

Strategies to Reduce Marine Plastic Pollution from Land-based Sources in Low and Middle - Income Countries



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The International Environmental Technology Centre works with developing countries to implement sustainable solutions to environmental challenges, with focus on holistic waste management.

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Key Messages

- Accumulation of plastic wastes in the marine eco-system is growing rapidly with the increase of plastic production and consumption patterns, particularly single-use plastics as well as unsustainable plastic waste management practices. Land-based sources are recognised as the main cause (up to 80% of total marine debris) of marine plastic pollution. Marine plastic pollution has thus become an issue of global focus and many national and local governments are searching for solutions to tackle it.
- Rapidly developing economies, including countries in Southeast and South Asia are contributors to marine plastic pollution due to the lack of plastic waste management policies, governance systems, resources, capacities and infrastructure to keep pace with urban growth and economic development in the respective countries. Many local governments lack sufficient plastic waste collection and environmentally sound treatment and disposal methods. Plastic waste recovery and recycling systems are also not well established and plastic recycling businesses are commonly operated by informal or small and medium enterprises (SMEs). Due to the lack of sustainable plastic waste management systems, littering, open burning and unmanaged disposal of plastic waste are common practices in low and middle-income countries and such practices have largely contributed to costs related to environmental pollution, public health and economy. Both regions have also been used as a dumping ground for plastic waste from other developed countries after China stopped importing waste from foreign countries since 2017.
- Based on the literature review and action research in two selected Asian countries, Indonesia (Southeast Asia) and India (South Asia), this report identifies the urgency of addressing plastic waste within the overall waste management policies and systems of the respective countries or cities to reduce marine plastic pollution. It also proposes a list of strategies and policy interventions to consider in reducing plastic pollution from land-based pathways. These strategies are discussed along the plastic value chain in a holistic manner and presented under key policy interventions, such as regulatory, economic, technology, data/information and voluntary measures, identified for the short, medium and long-term.
- Taking immediate actions to mitigate plastic waste leakages into oceans by stopping littering, improving plastic waste collection and their disposal in an environmentally sound manner are prioritised as short-term strategies. Establishing plastic waste separation at source, and introduction of appropriate plastic recovery, recycling and treatment systems, which are more economically viable, environmentally friendly and socially acceptable to the local context, are identified as mid-term strategies for optimal utilisation of plastic waste as a resource before final disposal. These short- and mid-term strategies can bring about a reduction in plastic waste leaked into the environment and creating effective plastic waste recycling systems. However, long-term strategies and actions, such as sustainable production (eco-designing and eco-labelling), and sustainable consumption (awareness of sustainable lifestyles) are required in order to bring about radical changes in the societal context towards establishing a circular economy and sustainable plastic production and consumer society.
- While transitioning to more eco-friendly and sustainable plastic production and consumer society is a long-term process requiring contributions from different stakeholders and close monitoring/evaluation, this report recommends developing a city/national road map to prevent plastic waste pollution in line with overall waste management policies involving all key stakeholders as a first step. For this, the IGES Centre Collaborating with UNEP on Environmental Technologies (CCET) in partnership with the International Environmental Technology Centre of United Nations Environment Programme (UN Environment-IETC) and the Ministry of Environment (MOEJ), Japan provide assistance to national/local governments and other interested parties in low and middle income countries in Asia in conducting a road mapping process, which aims at developing strategies, actions and model projects for reducing waste plastics through more and better waste prevention and recycling.
- Finally, the report concludes by identifying some key factors that are necessary to consider for the successful design and implementation of the plastic waste management strategic plans in low- and middle-income countries, such as (i) understand the baseline/ current conditions of plastic waste generation and management within the overall waste management system in the country or city, (ii) engage all relevant stakeholders for developing the plastic waste management strategy and its implementation, (iii) identify alternative actions and sustainable plastic waste recycling and treatment technologies that are adoptable to the local context, (iv) raise awareness on environmental and economic impacts of mismanaged plastic waste, (v) create an enabling environment and promote sound incentives to both industries and consumers, (vi) a guarantee of good governance and enforcement as well as a system to review, follow-up monitoring and adjustment to the plastic waste management strategy as necessary.

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1. Introduction

The rate of plastic production has grown faster than that of any other material in the world. More than half is single-use plastics and recognised as being one of the most noticeable pollutants affecting the ocean worldwide¹. Recent studies have suggested that approximately 8.3 billion tonnes of plastics have accumulated since the early 1950s, 79% of which has ended up in either disposal sites or the natural environment². About 8 million tonnes of plastic waste from deep inland areas ends up in the ocean every year, on top of the estimated 150 million tonnes that currently circulate marine environments³. Ten rivers alone, eight of them in Asia, carry more than a quarter of all that plastic waste into the oceans and create significant damage to economies, ecosystem, and societies⁴. According to the United Nations, 80% of ocean plastic comes from land-based sources⁵. If current trends continue, oceans could contain more plastic than fish by 2050^{6,7}.

Though developed nations such as the United States (US), Japan and many European countries generate significant amounts of per capita plastic waste, the rate of plastic leakage is relatively low due to high rate of waste collection, recycling, treatment and disposal. Calculations using globally available data however show that rapidly developing economies in Southeast and South Asia have not been able to keep pace with solid waste management policies and infrastructure, which can contribute significantly to marine plastic litter⁸. About half of all the plastic waste that ends up in the ocean comes from just five low- and middle-income countries in Southeast Asia - China, Indonesia, the Philippines, Thailand and Viet Nam⁹. Global data also revealed that approximately two billion people in low- and middle-income countries still lack access to regular waste collection services and three billion people do not have environmentally sound treatment and disposal facilities¹⁰. The average waste collection rate in low- and middle-income countries ranges from 39% to 51%¹¹, and tends to be less than 26% in peri-urban and rural areas of those countries. If national

and local governments are unable to improve the regular service of waste collection, environmentally-friendly waste treatment and disposal systems and infrastructure, households often practice open burning or unmanaged disposal of waste. Open burning of plastic wastes contribute to air pollution due to toxic smoke, negatively affecting human health and the climate. Unmanaged disposal of plastic wastes leads to leakage of plastics into canals and rivers. Collected waste can also contribute to riverine and marine plastic pollution through leakage from waste transport, treatment, storage and landfills.

In this regard, growing international efforts are made and actions are taken to address plastic pollution by reducing plastic leakage into waterways and oceans. The UN General Assembly adopted the United Nations Agenda 2030 for Sustainable Development on 25 September 2015, which represents a plan of action, including 17 Sustainable Development Goals (SDGs) and 169 targets¹². Goals 11, 12 and 14 appear particularly relevant to the subject of marine plastics, although all 17 goals are in some way involved. The UN Environment Assembly (UNEA) and the Convention on Biological Diversity (CBD) have taken up the issue in the form of resolutions and agreements^{13,14,15}. For example, UNEA 4 adopted seven resolutions related to waste management and out of them two specifically address plastic waste, such as Res No 6 (on Marine Plastic Litter) and No 7 (on single-use plastics) to addressing environmental challenges through advancing innovative solutions, and to moving towards sustainable and resilient societies through sustainable consumption and production patterns¹⁶. During Conference of the Parties to the Basel Convention from 29 April to 10 May 2019, Parties amended Annex II, VIII and IX: a new Y code, Y48 Plastic waste, including mixtures of such waste, with the exception; a new entry A3210 Plastic waste; and a new entry B3011 Plastic waste, respectively. As a result, transboundary movements of plastic waste will be controlled by the Basel Convention from

1 Kershaw, P. J. (2016): Marine Plastic Debris and Micro-plastics: Global Lessons and Research to Inspire Action and Guide Policy Change, UN Environment with UNEP, Nairobi

2 Jambeck, J. R., Geyer, R., Wilcox, C., Siegler, T.R., Perryman, M., Andrady, A., Narayan, R., Law, K.L. (2015): Plastic waste inputs from land into the ocean. *Science* 347, 768–771

3 IUCN (2018): Issue Brief - Marine Plastics, https://www.iucn.org/sites/dev/files/marine_plastics_issues_brief_final_0.pdf

4 Schmidt, C., Krauth, T., Wagner, S. (2017): Export of Plastic Debris by Rivers into the Sea. *Environmental Science & Technology*, vol. 51, no. 21. P. 12246-12253. The 10 most important rivers are mentioned in: http://pubs.acs.org/doi/suppl/10.1021/acs.est.7b02368/suppl_file/es7b02368_si_001.pdf

5 UNEP (2016): Marine plastic debris and microplastics – Global lessons and research to inspire action and guide policy change, United Nations Environment Programme, Nairobi.

