Moreover, the raw materials for domestic bio-based production are supplied by only a few producers, and their prices remain higher than SUPs, directly affecting consumers.

Reducing SUP use is primarily motivated by the belief that it contributes to the nation's waste problem, the value of recyclable materials for resale, and the desire to protect animals (Oludoye et al., 2024; Thailand Environment Institute, 2024). However, there are significant obstacles, such as an environment that is unsuitable for waste collection and segregation and the difficulty of separating various SUP types. Many customers do not trust that waste that has been properly separated will be handled appropriately (Thailand Environment Institute, 2024). However, some Thai citizens believe that halting both production and consumption is necessary for SUP reduction policies to be successful (Stithyudhakarn, 2021). While consumer-side measures should refrain from imposing additional costs or legal penalties, they contend that legislation should be enforced on beverage retailers and producers, as these approaches are more suitable for the Thai context (Stithyudhakarn, 2021).

3. Key Findings

The analysis of key findings in this section focuses on identifying policy-level gaps to reflect the current situation and provide insights useful for shaping strategic directions and designing measures that are appropriate to the Thai context. It also aims to highlight the linkages between policy and practice, indicating how the identified gaps may affect the effectiveness of existing measures. The analysis covers four key dimensions: policies and plans, legislation, infrastructure, and collaboration.

3.1 For key waste management initiatives

Thailand has established a Plastic Waste Management Roadmap (2018–2030) and is currently implementing the Phase II Action Plan, which focuses on reducing and phasing out SUPs. These initiatives are consistent with the BCG Economy Model and the 13th National Economic and Social Development Plan, which promote the circular economy. This represents significant progress in terms of structural policy development. However, a major obstacle is that many initiatives remain largely voluntary campaigns, while policy implementation at the local level is inconsistent due to limited resources and the absence of common standards.

To guarantee that producers and importers share accountability in take-back and recycling systems, the draft Sustainable Packaging Management Act, which embraces the EPR principle, has been advanced from a legal standpoint. This is a significant step in the direction of global standards (see also Chapter 6). Nevertheless, the current legal framework does not yet mandate waste separation at source or establish an official take-back system for packaging, resulting in a fragmented approach to plastic waste management.

Large cities have begun investing in infrastructure projects such as materials recovery facilities to expand their capacity for recycling and sorting. However, many locations continue to use generic mixed-waste collection systems that lack technical readiness. Contamination from food waste continues to degrade recyclable plastics. Systemic management is challenging due to fragmented data systems for tracking waste volume and quality, and most LAOs suffer from lack of staff and funding.

Currently, plastic management in Thailand is carried out by several organisations that address waste management, consumption, and production. However, production-related agencies have yet to assume a definitive role. LAOs, which are responsible for the collection, transportation, and disposal of waste, are still impacted by financial, personnel, and technological limitations. Therefore, in accordance with the principles of the circular economy, waste management continues to place a higher priority on collection and disposal than on resource recovery and efficiency. LAOs often assume the role of implementers rather than co-designers or decision makers regarding systemic solutions.

In terms of collaboration mechanisms, initiatives such as PPP Plastics and MOUs between various stakeholders show increasing multi-stakeholder commitment to tackle plastic waste and SUP reduction. These collaborations help raise public awareness and mobilise resources, but they remain largely project-based and have yet to drive systemic, long-term change. Yet, these efforts have largely taken the form of project-based or activity-oriented initiatives that, while important, have not yet been able to drive broad systemic change.

3.2 SUP transition

Thailand's Plastic Waste Management Plan has set clear targets to cut and ultimately phase out SUPs. This direction is fully aligned with the ASEAN Regional Action Plan on Marine Debris and Thailand's circular economy approach under its National Economic and Social Development Plan. The alignment of regional and national objectives is a significant strength to create opportunities for mutual support and reinforce each other's goals. A significant flaw, though, is that a lot of plans continue to prioritise voluntary campaigns over real enforcement. However, the results of SUP reduction are not as evident as anticipated due to the absence of a strong evaluation system in progress monitoring (Sedtha et al., 2023).

The attempt to connect SUP reduction with new legal frameworks, like the draft Sustainable Packaging Management Act, which reflects the goal of establishing stricter measures, is one of its strengths. Nevertheless, a significant gap remains; there is no legally enforced requirement for SUP waste separation at source, nor are there sufficiently clear standards for alternative products to assure consumers of their quality, safety, and practical usability. As a result, the transition to SUP substitutes continues to face obstacles in both regulatory enforcement and social acceptance.

Local efforts to decrease SUPs have also been started. However, these efforts are still limited to pilot projects or big cities. The main shortcoming is the insufficient infrastructure for the collection and segregation of SUPs, especially at the local level where resources and suitable technology are limited. Furthermore, contamination from food waste and mixed collection prevents most SUPs from being recycled, requiring the use of end-of-pipe solutions like ecological leakage or landfilling (Kamsook et al., 2023).

The partnerships for Thailand's SUP management include PPP Plastics, the No Plastic Bag Campaign, the suspension of plastic bag distribution in hospital outpatient departments, and MOUs between public and private organisations and food delivery services. The strength of these efforts resides in their ability to generate broad public awareness and momentum around the SUP issue. However, since the mechanisms for collaboration are not fully integrated yet, there are still limitations. LAOs are often only implementers of the system, rather than co-designers. Additionally, consumer awareness campaigns are inconsistent; for instance, SUP use dramatically increased during the COVID-19 pandemic. This demonstrates that the level of cooperation that exists now is not strong enough to endure shocks from the outside world or produce long-term changes in behaviours.

4. Discussion

Thailand's progress in reducing SUPs reflects a dynamic policy evolution that can be traced through a timeline analysis of key milestones – from the launch of the Plastic Waste Management Roadmap (2018–2030), the implementation of the Phase I and II Action Plans (2020–2027), and the adoption of the BCG Economy Model in 2021, to the ongoing drafting of the Sustainable Packaging Management Act based on the EPR principle. This timeline demonstrates a gradual transition from awareness-driven voluntary campaigns towards a more structured and legally oriented policy framework. However, implementation remains heavily reliant on public awareness and voluntary cooperation. The absence of mandatory measures, such as source separation of waste and clear product standards for SUP substitutes, represents a major gap that weakens policy enforcement and consumer confidence. Structural barriers also persist, particularly at the local level, where inadequate funding, outdated technology, and a shortage of personnel limit effective recycling and circularity efforts.

However, financial mechanisms remain one of the most vulnerable aspects of the system. At the local level, administrative organisations bear responsibility for waste collection and disposal but often operate with insufficient revenue from waste management fees, which rarely reflect the actual costs. As a result, operations largely depend on central government subsidies or private sector support. The variation in fee structures across localities also reflects inequalities and the absence of efficient economic mechanisms to encourage waste reduction at the source. This is mainly due to the lack of a clear mechanism for fee collection and allocation, which limits financial incentives to promote recycling or eco-friendly product design. Consequently, financial motivation for circularity and sustainable plastic management remains limited in scope.

Meanwhile, through programmes like PPP Plastics and the No Plastic Bag Campaign, government, business, and civil society collaboration mechanisms have increased public awareness. Nonetheless, there is still a lack of systemic integration between policy frameworks and actual implementation, with LAOs frequently acting merely as implementers rather than actively influencing policy direction. The foundation for a true shift to a circular economy is thus laid by achieving sustainable transformation with a combination of strong legal enforcement, efficient fiscal incentives, explicit product standards, and constant engagement of all stakeholders.

5. Conclusion

Thailand has continuously carried out regional and national plastic management programmes, setting clear objectives to reduce and eventually phase out SUPs. This demonstrates both a growing awareness of the problem and a strong commitment to addressing plastic pollution at all governmental levels. Progress has been fuelled by multi-stakeholder collaboration between the public and private sectors and civil society. However, there are still major barriers to implementation, including poor infrastructure, lack of legally binding production regulations, lack of product standards to ensure consumer confidence, and lack of strict enforcement of source separation. The stated goals have not been met by the results thus far.

One important lesson is that systemic and behavioural change in plastic management cannot be achieved solely through voluntary measures. Campaigns to raise awareness may have short-term advantages, but they will not last without clear laws and strong financial incentives. The vulnerability of a system devoid of structural integration was further highlighted by the COVID-19 pandemic. It is imperative that source separation be made mandatory, that alternative products be subject to explicit standards, and that financial incentives like EPR fees be reinforced. Enhancing collaboration at every level is essential to accelerating the circular economy transition and lowering plastic pollution in a long-term, sustainable manner.

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Chapter 20

Bridging Science and Policy: A Decade of China's Response to Plastic and Microplastic Pollution

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1. Introduction

Plastic pollution has emerged as one of the most pressing environmental challenges of the 21st century. Since the 1950s, global plastic production has increased exponentially, reaching over 400 million tons (Mt) per year by 2020 (Geyer, Jambeck, and Law, 2017). While plastics have revolutionised industries and everyday life due to their versatility and low cost, their persistence in the environment has created complex ecological, economic, and health-related consequences. It is estimated that more than 11 Mt of plastic waste enter the world's oceans annually, a figure projected to nearly triple by 2040 without urgent intervention (Lau et al., 2020). Microplastics – plastic particles less than 5 millimetres in size – have been detected across all environmental compartments, including marine and freshwater systems, soil, air, biota, and even human tissue (Bergmann et al., 2019; Cox et al., 2019; Thompson et al., 2024).

Global concern over plastic and microplastic pollution has intensified in recent years, prompting multilateral actions such as the United Nations Environment Assembly (UNEA) resolution to negotiate a legally binding international treaty on plastic pollution. Scientific research has played a pivotal role in informing this policy momentum by identifying pollution hotspots, tracing sources, modelling ecological risks, and proposing mitigation strategies. However, bridging science and policy remains a challenge in many parts of the world, particularly in developing and emerging economies, where institutional mechanisms for evidence-based governance are still evolving.

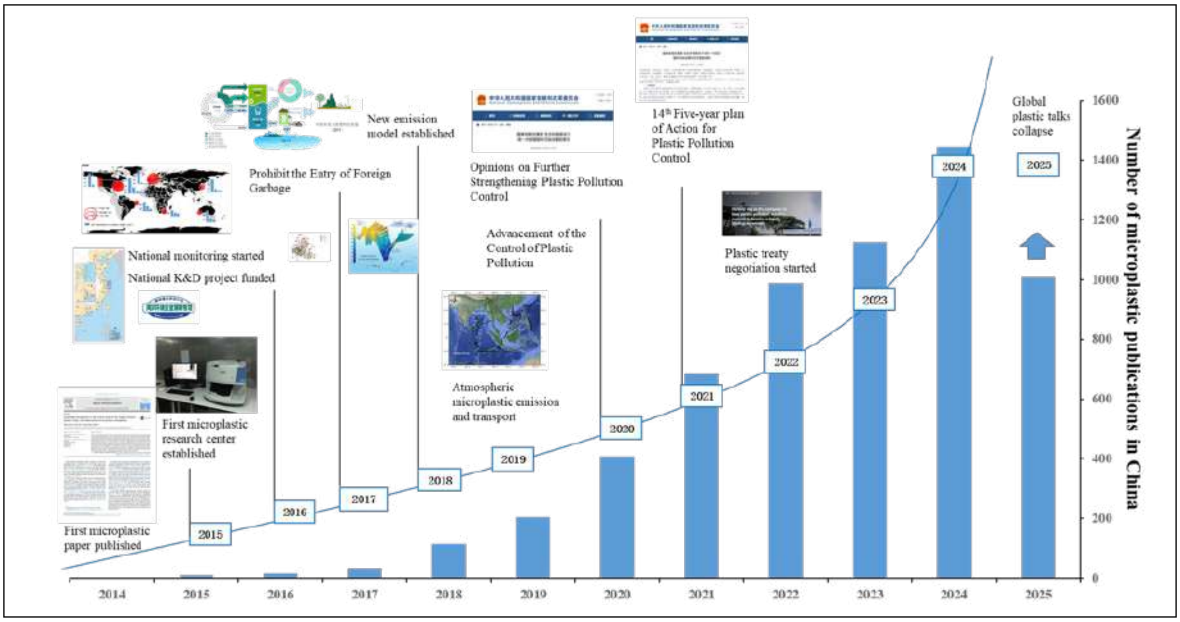
China plays a dual role in the global plastic narrative: as the world's largest producer and consumer of plastic materials, and as a critical actor in addressing the escalating crisis of plastic and microplastic pollution. China started to address the plastic pollution issue in the early 2000s. It launched a series of regulatory actions beginning in 2008 with the 'Plastic Shopping Bag Restriction Order', which banned free distribution of ultra-thin plastic bags in retail markets.

Over the past decade, China's approach to plastic pollution has evolved significantly and systematically, driven by a combination of intensified scientific inquiry and a growing commitment to environmental governance. The integration of science and policy in this domain exemplifies China's broader strategy of ecological civilisation and its pursuit of sustainable development.

China was once labelled as the top contributor to marine plastic waste via coast and rivers, largely based on early model estimations that lacked field validation (Jambeck et al., 2015; Lebreton et al., 2017). However, subsequent field-based studies revealed that such estimates significantly overstated China's actual discharge. In situ observations and regional assessments suggest that annual plastic inputs to the ocean from China range from 44,000 to 58,000 tons – just a fraction of earlier global model estimates (Bai et al., 2018). Ironically, previous international scrutiny catalysed policy change. In 2017, China launched its 'National Sword' policy, banning the import of most plastic waste and marking a turning point in both global waste trade and domestic plastic governance. The ban not only asserted environmental sovereignty but also accelerated upgrades in China's recycling systems and the development of a national plastic pollution control strategy.

Simultaneously, China's scientific community has played a growing role in characterising the sources, fluxes, fate, and ecological risks of plastic and microplastic pollution. Since 2013, research output in this field has grown exponentially, making China one of the top contributing countries to the global microplastics literature (Figure 20.1). Institutions such as East China Normal University and the Ministry of Ecology and Environment (MEE) have led national and regional-scale projects, such as the key national research and development (R&D) project, 'Marine Microplastics Monitoring and Ecological Risk Assessment Technology Research Project', and the United Nations Education, Scientific and Cultural Organization (UNESCO) and Intergovernmental Oceanographic Commission (IOC) IOC Sub-Commission for the Western Pacific (WESTPAC) Research Project on 'Distribution, Source, Fate and Impacts of Marine Microplastics in the Asia Pacific Region' (Li, Peng, and Zhu, 2019). Those projects expanded investigations from surface waters to deep seas, covering coastal and open ocean, and the polar regions (Li, Peng, and Zhu, 2019). This surge in scientific output has been closely tied to regulatory efforts, including national monitoring programmes, risk assessments, and integration into marine environmental planning. The growing synergy between science and policy in China's plastic governance reflects a broader shift towards evidence-based environmental management, aligned with the national agenda of building an ecological civilisation. This alignment is also visible in international dialogues. For example, China's participation in global platforms such as the United Nations Environment Programme (UNEP) Ad Hoc Open-Ended Expert Group on Marine Litter and Microplastics, the Group of Twenty (G20) Marine Litter Framework, and the China Council for International Cooperation on Environment and Development has helped bridge domestic action with global governance efforts.

Figure 20.1. Number of Scientific Paper Publications Relating to Microplastics Research in China and Important Progress Each Year



K&D = keywords & descriptors.

Note: Topic search = microplastic$ or microliter or 'microplastic$' and China.

Source: Web of Science.

China's experience via bridging scientific evidence with governance innovation offers valuable lessons for other developing economies seeking to tackle plastic pollution through integrated, science-informed approaches.

This chapter reviews the evolution of China's plastic and microplastic governance over the past decade, emphasising the interplay between scientific research and policy interventions. Its objectives are to:

(i) characterise the status of plastic and microplastic pollution in China, drawing on empirical monitoring and academic evidence;
(ii) analyse key national and local policies, especially those informed by scientific data;
(iii) present case studies of cities and provinces that pioneered integrated research-policy innovations; and
(iv) identify governance gaps and future pathways, with a focus on institutionalising science–policy linkages to enhance plastic governance efficacy.

2. Status Quo of Plastic and Microplastic Pollution in China

Over the past decade, China has significantly advanced its scientific understanding of plastic and microplastic pollution across multiple environmental compartments. It was not until 2014 that the first microplastic paper in China was published by researchers from East China Normal University (Zhao et al., 2014). Since then, China has undergone a rapid expansion in microplastic-related research across diverse ecosystems – from rivers and coastal waters to deep-sea trenches and the atmosphere, driven by rising environmental concerns and global scientific attention (Figure 20.1). In 2022, more than 1,000 papers were published. A wide range of academic institutions, including marine research centres, environmental science departments, and interdisciplinary policy think tanks, have contributed to building comprehensive research infrastructure. In parallel, this surge aligns with several key national milestones, such as the prohibition of the entry of foreign plastic waste.