6 Earth Day Network (2018): Fact sheet: Plastics in the ocean. <https://www.earthday.org/2018/04/05/fact-sheet-plastics-in-the-ocean/>

7 World Economic Forum (2016): The New Plastic Economy: Rethinking the future of plastics, Switzerland

8 Jambeck, J. R., Geyer, R., Wilcox, C., Siegler, T.R., Perryman, M., Andrady, A., Narayan, R., Law, K.L. (2015): Plastic waste inputs from land into the ocean. *Science* 347, 768–771

9 Jambeck, J. R., Geyer, R., Wilcox, C., Siegler, T.R., Perryman, M., Andrady, A., Narayan, R., Law, K.L. (2015): Plastic waste inputs from land into the ocean. *Science* 347, 768–771

10 UNEP, ISWA (2015) Global Waste Management Outlook. P. 270. <http://web.unep.org/ourplanet/september-2015/unep-publications/global-waste-management-outlook>

11 World Bank (2018): What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050. Washington DC

12 UNGA (2015) Transforming our world: the Agenda 2030 for Sustainable Development. Resolution adopted by the General Assembly on 25 September 2015. SDG 14.1. <https://sustainabledevelopment.un.org/post2015/transformingourworld>

13 UNEA (2016) 2/11 Marine plastic litter and micro plastics. <http://wedocs.unep.org/handle/20.500.11822/11186?show=full>; http://www.un.org/en/development/desa/population/migration/generalassembly/docs/globalcompact/A_RES_71_256.pdf

14 UNEA (2017) Resolution on marine litter and micro plastics; CBD (2016) Addressing impacts of marine debris and anthropogenic underwater noise on marine and coastal biodiversity. Decision XIII/10. <https://www.cbd.int/doc/decisions/cop-13/cop-13-dec-10-en.pdf>;

15 UN General Assembly (2016): 71/256. New Urban Agenda. Resolution adopted by the General Assembly on 23 December 2016. Par. 74. “We commit ourselves to promoting environmentally sound waste management and to substantially reducing waste generation by reducing, reusing and recycling waste, minimizing landfills and converting waste to energy when waste cannot be recycled or when this choice delivers the best environmental outcome. We further commit ourselves to reducing marine pollution through improved waste and wastewater management in coastal areas.”

16 UN (2019): Ministerial declaration of the United Nations Environmental Assembly at its fourth session. <http://wedocs.unep.org/bitstream/handle/20.500.11822/27925/K1901029%20-%20UNEP-EA.4-HLS.1%20-%20Advance.pdf?sequence=4&isAllowed=y>

1 January 2021¹⁷. Outside of the UN system, the G7 and G20 have adopted action plans on marine litter and resource efficiency (G20)^{18,19}. These various voluntary commitments complement legally binding international agreements such as the MARPOL Convention on Pollution from Ships, the London Protocol and the UN Convention on the Law of the Sea (UNCLOS), Regional Seas Conventions such as the Barcelona Convention for Protection of the Mediterranean and the Regional Seas Programme such as COBSEA Regional Action Plan on Marine Litter 2019^{20,21}.

However, a critical issue is how decision-makers and practitioners, particularly in low- and middle-income countries, improve their plastic waste management policy and systems by adopting more sustainable and circular economies in order to prevent plastic pollution and leakages into the ocean from land-based sources, thus transforming the above international agreements and commitments into reality at national and local levels. This report therefore seeks

to find some practical answers to these questions and identify strategic actions and policy interventions based on the review of two country studies, from South Asia (India) and Southeast Asia (Indonesia). It is structured under four sections. After this short introduction in section 1, the issue of plastic waste is examined in more detail at global and national levels in the section 2. Here, the two country studies that are part of the ongoing project activities of the IGES Centre Collaborating with UNEP on Environmental Technologies (CCET) in supporting respective governments in developing plastic waste management strategies and action plans examine key technologies, environmental policies and practices adopted by the respective countries in more detail. Based on the results of country studies and other literatures, section 3 identifies more practical and evidence-based strategies and policy interventions to reduce marine plastic pollution by improving land-based plastic waste management systems. Finally, the report concludes by giving some recommendations in section 4.



Photo 1: Plastic wastes dispose to marine ecosystem in Maldives.

¹⁷ For more information about Basel Convention and its activities, <http://www.basel.int/Implementation/Plasticwastes/Overview/tabid/6068/Default.aspx>

¹⁸ G20 (2017) G20 Action Plan on Marine Litter. Annex to G20 Leaders Declaration, https://www.g20germany.de/Content/DE/_Anlagen/G7_G20/2017-g20-marine-litter-en.pdf?__blob=publication-File&v=3

¹⁹ G7 (2015) G7 Action Plan to Combat Marine Litter. Annex to the Leaders' Declaration, G7 Summit, 7-8 June 2015 and https://www.g7germany.de/Content/DE/_Anlagen/G7_G20/2015-06-08-g7-abschluss-annex-eng.pdf?__blob=publicationFile&v=6

²⁰ UNEP (2009): Marine Litter: A Global Challenge, Nairobi

²¹ COBSEA (2019): COBSEA Regional Action Plan on Marine Litter 2019. Secretariat of the Coordinating Body on the Seas of East Asia (COBSEA) and United Nations Environment Programme, Bangkok

2. Marine Litter - the Issue of Plastic Wastes from Land-based Sources

2.1 Sustainable waste management is critical to preventing global plastic pollution and marine litter

The annual plastic production in the world has increased approximately 200-fold from 2 million tonnes in 1950 to about 400 million tonnes of plastic at present^{22,23} (see Figure 1), which is expected to reach about 1.6 billion tonnes in 2050²⁴. As shown in Figure 2, the largest groups in overall non-fibre plastics production are Polyethylene (PE) (36%), Polypropylene (PP) (21%) and Polyvinyl-chloride (PVC) (12%). This is followed by Polyethylene Terephthalate (PET), Polyurethane (PUR) and Polystyrene (PS) (<10% each). Approximately 42% of all non-fibre plastics have been used for packaging industries, which is predominantly composed of PE, PP, and PET^{25,26}.

An estimation also revealed that about 2.5 billion tonnes of plastics (30% of all plastic ever produced) are currently in use and cumulative plastic waste generation during the period of 1950–2015 amounted to 8.3 billion tonnes. Of this, approximately 800 million tonnes (12%) of plastics were incinerated and 600 million tonnes (9%) were recycled (see Figure 3). Only 10% of this has been recycled more than once. Around 4.9 billion tonnes (60% of all plastics ever produced) was discarded and is accumulating in

landfills or the natural environment^{27,28}.

The data reveals that high-income countries, including most of Europe, North America, Australia, New Zealand, Japan and South Korea have the highest per capita rate of plastic waste generation, over 10 times higher than many low- and middle-income countries. While there is some variation among countries, per capita plastic waste generation tends to increase with the scale of economic progress in a particular country (see Figure 4). In general, per capita plastic waste generation in low- and middle-income countries tends to be notably smaller. However, this general relationship has little relevance when we consider mismanaged plastic waste, which is either littered or inadequately disposed plastic waste having a high risk of entering the ocean via wind, tidal transport or carried to the ocean from inland waterways. As shown in Figure 5, mismanaged plastic waste generation tends to be low in high-income countries, but high in low- and middle-income countries. This has typically occurred where countries have rapidly industrialized (allowing for significant economic growth towards the middle and high-income spectrum), but at a rate far exceeding progress in waste

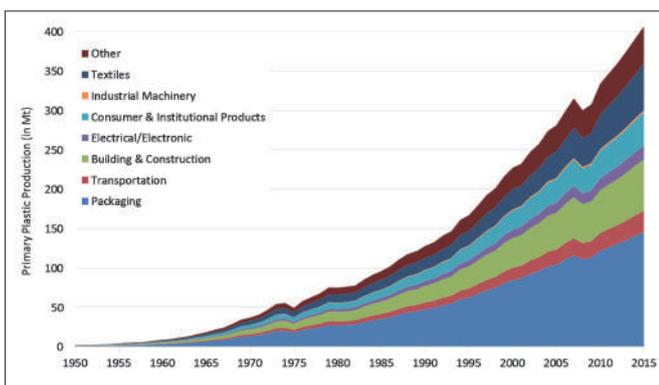


Figure 1: Global primary plastics production.
Source: Geyer et al., 2017²⁹

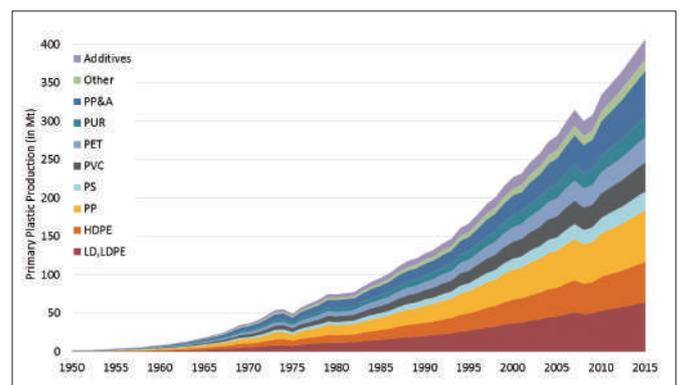


Figure 2: Different types of polymers.
Source: Geyer et al., 2017³⁰

22 Geyer, R, Jambeck, J. R, and Law, K. L (2017): Production, use, and fate of all plastics ever made, DOI: 10.1126/sciadv.1700782, *Sci Adv* 3 (7), e1700782.

23 Beckman E. (2018): The world's plastic problem in numbers, World Economic Forum, <https://www.weforum.org/agenda/2018/08/the-world-of-plastics-in-numbers>

24 EMF (2017): Rethinking the future of plastics and catalysing action. Accessed on 26 December 2018. https://www.ellenmacarthurfoundation.org/assets/downloads/publications/NPEEC-Hybrid_English_22-11-17_Digital.pdf

25 WEF (2016): The New Plastics Economy Rethinking the Future of Plastics; UNEP (2016): Marine Debris: Understanding, preventing and mitigating the significant adverse impacts on marine and coastal biodiversity; Geyer, R, Jambeck, J. R, and Law, K. L (2017): Production, use, and fate of all plastics ever made, DOI: 10.1126/sciadv.1700782, *Sci Adv* 3 (7), e1700782.

26 Beckman E. (2018): The world's plastic problem in numbers, World Economic Forum, <https://www.weforum.org/agenda/2018/08/the-world-of-plastics-in-numbers>

27 Geyer, R, Jambeck, J. R, and Law, K. L (2017): Production, use, and fate of all plastics ever made, DOI: 10.1126/sciadv.1700782, *Sci Adv* 3 (7), e1700782.

28 Jambeck, J. R, Geyer, R, Wilcox, C, Siegler, T.R, Perryman, M, Andrady, A, Narayan, R, Law, K.L (2015): Plastic waste inputs from land into the ocean. *Science* 347, 768–771

29 Geyer, R, Jambeck, J. R, and Law, K. L (2017): Production, use, and fate of all plastics ever made, DOI: 10.1126/sciadv.1700782, *Sci Adv* 3 (7), e1700782.

30 Geyer, R, Jambeck, J. R, and Law, K. L (2017): Production, use, and fate of all plastics ever made, DOI: 10.1126/sciadv.1700782, *Sci Adv* 3 (7), e1700782.

management systems. Waste management infrastructure has failed to keep pace with industrial and manufacturing growth, leading to higher rates of mismanaged plastic waste.

The global data also indicates that there is a wide gap in sharing mismanaged plastic waste among regions. As shown in Figure 6, the East Asia and Pacific region dominates in global mismanaged plastic waste, accounting for 60% of the world total. South Asia ranks second but contributes around five times less with 11% of the

total. This is followed by Sub-Saharan Africa (9%), Middle East & North Africa (8.3%), Latin America (7.2%), Europe and Central Asia (3.6%) and North America (1%). According to these global data, the fundamental role of improving the waste management in countries across Asia and the Pacific, which generate significant quantities of mismanaged plastic waste – altogether 71% of total production – is therefore crucial in tackling the issue of plastic pollution and marine plastic in the world.

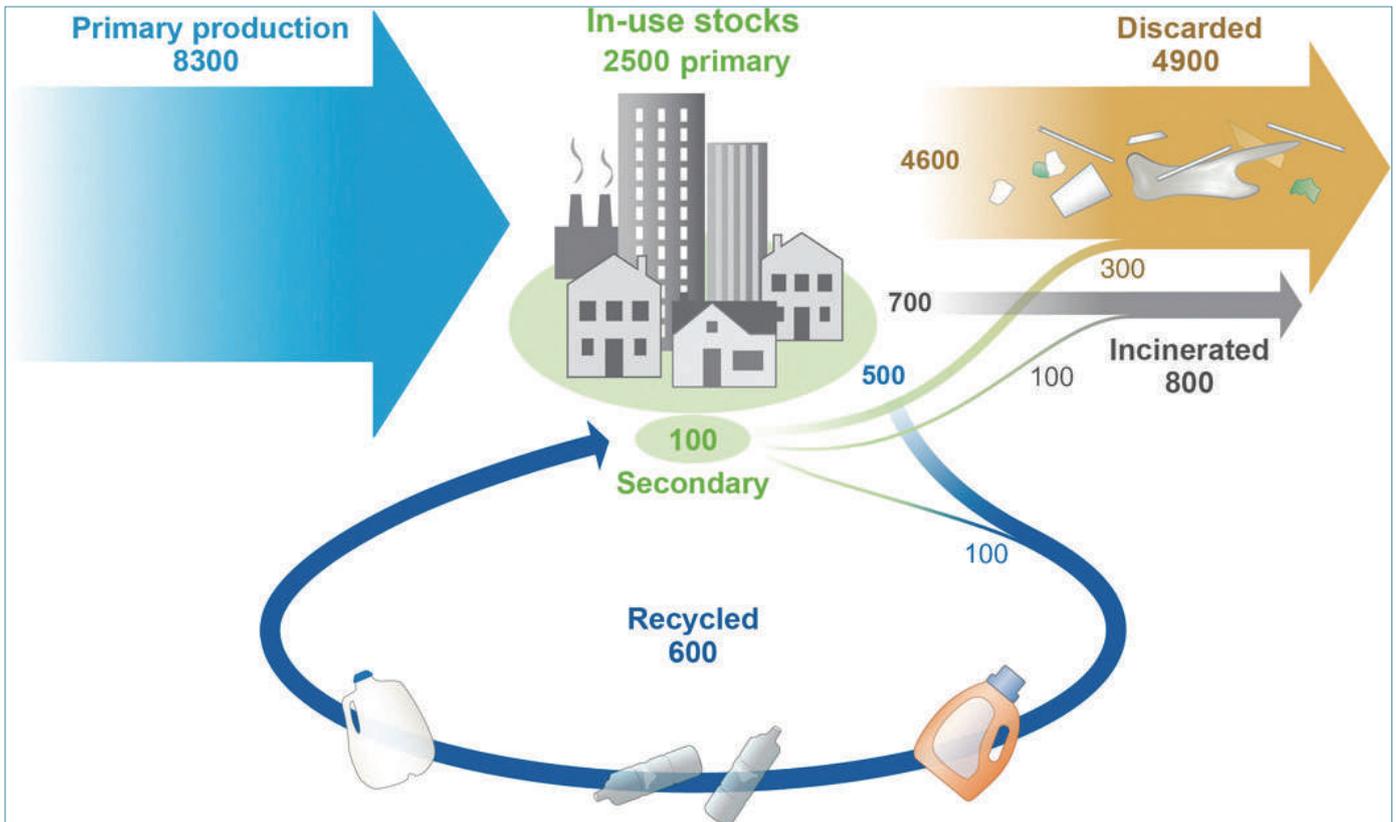


Figure 3: Global plastic production, use and treatment in million tonnes. Source: Geyer et al., 2017³¹

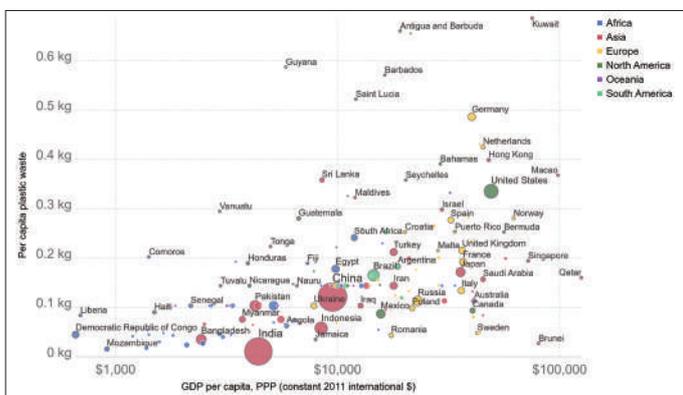


Figure 4: Per capita plastic waste vs GDP in selected countries. Source: Jambeck et al. (2015)³²; World Bank- WDI (2011)³³

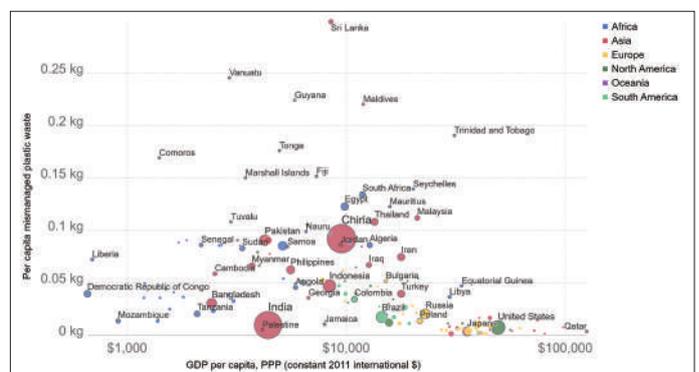


Figure 5: Per capita mismanaged plastic waste vs GDP in selected countries. Source: Jambeck et al. (2015)³⁴; World Bank- WDI (2011)³⁵

³¹ Geyer, R, Jambeck, J. R, and Law, K. L (2017): Production, use, and fate of all plastics ever made, DOI: 10.1126/sciadv.1700782, *Sci Adv* 3 (7), e1700782.