Meanwhile, in response to the challenge of methodological inconsistency across microplastic studies, China has made significant efforts to standardise microplastic sampling and analytical protocols. These standards – adapted from international practices but refined through extensive field trials in Chinese waters – cover sample pretreatment, polymer identification, quality control procedures, and metadata documentation. To enable long-term tracking of pollution trends, China has established robust monitoring systems. The National Marine Plastic Pollution Monitoring Program includes standardised sampling of beaches, surface waters, sediments, and marine organisms across 11 coastal provinces (Li, Peng, and Zhu, 2019). This programme, guided by national technical guidelines, has set a benchmark for environmental data collection and comparability. Additionally, academic consensus is emerging to expand standardisation efforts to encompass atmospheric microplastics (Allen et al., 2022) and emerging contaminants associated with plastics, including plastic additives (Wang et al., 2024). The breadth and depth of these monitoring activities reflect China's growing commitment to building an empirical foundation for plastic pollution governance. Through these efforts, China has transitioned from data-scarce conditions to becoming a key contributor to global microplastic data platforms.

Scientific research has played a critical role in shaping China's domestic policies and international engagement on plastic pollution. Through long-term monitoring, modelling, and methodological innovation, Chinese scientists have provided the empirical evidence base necessary to inform and justify regulatory action.

One striking example is the correction of earlier global models that overestimated China's plastic inputs into the ocean. Influential studies published in the early 2010s (Jambeck et al., 2015) suggested that China was the world's largest contributor of marine plastic debris, with estimates often based on insufficient or outdated waste management data. However, recent work led by Chinese scholars – through systematic field campaigns and improved modelling approaches – has highlighted the methodological flaws in these assessments and recalibrated national input figures (Bai et al., 2018; Zhao et al., 2019; Mai et al., 2020). These efforts helped shift the narrative from one of 'blame' to one of 'constructive engagement', and partially catalysed China's 2017 ban on imported plastic waste and the rollout of its plastic pollution control action plan (2020–2025).

In addition, the development of standardised methods for microplastic sampling and analysis across multiple environmental matrices – ranging from sediments and seawater to atmospheric fallout – has not only enhanced scientific consistency but also provided the technical foundation for national and provincial monitoring programmes. These standards, developed by institutions such as the MEE and East China Normal University, have enabled more reliable data collection, which in turn supports evidence-based policymaking at both the central and local levels.

Importantly, science–policy dialogues have been institutionalised through advisory panels, policy white papers, and participation in global forums. For example, data generated through China's United Nations (UN) Decade of Ocean Science for Sustainable Development projects have been presented at international conferences and incorporated into capacity-building programmes for regional partners.

The Chinese experience illustrates that rigorous science, when strategically communicated and embedded within policy mechanisms, can shift both national priorities and global narratives, enabling a transition from reactive governance to proactive stewardship.

3. Key Initiatives and Policies Against Plastic Pollution

The prevention and treatment of plastic waste in China have been through a long process (Table 20.1). China is one of the earlier countries to issue a 'plastic ban order' (Emergency Notice on Immediately Stopping the Production of Disposable Foam Plastic Tableware, 2001) and 'plastic restriction order' (Notice of the General Office of the State Council on Restricting the Production, Sales and Use of Plastic Shopping Bags, 2007).

China has also been active in cleaning up the blue ocean. On the one hand, in accordance with the requirements of relevant laws and regulations and international conventions, China has continuously improved the prevention and control mechanism of plastic pollution; actively promoted the management and control of land-based waste; established an environmental supervision system for the process of solid waste collection, transportation, and disposal; vigorously promoted waste classification; and improved the recycling rate of plastic products by reducing the use of single-used plastic products. On the other hand, China promotes the construction of ecological civilisation and reduces the amount of plastic waste that leaks into the sea through the construction of beautiful villages, as well as the implementation of the river head system and the lake head system.

China has also intensified public awareness and education on marine environmental protection; popularised knowledge on plastic and microplastic pollution prevention and control; effectively raised citizens' awareness of marine environmental protection; and constantly involved more enterprises, social organisations, and the public in marine ecological and environmental protection. Meanwhile, China is gradually promoting the application of degradable plastics, setting standards for the production of disposable degradable plastic bags, and promoting the development of the degradable plastics industry. In response to the lack of unified standards for the disposable plastics, the state is working on a unified standard for degradable plastics, formulating a unified label for degradable plastics, and promoting the promotion and application of sustainable plastics in all walks of life.

In terms of laws and policies, although there is no law to directly control marine waste in China, the state has formulated a series of regulations, policies, and measures for the prevention and control of plastic waste pollution since the 1990s, and constantly supplemented and revised them. These include the Regulations of the People's Republic of China on the Control of Pollution Damage to Marine Environment by Land-based Pollutants (1990); the Law of the People's Republic of China on the Prevention and Control of Environmental Pollution by Solid Waste, 1995; the Technical Specification for Pollution Control of Waste Plastics Recovery and Recycling (2007); the Law of the People's Republic of China on Promoting Circular Economy, 2009; the Cleaner Production Promotion Law of the People's Republic of China, 2012; the Environmental Protection Law of the People's Republic of China, 2014; the Law of the People's Republic of China on Marine Environmental Protection, revised in 2017; the Law of the People's Republic of China on the Prevention and Control of Water Pollution, revised in 2017; the Regulations of the People's Republic of China on the Management of Marine Dumping, revised in 2017; and the Implementation Plan for Banning the Import and Export of Solid Waste (2017). The regulations on solid waste management, such as the catalogue of imported waste management, have been revised and improved many times.

Over the past decade, China has experienced a marked shift from fragmented and reactive policy responses towards more integrated and proactive strategies for plastic pollution control. This transition has been driven by a combination of domestic priorities – such as environmental protection and the development of a circular economy – and international initiatives arising from global environmental governance. For example, the state has also successively issued environmental protection policies such as The Action Plan for Prevention and Treatment of Water Pollution (2015), the Action Plan for Prevention and Treatment of Soil Pollution (2016), and the River Chief System (2016). Some coastal cities have also carried out pilot work for the 'Bay Chief System' (2017) to prevent waste from directly entering the river or randomly stacking at the edge of the water body, and to strengthen the waste treatment of the water body and its shoreline through timely removal of waste and floating objects in the water body and properly handling of them. All these have played a positive role in the reduction of plastic waste and the control of plastic waste leakage into the sea.

In 2017, the Report of the 19th National Congress of the Communist Party of China clearly put forward that solid waste and rubbish disposal should be included. The watershed moment came with the 2017 National Sword policy, which prohibited the import of plastic waste and catalysed a major restructuring of global recycling markets. Domestically, it spurred the central government to tighten control over plastic use and disposal.

Since 2018, the MEE has continuously carried out actions such as the Waste Removal Action of the Yangtze River Economic Belt and the Action Plan for Comprehensive Treatment of the Bohai Sea, as well as comprehensive treatment of waste in the rivers and coastal waters of the Yangtze River and the Bohai Sea, to reduce the leakage of plastic waste into the sea at the source. In the same year, the Action Plan for Tackling Key Problems of Agricultural and Rural Pollution Control was issued to strengthen the prevention and control of rural production and domestic waste pollution, and pilot test the extended producer responsibility (EPR) system of 'who produces, who recycles'. The action plan also required the national recovery rate of agricultural plastic film to reach 80% and near-universal coverage of rural domestic waste collection and disposal systems to be achieved by 2020.

In September 2015, the Ministry of Transport issued the Implementation Plan of Special Action on Pollution Prevention and Control Between Ships and Ports (2015–2020), which requires that the transfer and disposal facilities of domestic waste and other pollutants between ships and ports and between port cities be well connected, to improve the receiving and disposal capacity. In March 2018, the Maritime Safety Administration issued a notice on the implementation of the 2016 Amendments to Annex V of the International Convention for the Prevention of Pollution from Ships (MARPOL), prohibiting ships from discharging harmful wastes such as plastics into the sea. In 2019, the Ministry of Agriculture and Rural Affairs, together with nine other ministries, jointly issued 'Opinions on Promoting the Green Development of Aquaculture Industry', which proposed the lawful removal of illegal cage and enclosure aquaculture facilities, strengthened the management of aquaculture-related waste, and promoted the use of floating balls made of new environmentally friendly materials. These policies and regulations effectively strengthen the control of marine plastic debris in China.

In 2016, China released the Implementation Plan for the EPR System, which explored institutional innovations tailored to national conditions and the country's stage of development. The plan called for the establishment of a credit information collection system for EPR, the development of evaluation and management methods and policy guidelines, increased support for scientific research, and accelerated promotion of recycled products and secondary raw materials. In 2017, the Action Plan for Leading Circular Development was issued, setting targets that by 2020 the output efficiency of major resources would increase by 15% compared with 2015, and that the recycling rate of major wastes would reach about 54.6%.

In January 2019, the General Office of the State Council issued the Work Plan on 'Zero-Waste City' Pilot Program in China. On 30 April 2019, the MEE announced the construction of 11 pilot cities for Zero-Waste City construction. In parallel, the Ministry of Housing and Urban-Rural Development (MOHURD) actively advanced urban solid waste management by designating 46 key cities, including Beijing, as national priorities for municipal waste classification. From 2019 onwards, household waste classification was fully launched in prefecture-level and above cities nationwide, alongside strengthened efforts to manage rural domestic waste, with the goal of achieving effective treatment in about 90% of villages. On 1 July 2019, Shanghai's municipal domestic waste management regulations were formally implemented, and the compulsory domestic waste classification action was first implemented. So far, the overall effect has far exceeded expectations.

In September 2019, the 10th meeting of the Central Commission for Deepening Overall Reform set out new requirements specifically targeting plastic pollution. The meeting called for proactive responses to plastic pollution under the guiding principles of the new development philosophy, including the orderly banning and restriction of the production, sale, and use of selected plastic products; the active promotion of recyclable, easily recoverable, and degradable alternatives; the expansion of green product supply; the standardisation of plastic waste collection and recycling; and the establishment of comprehensive management systems across the entire plastic life cycle. These measures underscore China's strong commitment to addressing plastic pollution in a systematic and effective manner.

On 30 October 2019, the National Development and Reform Commission issued the Industrial Structure Adjustment Guidance Catalogue (2019 edition), which explicitly stipulated that the production of personal care products containing plastic microbeads would be banned from production by 31 December 2020, and banned from sale by 31 December 2022.

On 19 January 2020, the National Development and Reform Commission and MEE jointly released 'Opinions on Further Strengthening Plastic Pollution Treatment', a comprehensive action plan that defined phased targets and responsibilities across government levels and sectors. Key policy instruments included the gradual phase-out of non-degradable plastic bags, straws, and utensils in the retail, hospitality, and postal sectors; support for biodegradable materials and green packaging design; and the inclusion of EPR, eco-design standards, and traceability systems. The document prohibited and restricted the production, sale, and use of plastic products; promoted alternative products and models, such as non-plastic products, biodegradable plastic bags, and biodegradable agricultural films; and emphasized source reduction of plastic products. It further specified that by 2020, selected plastic products would be prohibited or restricted on a pilot basis in certain regions and sectors. The policy outlined an integrated approach to plastic pollution control based on the principles of 'banning and restricting a group, replacing and recycling a group, and regulating a group' (Article 1.1). In line with this framework, implementation at the sub-national level has progressed rapidly. In July 2020, the National Development and Reform Commission, MEE, and seven other ministries jointly issued the 'Notice about Promoting Plastic Pollution Control Work', which clarified timelines for bans and restrictions and marked the launch of a new, nationwide phase of plastic pollution governance involving multiple ministries and local governments. Collectively, these measures are expected to substantially accelerate the reduction of plastic waste generation in China. In March 2021, the Fourth Session of the 13th National People's Congress voted to adopt the '14th Five-Year Plan for National Economic and Social Development of the People's Republic of China and the Outline of Vision Goals for 2035 (the 14th Five-Year Plan)'. The plan emphasises integrated land–sea management, harmony between human activities and the marine environment, and cooperative governance, while further consolidating and strengthening measures for marine ecological protection and environmental sustainability. Under the 14th Five-Year Plan, controls on land-based pollutants entering the ocean are expected to become both stricter and more comprehensive, implying more stringent regulation of marine plastic litter. The 14th Five-Year Plan for Ecological and Environmental Protection (2021–2025) further institutionalised these efforts, establishing plastic governance as a cross-sectoral priority. Targets include increasing recycling rates, enhancing monitoring of plastic waste in rivers and seas, and fostering innovation in biodegradable technologies.

These national policies were operationalised through local regulations, pilot programmes, and special action campaigns. For instance, Hainan provincial government launched a total ban on non-degradable single-use plastics in 2020, supported by clear substitution pathways and technical guidelines. Shanghai and Beijing implemented mandatory waste sorting schemes, while other regions experimented with deposit-refund systems and zero-waste city pilot programmes.

Beyond domestic policy measures, China has actively engaged in international, bilateral, and multilateral initiatives to address marine plastic pollution. These efforts include participation in the United Nations Regional Seas Action Plans for the East Asian Seas and the Northwest Pacific; the promotion and signing of trilateral cooperation on marine litter among China, Japan, and the Republic of Korea under the Tripartite Environment Ministers Meeting (TEMM) framework; the Declaration on Combating Marine Plastic Litter adopted at the East Asia Summit; the Association of Southeast Asian Nations Plus Three (ASEAN+3)[1] Initiative on Marine Litter Cooperation; and the China–Canada Joint Statement on Addressing Marine Litter and Plastics. Through cooperation in scientific research, capacity building, information sharing, and public engagement, these initiatives aim to advance regional marine environmental protection. China also participates in global negotiations for a legally binding instrument on plastic pollution under UNEA. These platforms facilitate knowledge sharing, technical cooperation, and alignment with emerging global norms.

With the help of these policies, the recycling rate of waste plastics in China has greatly increased over the years since 2000, placing the country amongst the leading contributors to global plastic waste recovery and treatment. The life cycle of waste plastic products in China comprises raw material extraction, processing and forming, storage and circulation, use, disposal, and recycling. Historically, China has played a major role as both an importer and recycler of global plastic waste. The average recycling rate of plastic waste in China had reached 25.6% by 2016 (Law et al., 2020), representing a substantial contribution to global plastic waste management. In contrast, recycling statistics reported by other countries often include exported plastic waste. For example, the recycling rate of plastic waste in the United States has remained below 10%, while the European Union and Japan reported recycling rates of 32.5% and 28%, respectively, in 2018. Following China's ban on plastic waste imports, plastic waste exports from the European Union declined by 39% in 2018 compared with 2016, mainly due to 2017 National Sword policy (D'Amato et al., 2023).

In recent years, China has also gradually improved its plastic additive standards and industry guidelines. Plastic waste in the ocean may release toxic chemicals, of which plastic additives are a major factor. Laws and standards related to plastic additives have been promulgated at home and abroad. In 2016, the former National Health and Family Planning Commission and the China Food and Drug Administration issued the National Food Safety Standard – General Safety Requirements for Food Contact Materials and Articles (GB 4806.1–2016), along with 53 related food safety standards, forming a comprehensive regulatory system covering hygienic production requirements and migration testing. These standards impose restrictions on plastic additives such as Di-(2-Ethylhexyl) phthalate (DEHP) and specify limitations on plastic resins and their use in contact with certain food categories. In 2017, the Expert Committee on Food Contact Materials of the China Food Industry Association released the Industry Guidelines on Supply Chain Responsibility and Compliance Declarations for Plastic Food Contact Materials, further strengthening governance across the plastic value chain. The standards restrict the plastic additive DEHP, require that materials or products not be used in contact with some foods, and restrict the use of plastic resins.

[1] ASEAN+3 refers to the 11 ASEAN Member States (Brunei Darussalam, Cambodia, Indonesia, the Lao People's Democratic Republic (Lao PDR), Malaysia, Myanmar, the Philippines, Singapore, Thailand, Timor-Leste, and Viet Nam) plus China, Japan, and the Republic of Korea.

Despite these advancements, enforcement challenges persist. In rural and peri-urban areas, plastic waste may escape formal collection systems. Informal recycling networks – while vital for resource recovery – operate with limited oversight, sometimes contributing to secondary pollution. Scaling up biodegradable alternatives also requires investment in industrial capacity and supportive procurement policies.

In conclusion, China has moved rapidly to elevate plastic pollution as a strategic environmental issue, linking scientific evidence with policy innovation. Continued progress will depend on improving institutional coordination, scaling up successful pilot projects, and ensuring equitable access to sustainable alternatives across diverse regions and populations.