³² Jambeck, J. R, Geyer, R, Wilcox, C, Siegler, T.R, Perryman, M, Andrady, A, Narayan, R, Law, K.L (2015): Plastic waste inputs from land into the ocean. *Science* 347, 768–771

³³ World Bank (2011): World Development Indicators, Washington D.C.

³⁴ Jambeck, J. R, Geyer, R, Wilcox, C, Siegler, T.R, Perryman, M, Andrady, A, Narayan, R, Law, K.L (2015): Plastic waste inputs from land into the ocean. *Science* 347, 768–771

³⁵ World Bank (2011): World Development Indicators, Washington D.C.

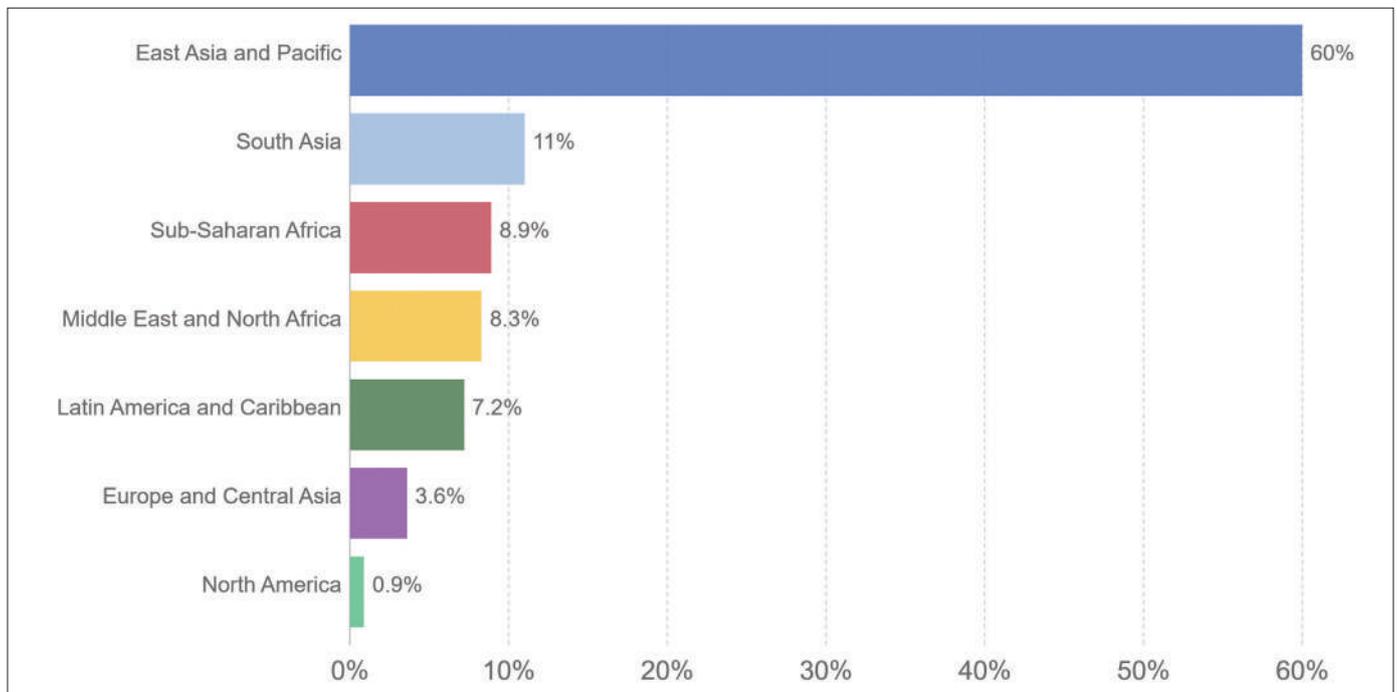


Figure 6: Global mismanaged plastic by region. Source: Geyer et al., 2017³⁶

2.2 Overview of plastic waste management in low- and middle-income countries in Asia and the Pacific - a review of case studies of India and Indonesia

The total municipal solid waste generation in Asia and the Pacific was estimated at about 870 million tonnes in 2014, with an average generation rate of 1.4 kilograms (kg) per person per day, accounting for 43% of the world total³⁷. This figure is expected to be 1.4 billion tonnes with a rate of 1.6 kg per person per day in 2030. While the organic component comprises the highest portion in the composition of municipal solid waste, accounting for 50–70% in low- and middle-income countries, the proportion of plastic waste is about 8–12% in those countries³⁸. Considering this composition, plastic waste generation in the region is expected to reach 140 million tonnes by 2030. In contrast, waste management in the region can be rated as low to moderate in general. Average waste collection rates are 44% in South Asia while 71% in East Asia and the Pacific³⁹. However, waste collection services approach 100% in more developed economies such as Japan, Australia, Republic of Korea and Singapore. Waste separation at source is a common practice in more developed countries while in low- and

middle-income countries there has been informal waste separation by waste pickers and transport to a facility for recycling. More than two-thirds of municipal solid waste is disposed at final disposal sites with or without sanitary operations⁴⁰. Considering the poor waste management system and infrastructure in the region, it is estimated that volumes of mismanaged plastic waste entering the ocean from the Asia and Pacific region will range from 2.3 to 6.4 million tonnes in 2030⁴¹.

Aiming to identify sources and seek practical solutions to address plastic waste mismanagement in the Asia and Pacific region, this report summarises the key findings from a more in-depth review of plastic waste generation and management policies, actions, existing technologies and innovations in India and Indonesia. These two countries were selected considering their presence and importance on the global level. Both countries are members of the G20 and belong to the Top 11 countries ranked by mass of mismanaged

³⁶ Geyer, R., Jambeck, J. R., and Law, K. I. (2017): Production, use, and fate of all plastics ever made, DOI: 10.1126/sciadv.1700782, *Sci Adv* 3 (7), e1700782.

³⁷ UNEP-IETC, AIT, ISWA (2017): Asia Waste Management Outlook, Osaka

³⁸ UNEP-IETC, AIT, ISWA (2017): Asia Waste Management Outlook, Osaka

³⁹ World Bank (2018): What a Waste 2.0 – A global snapshot of solid waste management to 2050, Washington DC

⁴⁰ World Bank (2018): What a Waste 2.0 – A global snapshot of solid waste management to 2050, Washington DC

⁴¹ Laurent C. M., Lebreton, J. V. Z., Willem, D., Boyan, S., Anthony, A., Julia, R (2017): River plastic emissions to the world's oceans, *Nature Communications*, Volume 8, 15611

plastic waste in global research⁴². In addition, CCET in partnership with UNEP-IETC has been supporting both countries to develop national and local waste management strategies, particularly focusing on plastic waste management and this helps with access to the relevant data, recycling facilities and key stakeholders. The information was gathered through a literature review, focus group discussions, and consultations with key stakeholders as well as field visits conducted during the period of August 2018 to March 2019.

2.2.1 India

Context

In 2008, approximately 8 million tonnes of plastic products were consumed in India, which rose to 12 million by 2012⁴³ and is expected to reach 22 million tonnes by 2020⁴⁴. The average annual per capita consumption of plastic in India was about 6–7 kg in 2012⁴⁵. However, a recent study gave a figure of about 11 kg in 2018, which is still low when compared to the global average of 28 kg⁴⁶. According to a Ministry of Petroleum and Natural Gas estimation, the annual per capita plastic consumption in India is anticipated to be 20 kg by 2022⁴⁷. About 35% of plastic consumption is in packaging, with 23% in building and construction. Other relevant categories are transport (8%), electronics (8%) and agriculture (7%). Consumption of plastics in consumer goods is growing at a fast rate, and much of this growth is likely to originate in rural areas⁴⁸.

It is also estimated that approximately 70% of total plastic consumed is discarded as waste. About 5.6 million tonnes per annum of plastic waste is generated in the country, which amounts to 15,342 tonnes per day⁴⁹. As per the Central Pollution Control Board (CPCB), plastic contributes 8% to the total waste generated⁵⁰, with Delhi producing the most followed by Kolkata and Ahmedabad⁵¹. Littering of single-use plastic waste especially plastic carrying bags is a major environmental and public health issue in India⁵². Plastic carry bags are often found in the environment, which degrades the city's aesthetics and leads to clogged drains, gutters, and rainwater vents, thereby creating flood-like scenarios even for sparse rainfall. They also pose a danger to stray animals, such as cattle and dogs, who are likely to consume

them.