Table 20.1. China's Main Plastic-Related Policies

Date	Policy name	Plastics-related content
Oct 1995	Law of the People's Republic of China on the Prevention and Control of Solid Waste Pollution	• Underwent repeated revisions to gradually increase the content of managing waste plastics
Jan 1999	Emergency Notice on the Immediate Cessation of the Production of Disposable Foamed Plastic Tableware issued by State Economic and Trade Commission	• By the end of 2000, the production and application of disposable foam plastic catering utensils was to be prohibited nationwide.
Dec 2004	Law of the People's Republic of China on the Prevention and Control of Solid Waste Pollution	• Aimed to encourage the use of regenerated biomass energy and degradable plastics
Mar 2007	'Administrative Measures for Recycling of Renewable Resources' was jointly issued by MOFCOM, the NDRC, the Ministry of Public Security, the Ministry of Construction, the State Administration for Industry and Commerce, and the State Environmental Protection Administration	• Encouraged all section of society, including urban and rural residents, to accumulate and sell renewable resources; recycle and treat renewable resources in an environmentally sound manner; and carry out scientific research, technological development, and dissemination on the recycling and treatment of renewable resources.
Dec 2007	Notice of the General Office of the State Council on Restricting the Production, Sale and Use of Plastic Shopping Bags	• Banned the production, sale, and use of thin plastic shopping bags (less than 0.025 mm) nationwide from 1 June 2008 • Implemented the payment system for plastic shopping bags in retail stores
Aug 2008	Circular Economy Promotion Law of the People's Republic of China	• Promoted the development of a circular economy, enhanced resource-use efficiency, protected and improved the environment, and achieved sustainable development
Oct 2011	'Opinions on the Establishment of a Complete and Advanced System for Recycling Waste Commodities' issued by the General Office of the State Council	• Emphasised the importance of establishing a recovery system for end-of-life products, with the aim of conserving resources and protecting the environment
Feb 2012	Law of the People's Republic of China on Cleaner Production Promotion	• Mandated the design of products and packages to consider their impact on human health and the environment during the life cycle, and prioritise packages that are non-toxic, non-hazardous, easy to degrade, or easy to recycle

Date	Policy name	Plastics-related content
Feb 2012	'Petrochemical and Chemical Industry Development Plan During the 12th Five-Year Plan Period' issued by the MIIT	• Proposed the development of PLA and PBS **degradable** plastics
May 2012	'Guiding Opinions on China Plastics Processing Industry "Twelfth Five-Year" Development Plan' issued by the China Plastics Processing Industry Association	• Proposed the promotion of biodegradable **materials** and products, personalised packaging film logo design, functional materials, and products, etc.
Jan 2015	Medium- and Long-Term Plan for the Construction of Renewable Resources Recovery System (2015–2030) issued by MOFCOM, the NDRC, the Ministry of Land and Resources, the Ministry of Housing and Urban–Rural Development, and the General Supply and Marketing Cooperatives	• Identified key systemic challenges in plastic waste management, including the widespread misperception of recyclables as general waste, insufficient emphasis on recycling, inadequate source separation that increases downstream recovery costs, unclear stakeholder responsibilities, weak policy coordination, and the absence of explicit institutional requirements for waste plastics • Highlighted the need for a more integrated and standardized recycling framework to address these gaps
May 2017	Circular Development Leading Action jointly issued by the NDRC, the Ministry of Science and Technology, and 14 other departments	• **Main** targets: by 2020, the output rate of major resources would increase by 15% compared with 2015, and the recycling utilisation rate of major wastes would reach about 54.6%
Jul 2017	'Prohibit the Entry of Foreign Garbage and Promote the Implementation Plan for the Reform of the Import Management System of Solid Waste' issued by the General Office of the State Council	By the end of July 2017: • The management catalogue of imported solid **waste** was to be adjusted. • China would ban imports of household waste **plastics**, unsorted waste paper, textile waste, and vanadium slag.
Jul 2017	China Plastics Processing Industry Association compiled the 'Development Guiding Opinions on Plastics Processing Industry Technological Progress During the 13th Five-Year Plan'	• Promoted research and development on **cutting**-edge technologies and emerging processes • **Encouraged** the development of energy-saving and environment-friendly materials and technologies • **Aimed** to improve the recycling and processing system of waste plastics
Nov 2017	'Guiding Opinions on Collaborative Promotion of Green Packaging in the Express Industry' jointly issued the State Post Bureau, the NDRC, the Ministry of Science and Technology, and 10 other departments	• By **2020**, the proportion of biodegradable green packaging materials would increase to 50%.
Nov 2017	Conditions of Specification for Agricultural Film Industry (2017 Version) issued by the MIIT	• **Emphasised** that agricultural film products should not be produced with inferior recycled plastics as raw materials • Stated that the quality of products should meet **national** and industrial standards, and the qualified rate of products should reach 100%
Feb 2018	A new version of 'National Standard for Express Packaging Products Series' issued by the General Administration of Quality Supervision, Inspection and Quarantine and Standardization Administration of the People's Republic of China	• **From** 1 September 2018, delivery bags were to be made of biodegradable plastic to reduce plastic pollution.

Date	Policy name	Plastics-related content
Apr 2018	The MEE, MOFCOM, the NDRC, and the General Administration of Customs jointly issued the 'Announcement on Adjustment'	• **Revised** the Catalogue for the Management of Imported Solid Wastes in phases • **Strictly** prohibited the import of 'foreign waste' into China
Oct 2019	Guiding Catalogue of Industrial Structure Adjustment (2019 version) issued by the NDRC	• **Phased** out disposable foam plastic tableware and disposable plastic swabs by 2021 • Banned the production of daily chemical **products** containing plastic microbeads by the end of 2020 and the sale of plastic microbeads by the end of 2022 • **Aimed** to phase out ultra-thin plastic bags (less than 0.025 mm thick) and polyethylene agricultural mulching film (less than 0.01 mm thick)
Oct 2019	National Standard: GB/T 38082-2019 Biodegradable Plastic Shopping Bags	• **Stipulated** the definition requirements, test methods, inspection rules, packaging, transportation, and storage of biodegradable plastic shopping bags
Jan 2020	'Opinions on Further Strengthening Plastic Pollution Control' issued by the NDRC and the MEE	• Proposed banning and restricting the **production**, sale, and use of some plastic products in an orderly way, and promoting alternative products
Jun 2020	The State Development and Reform Commission, the MEE, the MIIT, the Ministry of Housing and Urban–Rural Development, the Ministry of Agriculture and Rural Affairs, MOFCOM, the Ministry of Culture and Tourism, the State Administration for Market Regulation, and the All-China Federation of Supply and Marketing Cooperation jointly issued the Notice on Solid Advancement of the Control of Plastic Pollution	• Starting on 1 January 2021, banned the **production** and sale of disposable plastic cotton swabs, disposable foam plastic tableware, and rinsing cosmetics and toothpastes with plastic microbeads added on purpose nationwide • Prohibited the production and sale of thin **plastic** shopping bags (less than 0.025 mm thick) and polyethylene agricultural mulching film (less than 0.01 mm thick) • Banned non-biodegradable plastic shopping **bags** in some cities and public places from 2021
Nov 2020	The MEE, MOFCOM, the NDRC, and the General Administration of Customs jointly issued the 'Announcement on Relevant Matters Concerning the Comprehensive Ban on the Import of Solid Waste'	• Prohibited the import of solid waste in any form from 1 January 2021
Mar 2021	14th Five-Year Plan	• Established plastic governance as a cross-sectoral priority • Targets include increasing recycling rates, enhancing the monitoring of plastic waste in rivers and seas, and fostering innovation in biodegradable technologies

MEE = Ministry of Ecology and Environment, MIIT = Ministry of Industry and Information Technology, mm = millimetre, MOFCOM = Ministry of Commerce, NDRC = National Development and Reform Commission, PBS = poly (butylene succinate), PLA = poly (lactic acid).

Source: Authors.

4. China's Role in Regional and Global Governance of Plastic Pollution

Over the past decade, China has transformed from being portrayed as a major source of marine plastic pollution to becoming an active and constructive contributor to regional and global plastic governance. This transformation reflects a strategic shift in both national priorities and international engagement, aligning scientific progress with diplomatic outreach and multilateral cooperation.

At the regional level, China has played a catalytic role in fostering collaboration under the framework of ASEAN, the Northwest Pacific Action Plan (NOWPAP), and the UNESCO/IOC-WESTPAC. Notably, China leads the UN Ocean Decade Action to 'Stem the Tide of Asia's Riverine Plastic Emission into the Ocean' (UN22), which brings together multinational research teams to assess plastic fluxes in key rivers across Southeast Asia, including the Yangtze, Mekong, and Chao Phraya rivers. This project not only enhances regional data comparability but also supports policy harmonisation and capacity building through field manuals, standardised training, and community outreach (WESTPAC, 2024). In doing so, China acts as a regional hub for plastic pollution science–policy integration, providing technical leadership and financial support for joint action.

China has also contributed substantively to international treaties and negotiations, particularly within the context of UNEA and the Intergovernmental Negotiating Committee on Plastic Pollution (INC) on the global plastics treaty. As a signatory party, China has emphasised a balanced approach that recognises the diversity of national capacities and promotes sustainable solutions across the life cycle of plastics during the negotiations. Chinese experts have participated actively in expert groups under the Basel and Stockholm conventions, offering data and perspectives on plastic additives, transboundary waste trade, and environmentally sound management.

Furthermore, China has promoted South–South cooperation on marine debris through multilateral platforms such as the Belt and Road Initiative and the China–ASEAN Environmental Cooperation Center. These platforms serve as vehicles for sharing best practices, technology transfer, and supporting regional demonstration projects. One key initiative includes the development of plastic and microplastic pollution monitoring and assessment tools tailored for low- and middle-income countries, co-developed by Chinese and Southeast Asian researchers, which have been used to guide national action plans and public awareness campaigns.

China's leadership is also reflected in its domestic policy actions, which increasingly align with global environmental norms. The implementation of a nationwide plastic ban roadmap (2020–2025), the establishment of marine ecological redlines, and the adoption of national standards for microplastic monitoring all demonstrate a commitment to evidence-based governance. These domestic efforts reinforce China's credibility in international negotiations and offer replicable models for countries seeking to strengthen their own plastic governance frameworks.

In sum, China's evolving role in global plastic governance is characterised by a combination of scientific leadership, regional cooperation, treaty engagement, and domestic policy innovation. By leveraging its scientific capabilities and regional influence, China is positioning itself not only as a responsible stakeholder but also as a strategic partner in the collective effort to address the global plastic crisis.

5. Case Studies: Local Innovations

Building on China's regional contribution and global governance role, it is essential to explore how national strategies are reflected in tangible local innovations. The following case studies illuminate how provincial governments, private enterprises, and research institutions translate science-informed policy frameworks into practical solutions. These examples span diverse approaches – from Hainan's zero-waste pilot cities to intelligent marine litter-collecting vessels, high-tech urban recycling systems, and circular value chains for ocean plastic. Together, they showcase a dynamic synthesis of evidence-based policy, technological innovation, and localised governance in China's response to plastic pollution.

Case 1: Hainan Province – Sanya's Zero-Waste City Innovation
Sanya, situated at the southern tip of Hainan Island, has been designated as a pilot Zero Waste City and a Model City for Ecological Civilization under China's broader environmental strategy (Wu et al., 2025). As a major tourism hub with over 20 million annual visitors, Sanya faces acute pressure from plastic waste, with plastics comprising up to 86% of beach litter. To address this, local authorities partnered with Tsinghua University to develop a comprehensive environmental emission assessment model and life-cycle solid waste inventory, forming the backbone of the city's zero-waste roadmap. This modelling enables targeted reduction strategies and carbon accounting, aligning plastic governance with Hainan's broader ecological and climate goals. Furthermore, Sanya has integrated 'Plastic Smart City' initiatives by encouraging circular economy engagement amongst businesses and communities and enhancing public awareness through outreach campaigns.

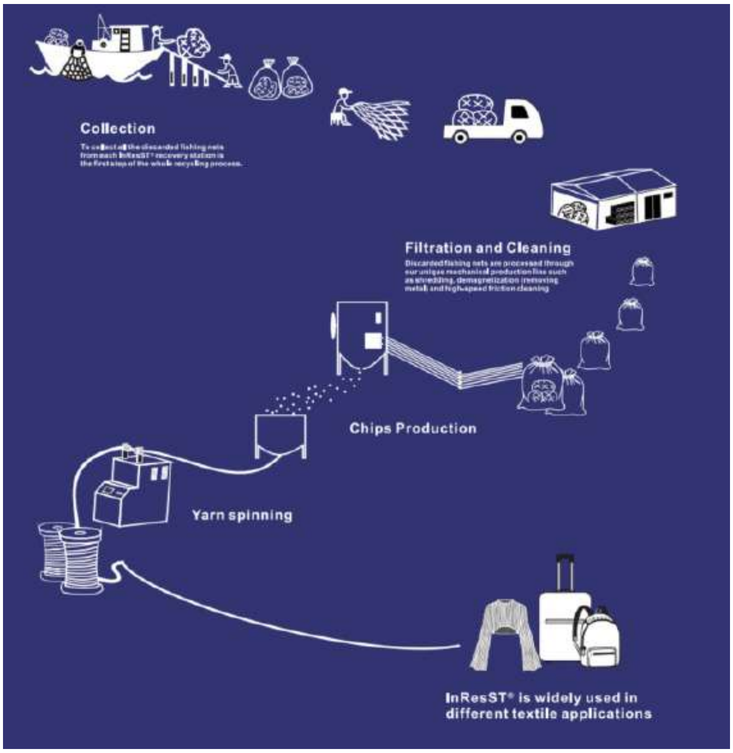
Case 2: Luhai Pro-Environment – High-Tech Recycling for Low-Value Plastics
In Xiamen, Fujian Province, China Luhai Pro-environment, a leader in urban recycling, has established an advanced processing platform for low-value plastic waste (Xiamen Luhai Pro-Environment Inc., n.d.). The company uses artificial intelligence (AI)-enabled near-infrared sorting technology – developed with support from Tetra Pak – to automate the recovery of beverage cartons and lightweight packaging at unprecedented efficiency. A collaboration with Dow Corporation further explores circular pathways for recycled materials, enhancing the industrial chain for post-consumer plastics. Luhai's multi-product portfolio, including wood–plastic composites, refuse-derived fuel, and the 'Luhai Re-fine' brand, demonstrates how innovative technologies and industry partnerships can elevate the value of otherwise hard-to-recycle waste streams.

Case 3: Intelligent Rubbish Boats – Autonomous Waterway Cleaners
In China's urban and coastal environments, autonomous rubbish-collecting vessels are transforming waterway maintenance. Start-ups such as Orca-Tech have developed smart unmanned boats equipped with dual hydrodynamic arms that automatically scoop litter into onboard holding compartments (Orcauboat, n.d.). These vessels can operate for 8 hours at a time, return autonomously to charging stations, and offload collected rubbish without human intervention. Relong Technology offers high-precision models featuring centimetre-level real-time kinematic (RTK) navigation, intelligent path planning, flexible boom extensions, and obstacle avoidance via radar and vision sensing. Such innovations demonstrate the potential of autonomous systems to augment municipal capabilities in maintaining clean waterways efficiently and safely.

Case 4: InResST – Circular Economy from Ghost Fishing Nets

Zhejiang InResST Co., Ltd. (InResST) tackles the critical issue of ghost fishing nets through a pioneering closed-loop recycling model (Figure 20.2). The company incentivises fishers to return discarded nylon nets, which are then processed into recycled nylon chips (PA6) via zero-carbon facilities. These chips are converted into yarn and fabrics that match virgin nylon in quality. Recognised with Ocean Bound Plastic (OBP) certification, InResST's approach yields profound environmental co-benefits: life-cycle assessments reveal reductions of more than 90% in carbon, energy, and water usage compared with virgin nylon production. The model not only removes harmful marine debris but also provides economic opportunities to vulnerable communities – including fishers and older women – highlighting the socio-economic dimension of circular governance.

Figure 20.2. Closed-Loop Recycling Process of Discarded Fishing Nets by InResST – From Collection to Textile Applications



Source: InresST

Case 5: Blue Circle – A Digitally Enabled Circular Model for Marine Debris

Zhejiang Blue Circle Technology has pioneered the 'Blue Circle' model, a digitally enabled approach that integrates the internet of things (IoT) and blockchain platforms to coordinate marine debris governance (VisionBlue, n.d.). By engaging coastal governments, fishing communities, and recycling enterprises, the model creates an end-to-end chain covering source separation, collection, recycling, and high-value applications.

Since 2020, Blue Circle has established 82 collection facilities such as 'Ocean Cloud Warehouses' (Figure 20.3) and 'Blue Circle Homes' across Zhejiang, Jiangsu, Hainan, Guangdong, and Shandong, mobilising over 13,000 fishing vessels and 1,300 coastal residents. The company operates a 30,000-ton per year recycling plant and collaborates with more than 280 partners, enabling certified recycled plastics to enter international markets in apparel, automotive, and electronics.

The model also incorporates inclusive benefit-sharing. Through a 'Common Prosperity Fund', frontline collectors gain about CNY1,200 in additional monthly income, while fishers have accessed CNY143 million in low-interest green loans via an environmental credit system. Recognized by the UN Champions of the Earth Award (2023) and included in China's Action Plan for Marine Debris Clean-up in Coastal Cities, Blue Circle provides a scalable and replicable Chinese solution for circular ocean governance.

Figure 20.3. Ocean Cloud Warehouse Operating at Jiaojiang Central Fishing Port, Taizhou, Zhejiang

Source: Blue Circle Technology.

6. Challenges and Future Outlook

Despite China's notable progress in plastic pollution governance – ranging from national bans and regional frameworks to technological innovations and localised interventions – significant challenges remain. These challenges are multidimensional, involving institutional capacity, infrastructure, enforcement, scientific uncertainty, and the integration of social equity considerations. Addressing them is essential not only for consolidating past gains but also for positioning China as an important participant in the evolving plastic treaty negotiations and sustainable development agenda.

China's governance of plastic pollution involves a mosaic of agencies across environmental protection, housing and urban development, commerce, customs, agriculture, and fisheries. While recent initiatives like the 'Opinions on Further Strengthening Plastic Pollution Control' (2020) have improved inter-agency coordination, implementation at the sub-national level remains uneven. Local governments often face a lack of dedicated personnel, technical knowledge, or fiscal resources to enforce national regulations, especially in rural and coastal zones where plastic leakage is most acute. Aligning incentives and creating cross-sectoral coordination mechanisms will be critical for the next phase of governance.

Although China has launched extensive monitoring efforts, systematic, long-term, and harmonised datasets are still lacking. Challenges include inconsistent sampling methodologies, limited data on micro- and nanoplastics, sparse coverage of freshwater and atmospheric inputs, and insufficient monitoring of chemical additives and plastic leachates. Improved standardisation, capacity building, and open-data platforms are needed to generate robust scientific evidence to support policy, modelling, and enforcement.

China's 2018 ban on imported plastic waste reshaped global recycling flows but also exposed domestic vulnerabilities. Many low-grade plastics, multilayer packaging, and contaminated streams remain uneconomical to recycle, leading to stockpiling, incineration, or illegal dumping. Meanwhile, a fragmented informal sector coexists with formal recyclers, creating challenges for traceability, safety, and quality control. Expanding EPR, fostering green design and eco-labelling, and incentivising high-value recycling industries – especially in coastal provinces – will be vital to scale circularity.

Moreover, current policies often emphasise technological or regulatory solutions, yet behavioural, social, and equity dimensions receive comparatively less attention. Public participation remains limited outside urban campaigns, and the needs of vulnerable populations – such as fishers, informal recyclers, and remote communities – are often overlooked. Future interventions should integrate community-based monitoring, youth engagement, and gender-sensitive approaches. Moreover, risk communication around plastic additives, seafood contamination, and health impacts must be improved to build broad-based societal support.

Looking ahead, China is well positioned to shape the global plastic governance landscape through both domestic leadership and international engagement. As the INC advances towards a legally binding plastic treaty, despite ongoing challenges and complex negotiations, China's experiences offer a valuable blueprint for linking upstream reduction, downstream recovery, and cross-border cooperation. Strengthening science–policy interfaces, investing in digital monitoring infrastructure, and participating in global knowledge-sharing platforms – such as the Integrated Marine Debris Observing System (IMDOS), IOC-WESTPAC, and the Ocean Decade Actions – can help bridge implementation gaps and align China's plastic pollution strategy with the Sustainable Development Goals (SDGs) and climate-biodiversity agendas.

7. Conclusion

China's journey in addressing plastic pollution offers valuable insights for both developing and developed countries navigating the complex intersection of science, governance, and innovation. Over the past decade, the country has made remarkable progress in establishing a scientific foundation for plastic pollution research, ranging from national monitoring systems and source-tracing models to cutting-edge studies on microplastics, additives, and deep-sea accumulation. These advancements have not only contributed to global scientific understanding but have also directly informed domestic policies and international dialogues.

China's evolving policy landscape – characterised by its bans on foreign waste, phased plastic restrictions, and ambitious Zero-Waste City initiatives – demonstrates the critical role of top–down regulation, inter-ministerial coordination, and science-driven governance. Moreover, China's proactive engagement in regional and global governance frameworks, including ASEAN cooperation, the UNEP-led INC, and various Ocean Decade initiatives, signals its commitment to co-shaping international rules and solutions.

Importantly, China's experience underscores the significance of bottom–up innovation. Case studies from Hainan, LuHai Environmental, Orca-Tech, and InResST show how localised technologies, public–private partnerships, and circular economy pilot projects are bridging policy implementation gaps and engaging communities in meaningful ways. These examples reflect an emerging ecosystem of actors – from local governments to start-ups – that is collectively contributing to national and global plastic solutions.

Despite these achievements, critical challenges remain: data integration, standard harmonisation, enforcement disparities, and the need for more inclusive and equitable solutions. Looking forward, China's dual role – as a scientific contributor and governance leader – positions it to catalyse transformative regional collaboration, foster South–South learning, and inspire pragmatic pathways towards a circular and plastic-free future.

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Chapter 21

Japan – Transformation from Streets Filled with Debris to a Clean City

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1. Introduction

This chapter assesses policy implications to the Association of Southeast Asian Nations (ASEAN) Plus Three (ASEAN+3) countries[1] from Japan's experience of developing its waste management system. Japan now has less plastic waste leakage than other Asian countries (e.g. Jambeck et al., 2015; Meijer et al., 2021). Its current waste management system was established through decades of efforts. The 1960 film Refuse and Daily Life (JICA-Net Library, 2020) showed how Japanese citizens threw rubbish on the street, in the river, and in front of 'No Littering' signs. Discarded waste attracted flies, cockroaches, and rats, which entered houses. The Tokyo Olympics 1964 was a symbol of Japan's rapid economic growth era, with the construction of extensive infrastructure, including the Shinkansen bullet train (Japanese Olympic Committee, n.d.). The public health issue, however, remained unsolved. While typhoid and paratyphoid fever had been controlled, over 50,000 cases of dysentery were still recorded in 1964 (Inamura, 2020). Tokyo also suffered from thousands of tons of illegal dumping in rivers, roads, and vacant lots. To combat this, Tokyo Metropolitan Government conducted a capital clean-up campaign for the Olympic Games and improved the facilities and frequency of municipal waste collection services (Inamura, 2020).

The national government also tackled waste issues through a series of policy interventions. The Public Cleansing Act, 1954 set the obligation for national and prefectural governments to provide financial and technological support to municipalities that provided waste collection and disposal services. In 1963, the Act on Emergency Measures Concerning the Development of Living Environment Facilities led to the formulation of a five-year plan to support the development of waste management facilities, including incinerators (Ministry of the Environment, 2014). According to the White Paper on Public Health in 1970, the Act on Emergency Measures, accompanied by the provision of a central government subsidy, contributed to the enhancement of waste collection coverage and the introduction of incinerators, which were regarded as sanitary waste disposal.

'Plastic waste' was mentioned in the White Paper on Public Health in 1970. It was regarded as an emerging issue because plastics could not be disposed of by the available technologies, including incinerators, at that time (Ministry of Public Health, 1970). Plastics, as inflammable waste, were landfilled. However, the increase in such waste caused a shortfall in landfill capacity in the 1990s. As the plastics were mainly discarded as packaging waste, Japan passed the Container and Packaging Recycling Law, 1995, based on the concept of extended producer responsibility (EPR). This law has been fully implemented since 2000 (see Chapter 6). With the progress of the establishment of this law and other recycling acts,[2] the waste inflow to the landfill sites has been reduced. Since then, the landfill capacity has been recovered (Ministry of the Environment, n.d.-a).

[1] ASEAN+3 refers to the 11 ASEAN Member States (Brunei Darussalam, Cambodia, Indonesia, the Lao People's Democratic Republic (Lao PDR), Malaysia, Myanmar, the Philippines, Singapore, Thailand, Timor-Leste, and Viet Nam) plus China, Japan, and the Republic of Korea.

[2] The other recycling laws enacted in the 1990s and the early 2000s include the Home Appliance Recycling Act, 1998; the Basic Act for Establishing a Sound Material-Cycle Society, 2000; the Construction Recycling Act, 2000; the Food Recycling Act, 2000; and the Automobile Recycling Act, 2002 (Ministry of the Environment, 2014).

Today, Japan is pursuing a transition to a circular economy on a national level and facilitating 3R (reduce, reuse, recycle) national strategies in Asian countries on an international level. Based on its experience, Japan aims to lead international negotiations on developing plastic pollution countermeasures, exemplified in the adoption of the Group of Twenty (G20) Osaka Blue Ocean Vision.

1.1 Country profile

Japan is an island nation located west of the Pacific Ocean in the Northern Hemisphere, neighbouring the Republic of Korea (henceforth, Korea), China, and Russia. Its land area is 377,975.26 square kilometres, composed of over 14,000 islands. Japan is also a mountainous country, with two-thirds of its territory covered in forest (Cabinet Office, n.d.; Ministry of Foreign Affairs, n.d.).

Japan's population peaked in 2010, but has shown a downward trend since then, decreasing to 124,516,650 in 2023 (World Bank, n.d.). However, it remains one of the most densely populated countries in the world (338 people per square kilometre) and is ranked fourth amongst ASEAN+3 countries (World Population Review, n.d.).

Japan experienced rapid economic growth in the 1960s, which slowed significantly after the 1973 oil crisis. Japan's gross domestic product (GDP) was ranked second in the world from 1968 to 2010, but is now ranked fourth, surpassed by China in 2010 and Germany in 2024. Japan's nominal GDP is US$4.19 trillion and its GDP per capita is US$33,960 (International Monetary Fund, n.d.; Iwamoto, 2024).

1.2 Waste management performance

Since the Waste Management and Public Cleansing Act in 1970, Japan has managed waste by segregating it into municipal and industrial waste. The total amount of municipal waste peaked at 55 million tons (Mt) (about 150,000 ton/day) in fiscal year (FY) 2000,[3] then decreased to 39 Mt (about 107,000 ton/day) in FY2023. Municipal governments collect 96% of the waste, while residents' voluntary activities to promote recycling, known as the 'Group Collection' system, collect the remaining 4%. Some 91% of the total waste goes to intermediate processing, mainly incineration. Part of the waste is transferred from the intermediate processing to the recycling process. Finally, 19.5% of the total municipal waste was recycled as a resource. Some 72.4% was disposed of through volume reduction (i.e. incinerated), while 8.1% was landfilled. Industrial waste amounts to about 400 Mt per year and shows no large increase or decrease (Ministry of the Environment, 2025).

Japan has been recognised as the country with the least plastic waste leakage into the environment due to a well-established waste management system. Although Japan is ranked second in terms of plastic waste generation, several international comparative analyses categorise Japan as the lowest plastic emitter to the ocean (e.g. Jambeck et al., 2015; Mejier et al., 2021). Estimates by the Organisation for Economic Co-operation and Development (OECD) have shown that, in OECD Asia (Japan and Korea), only 1% of the total waste was mismanaged in 2019 (OECD, 2022).

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[3] Japan's fiscal year runs from April to March.

2. History of Waste Management in Japan

This section details the process through which Japan's waste management system reached its current level, based on records from the White Paper on Public Health,[4] which contained statistical data on waste management and the ministry's understanding of waste issues.

2.1 From 1955 to 1970: overcoming lack of capacity of waste management in Japan

The White Paper 1956 states that 'significant difficulties' arose in managing increasing human waste and other types of waste because of various factors including urban population growth. It also noted that inadequate waste disposal was a 'source of flies and foul odours', leading to the 'pollution of the people's living environment everywhere, adversely affecting their health' (Ministry of Public Health, 1956: 123). In 1955, 80,654 dysentery cases were reported, and the mortality rate was over 10 times higher than in Western countries. In 1954, the Public Cleansing Act clarified the responsibilities of national, prefectural, and municipal governments regarding the disposal of human waste and other types of waste. Additionally, in 1955, a 3-year campaign titled 'Life Without Mosquitoes and Flies' began to promote regional clean-up activities nationwide (Ministry of Public Health, 1956).

However, the hygiene situation in Japan did not improve dramatically. The White Paper 1959, published in the year when Tokyo was selected as the first Asian city to host the Olympics, lamented that 'the occurrence of mosquitoes and flies still remains at the level of underdeveloped countries, a truly regrettable situation'(Ministry of Public Health, 1959: 10). Additionally, over 80,000 dysentery cases were still being reported (Ministry of Public Health, 1959). In preparation for the Olympics, Tokyo Metropolitan Government decided to develop infrastructure related to transportation and public health. In FY1959, however, 10,000 tons of waste were illegally dumped into rivers in Tokyo. In 1961, a fireworks festival on Sumida River (one of the most famous fireworks festivals in Japan) was cancelled due to river pollution (Inamura, 2020).

Furthermore, national data on waste management were incomplete. Data on the previous year's total volume of discharge, collection, and treatment by the disposal method only began to be published in the White Paper 1959 (Ministry of Public Health, 1959). The White Paper 1960 included data for 1955 and 1958. No data were recorded on waste management for 1956, 1957, or 1959, even in the following years' white papers. In 1955, the total discharge was 17,022 tons/day, while the collection volume was 12,621 tons/day, resulting in a collection rate of 74%. Disposal methods included 3,685 tons/day by incineration, 7,434 tons/day by landfill, 1,237 tons/day by compost, and 265 tons/day by other methods. Uncollected waste went to self-disposal[5] (Ministry of Public Health, 1960). It should be noted that these data did not

[4] The White Paper was an annual report published from 1956 to 1999 by the Ministry of Public Health (currently, the Ministry of Health Labor and Welfare), the authority in charge of waste management at that time. Waste management administration was transferred to the Ministry of the Environment in January 2001.

[5] Self-disposal means the waste was treated (i.e. burned or buried) by individuals, e.g. in their back garden.

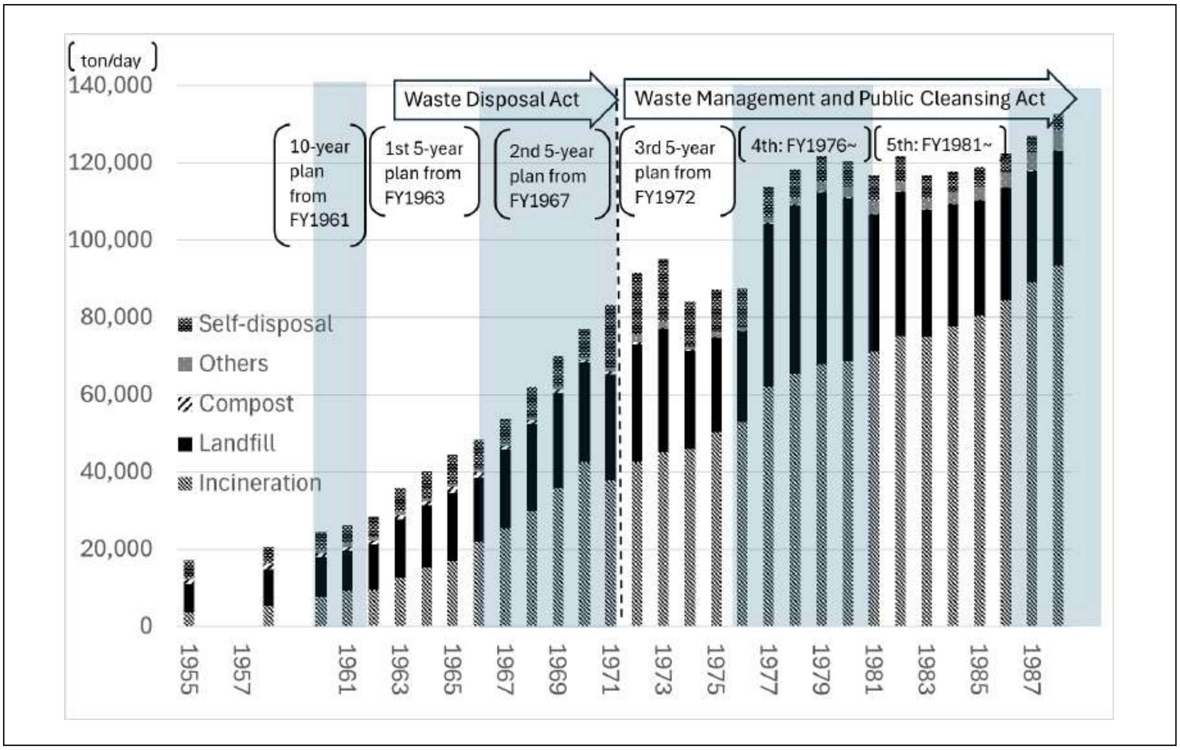
cover all of Japan but were limited to 'Special Cleansing Areas', which were designated regions where municipalities collected waste in a planned manner. At the Social and Labor Committee of the House of Representatives in 1956, the Director-General of the Environment and Health Bureau of the Ministry of Public Health explained that the Special Cleansing Areas covered about 35 million people, meaning the population coverage was less than 40% (House of Representatives, 1956). This marked the starting point for the development of Japan's waste infrastructure.

The Ministry of Public Health developed a 10-year plan, starting from FY1961, to establish waste treatment facilities, as well as water supply and sewage treatment plants (Ministry of Public Health, 1960). In 1963, the Act on Emergency Measures concerning the Development of Living Environment Facilities was passed. Based on this law, the First Five-Year Plan was implemented from FY1963, aiming for robust and systematic development of these facilities. However, at the initial stage of this plan, water supply, sewage, and human waste treatment were prioritised, while the finance for waste treatment was to be secured mainly through local bonds. For example, in FY1964, while 191 human waste treatment facilities and 151 waste treatment facilities were planned, the project cost for human waste facilities was ¥18 billion, significantly greater than the ¥5 billion for waste treatment facilities. Subsidies from the central government also reflected this disparity: ¥4.00 billion for human waste facilities versus ¥0.09 billion for waste treatment facilities (Ministry of Public Health, 1964). In FY1964, the central government's general account expenditure was ¥3,311 billion. The central government's subsidies for human waste facilities accounted for 0.120%, while those for waste treatment facilities accounted for 0.003% (Ministry of Finance, 1990). Furthermore, local bonds for waste treatment facility development in FY1964 amounted to ¥3.2 billion, 35 times the subsidy, yet this represented only 0.08% of local governments' total revenue of ¥3.9 trillion (Ministry of Home Affairs, 1971).