In India, open dumping of plastic waste is a common practice. If municipal waste continues to be dumped at the current rate, it is estimated that about 1,240 hectares of additional land would be required every year as a landfill site⁵³, based on estimations of solid waste generation per capita of from 0.17 kg/person/day in small towns to about 0.62 kg/person/day in mega cities⁵⁴. In landfills, plastic degrades into its smaller components and leaches into the soil and water table, ultimately making its way into the food chain and causing massive health hazards. Uncontrolled landfills are a key source of groundwater contamination. Several Green House Gases (GHGs) are emitted from landfills, of which carbon dioxide and methane constitute altogether 90–98%⁵⁵. Plastic waste burning is another issue facing municipalities around the country. Thick black smoke (black carbon - BC) emanating from dumping grounds has become a common sight. These practices have been one of the key causes behind Delhi's smog situation and deterioration of air quality indices in cities such as Varanasi. While the National Green Tribunal (NGT) declared a ban on the burning of solid waste, announcing a fine of 25,000 INR on every incident of bulk waste burning in open spaces and 5,000 INR in the case of backyard burning, clearly a need for the government to better enforce this ban, as well as take initiatives to combat air pollution at the local level exists⁵⁶.

Policies, laws and regulations

In order to ensure environmentally friendly management of plastic waste in India, Plastic Waste Management Rules (PWA Rules) 2011 were developed under the 1986 Environment Protection Act. These Rules provide a regulatory framework for managing plastic waste in the country and assign responsibilities to urban local bodies (ULB)⁵⁷ for plastic waste management, as well as led to formation of a state-level monitoring committee. The Rules further addressed the issue of plastic carry bags (single-use plastics) by setting minimum standards for the thickness and a mandate for retailers to charge a fee for each plastic bag made available. Other key features of the PWM Rules, 2011⁵⁸ are:

- Plastic carry bags used for the purpose of carrying or dispensing commodities but excluding bags which are an

42 Jambeck, J. R., Geyer, R., Wilcox, C., Siegler, T.R., Perryman, M., Andrady, A., Narayan, R. Law, K.L. (2015): Plastic waste inputs from land into the ocean. *Science* 347, 768–771

43 CPCB (2013): Overview of Plastic Waste Management, New Delhi. <http://cpcb.nic.in/displaypdf.php?id=cGxhc3RyY3dhc3RlL2hhbmFnZWl1bnRfcGxhc3RyY3dhc3RlLnBkZg==>

44 TERI (No date): Challenges and Opportunities – Plastic waste management in India, New Delhi. http://www.teriin.org/sites/default/files/2018-06/plastic-waste-management_0.pdf

45 Sangawar, V.S., Deshmukh, S.S. (2012): A Short Overview on Development of the Plastic Waste Management: Environmental issues and challenges, *Sci. revs. Chem. Commun.*, 2(3), 349-354. <https://www.tsijournals.com/articles/a-short-overview-on-development-of-the-plastic-waste-management-environmental-issues-and-challenges.pdf>

46 TERI (No date): Challenges and Opportunities – Plastic waste management in India, New Delhi http://www.teriin.org/sites/default/files/2018-06/plastic-waste-management_0.pdf

47 TERI (No date): Challenges and Opportunities – Plastic waste management in India, New Delhi http://www.teriin.org/sites/default/files/2018-06/plastic-waste-management_0.pdf

48 MoDWS (No date): Solid and Liquid Resource Management: Plastic Waste Management (Draft implementation framework). http://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=2ahUKEwjx77uw-TdAhWafogKHSvKd00FjAAegQICRAC&url=http%3A%2F%2Fswachhbaratmission.gov.in%2FSLRM%2FDownload.aspx%3FFileName%3DRsource%2520book_Plastic%2520Waste%2520Management.pdf&usq=AOvVaw0S-r28C1m4Qj2MT6FJJ2K

49 Ghosh S (2018): India to galvanise greater action against plastic waste on World Environmental Day, MONGABAY. <https://india.mongabay.com/2018/04/16/india-to-galvanise-greater-action-against-plastic-waste-on-world-environment-day/>

50 CPCB (2013): Overview of Plastic Waste Management, New Delhi.

51 TERI (No date): Challenges and Opportunities – Plastic waste management in India, New Delhi. http://www.teriin.org/sites/default/files/2018-06/plastic-waste-management_0.pdf

52 Tammemagi, H Y. 1999. *The Waste Crisis: Landfills Incinerators and the Search for a Sustainable Future*. New York: Oxford University Press.

53 Ilangoan, R (2018): Will India Need a Landfill the Size of Bengaluru By 2030, *the Wire*; www.thewire.in; last accessed on May 29, 2018.

54 Kumar, S, Bhattacharyya J K, Vaidya A N, Chakrabarti T, Devotta S, and Akolkar A B. (2009): Assessment of the Status of Municipal SWM in Metro Cities, State Capitals, Class I Cities, and Class II Towns in India: An Insight'. *Waste Management* 29 (2): 883–95

55 Environmental Research Foundation (2018): The Basics of Landfills, Smithsonian: Landfills Affect Soil.

56 TERI (No date): Challenges and Opportunities – Plastic waste management in India, New Delhi. http://www.teriin.org/sites/default/files/2018-06/plastic-waste-management_0.pdf

57 Press Information Bureau (2011): Plastic Waste (Management and Handling) Rules, 2011; <http://pib.nic.in/newsite/PrintRelease.aspx?relid=69649>; last accessed on May 29, 2018.

58 MoEF (2016): Plastic waste management rules 2016. <http://moef.gov.in/division/environment-divisions/hazardous-substances-management-hsm/publications/>

integral part of packaged products. The bag thickness shall not be less than 40 µm.

- Carry bags can also be made from compostable plastics conforming to IS/ISO:17088:2008.
- The prescribed authority for registration, manufacture & recycling shall be State Pollution Control Board (SPCB) or Pollution Control Committee (PCC) and for enforcement of Rules relating to use, collection, segregation, transportation & disposal of plastic waste, shall be the Municipal Authority concerned.
- Multi-layered pouches or sachets used for packaging of gutkha, etc. shall not use plastic material in any form.
- Every carrying bag made from plastic shall bear a label or mark “recycled” as per IS:14534:1998. Each carry bag made from “Compostable Material” shall bear a label “Compostable” & shall conform to IS/ISO:17088:2008.
- No carry bag shall be made available free of charge by retailers to consumers. The concerned Municipal Authority may provide notification of the minimum price for carry bags in order to encourage re-use so as to minimise plastic waste generation.
- Each State Government shall establish a State Level Advisory (SLA) Body to monitor implementation of Rules.

The Plastic Waste Management Rules 2016⁵⁹, succeeding the 2011 Rules, were far more comprehensive and extended the purview and applicability to rural areas and plastic importers in the supply chain. Further, the minimum thickness of plastic carry bags was increased from 40 microns to 50 microns. The new Rules also mandated the Extended Producers Responsibility (EPR) to apply for collection of a fee from the producers and importers of plastic carrying bags or multi-layered packaging in order to strengthen the financial status of local authorities and, therefore, the plastic waste management system.

The 2016 rules were then further revised and extended into the Plastic Waste Management (Amendment) Rules 2018⁶⁰, with three major changes: (i) the term ‘non-recyclable multi-layered plastic’ was substituted by ‘multi-layered plastic which is non-recyclable or non-energy recoverable or with no alternate use’ (Section 9(3)); (ii) section 15 dealing with the pricing of carrying bags was omitted (the rules previously required vendors who made plastic bags available to register with the respective urban local body and pay an annual fee of 48,000 INR); and (iii) establishment of a centralized registration system by mandating brand owners and producers operating in more than two states to register with the CPCB.

In addition, the Indian government has pledged to ban all single-use plastics by 2022. This pledge was made by the Prime Minister, Narendra Modi at the World Environmental Day 2018⁶¹. At present, out of 29 states and 7 union territories in the country, 25 have already passed legislations on either complete or partial prohibition of the manufacture, stock, sale and use of plastics, especially plastic bags with thickness of less than 50 microns. For example, Haryana, Himachal Pradesh, Jharkhand, Meghalaya, Nagaland, Rajasthan, Sikkim, Tripura, Delhi and Chandigarh have enacted total bans on plastic bags. Gujarat, Kerala, Madhya Pradesh, Odisha, Uttar Pradesh and West Bengal have enacted bans in some areas within their states. However, some challenges in implementing the plastic ban regulations were also evident – the CPCB, a statutory body under the Ministry of Environment and Forests, has stated that plastic bags were still being sold and used in states where the ban is in place⁶². According to the President of All India Plastic Manufacturers Association (AIPMA), the plastic ban is not properly implemented because, “*Plastic is not the problem, littering is the issue that needs to be addressed*”. *In evolved economies, things are phased out over a period of years and not suddenly. We must check for alternatives before implementing the ban or we may end up introducing something even more harmful*”⁶³. Another plastic manufacturer said, “*Most Indian states use a top down approach with these bans. Retailers and end-users have not been educated or provided with alternatives*”⁶⁴.