By 1967, facing a rapid increase in waste generation, the government recognised the necessity to revise the First Five-Year Plan. The Second Five-Year Plan was formulated and implemented without waiting for the completion of the first plan. This new plan aimed to establish a system capable of disposing of 75% of waste through incineration, which was regarded as a 'sanitary' method, by FY1971 (Ministry of Public Health, 1966). The central government subsidies, which were ¥94 million until FY1965, increased to ¥400 million in FY1966 and ¥600 million in FY1967, rising by ¥100 million in the following years. The total project cost, including local bonds, reached ¥11.5 billion in FY1966, surpassing that of human waste treatment facilities (Ministry of Public Health, 1970). In FY1969, the central government subsidies for waste treatment facilities amounted to ¥0.83 billion, about nine times the FY1964 amount, but still only 0.01% of the central government's general account expenditure of ¥6,918 billion (Ministry of Finance, 1990). Local bonds for waste treatment facilities in the same year reached ¥11.8 billion, about 3.7 times the FY1964 amount, representing 0.14% of local governments' total revenue of ¥8.3 trillion (Ministry of Home Affairs, 1971).

As a result, over the 15 years from 1955 to 1970, the waste collection volume increased 5.5 times from 12,621 tons/day to 69,899 tons/day, while the total waste volume increased 4.5 times from 17,022 tons/day to 76,998 tons/day. Consequently, the waste collection rate rose from 74% to 91% (Figure 21.1). Treatment by landfill increased 3.5 times from 7,434 tons/day to 25,715 tons/day. Incineration increased 11.5 times from 3,685 tons/day to 42,559 tons/day. While these indicators were limited to the Special Cleansing Areas, the population coverage of the waste management system reached 75.5% in 1968, up from less than 40% in 1956. Dysentery patients had drastically decreased, but were still numerous at 12,954 in 1969 (Ministry of Public Health, 1970).

Figure 21.1. Historical Changes in Waste Disposal Volume by Treatment Method in Japan, 1955–1988



Source: Authors, based on Ministry of Public Health, 1956–1990.

It should be noted that a simple increase in the number and capacity of facilities is not always a feasible and realistic solution for efficient and effective waste management. Economies of scale are an important factor to be considered. From the 1950s, and especially in the 1970s, inter-municipal cooperation on waste management was actively pursued by municipal governments in Japan, as a measure to secure economies of scale for their waste management services (Box 21.1).

Box 21.1. Inter-Municipal Cooperation on Waste Management

Economies of scale facilitate waste management, especially in the construction of landfills, waste-to-energy plants, and waste incineration plants. Guidance from the Government of India urged municipalities to invest in waste management facilities with neighbouring municipalities (Government of India, Ministry of Urban Development, 2011). An example of the effect of such co-investment by municipalities on economies of scale in the construction of landfills is shown in Figure 21.2.

The hypothetical cases on landfill economies of scale are based on the following assumption: Larger landfills can reach a greater height, so they can contain a greater load per unit area of land. For example, assume a land area of 'x' square metres (m2). Landfilling is done up to a height of 'y' metres (m) above ground level and a depth of 5 m below ground level. The horizontal and vertical ratio of the side slopes are 4:1 above ground level and 3:1 below ground level. Then, the area and total air space available for landfilling for the different values of 'x' and 'y' are increased by the factors listed in Table 21.1.

Table 21.1. Economies of Scale on Landfill – A Hypothetical Case

x = (m)	Land area (m2)	y = (m)	Air space (m3)	Factor increase in	
				Area	Air space
100	10,000	10	82,000	1	1.0
300	90,000	15	1,302,667	9	17.5
500	250,000	20	4,771,331	25	67.3

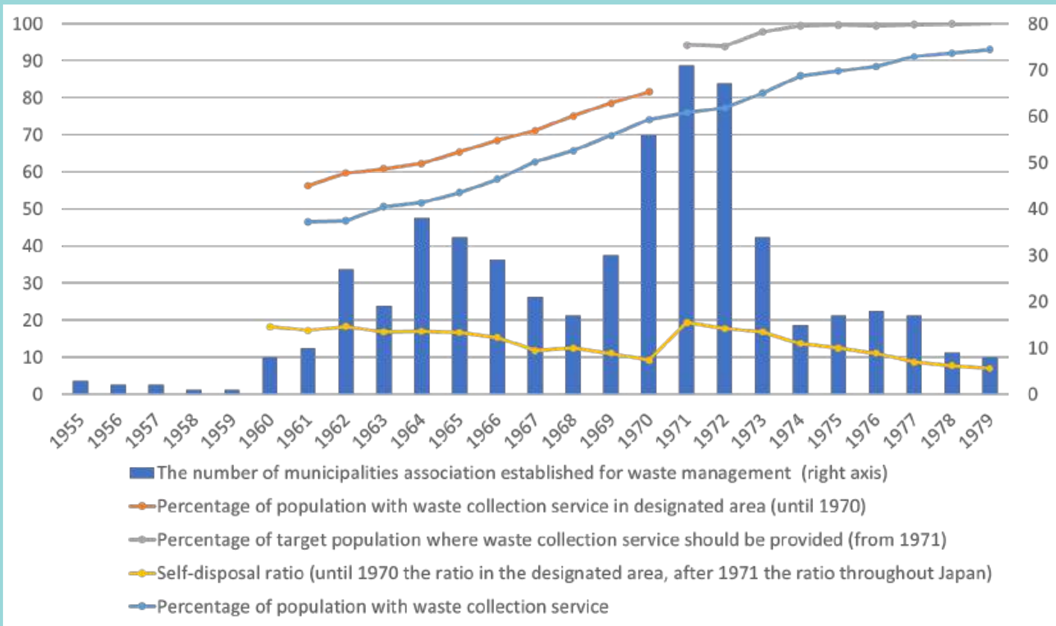
m = metre.

Source: Government of India, Ministry of Urban Development (2011: 46).

Economies of scale also apply to incineration plants and waste-to-energy plants. The construction costs of facilities are basically proportional to m^2, while the capacity of waste reception is proportional to cubic metres m^3). Larger facilities have lower unit costs of capacity to treat waste.

In Japan, many local governments conduct inter-municipal cooperation, whereby several municipalities invest jointly in waste disposal facilities, such as landfills, waste incineration plants, and waste-to-energy plants. Article 284 of the Local Autonomy Act, 1947, provides that local governments can establish Partial Affairs Associations to handle a designated function of local government affairs, under the permission of the Minister of Internal Affairs and Communications or Governor. Such initiatives started in the 1950s, while the number of Partial Affairs Associations peaked around 1971 (Figure 21.2).

Figure 21.2. Partial Affairs Associations Tasked with Waste Management and Population Coverage of Waste Collection Services



Source: Compiled by the authors based on Ministry of Public Health (1969, 1974, 1979, and 1981).

In the 1990s, incinerator exhaust gas was found to contain significant amounts of dioxins, causing a nationwide problem. The Act on Special Measures Against Dioxins, 1995 required large-scale renovation of existing incinerators to cut dioxin emissions drastically. This requirement significantly increased the unit cost of small-scale incineration plants, pushing local governments to pursue further inter-municipal cooperation on waste management. According to Yagi (1999), the construction unit cost per incineration capacity of the plant, which contracted with the municipality associations from 1990 to 1998, was smaller at the plant with bigger incineration capacity. This tendency was observed when the capacity fell into the range of 0-200 tons per day. Above 200 tons per day, the unit cost could be increased due to the air pollution prevention facilities' cost. This indicates that economies of scale work for incineration plants in Japan.

An effective measure to reduce the generation of dioxins is continuous incineration at high temperatures (Ministry of the Environment, n.d.-b). This is possible for large-scale incineration plants. Inter-municipal cooperation was expected to ensure economies of scale for large-scale plants by expanding the geographical coverage of each incineration plant. For investment in larger waste management facilities, multiple municipalities established inter-municipal cooperation on waste management. Another option is for state governments to lead small municipalities – including small cities, towns, and villages – to invest in waste disposal (Hiratsuka-Sasaki and Kojima, 2020).

2.2 From 1970 to 1990: plastic and package waste as emerging issues

In December 1970, the Waste Management and Public Cleansing Act replaced the Public Cleansing Act. This new law abolished Special Cleansing Areas, mandating all municipalities to undertake planned waste collection and disposal. Furthermore, it clarified the responsibilities of businesses regarding industrial waste management and established a system for its treatment (Ministry of Public Health, 1971).

The total volume of municipal waste decreased temporarily due to the economic slowdown during the 1973 oil crisis, but it soon resumed an upward trend. The development of waste treatment facilities continued under a series of five-year plans, leading to increased landfill and incineration capacity. According to the White Paper 1990, the total waste volume was 132,582 tons/day, with 128,614 tons/day collected – a collection rate of 97% in FY1988. Incineration accounted for 93,552 tons/day (73% of collected waste), and landfill for 29,613 tons/day (23%), roughly indicating that the share of incineration had reached the levels in the 2020s, as shown in Section 1.2 of this chapter (Ministry of Public Health, 1990). The central government subsidies for waste treatment facilities also increased, reaching ¥1.8 billion in FY1975 and ¥3.9 billion in FY1980. The overall project cost for the Fifth Plan, which began in FY1981, exceeded ¥1.5 trillion (Ministry of Public Health, 1985). The central government subsidies in FY1980 represented 0.09% of the central government's general account expenditure of ¥45 trillion (Ministry of Finance, 2005).

During this phase, the mixture of plastic waste in incineration processes emerged as a new challenge. Plastics were first mentioned in the White Paper 1970. At that time, plastic waste in Japan was sorted as 'non-burnable waste' and landfilled. However, in Tokyo, the proportion of plastic waste mixed into the incineration process increased rapidly from 2.2% in 1963 to 8.7% in 1968. That posed a problem because incinerating plastic waste could damage furnaces and emit harmful substances, and it was unsuitable for landfill as it was not naturally degradable. Thus, it 'presented a new challenge for the future of household waste management' (Ministry of Public Health, 1970: 17). The following year's white paper noted that municipal waste treatment facilities in operation at that time had a 'limit of approximately 10% plastic content on average' (Ministry of Public Health, 1971: 4). It pointed out that advanced treatment technologies and prevention of the mixture through separate collection were necessary. It also stated that the Ministry of Public Health had begun considering measures for the effective utilisation of plastics and the advancement of waste treatment (Ministry of Public Health, 1971).

Plastic waste, which is difficult to incinerate, continued to be frequently cited as an issue. The White Paper 1990 highlighted that the disposal of various 'one-way' (single-use) products, including those made of plastic, was generating waste. It noted that actual waste generation continued to rise, leading to a pressing shortage of capacity at landfill sites. In the Tokyo Metropolitan Area – comprising Tokyo, Saitama, Chiba, and Kanagawa prefectures (covering more than one-quarter of Japan's population) – the remaining capacity of landfill sites for municipal waste was about 4 years as of 1988. In addition, constructing new landfill sites was proving difficult due to land constraints in this area. To address these challenges, the White Paper 1990 emphasised the need for 'establishing a new socio-economic system that incorporates appropriate treatment costs' and 'a recycling society built upon appropriate cost burdens' (Ministry of Public Health, 1990: 34).

Consequently, an understanding of the importance of reducing waste generation and decreasing waste through recycling was shared within the government ministries. An urgent priority was set on addressing container and packaging waste, which accounted for about 60.1% of municipal waste by volume and 20.1% by weight. Concrete measures were considered and developed, primarily led by the Ministry of International Trade and Industry (now the Ministry of Economy, Trade and Industry), resulting in the enactment of the Containers and Packaging Recycling Act in 1995. This law defines the roles of consumers (separate discharge), municipalities (separate collection), and businesses (recycling). It also established a system whereby economic benefits accrue from reducing waste and economic disadvantages from increasing it (see Chapter 6.). Following the enforcement of this act, the recycling rate for municipal waste increased from 9.8% to 19.0% between 1995 and 2005. Simultaneously, the landfill volume of municipal waste decreased from 13,093 tons/day to 7,341 tons/day, and the remaining capacity of landfill sites improved from 9.9 years to 14.8 years (Ministry of the Environment, n.d.-a).

2.3 Japan's international contribution to policymaking on waste management

The Government of Japan has implemented a variety of initiatives to support the establishment of sound 'material-cycle societies' (i.e. circular economy) in Asia. These are based on Japan's decades of experience establishing a comprehensive waste management system incorporating the 3Rs concept. Amongst ASEAN Member States, Japan has supported the formulation of the 3R national strategies of Indonesia, the Philippines, Thailand, and Viet Nam since 2005, of Cambodia since 2006, and of Malaysia since 2010 (Ministry of the Environment, 2014). Moreover, Japan has supported the development of waste-related systems in Asian countries by leveraging Japan's experience and technology in collaboration with its circular economy industries. Under the Strategic International Expansion and Development Project for Japan's Circulation Industry, the Government of Japan has supported the preparation and implementation of the commercialisation of waste disposal and recycling for Japanese companies developing circular economy businesses in Asia. Some of the supported businesses are operational and have already generated revenue (Ministry of the Environment, 2025).

Another notable example is the Regional 3R Forum in Asia and the Pacific, which was established in 2009 as the 'Regional 3R Forum in Asia' and renamed in 2014. The forum is a platform to promote the 3Rs in Asia. It collaborates with a broad range of stakeholders, including central governments, international agencies, aid agencies, private sector entities, research bodies, nongovernmental organisations (NGOs), and other relevant parties. It is centred around high-level policy discussions to provide support for the implementation of the 3Rs, sharing useful information and building networks. Several high-level commitments have been formulated in this forum, including the Ha Noi 3R Declaration – Sustainable 3R Goals for Asia and the Pacific for 2013–2023, adopted in 2013, and the Jaipur Declaration on 3R and Circular Economy, adopted in 2025 (Ministry of the Environment, n.d.-c).

2.4 Japan's contribution to international negotiations on combatting plastic pollution

Building on its existing framework of product-specific recycling laws, the Government of Japan has expanded its focus to material-specific recycling, aiming for sufficient recycling both qualitatively and quantitatively. In June 2018, the 4th Fundamental Plan for Establishing a Sound Material-Cycle Society was approved by the cabinet. This plan stipulated the formulation of a comprehensive strategy for plastic resource circulation. Following discussions on the Ocean Plastics Charter at the G7 Charlevoix Summit in June 2018, deliberations commenced within the Central Environment Council in July 2018. A draft strategy was compiled in February 2019 (Kaneko, 2019). The Plastic Resource Circulation Strategy, formally adopted in May 2019, established '3R + Renewable' as its fundamental principle. It outlined key strategic priorities, including reduction of the use of single-use plastics, promotion of the development and utilisation of petroleum-derived plastic alternatives, and facilitation of clear and effective separate collection and recycling of plastic resources (Ministry of the Environment, 2019).

At the G20 Osaka Summit in 2019, the Government of Japan, based on this strategy, aimed to communicate its countermeasures to other nations and lead discussions towards promoting effective global initiatives that include emerging economies. Japan proposed the Osaka Blue Ocean Vision, which aims to reduce additional pollution by marine plastic litter to zero by 2050. The vision was shared as a common global vision by the G20 summit leaders, and 87 states and regions had shared the vision as of December 2024 (Ministry of Foreign Affairs, 2026). The G20 Implementation Framework for Actions on Marine Plastic Litter was also endorsed at the summit to realise the vision (Ministry of the Environment, n.d.-d). Based on the framework, information sharing for peer learning amongst G20 and outreach countries has been conducted. Since 2020, the G20 Report on Actions Against Marine Plastic Litter has been published annually (Ministry of the Environment, n.d.-e).

3. Conclusion

This chapter has described the challenges and development of the Japanese waste management system, plastic-related policies, and current efforts for combating plastic pollution – both domestically and internationally. As detailed above, since 1955, Japan has developed its waste treatment facilities incrementally and continuously through central government subsidies and local bonds to manage the increasing volume of waste accompanying its economic growth. Consequently, a nation that in the mid-1950s evaluated itself at 'the level of underdeveloped countries', with insufficient waste treatment and prevalent infectious diseases, successfully established a waste treatment system by the 1990s, primarily centred around incineration as a 'sanitary treatment method'.

However, the quantitative increase in waste unsuitable for incineration, including plastics, and the qualitative changes in waste composition, led to a critical shortage in landfill capacity. This prompted the establishment of new mechanisms to promote waste reduction and recycling, initially driven by packaging waste. Although not detailed in this chapter, Japan has developed various other recycling laws and systems beyond the Containers and Packaging Recycling Law. These mechanisms have yielded positive results, including increased recycling rates, decreased landfill volumes, and an extension of the remaining lifespan of landfill sites.

Based on its long-standing experience in improving its own waste management, Japan is now engaged in disseminating the necessary knowledge and technology for institutional development and countermeasures to other Asian countries. Furthermore, to advance international efforts against plastic pollution, Japan is facilitating consensus-building and information sharing within the G20.

We hope that Japan's experience will contribute to the improvement of waste management systems in ASEAN Member States.

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Chapter 22

Extending Producer Responsibility from Recycling to Circularity: The Evolution of the Republic of Korea's EPR System for Plastic Packaging

Sora Yi

1. Introduction

Waste generation in the Republic of Korea (henceforth, Korea) has shown a new growth trend since the 1970s, along with the advancement of industrialisation. By the 1990s, waste management challenges had intensified significantly due to rapid economic growth and increased consumption. Although the government had begun establishing the foundations of proper waste management with the enactment of the Waste Management Act in 1986, Korea's per capita waste generation reached 2.3 kilograms (kg) per day in 1991, compared with a 54% recycling rate for industrial waste, while that of household waste remained at only 7.4% with most of the waste going to landfills (MOE, 1992).[1]

On 1 January 1992, the government introduced the Waste Deposit System (WDS), which requires producers to pay deposits based on the amount of waste they produce and receive a refund based on their recycling performance, to encourage product manufacturers to participate in the recovery and recycling of waste resources. However, despite expanding the products subject to WDS, starting with several types of containers (e.g. containers for food and beverages, pesticide butane gas, and toxic substances) to include items that are not easy to collect or recycle, the amount of deposit that producers were required to pay was not high enough to incentivise their participation in recycling.

The plan to introduce the extended producer responsibility (EPR) system to substitute the WDS was formed in 2000 as the Korean government sought to shift the basic direction of the country's waste recycling policy to building a resource-circulating economic and social structure through balanced development across all waste management stages, including collection, recycling, reprocessing, sales, and consumption. The EPR system became formally legislated for on 4 February 2002 through amendments to the 1992 Act on the Promotion of Saving and Recycling of Resources (Resource Recycling Act) and implemented from 1 January 2003. Korea's EPR system sought to introduce a new system led by the private sector, unlike the primarily government-led WDS.

The implementation of the EPR system transformed the landscape of Korea's waste management, especially in managing packaging waste. The system gained further momentum following the 2018 waste vinyl crisis,[2] which prompted Korea to adopt more proactive approaches to plastic packaging waste pollution. This chapter examines the evolution of Korea's EPR system for plastic packaging, highlighting the transformation towards plastic circularity.

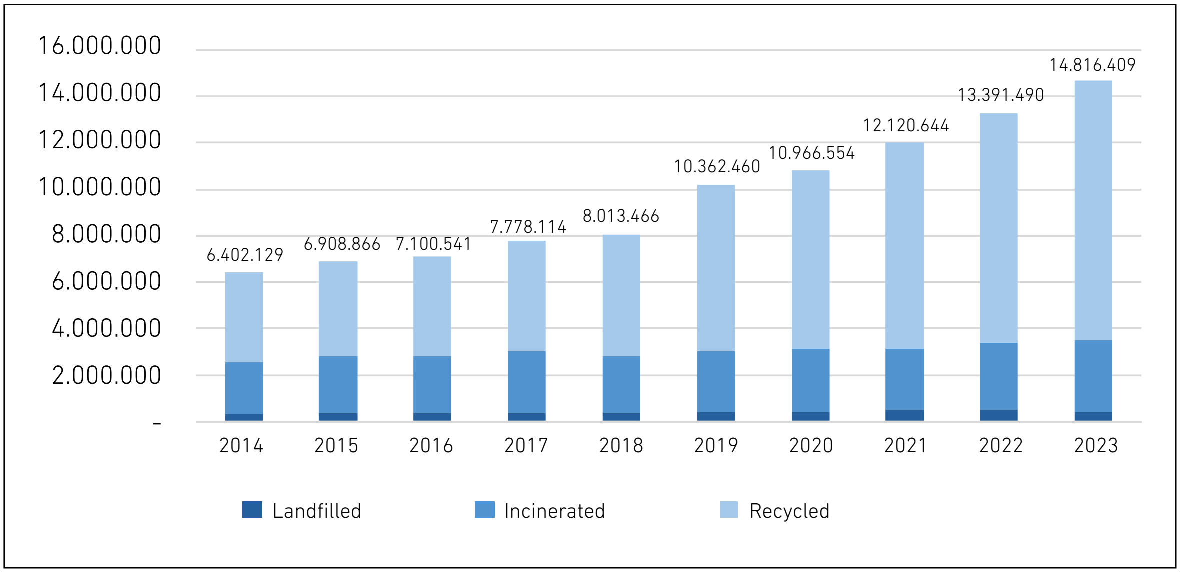
1 Korea's Ministry of Environment (MOE) was renamed as the Ministry of Climate, Energy, and Environment (MCEE) on 1 October 2025. However, for the purposes of this paper, its former name (MOE) shall be used to refer to this ministry.

2 China's decision to ban the import of plastic waste in 2017, effective January 2018, severely impacted Korea, as Korea had been exporting a substantial amount of plastic waste to China every year. In April 2018, 48 recycling firms in Seoul and surrounding areas suddenly stopped collecting plastic waste, especially plastic bags, packaging, and styrofoam products, as they could no longer export plastic waste to China and faced declining profitability due to falling prices of recyclable materials. This caused waste to pile up at apartment complexes, and became known as the 'waste vinyl crisis'.

1.1 Status quo of plastic pollution in Korea

Korea is a country located in East Asia with a land area of 100,459.9 square kilometres (Ministry of Land, Infrastructure and Transport, 2024) and a population of about 51.68 million (Korean Statistical Information Service, 2025), making it one of most densely populated countries (515 people per square kilometre) amongst the Organisation for Economic Co-operation and Development (OECD) member countries. This high population density and rapid industrialisation have become major contributing factors to the country's continual increase in waste generation. Korea's plastic waste generation has also been growing: Over the 10-year period from 2014 to 2023, plastic waste in Korea increased by about 2.3-fold (Figure 22.1). As of 2023, the amount of plastics in household waste was around 3.61 million tons (Mt)/year, or about 0.2 kg/day per capita – almost 23% of the daily waste generated per capita (0.88 kg). In other words, despite the overall reduction in household waste generation, the proportion of plastic waste has increased. Plastic waste increased drastically after the 2018 waste vinyl crisis, and following the emergence of the coronavirus disease (COVID-19) pandemic in 2020, the expansion of contactless consumption and delivery services led to heightened demand for packaging materials, resulting in an approximate 30% rise in plastic waste generation between 2019 and 2022 (Figure 22.1).

Figure 22.1: Plastic Waste Generation in Korea, 2014–2023 (ton)



Source: Compiled by extracting plastic waste generation data from household waste, non-regulated commercial waste, regulated industrial facility waste, construction waste, and designated waste categories in the 'National Waste Generation and Treatment Volume (2014–2023)' data from Korean Statistical Information Service (2016–2025).

1.2 Korea's key institutional mechanisms for promoting recycling

To address the country's growing waste generation, Korea has implemented comprehensive measures employing various approaches, including waste prevention strategies, improvements to collection and transportation systems as well as treatment and recycling infrastructure, and public awareness and education campaigns. Amongst these diverse efforts, the three institutional pillars that constitute the core of Korea's plastic waste management system are the volume-based waste fee (VWF) system, waste separation system, and the EPR system.

1.2.1 Building the foundation for recycling: VWF and separate disposal labelling

The necessity of separating waste at the source, which is essential for recycling waste, had been continuously raised since the late 1970s and was partially introduced from the early 1980s. However, its implementation faced considerable difficulties, including insufficient infrastructure to utilise and process separated waste, unclear separation criteria, and conflicts with waste collectors. In 1991, waste separation became mandatory, with fines of up to W1 million imposed on violators. Recycling volumes increased with the implementation of national policies promoting waste reduction and recycling; however, challenges in establishing waste separation practices persisted.

The waste separation system and VWF were introduced to facilitate the establishment of source separation practices. Prior to the VWF, household waste disposal fees operated under a flat-rate system determined based on the building area for multi-unit housing and the amount of property tax for single-family homes. These fees were considerably low and inadequate to cover the budget needed for proper waste management. To replace this waste fee structure, which lacked direct correlation between waste generation and charges and provided no incentive for waste reduction, the VWF was implemented nationwide simultaneously on 1 January 1995, applying the polluter-pays principle whereby waste generators bear disposal costs according to their waste output.[3]

The initial implementation of the VWF met with several difficulties due to the sudden introduction of the system before a proper distinction was established between recyclables and general waste, enforcement that failed to take regional circumstances into account, and inadequately prepared administrative systems. Problems included increased illegal dumping and incineration, complaints about the quality and pricing of VWF bags, difficulties in implementing the system in rural areas, and increases in collection costs. Nevertheless, the system demonstrated successful outcomes, including reduced waste generation and increased recycling rates, by directly affecting the financial cost of discharging waste at the individual level. Now that people had to purchase VWF bags to discharge non-recyclable waste, they became more motivated to separate recyclables. The establishment of the VWF led to the diffusion of waste separation

3 Korea was the first country to implement the VWF nationwide simultaneously. As the first economic incentive system in the environmental sector targeting the entire population, the VWF had extensive ripple effects across various sectors of society. Therefore, substantial preparation processes were undertaken before its introduction, including feasibility studies for system adoption, revision of waste regulations, opinion gathering from various sectors regarding the necessity of system introduction, consultation with relevant agencies on standardised bag production, pilot implementation with interim evaluation by civilian assessment teams, and preparation for nationwide expansion.

practices, which had previously encountered significant implementation challenges. The VWF also significantly contributed to enhancing public awareness of waste issues and the need to reduce waste, induced understanding and acceptance of waste disposal costs and increased fee burdens, and boosted motivation for participating in waste separation (Kim and Kim, 2012).

Concurrent with the VWF, the recycling mark system, designed to assist consumers in determining how to dispose of products and packaging at their end-of-use, was also implemented. However, the recycling mark was frequently confused with the material classification mark indicating the type of packaging material used (e.g. metal, synthetic resin), which was also in place to help recycling businesses identify materials, leading to incorrect waste separation. Consequently, in 2003, coinciding with the implementation of the EPR system, the material classification mark and recycling mark systems were integrated into the unified Recyclable Resource Separate Discharge Labelling System (MOE, 2002b). The separate discharge labelling system has undergone continuous improvements to address elements that cause difficulties in waste separation, such as simplifying labelling designs and defining appropriate locations for the label on packaging, while reflecting changes in Korea's waste separation system and new regulations introducing assessments of recyclability. As of 2025, separate discharge labelling is mandatory for paper cartons, metal cans, glass bottles, synthetic resin packaging materials, synthetic resin film and sheet-type packaging materials, expanded synthetic resin cushioning materials, and single-use synthetic resin bags and shopping bags (excluding VWF bags).

1.2.2 From disposal to producer responsibility: the EPR system

Korea's EPR system is recognised for its sophisticated implementation and enforcement mechanisms including recycling quotas, long-term targets, EPR contributions, and recycling charges. As illustrated in Figure 22.2, Korea's EPR system realises waste management and recycling quota fulfilment through a comprehensive stakeholder network, with each actor bearing clear roles and responsibilities. Korea has adopted a 'single PRO system' for EPR-covered items to prevent market distortions caused by inappropriate manipulation of recycling costs in the recycling market and to avoid issues arising from competition. Currently, 14 EPR-related Producer Responsibility Organisations (PROs) are in operation in Korea, with the Korea Packaging Recycling Cooperative specifically responsible for plastic packaging materials.

The items regulated by EPR have expanded continuously from 12 types in 2003 to the current 28 groups in 2023, which includes four packaging material groups (paper cartons, glass bottles, metal cans, and plastic packaging materials) and 24 product groups.[4] From 1 January 2026, all electrical and electronic products will be subject to EPR, expanding the current scope covering 50 types of medium-sized and large home appliances. Recycling quotas are calculated by applying mandatory recycling rates, which are announced annually by the Ministry of Environment (MOE), to sales or import.

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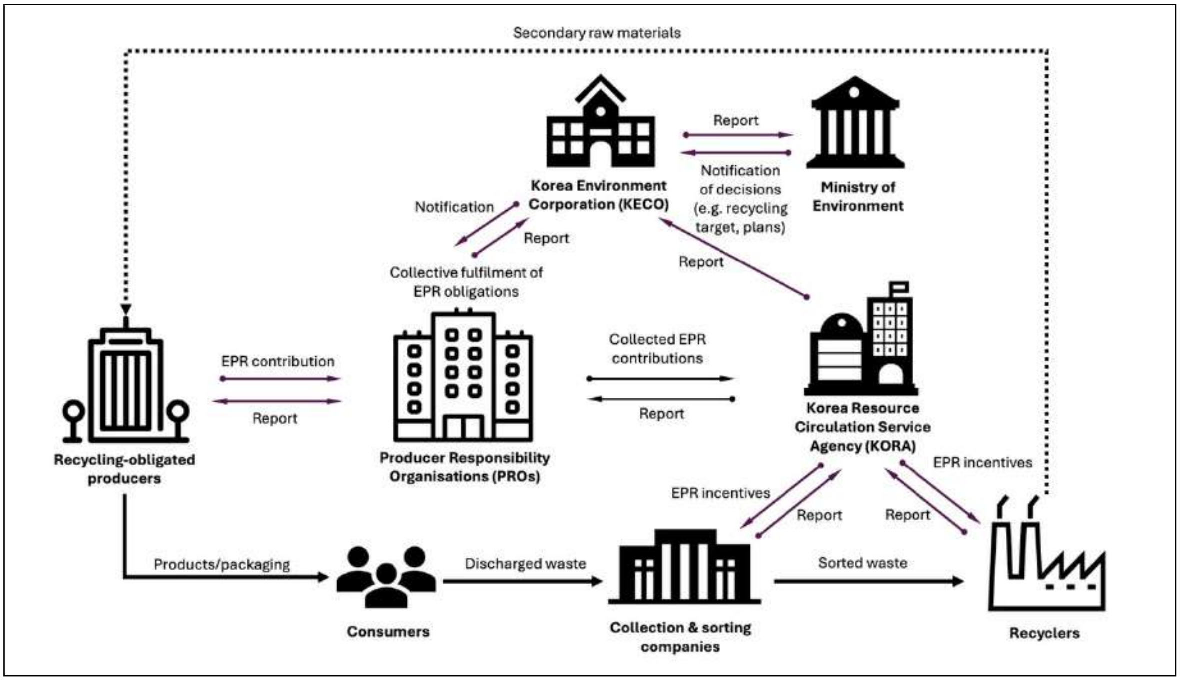
[4] The items subject to EPR under Article 18 of the Enforcement Decree of the Resources Recycling Act, as amended, effective 1 January 2023, include four packaging material groups (paper cartons, metal cans, glass bottles, and synthetic resin packaging materials) and 24 product groups (lubricating oil, batteries, tyres, fluorescent lamps, aquaculture floats, bale silage film, seaweed cultivation nets, five types of film products, industrial film, replacement water purifier filter, safety nets, fishing nets, ropes, polyethylene pipes, polyvinyl chloride products, polypropylene household goods, pallets, plastic transport boxes, window frames and door frames, flooring materials, construction insulation materials, power and communication cables, automotive maintenance parts, and LED lighting). From 2026, this scope will be expanded to include plastic toys. Electrical and electronic products are also subject to EPR; however, they are primarily governed by a different law, i.e. the Act on Resource Circulation of Electrical and Electronic Equipment and Vehicles, which took effect on 1 January 2008. As of 2025, 50 categories of electrical and electronic goods are governed by EPR, but from 2026, nearly all electrical and electronic products (excluding military and medical equipment) will also be subject to EPR obligations.

Figure 22.2: Flow Diagram of Korea's EPR System



EPR = extended producer responsibility.

Source: Author, based on Korea Packaging Recycling Cooperative (2024) and Rhee (2025).

1.3 Korea's EPR system for plastic packaging

Korea's EPR system is recognised as one of the most advanced in the world, especially in terms of its detailed and comprehensive approach to assigning recycling obligations to manufacturers, importers, and sellers. This robust EPR system has substantially improved Korea's waste management, resulting in significant advancements in waste recycling. Amongst the product categories subject to the EPR system, plastic packaging has been an area that has been at the forefront of Korea's concerns from early on, and as such, showcases the significant evolution in the country's waste management approach. Notably, plastic packaging is the area of Korea's EPR system that most representatively demonstrates Korea's relatively recent efforts to progressively transform its EPR framework to embrace broader circular economy principles. This is evident in how the system has expanded beyond simply placing financial responsibility on producers for collection and recycling, to incorporating design requirements, material restrictions, and incentives that encourage the entire life-cycle management of plastic packaging. By examining Korea's implementation of EPR for plastic packaging, we can observe how policy instruments can evolve from linear recycling-oriented approaches to more comprehensive circularity-oriented systems that address production, consumption, and recovery phases simultaneously. The Korean case illustrates how EPR can serve as a foundational policy mechanism that, when properly designed and continuously refined, can drive systemic changes towards circular plastic management.

1.4 Analytical framework for assessing Korea's EPR system and deriving implications

Korea's EPR system for plastic packaging is presented as a case study for driving systemic changes towards circular plastic management. The case study takes a mixed-method approach, including qualitative policy analysis supported by quantitative data, and covers policy evolution and implementation mechanisms. The case study takes the following structure:

(i) The evolution of Korea's EPR system for plastic packaging, focusing on key policy goals, regulatory amendments, and their outcomes.
(ii) Recent policy developments geared towards enhancing plastics circularity, analysing measures taken by Korea to address barriers and challenges.
(iii) Identification of key factors that need to be addressed to realise a circularity-focused EPR system.
(iv) Implications for Association of Southeast Asian Nations Plus Three (ASEAN+3)[5] countries.

2. Korea's EPR Journey: From Recycling to Circularity

2.1 The evolution of Korea's EPR system for plastic packaging

As mentioned earlier, Korea's EPR system was implemented in 2003 to replace the WDS implemented in the 1990s. The evolution of plastic packaging EPR within the broader framework of Korea's EPR system can be classified into three major phases, as shown in Table 22.1.