Technologies and innovations

In India, the most popular technology for plastic waste management is mechanical recycling. About 9,205 tonnes of plastics, which correspond to approximately 60% of the total quantity generated, are recycled daily. Scrap dealers typically collect discarded PET bottles in India for 14–15 INR/kg. According to the data, about 90% of all PET bottles are recycled in India: 65% at registered facilities, 15% in the unorganised sector and 10% at homes⁶⁵. The typical treatment process includes shredding, washing and selling as flakes and for use in upholstery and apparel production. More than 40 large manufacturers use recycled PET as a raw material. Flakes are sold to them for 50–100 INR/kg. The recycling business for PET alone is estimated to be worth 3,000–4,000 INR Cr annually⁶⁶.

In addition, other technologies have been developed and applied to manage plastic waste. For example, utilisation of plastic waste for road construction is being carried out in various cities. In this process, plastic waste is first segregated (except chlorinated/

59 MoEF (2016): Plastic waste management rules 2016. <http://envfor.nic.in/sites/default/files/PWM%20amendment%20english%202018.pdf>

60 MoEF (2016): Plastic waste management rules 2016. <http://envfor.nic.in/sites/default/files/PWM%20amendment%20english%202018.pdf>

61 Carrington, D (2018): India will abolish all single-use plastic by 2022, vows Narendra Modi, the Guardian. <https://www.theguardian.com/environment/2018/jun/05/india-will-abolish-all-single-use-plastic-by-2022-vows-narendra-modi>

62 Jestin, P (2018): India's plastics ban faces implementation hurdles, BORDERLESS. <https://www.borderless.net/indias-plastics-ban-faces-implementation-hurdles/>

63 Jestin, P (2018): India's plastics ban faces implementation hurdles, BORDERLESS. <https://www.borderless.net/indias-plastics-ban-faces-implementation-hurdles/>

64 Jestin, P (2018): India's plastics ban faces implementation hurdles, BORDERLESS. <https://www.borderless.net/indias-plastics-ban-faces-implementation-hurdles/>

65 Chatterjee, B (2017): India recycles 90% of its PET waste, outperforms Japan, Europe and US: Study, Hindustantimes. <https://www.hindustantimes.com/mumbai-news/india-recycles-90-of-its-pet-waste-outperforms-japan-europe-and-us-study/story-yqphS1w2GdlwMYPgPtyb2L.html>

66 MoDWS (No date): Solid and Liquid Resource Management: Plastic Waste Management (Draft implementation framework). http://www.google.com/url?sa=t&ret=j&q=&esrc=s&source=web&cd=1&ved=2ahUKewjgx77uw-TdAhWafogKHSvKDd0QFjAAegQICRAC&url=http%3A%2F%2Fswachhbaratmission.gov.in%2FSLRM%2FDownload.aspx%3FFileName%3DRsource%2520book_Plastic%2520Waste%2520Management.pdf&usg=AOvVaw0S-r28C1m4I0i2MT6FJ2K

brominated plastic waste) and then shredded into a particular size (2–4 mm). The shredded plastic waste is then added to the aggregate and the bitumen is heated to 160°C to enable good binding. Since the construction of Jambulingam Street in Chennai, which was India's first plastic road in 2002, CPCB has been supporting the use of waste plastic in making rural roads. Over 2015–2016, the National Rural Road Development Agency laid around 7,500 km of roads using plastic waste and more than 33,800 km of plastic roads exist in India today. According to estimations, for every km of road (3.75 m width), one tonne of plastic (1,000,000 carrying bags) is used and this can serve to mitigate plastic waste considerably and ensure petrochemical resource conservation.

Another technology is co-processing of plastic waste as Alternative Fuel and Raw Material (AFR) in cement kilns and power plants. Co-processing refers to the use of waste materials as an alternate fuel or raw material in industrial processes such as cement plants. Separated plastic waste from other MSW can be utilised as an alternate fuel or raw material, thus substituting the use of coal. Co-processing of plastic waste offers advantages for both the cement industry as well as municipal authorities responsible for waste management – for example, cement producers or power plants can save on fossil fuel and raw material consumption, contributing to more eco-efficient production, and municipal authorities benefit by using the recovery method and eliminating plastic waste disposal in open landfills. However, the use of these energy sources calls for an assessment of various factors, such as the availability of processing technology, economic viability, potential environmental and health impacts, and CO₂-emission reduction. Waste materials cannot always be combusted in the plant as received owing to their mixed nature, necessitating further pre-processing to transform the waste to suit the chemical and physical specifications acceptable to kilns. This includes calorific and/or material value, water content, ash content, and concentration of sulphur, chlorine, and heavy metals, which can affect the overall performance of the cement plant. Thus, the CPCB has prescribed guidelines on the co-processing of plastic waste as an alternate fuel⁶⁷.

In addition, plastic waste to oil is currently in the experimental stage. The Indian Institute of Petroleum (IIP), one of the constituent laboratories of the Council of Scientific and Industrial Research (CSIR) laboratory in Dehradun, developed a model project that can be used for conversion of plastic waste, such as polyethylene and polypropylene to fuel oils, either gasoline or diesel. The technology can convert one kg of plastic to 700–750 ml of automotive grade gasoline⁶⁸. Rudra Environmental Solutions in Pune has designed

and developed a pyrolysis plant where one tonne of plastic waste can be converted to 600–650 litres of fuel at an approx. 60% conversion rate. M K Aromatics Ltd. has set-up another two plants in Goa to convert plastic waste to fuel. Hydroxy systems Pvt. Ltd. Hyderabad, has also adopted a different technique in the production of fuel oil from plastic waste. It has been claimed that the process is safe, controllable, and pollution-free and holds the approval of the State Pollution Control Board. The facility has the capacity to convert around 13–15 tonnes of plastic waste per month into approximately 500 litres of fuel. The oil produced from the pyrolysis process is comparable to conventional diesel. Therefore, this may be an effective way to recycle plastic waste into fuels. In comparison with many developed countries, India has yet to generate a business model for the conversion of plastic waste to fuel.

2.2.2 Indonesia

Context

In Indonesia, the per capita consumption of plastic is about 17 kg, which is comparatively lower than some other ASEAN nations such as 35 kg in Malaysia, 40 kg in Thailand and Singapore, and 41 kg in Vietnam^{69,70}. However, with a population of 250 million, as the fourth most populous country and second-largest plastic polluter in the world after China, Indonesia produces 3.2 million tonnes of unmanaged plastic waste a year, 1.29 million tonnes of which ends up in the sea⁷¹.

The crisis of plastic waste has also affected Indonesian rivers and the ocean. Data from Nature Communications revealed that four of Indonesia's rivers – Brantas, Solo, Serayu and Progo – rank among the 20 most polluted rivers in the world. Meanwhile, plastic waste choking rivers deprive local communities of their source of food and water. Clogged rivers also increase flooding, which could cause damage to surrounding communities⁷². Most plastic waste ends up in landfills in Indonesia, with Bantar Gebang, the largest landfill in Jakarta receiving more than 5,000 tonnes of solid waste every day. These landfills pollute the groundwater as chemicals seep into the ground and eventually make their way to rivers and lakes. Landfills also emit methane gas, which is known to contribute to air pollution⁷³.

Policies, laws and regulations

The Indonesian government has recently adopted Indonesia's Plan of Action on Marine Plastic Debris 2017–2025 aiming to reduce marine plastic debris by 70% by 2025⁷⁴. The action plan aims to achieve prevention of marine litter at source, coordination between

⁶⁷ CPCB (2017): Guidelines for Co-processing of Plastic Waste in Cement Kilns (As per Rule 5(b) of Plastic Waste Management Rules, 2016). New Delhi. http://cpcb.nic.in/uploads/plasticwaste/Co-processing_Guidelines_Final_23.05.17.pdf

⁶⁸ Press Information Bureau (2017): Plastic Converted in to Petrol. <http://pib.nic.in/newsite/PrintRelease.aspx?relid=169476>

⁶⁹ BPF (2015): Indonesia Report 2015. http://bpf.co.uk/exporters_toolbox/indonesia-report-2015.aspx

⁷⁰ GIZ (2018): Managing Packaging Waste in the ASEAN Region: From linear to Circular Packaging Value Chains, Circular Economy Briefing Series, Bonn. https://www.giz.de/de/downloads/giz2018_ASEAN-Packaging-Waste_web.pdf

⁷¹ World Bank (2018): Indonesia Marine Debris Hotspot – Rapid assessment. <http://documents.worldbank.org/curated/en/983771527663689822/pdf/126686-29-5-2018-14-18-6-SynthesisReportFullReportAPRILFINAL.pdf>

⁷² Arifin E (2018): Indonesia's plastic waste problem. The Asean Post. <https://theaseanpost.com/article/indonesias-plastic-waste-problem-0>

⁷³ Arifin E (2018): Indonesia's plastic waste problem. The Asean Post. <https://theaseanpost.com/article/indonesias-plastic-waste-problem-0>

⁷⁴ The Government of the Republic of Indonesia (2017): Indonesia's National Plan of Action on Marine Plastic Debris 2017-2025 – Executive Summary. <http://www.indonesianwaste.org/en/indonesias-national-plan-of-action-on-marine-plastic-debris-2017-2015-executive-summary-2/>

institutions responsible for waste management, and application of science-based technology to control plastic waste. It has five main pillars of focus: 1) improving behavioural change, 2) reducing land-based leakage, 3) reducing sea-based leakage, 4) reducing plastics production and use, and 5) enhancing funding mechanisms, policy reform and law enforcement. It calls for actions at local, national and international levels and addresses the roles and responsibilities of the plastic industry as well as academia and community-based organisations. In order to achieve the 70% reduction goal, the Indonesian government has pledged to contribute 1 billion USD annually, according to Indonesia's coordinating minister for maritime affairs as presented at the 2017 World Oceans Summit in Nusa Dua, Bali⁷⁵.

In addition, Indonesia has made some efforts to reduce plastic use by imposing a 200 Rupiah (0.02 USD) tax on single-use plastic carry bags. This paid plastic carry bag programme was piloted in 2016 as an agreement between the Ministry of Environment and Forestry (KLHK), National Consumer Protection Agency, Indonesia Consumers Foundation (YLKI) and the All Indonesian Retail Entrepreneurs Association. The programme in general was well received in the initial stage, with some local governments even setting higher prices than the nationally set price, e.g., Balikpapan city government applied a price of 1,500 Rp per bag and Makassar set a price of 4,500 Rp. The programme also achieved a 55% reduction in plastic waste over the three months it ran, according to Indonesia Plastic Bag Diet Movement, an advocacy group. However, retailers refused to extend the pilot programme after three months citing impacts on their business and weak legal basis. Critics also pointed out that the charge was not high enough to deter consumers. On the other hand, consumers complained about the lack of clarity over management of proceeds from the sales of plastic bags by the retailers, since the individual retailers themselves managed the funds generated from the paid plastic bags programme. Meanwhile, the government has a plan to impose a new tax targeting the producers of plastic bags rather than consumers. Exact figures have not been released yet, but observers are sceptical of its impact on plastic use⁷⁶.

The Indonesian government is also set to make a more comprehensive policy framework for consumer goods manufacturers to take more responsibility for managing the waste from their product packaging. The regulation, expected before the end of this year, is part of a wider effort to reduce Indonesia's waste by 30% by 2025 from current levels, according to the head of waste management in the KLHK⁷⁷. The so-called EPR regulation will oblige producers and retailers to redesign their product packaging

to have a higher proportion of recyclable material. It will also require them to take greater responsibility for the management of waste from their products. Those affected will include makers of processed foods and beverages, who rely heavily on plastic packaging for their products. Retailers such as supermarkets and convenience stores will also be subject to the EPR requirements in terms of the packaging options they offer customers, as will food and beverage outlets that currently use plastic utensils, plates and cups. It was found that while an EPR requirement already exists under the Waste Management Act of 2008, the challenge remains as to its implementation and proper enforcement.

In addition to the above national efforts, some cities have taken local actions to address plastic waste. For example, Surabaya, Indonesia's second-largest city introduced a new initiative in April 2018 to encourage residents to recycle plastic waste by offering free bus rides in exchange for used plastic bottles⁷⁸. Under this scheme, residents can ride red city buses by dropping off plastic bottles at terminals or directly 'paying' a fare with bottles. A two-hour bus ticket costs 10 plastic cups or up to five plastic bottles, depending on size, which the city hopes will help it meet an ambitious target of becoming free of plastic waste by 2020. Surabaya is the first city in Indonesia to implement this scheme. According to city data, 15% (about 400 tonnes) of Surabaya's daily waste is plastic. At present, the project collects about 250 kg of plastic bottles a day, which is about 7.5 tonnes a month. After collection, labels and bottle caps are removed from the waste, which are then auctioned off to recycling companies. The income earned from sales of plastic bottles is used for bus operations and funds for green spaces in the city. Further, many local governments organise clean-up actions in partnership with private and civil society with the aim of socialisation and education of plastic waste and its damage to the environment. Some local governments have led several proactive initiatives, including plastic bag bans, in several localities, such as Banjarmasin City, Balikpapan City, Bogor City, and Bali Province. According to a report by the Jakarta Post, Bali has enacted a ban on single-use plastics (shopping bags, styrofoam and straws) in efforts to curb pollution in its waters by reducing 70% of Bali's marine plastics by 2019⁷⁹.

Technologies and innovations

Increasing the rate of material recovery and recycling is one of the fundamental ways to address the local plastic industry's dependence on imports while at the same time tackling the pressing issue of municipal waste in Indonesia. At present, Indonesia imports over 40% of its plastics, most arriving from Singapore, Malaysia, Thailand, Europe, and the United States⁸⁰ and primary

⁷⁵ Langenheim, J (2017): Indonesia pledges 1 billion USD a year to curb ocean waste, the Guardian. <https://www.theguardian.com/environment/the-coral-triangle/2017/mar/02/indonesia-pledges-us-1-billion-a-year-to-curb-ocean-waste>

⁷⁶ Ariffin E (2018): Indonesia's plastic waste problem. The Ascan Post <https://theascanpost.com/article/indonesias-plastic-waste-problem-0>

⁷⁷ Gokkon, B (2018): Indonesia leans on businesses to do more about plastic waste, MONGABAY. <https://news.mongabay.com/2018/11/indonesia-leans-on-businesses-to-do-more-about-plastic-waste/>

⁷⁸ Wardoya, P (2018): Plastic to ride: Indonesians swap bottles for bus tickets. REUTERS. <https://www.reuters.com/article/us-indonesia-environment-plastics-bus/plastic-to-ride-indonesians-swap-bottles-for-bus-tickets-idUSKCN1MX10D>

⁷⁹ CAN (2018): Bali bans single-use plastics, aims to cut marine plastics by 70%: Report. <https://www.channelnewsasia.com/news/asia/bali-bans-single-use-plastics-aims-to-cut-marine-plastics-by-70-11062738>

⁸⁰ BPF (2015): Plastics and Rubber Indonesia 2015 Post Show Report. <http://www.bpf.co.uk/article/plastics-and-rubber-indonesia-2015-post-show-report-973.aspx>

consumer usages of purchased plastic are food and beverage packaging, followed by agricultural, automotive, and electronics sectors. In order to grow the country's economy the Indonesian government has focused on cultivating domestic plastic production. According to the Indonesian Packaging Association, food packaging accounts for 70% of plastic consumption. However, this move needs to address two main concerns – regulatory mechanisms to control the import of plastic from outside, which in particular are increasing since 2017 when China announced a new import policy permanently banning the import of nonindustrial plastic waste, and improvement in the domestic recycling system⁸¹.

Plastic recycling is still in its early stages in Indonesia due to a lack of supporting infrastructure for plastic waste collection, processing and recycling. The plastic recycling business is mostly handled by informal, community-based, small-scale enterprises. Estimates of the plastic waste recycling rate in Jakarta range from about 24–29% while the remaining 71–76% goes to landfill⁸². The same study also identified that Jakarta recovers 34–43% of plastic waste at source through scavengers and waste banks, called Bank Sampha, which is a community-based mechanism for collecting sorted inorganic waste including plastic waste of economic value. Set up in neighbourhoods typically for each 100–1,000 residents, waste banks are usually run by people on low incomes as an income supplement. Bank customers bring separated plastic waste to the banks where it is treated as a deposit, and transactions are recorded preferably in a bankbook of the customer's or in lists kept by the bank. The waste banks sell the deposited plastic materials to buyers for reuse or recycling, thus waste deposits are transformed into a currency that can be withdrawn when needed after a contribution of about 10–15% is deducted to cover the bank's operating costs⁸³.

National interest in increasing plastic recycling is also growing, through use of modern, larger-scale recycling facilities, as illustrated by the case of PT Enviro Pallets, which recently set up a plant in Bali handling around 30 tonnes of household and industrial waste per day, which is turned into plastic pallets⁸⁴. With most plastic waste still disposed of in landfills and accelerating private consumption, there is plenty of room for growth. Investing in environmentally sustainable solutions is also a prudent measure for plastic manufacturers in anticipation of growing environmental awareness among the Indonesian population.

Further, the government of Indonesia has also been experimenting with new technologies such as converting plastic scraps into road materials. Plastic roads comprised of shredded, melted plastic waste mixed with road tar are being promoted as an inexpensive,

more durable surface than standard roadways, and are considered as a good alternative to discarding through landfilling while also avoiding clogged waterways. In July 2017, Indonesia conducted its first plastic road test with a 700-m stretch at Udayana University in Bali. Officials now plan to use the dump mix on urban roads in Jakarta, Bekasi and Surabaya. Volumes of plastic pollution in Indonesia are estimated to increase to nearly 9.52 million tonnes, or about 14% of the country's waste, by 2019. If each km of road requires 2.5–5 tonnes of plastic waste, this results in potential paving for 190,000 km of roads. The plastic-road project is a joint effort between the Coordinating Ministry for Maritime Affairs and the Ministry of Public Works and Housing. According to Safri Burhannudin, a deputy minister at the coordinating maritime ministry, these two agencies will be working with the Indonesian Plastic Recycling Association (Adupi) to collect and sort waste in 16 large cities in the future^{85,86}.