[5] ASEAN+3 refers to the 11 ASEAN Member States (Brunei Darussalam, Cambodia, Indonesia, the Lao People's Democratic Republic (Lao PDR), Malaysia, Myanmar, the Philippines, Singapore, Thailand, Timor-Leste, and Viet Nam) plus China, Japan, and Korea.

Table 22.1. Phases of the Republic of Korea's EPR System for Plastic Packaging

Phase	Policy direction	Major measures
Phase 1 (2003–2010): Quantitative expansion	Enhancing the recycling rate	• Introduction of EPR system (2003) • Establishment of PROs • Implementation of separate discharge labelling system (2003) • Adjustments in waste charges (2008) to enhance equity with EPR contributions • 4th Basic Plan for Resource Recycling (2008–2012) setting recycling target rates and policy tasks for each plastic packaging material category • Operation of 'stores without disposable plastic shopping bags' (2010)
Phase 2 (2011–2017): Shift to qualitative management	Realising high-quality recycling	• Introduction of packaging material/structural pre-assessment system (2011) • Integration of 6 packaging-related PROs into Korea Packaging Recycling Cooperative (2013) • Establishment of Korea Resource Circulation Services Agency (2013) to support resource recovery and recycling by recycling businesses
Phase 3 (2018–present): Transition to circularity	Transition to circular economy	• Comprehensive Measures for Recycling Waste Management (2018) implementing gradual phase-out of coloured PET bottles and improvement of PET bottle materials/structures • Amendment of subordinate laws to promote fundamental reduction of packaging waste and prevent excessive packaging, including elimination of unnecessary double plastic packaging • Zero-Plastic Measures for Household Waste (2020) replacing imported waste plastics with domestic ones and reducing the proportion of difficult-to-recycle packaging materials from 34% (2020) to 15% (2025); banning the production and use of single-use plastics on principle, implementing mandatory separate disposal of transparent PET bottles, and introducing thickness restrictions/material standardisation for food delivery containers • Revisions of the packaging material/structural assessment system • K-Circular Economy Implementation Plan (2021), Full-Cycle Zero-Plastic Measures (2022), and Industrial New Growth Strategy for Promoting a Circular Economy (2023) presenting goals for the gradual expansion of mandatory recycled content centred on the use of recycled PET from 3% in 2023 to 10% in 2025 and 30% in 2030 • Introduction of waste plastic recycled content labelling system (2024)

EPR = extended producer responsibility, PET = polyethylene terephthalate, PRO = Producer Responsibility Organisation.

Source: Author, based on related policy documents including MOE (2002a, 2002b, 2007, 2008, 2011, 2018, 2020b, 2022); Ministry of Trade, Industry and Energy and MOE (2021); and Ministry of Environment et al. (2023).

Phase 1 (2003–2010) can be described as the quantitative expansion period. This phase marked a paradigm shift from simple final disposal of waste to recycling through the implementation of the EPR system. In terms of packaging, EPR initially covered four major packaging materials that were previously subject to the WDS – paper cartons, glass bottles, metal cans, and polyethylene terephthalate (PET) bottles – along with plastic packaging materials and polystyrene cushioning materials that were relatively easy to recycle (MOE, 2002a).[6] For other plastic products, waste charges were imposed with plans to gradually incorporate them under EPR as recycling conditions and infrastructure became established. To enhance EPR effectiveness, the primary responsible parties were defined as the product manufacturers (fillers) and importers, as they were the main decision-makers of product/packaging design. This period focused on establishing the EPR system while enhancing its effectiveness, implementing various policies to promote recycling, such as improving equity between EPR contributions and waste charges (Korea Environmental Resources Corporation, 2007) and establishing five-year long-term recycling target rates and objectives for EPR-covered items, including plastic packaging materials (MOE, 2008). However, the focus on quantity-centred recycling limited effectiveness in addressing qualitative aspects of recycling and fundamental waste reduction.

Phase 2 (2011–2017) represents a period when Korea's waste management policy sought the transition from a quantitative recycling system to a qualitative management system, prominently centred on plastic packaging EPR. Beginning with PET Recycle 2020, which was announced as a medium- to long-term plan in 2011, followed by the First Basic Plan for Resource Circulation (2011–2015) in 2011 and EPR system reforms in 2013 (MOE, 2013), efforts were made to establish an upcycling system for waste resources from the production stage through various measures encouraging companies to voluntarily improve material and structural designs. These included differentiated recycling fees by material/structure, weighted scoring by recycling method for high-value product production, and other measures to incentivise voluntary material/structural improvements by EPR-obligated companies. Notably, the pre-assessment system for packaging material/structure was introduced at the end of 2011, establishing material/structural standards for packaging considering the recycling value and providing incentives of up to 20% reduction in EPR contributions for compliant companies (MOE, 2011). Amendments to the Resources Recycling Act, 2013 legally stipulated packaging material/structural improvement standards.[7] The amended law also comprehensively reformed the EPR system, including strengthening the responsibility for recyclable resource collection, establishing EPR distribution support centres – for packaging EPR, the Korea Resource Circulation Service Agency (KORA) – to enhance transparency in waste resource collection and recycling, integrating packaging-related PROs into the Korea Packaging Recycling Cooperative, and introducing the recycling obligation compliance certification mark to encourage corporate collection and recycling activities (MOE, 2013).

[6] A grace period was given for film-type plastic packaging materials, and EPR for this type of packaging was enforced from January 2004.

[7] The material/structural improvement standards for packaging materials at this time classified packaging as 'easy to recycle' (Grade 1) and 'difficult to recycle' (Grades 2 and 3). Grade 1 represented materials/structures that are easy to recycle, Grade 2 covered materials/structures that are difficult to recycle but inevitably used under current technological and market conditions, and Grade 3 represented materials/structures that could be improved under current technological and market conditions but that cause problems during recycling.

The waste vinyl crisis triggered by China's ban on plastic waste imports in 2018, and the detection and return of plastic waste illegally exported to the Philippines exposed structural vulnerabilities in Korea's EPR system, such as its heavy reliance on overseas recycled materials and inadequate domestic resource circulation, where recycled PET raw materials were being imported while domestically recycled PET waste was being exported. This marked a major turning point in Korea's waste management policy.

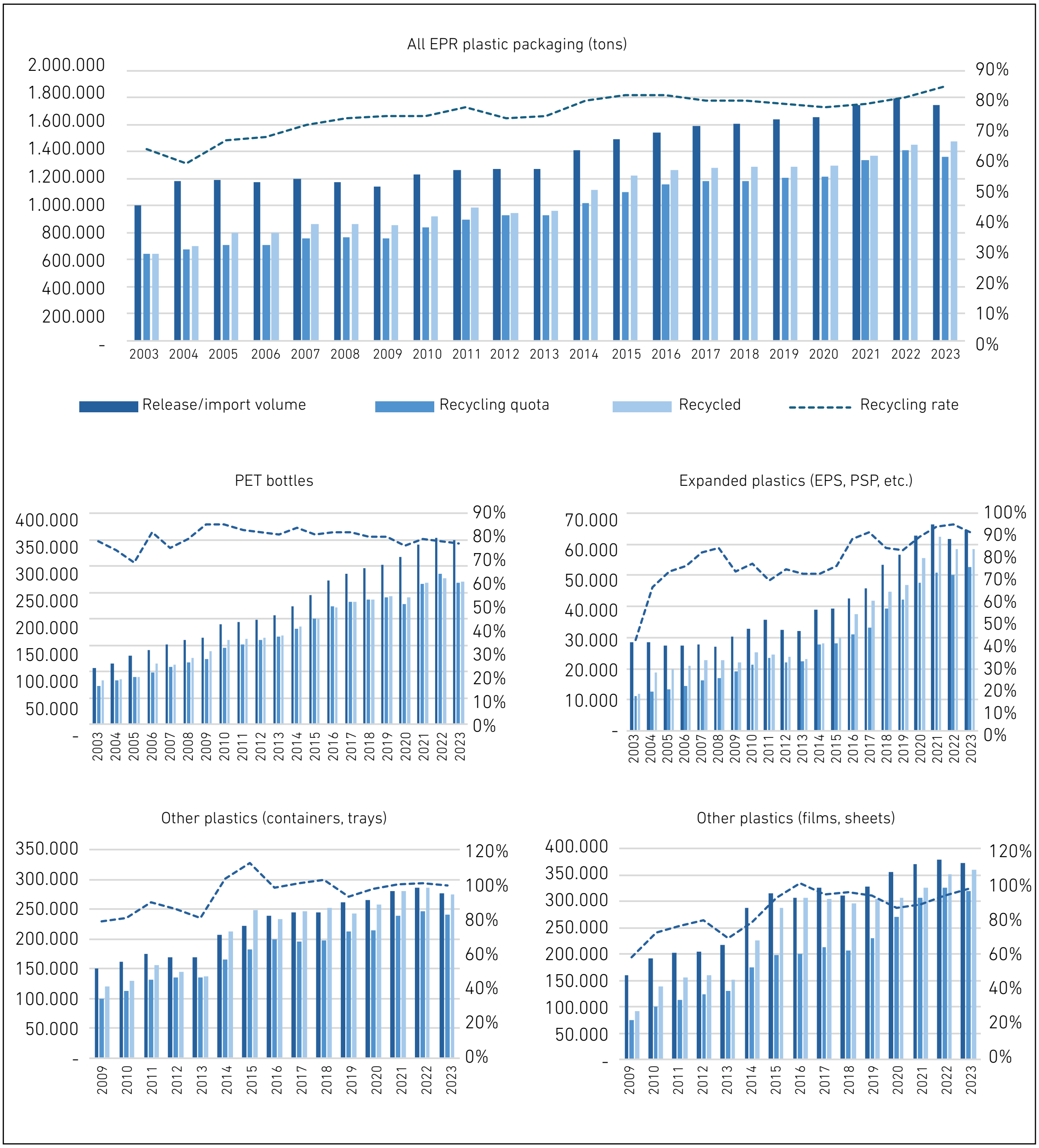
Phase 3 (2018–present), involving the transition to circularity, saw Korea develop comprehensive measures to improve each stage of resource circulation across the entire life cycle, encompassing production, distribution, consumption, collection, and recycling through pan-governmental efforts via the Comprehensive Measures for Recycling Waste Management (MOE, 2018). Especially from 2020, Korea has been working towards realising a genuine transformation into a circular economy through mandatory recycled content requirements and packaging recyclability grade assessments, which will be explained in greater detail in the following section.

Korea's plastic packaging EPR has achieved considerable success in expanding recycling. As of 2021, it achieved a total recycling rate of 52.7%, with PET bottles showing a high recycling rate of 74.0%. As shown in Figure 22.3, the market release/import volume of packaging materials subject to recycling quotas initially stood at 999,823 tons during the early EPR implementation but increased to 1,746,771 tons in 2023.[8] The proportion processed through recycling also increased from 64% in 2003 to 85% in 2023. The recycling quota fulfilment rate, which is the percentage of mandatory recycled quotas that is achieved, reached 100% in 2003, the first year of EPR, and has consistently been maintained at over 100% thereafter.

Significant EPR performance is not limited to plastic packaging – overall, Korea's EPR system has also achieved considerable growth and delivered substantial benefits to the nation. During the period from 2003 to 2022, the number of recycling-obligated producers and recycling businesses also increased from 2,747 to 12,076 establishments and from 418 to 873 establishments, respectively (Korea Environment Corporation, 2024). Considering the cost savings from reduced landfilling/incineration through mandatory recycling and the economic value of recyclables, the total economic benefit of Korea's EPR system can be estimated at around US$1 billion in 2022 (Figure 22.4). From an environmental perspective, carbon dioxide (CO_2) emissions through recycling amounted to 7.45 Mt, while estimated CO_2 emissions if the recycled waste had been sent to landfills or incinerators totalled 18.64 Mt, suggesting a total greenhouse gas reduction effect of 11.19 Mt (Kim, 2023).

[8] Statistics related to Korea's EPR performance include both comprehensive statistics covering all EPR-obligated items (products + packaging materials) and statistics managed by KORA that address only packaging materials amongst EPR-obligated items. The data presented in Figure 22.3 utilised data compiled by KORA, while the data presented in Figure 22.4 utilised comprehensive data covering all EPR-obligated items.

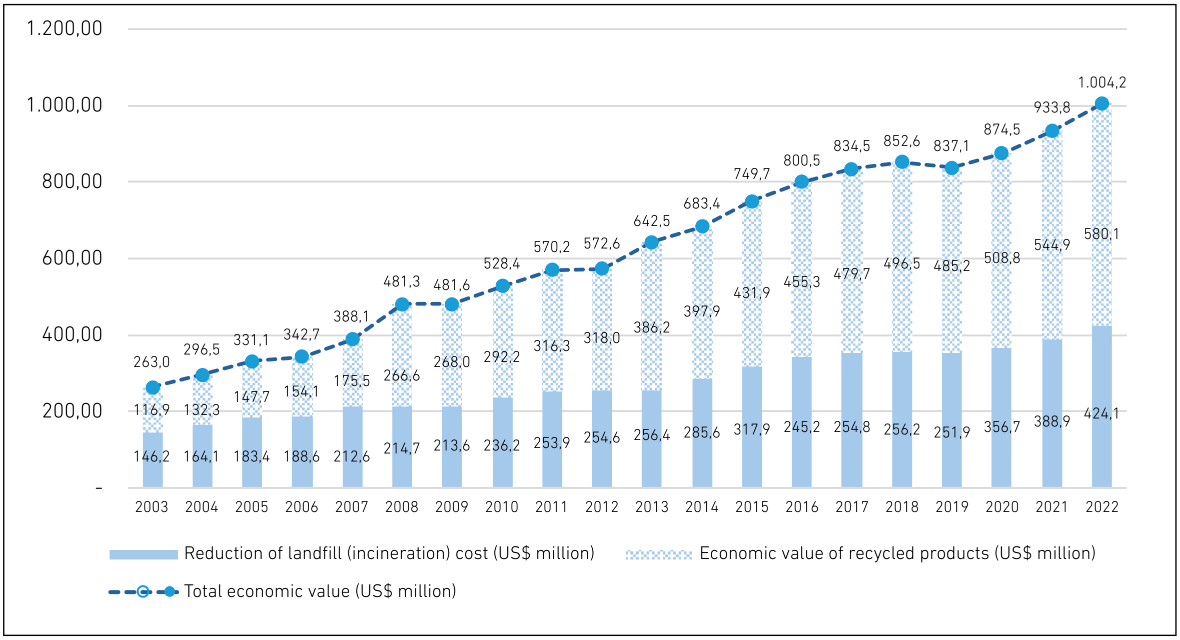
Figure 22.3. Performance of Korea's EPR for Plastic Packaging (tons, %)



EPR = extended producer responsibility, EPS = expanded polystyrene, PET = polyethylene terephthalate, PSP = polystyrene paper.

Source: Korea Resource Circulation Service Agency (2003–2023).

Figure 22.4: Economic Benefits of Korea's EPR System



EPR = extended producer responsibility.

Notes: Total economic benefit = savings from landfill diversion + economic value of recyclables, net economic profit = total economic benefit – direct recycling costs. Figures in Korean won were converted to United States dollars based on the base exchange rate of 31 July 2025 (U$1 = W1,396.50).

Source: Rhee (2025).

2.2 Moving forward from recycling to circularity

As explained earlier, Korea's EPR system has served as a major pillar in establishing infrastructure and ecosystems for systematic recycling of plastic packaging materials and has achieved considerable success in increasing recycling rates for plastic packaging. However, despite the major policy shift from recycling-centred approaches to resource circulation since the mid-2000s, the focus remained on reducing the amount of waste sent to landfills, and measures for improving product design to reduce waste generation did not show distinct effects until the 2020s. According to material flow analysis by Choi et al. (2024), Korea's per capita plastic packaging consumption in 2021 was 48.7 kg/year, higher than the European Union (44.0 kg) and Japan (39.1 kg). While the total recycling rate for packaging materials and disposables was 52.7% – with PET bottles (74.0%), disposables (68.4%), and containers (62.3%) – the recycling rate for plastic films was only 31.6%, showing significant disparities by material type (Choi et al., 2024).[9] Furthermore, in 2021, a considerable amount of plastic waste was still being discharged in VWF bags with an average recycling rate of 10.5% (Choi et al., 2024), revealing a critical shortfall in Korea's waste separation system.

[9] This material flow analysis result differs from the recycling rates discussed in the plastic packaging EPR performance section because it includes not only separately disposed plastic packaging materials but also packaging materials discarded in VWF bags.

In fact, the realisation of circularity has been an integral part of Korea's waste management policies since the 1990s. Circularity is mentioned in the policy direction of the 1993 Basic Plan for Resource Recycling, incorporating basic circular concepts such as mandatory use of recycled materials and excessive packaging regulations, while promoting product structural/material improvements and resource recycling within production processes. Through the Rules on Product Packaging Methods and Standards for Packaging Material Properties (1993), Korea also began implementing regulations for reducing packaging waste, including limiting packaging space ratios within 35%, packaging frequency within two layers, prohibition of polyvinyl chloride (PVC) coating, and reuse of packaging containers. Policies for realising the circularity of plastic packaging materials were continuously attempted and implemented, such as establishing eco-friendly packaging guidelines in the 2000s to suppress packaging waste generation in distribution stages (MOE, 2007) and initiating design-stage interventions for packaging material improvements in the 2010s as mentioned above. While these measures were quite effective in steadily increasing the recycling rates of plastic packaging materials, several challenges remained in achieving genuine circularity where post-consumer recycled (PCR) plastics substantially replace primary raw materials.

2.2.1. Packaging recyclability assessment leading to suitable secondary raw materials for production

The first challenge involves restricting the use of packaging materials that are difficult to recycle and their gradual phase-out through mandatory packaging material/structural grade assessment and labelling. Although standards for packaging material/structural improvements were legally stipulated in 2013 and incentives of a reduction of up to 20% in EPR contributions were provided to compliant companies, these measures stopped at encouraging voluntary improvement efforts by producers.

Consequently, the government refined the standards for packaging material/structural improvements into four grades (excellent, good, standard, and difficult) in 2019 and mandated the packaging recyclability grade assessment system. EPR contributions were increased by 10%–20% for items receiving 'difficult to recycle' grades, and these additional funds were used to establish to provide incentives of up to 50% for 'excellent' grade items. The 'excellent' grade was reserved for priority packaging types, so that incentives could drive faster improvements in their materials and structures.

The packaging recyclability grade assessment standards are continuously revised to reflect the emergence of new packaging materials and changes in recycling practices (Table 22.2). Revisions are being made not merely to distinguish easily recyclable packaging materials but to induce a transition towards eco-friendly materials and structures by requiring structural improvements within single materials, considering recyclability from the packaging design stage. Accordingly, various attempts are being made to meet these requirements, including the introduction of 'lightweighting' technologies[10] for reducing packaging material usage. These revisions play an important role in enhancing the efficiency of recycling processes, reducing plastic usage, and ultimately decreasing carbon emissions, thereby contributing to the establishment of a circular economy.

[10] Lightweighting technologies refer to technology (such as material optimisation or design changes) aimed at reducing the weight and volume of packaging to use less material while maintaining structural integrity and functional performance.

However, as shown in Table 22.3, numerous 'difficult to recycle' grade packaging materials – comprising less than 10% of total market release/import volumes – are still being produced and distributed, pointing to the challenges faced by related industries in introducing new materials and equipment to their existing processes, embracing and managing increased production costs, and working around relative quality degradation (Kim et al., 2025).

Table 22.2. Amendments to Packaging Recyclability Grade Assessment Standards for Plastic Packaging

MOE notice	Main amendments
No. 2019-265 (30 Dec 2019)	• Changed name from 'Standards for Packaging Material/Structural Improvements' to 'Packaging Recyclability Grade Assessment Standards' • Improved and supplemented existing regulations to help obligated producers understand packaging material/structural grade assessments by adding term definitions, revising language, and improving some grading standards • Changed legal basis provisions and implementing agencies following amendments to the Act on the Promotion of Saving and Recycling of Resources, 2019 • Added detailed testing and analysis method guidelines for determining packaging material/structural properties and recyclability
No. 2021-2 (7 Jan 2021)	• (PET bottles) Upgraded label-free bottles and cap-attached labels to 'excellent'
No. 2022-44 (28 Feb 2022)	• (All) Included as 'inseparable' cases when parts remain even when labels, caps, and miscellaneous materials are separated from the body without using separate tools • (PET bottles) Excluded bottles with inner caps (lids) that can only be used when completely separated from the body from being graded as 'difficult to recycle' considering the high likelihood of separate disposal • (Synthetic resin packaging) (i) Adjusted detailed classification standards for synthetic resin packaging materials/structures, (ii) adjusted recyclability grade range for composite material containers/trays from 'good recyclability' or below to 'standard recyclability' or below, and (iii) synthetic resin containers using lids/caps and straws made from non-synthetic resin materials were determined as 'difficult to recycle' regardless of body material
No. 2023-73 (14 Apr 2023)	• (PET bottles) Established assessment standards for new types of labels printed with thermally alkali-separable ink on the same material as the bottle body; established criteria for determining whether PET bottle labels use thermally alkali-separable ink
No. 2024-131 (11 Jul 2024)	• (PET bottles) Established standard calculation formula for PET bottle 'lightweighting' index; upgraded products with lightweighting index of 1 or below to 'excellent recyclability' grade and classified them into 4 product groups, reflecting the characteristics of PET bottle packaging
No. 2025-2 (7 Jan 2025)	• (Synthetic resin containers/trays) Established new 'excellent recyclability' grade for cases where the body is colourless PET and miscellaneous materials are not used

EPR = extended producer responsibility, MOE = Ministry of Environment, PET = polyethylene terephthalate.

Source: Author, based on past and current versions of Packaging Recyclability Grade Assessment Standards from Korea National Law Information Center (2019, 2021, 2022, 2023, 2024, 2025).

Table 22.3. Percentage of 'Difficult to Recycle' Graded Packaging and Their Market Release/Import Amount

Plastic packaging type	'Difficult to recycle' graded packaging in 2022	Total market release/import amount in 2021	Total market release/import amount of 'difficult to recycle' graded packaging in 2021	Percentage of 'difficult to recycle' graded packaging in terms of market release/import amount
PET bottles	84.8% (1,453 items out of 1,714 in total)	315, 594 tons	21,841 tons	6.9%
Expanded synthetic resin	32.6% (125 items out of 383 in total)	57,047 tons	456 tons	0.8%
Synthetic resin containers/trays	41.4% (2,135 items out of 5,160 in total)	638,825 tons	44,931 tons	7.0%

PET = polyethylene terephthalate.

Source: Analysis of market release/import amounts extracted from Kim (2025). Data for 'difficult to recycle' graded packaging in 2022 obtained from All Packaging (2024).

2.2.2 Advanced disposal and sorting for producing high-quality secondary raw materials

The second challenge involves the refinement of waste separation and sorting. While Korea's waste separation system is already relatively sophisticated, the need for more detailed source separation aligned with advancements in technologies and recycling processes has emerged to achieve high-quality secondary raw material production. A representative example demonstrating this is the separate discharge of transparent PET bottles. After requiring all PET beverage bottles to be transparent, the government mandated separate disposal of transparent PET bottles for all multi-unit housing nationwide from the end of 2020 and expanded this obligation to all housing types from the end of 2021 to facilitate high-quality recycling of transparent PET bottles (Korea Policy Briefing, 2021).

The transparent PET bottle collection rate has steadily improved from 7.6% in 2021, the year following policy implementation, to 17% in 2022 and 18.9% in 2023. The proportion of high-quality recycling amongst transparent PET bottle recycling has increased annually from 13.0% in 2021 to 28.0% in 2022 and 38.0% in 2023 (The JoongAng, 2024).

Additionally, field inspections were conducted in cooperation with local governments nationwide to ensure that transparent PET bottles are not mixed with other plastic items during the collection and sorting stages, and projects for constructing separate transparent PET bottle sorting facilities were implemented at public and private sorting facilities nationwide to support the separate sorting of collected transparent PET bottles (MOE, 2021). In this way, continuous institutional improvements will be necessary in the future to ensure the separate disposal, collection, and sorting of various packaging materials as difficult-to-recycle packaging is gradually phased out and the use of easily recyclable single-material packaging increases.

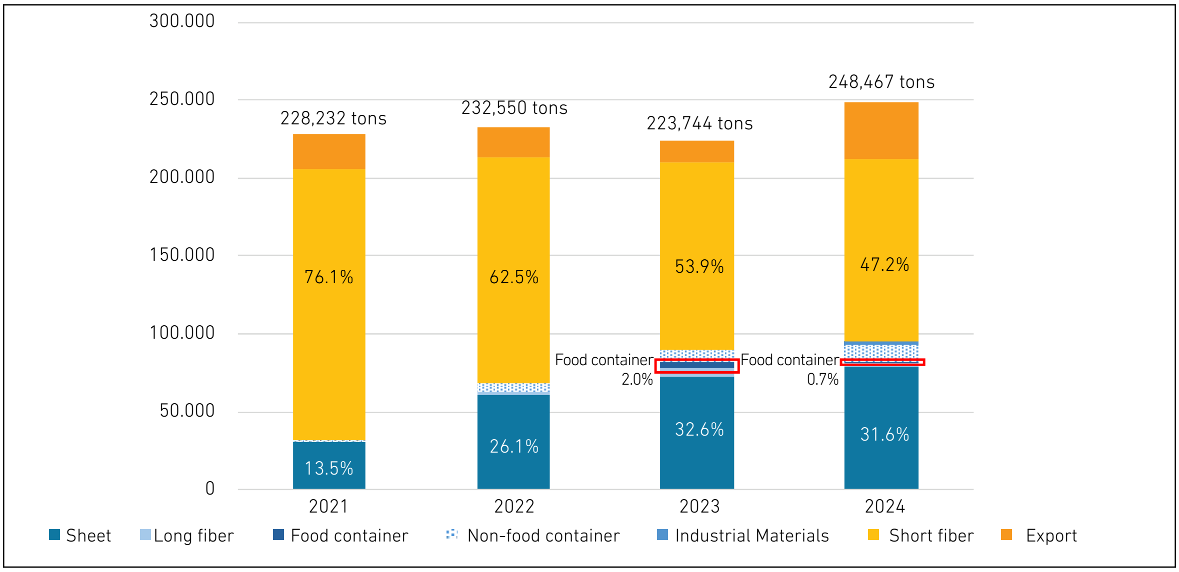
2.2.3 Regulatory adjustments for mandatory bottle-to-bottle recycling

The third challenge involves mandatory recycled content and revision of laws and regulations for its implementation. In the K-Circular Economy Implementation Plan announced at the end of 2021, Korea planned to expand the mandatory use of secondary raw materials, previously imposed only on paper, steel, and glass manufacturers, to plastic manufacturers from 2023 in alignment with global trends (Ministry of Trade, Industry and Energy and MOE, 2021). It was planned to mandate plastic PET producers to increase recycled content to at least 30% by 2030.

However, realising this ambitious plan required prior revisions in laws and regulations. Specifically, under the Korea Food and Drug Administration (KFDA) regulations, the use of recycled plastics, such as waste PET bottles, in food container manufacturing was only permitted when plastics were recycled through chemical methods involving decomposition into raw materials through heating and chemical reactions followed by purification and polymerisation, thereby preventing complete circular utilisation of waste PET bottles. Thus, the MOE and KFDA came to an agreement to establish a dual verification system for secondary raw materials obtained through physical recycling of waste PET bottles to expand transparent PET bottle recycling and ensure the safety of food containers, permitting the use of physically recycled materials as food container raw materials from January 2022 if safety standards are met (Park, 2023).

Subsequently, the MOE established the Standards for Recycled Materials Used in Food Containers on 24 February 2022, announcing recycled content standards for PET (Choi, 2022). These legal improvements resulted in the first domestic recognition of physical recycled material use in food containers on 17 January 2023, following the KFDA safety review (Park, 2023), and as shown in Figure 22.5, waste PET bottles began to be used as secondary raw materials for food and beverage containers. Accordingly, through amendments to subordinate laws of the Resources Recycling Act on 19 February 2025, mandatory recycled content previously imposed on producers was also extended to final product (PET bottle) producers to promote the use of water and beverage PET bottles using recycled materials (Choi, 2025).

Figure 22.5. Trends in the Application of Secondary Raw Material from Waste PET Bottles



PET = polyethylene terephthalate.

Source: Korea Resource Circulation Service Agency (2025).

2.3 What lies ahead

Many challenges remain for Korea to achieve the transition to a circular economy society for carbon neutrality by 2050. Amongst these challenges, the following deserve particular attention. First, institutional redefinition must be prioritised. The literal English translation of the Korean term for EPR is 'producer recycling responsibility', which conceptually constrains the producer's responsibility as pertaining to recycling only. Thus, a revision of terminology is required to accommodate the extension of producer responsibility from recycling to the entire life cycle from product design to waste disposal and reuse. This nomenclature change goes beyond mere terminology modification to ensure that the system achieves complete circularity. Second, it is critical to establish a high-quality secondary raw material supply chain, beginning with the establishment of comprehensive safety certification systems for recycled PET (rPET) for food and beverage applications and certification systems capable of tracking the entire process from recycled material production to use and consumption. This will create a recycled material market trusted by both consumers and businesses, expanding demand for high-quality recycled materials. Finally, Korea needs to prepare strategic responses to the rapidly changing international environment. With intensifying competition over recycled material procurement with major countries such as the European Union member states, international cooperation strategies in trade policy and technical standards must be systematically established. Through this, national competitive advantages can be secured in the global circular economy system, achieving sustainable growth.

3. Implications for ASEAN+3 countries

Korea's experience demonstrates that EPR systems can evolve from being a mechanism for imposing mandatory recycling to a platform for realising comprehensive transformation into a circular economy. The lessons that ASEAN+3 countries can derive from Korea's process of shifting the focus of plastic packaging EPR from recycling to circularity are as follows.

First, it is necessary to maintain stable market mechanisms by raising mandatory recycling quotas gradually. Recycling goals should be realistic and achievable in the early stages of introducing the EPR system to provide market participants time to adapt to the system, while presenting clear long-term target rates can help enhance predictability so that businesses can forecast the future and establish investment plans.

Second, the efficiency of the EPR system can be maximised through PROs. By establishing PROs, it becomes possible to lessen the burden of recycling obligation compliance that individual companies, particularly small and medium-sized enterprises, find difficult to bear alone, while securing system credibility through transparent execution and management of recycling costs.

Third, it is essential to introduce material and structural assessment systems. Evaluating and regulating recyclability from the packaging design stage is the most effective means of fundamentally reducing recycling costs, as opposed to merely remaining at post-treatment processing. Material and structural assessment systems can induce producers to design easily recyclable packaging from the outset.

Fourth, it is important to establish and implement a mandatory recycled content roadmap. Mandatory recycled content can create stable demand for recycled products, which can generate a virtuous cycle that drives investment attraction and technological innovation across the recycling industry. This approach can contribute to building a genuine circular economy beyond simple waste treatment.

4. Conclusion

Korea's EPR system demonstrates a phased development trajectory that shifted focus from implementing producer obligations to improving recycling rates to inducing design innovation, ultimately with the aim of realising a circular economy. The achievements Korea has made through the EPR system, particularly regarding packaging materials, show that EPR systems can evolve beyond simple cost-burden mechanisms to become policy platforms that promote the transition to a circular economy. Korea's plastic packaging EPR system has achieved institutional stability while systematically processing various plastic types – including PET, expanded polystyrene (EPS), polystyrene paper (PSP), polyvinyl chloride (PVC), single-material containers/trays (polyethylene (PE)/polypropylene (PP)/polystyrene (PS)), and composite films/sheets – through a single PRO system supported by EPR distribution support centres under the systematic supervision and direction of the MOE and Korea Environment Corporation (KECO) within one integrated framework. However, establishing this system required around 30 years, from building the institutional foundations in the 1990s and undergoing various trial-and-error processes and regulatory adjustments from 2003 to the present, with continuous legal and institutional improvements still being made towards genuine circularity. This indicates that, despite early recognition of the need for circular design, considerable time is required to prepare and establish actual implementation mechanisms.

For ASEAN+3 countries to accelerate the establishment of circularity-oriented EPR systems, it is essential to (i) comprehensively review the legal and institutional foundations of EPR systems, establishing and refining them with consideration for 'circularity' from the initial stages; (ii) form a preliminary consensus through active explanation, opinion gathering, and persuasion, targeting stakeholders by sector when introducing new regulations or expanding existing ones, especially focusing on strengthening and maintaining the willingness of producers to participate; (iii) continuously improve existing recycling waste collection systems while establishing stable waste separation and collection through public education and promotion; and (iv) integrate businesses that receive recycled materials into the institutional framework for waste management and induce their wider participation through EPR support. Considering these aspects when designing phased EPR roadmaps suited to each country's national conditions will enable ASEAN+3 countries to achieve EPR performance at a faster pace.

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Plastic pollution has emerged as a critical global challenge, with the ASEAN+3 region identified as a major hotspot due to high emission levels and persistent gaps in waste management systems. This handbook offers a comprehensive, evidence-based overview for policymakers, practitioners, and researchers, presented in two main parts.

Part I provides a cross-national assessment of plastic pollution and its broader implications. It highlights that investing in sound waste management systems is significantly more cost-effective than post-pollution remediation. The section also outlines the environmental and human health impacts of plastics, reviews full life-cycle countermeasures – including behavioural change, Extended Producer Responsibility (EPR), and leakage prevention – and summarises relevant regional initiatives and the ongoing INC negotiations toward a global plastics agreement.

Part II presents country case studies from Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, the Philippines, Singapore, Thailand, China, Japan, and the Republic of Korea. These chapters showcase diverse national contexts, policy responses, and practical approaches to reducing plastic pollution, offering valuable lessons for regional adaptation.

The handbook concludes that strengthened regional co-operation, targeted investment in waste management infrastructure, and data-driven policymaking are essential to effectively address plastic pollution in ASEAN+3.

This publication is a joint effort of experts from ASEAN+3 Member States, the Economic Research Institute for ASEAN and East Asia (ERIA), and the Institute for Global Environmental Strategies (IGES).

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