2.2.3 Discussions - key challenges and opportunities

The review of case studies identified that both countries have made some progress at national and local levels to introduce new policies, technologies and innovations in order to manage plastic waste and reduce its negative impacts to the environment, including marine ecosystems. Some of the common features are summarised below.

- Plastic as a waste category comprises on average 8–12% of total municipal solid waste in both countries. Even though, the biggest challenge is still organic waste, which represent the largest share of the waste produced by these countries, the total volume of plastic waste, mainly packaging wastes, has grown rapidly in past decades due to population growth and changes in consumption and production patterns and there is no adequate system nor infrastructure in place to properly manage this fast growing waste stream.
- Local governments are responsible for managing plastic waste along with other municipal wastes in the cities. Both countries have set national regulations for separated waste collection, though plastic waste separation at source is often non-existent or rarely practiced in either country due to insufficient financial capacity, inadequate organisation and equipment, lack of competency or experience, as well as low general public awareness or interest in separating waste at source.
- Informal, decentralised or community-based plastic waste collection systems are well established in both countries, such

⁸¹ Brooks, A. L., Wang, S., Jambeck, J. R (2018): The Chinese import ban and its impacts on global plastic waste trade. *Science Advances*, Vol 4 (6), eaat0131. <http://advances.sciencemag.org/content/4/6/eaat0131.full>

⁸² Putri, A. R (No date): Plastic waste management in Jakarta, Indonesia: Evaluation of material flow and recycling scheme, http://www2.ges.kyoto-u.ac.jp/wp-content/uploads/2018/05/30.Anissa-Ratna-Putri_E.pdf

⁸³ Premakumara, D.G.J, Eddy S. S, Kataoka, Y, and Nurina F (2016): Transition from Waste Management to Resource Management: A Potential of Waste Bank Program in Indonesian Cities, *JSM Environ Sci Ecol* 4(4): 1037

⁸⁴ Jelita, A (2015): Producing durable pallets from recycled plastic waste, Indonesia expat. <https://indonesiaexpat.biz/business-property/business-profile/producing-durable-pallets-from-recycled-plastic-waste/>

⁸⁵ Adebayo, Z (2018): New road material reducing plastic pollution in Indonesia, the Borgen Project. <https://borgenproject.org/tag/plastic-pollution-in-indonesia/>

⁸⁶ Wright T., Waddell, S (2016): How can Indonesia win against plastic pollution?, *the Conversation*. <https://theconversation.com/how-can-indonesia-win-against-plastic-pollution-80966>

as Waste Banks in Indonesia and Dry Waste Collection Centres (DWCC), Swachh Auto Tippers and Self-help Groups in India, which are playing an important role in extracting some high value plastic materials at households or points of collection or transfer stations. The analysis revealed an extraction rate of plastic bottles (PET bottles) in India by the informal sectors of about 90%, which is higher than the formal recycling rate for PET in advanced countries such as Japan (72.1%), Europe (48.3%) or the USA (31%).

- No accurate official data gathering takes place for monitoring and evaluation regarding amounts of plastic recovered or disposed, and most of the valuable and non-valuable, such as single-use plastic (such as plastic carry bags) are frequently mixed with other municipal waste which ends up at open disposal sites, or is openly burnt or littered.
- Both countries have made some progress, at varying scales and with different levels of success, in establishing plastic material recovery, recycling and treatment systems and infrastructure, such as mechanical recycling, use of plastic waste for rural road construction, chemical and thermal recycling (plastic to oil), and energy recovery (plastic to cement kilns).
- However, the current recycling and treatment industries face many challenges, despite their potential to handle plastic waste. For example, (1) poor waste segregation and collection (lack of proper waste segregation results in some valuable plastic waste being mixed with organic waste and becoming too wet and unsuitable for recycling and treatment methods), (2) business viability or lack of financial sustainability (the investment and operational costs of the recycling and treatment plants remain high and often owners fail to recoup costs through income generation from the source without public subsidies), (3) environmental concerns (most plants have environmental risks as there are hazardous by-products involved during the process and lack of emission and environmental standards and guidelines for monitoring and enforcement), and (4) social concerns (public protests occur against the operation of existing plastic recycling and treatment plants and construction of new plants in the proximity of residential areas (i.e., “NIMBY”: Not-In-My-Back-Yard) due to concerns over environmental pollution and lack of regulatory and enforcement mechanisms).
- Both countries have also adopted some policies, rules and regulations to address plastic waste and marine litters. For example, the Plastic Waste (Management and Handling) Rules 2016 (amended in 2018) in India and Presidential Regulation No. 97/2017, Solid Waste Management National Policy and Strategy (2017–2025) in Indonesia. These national policies and regulations set legal frameworks and policy directions for local governments and others in setting up sustainable plastic waste management systems including infrastructure



Photo 2: Different types of plastic use in developing countries

for segregation, collection, storage, transport, processing and disposal in partnership with public and private sectors. The case study countries have also developed specific strategies and action plans to tackle land-based plastic pollutions and marine plastics. For example, Indonesia launched its National Action Plan on Marine Debris (2017-2025) that calls for efforts to reduce its plastic debris by 70% from a 2017 baseline by the end of 2025. However, both countries are facing similar challenges in terms of effective implementation, monitoring and enforcement of these policies, laws, regulations and strategies.

- The case study countries have also laid down some specific regulatory measures to prevent or ban plastic waste generation at source. For example, setting a minimum thickness of plastic carry bags of 50 microns in India and imposing a plastic bag tax (200 rupiah/ 0.01 USD per bag) on a trial basis in 23 cities in 2016 in Indonesia. India’s government has also pledged to ban all single-use plastics by 2022 and about 25

states and unions have already passed legislations on either completely or partially banning the manufacture, stock, sale and use of plastics, particularly plastic bags with thickness of less than 50 microns. In Indonesia, cities such as Banjarmasin, Balikpapan, Bogor, Bali and Bandung (only use of styrofoam) have banned the use of plastic bags at retailers to reduce the amount of plastic waste produced. However, the experiences of the case study countries and the cities therein have shown that implementation of single-use plastic or plastic bag banning policies and measures come with many challenges, such as finding alternatives to plastics, public awareness raising and education to change attitudes, and lack of enforcement and monitoring mechanisms.

- Plastic production and packaging industries in both countries still follow a linear model of excavation/production, retail/consumption and disposal rather than a circular economy of reduce, reuse and recycle. Due to the absence of proper implementation of EPR mechanisms (though both countries have some regulations), post-consumer plastic waste management is the responsibility of local governments, which often lack sufficient infrastructure and resources to carry this out. Both countries have therefore made some attempts

to introduce EPR principles in order to oblige producers to manage their non-decomposable product packaging. For example, Indonesia has included the EPR concept in its Waste Law 18/2008 and EPR has been added to the Plastic Waste Management Rules 2016 in India as a policy measure. In practice however, EPR has not been fully applied in either country.

- Strengthening overall municipal solid waste management systems based on the principles of circular economy, resource efficiency and waste hierarchy (3Rs) is therefore essential to address plastic waste in the respective countries. Experience has shown, however, that sustainable plastic waste management can be better integrated if policy makers address both physical and governance components in integrated waste management. The physical components include plastic waste collection (reduce public health hazards), treatment and disposal (reduce environmental impacts) and 3R (reduce, reuse and recycle) to achieve a resource efficient and circular economy. The governance component includes inclusivity of all key stakeholders in decision making, financial sustainability for recovery of operating and investment costs, and institutions and policies to create an enabling environment.



Photo 3: Informal workers are separating valuable plastic materials from the secondary collection points.

3. Sustainable Plastic Waste Management Strategies and Policy Interventions to Prevent Marine Plastic Waste from Land-based Sources

Based on the experiences from the country case studies and elsewhere⁸⁷, a list of seven strategies and a number of policy interventions to prevent plastic-waste pollution from land-based sources in low- and middle-income countries are identified and discussed in this section (Figure 7). These proposed strategic measures and policy interventions are aimed at mitigating the flow of plastics into the ocean along the plastic value chain, including reducing plastic production, providing innovative materials and product design, reducing plastic waste generation at source,

and improving waste management to reduce plastic leakage in a holistic manner. The remainder of this chapter describes those strategic actions and policy interventions with the highest potential to reduce plastic pollution over the short-, medium- and long-term. The strategic actions are presented under five policy interventions: regulatory, economic, technology, data/information and voluntary measures. However, there is no one-size fits all solution. Proposed time-frame and actions need to be tailored to local situations.

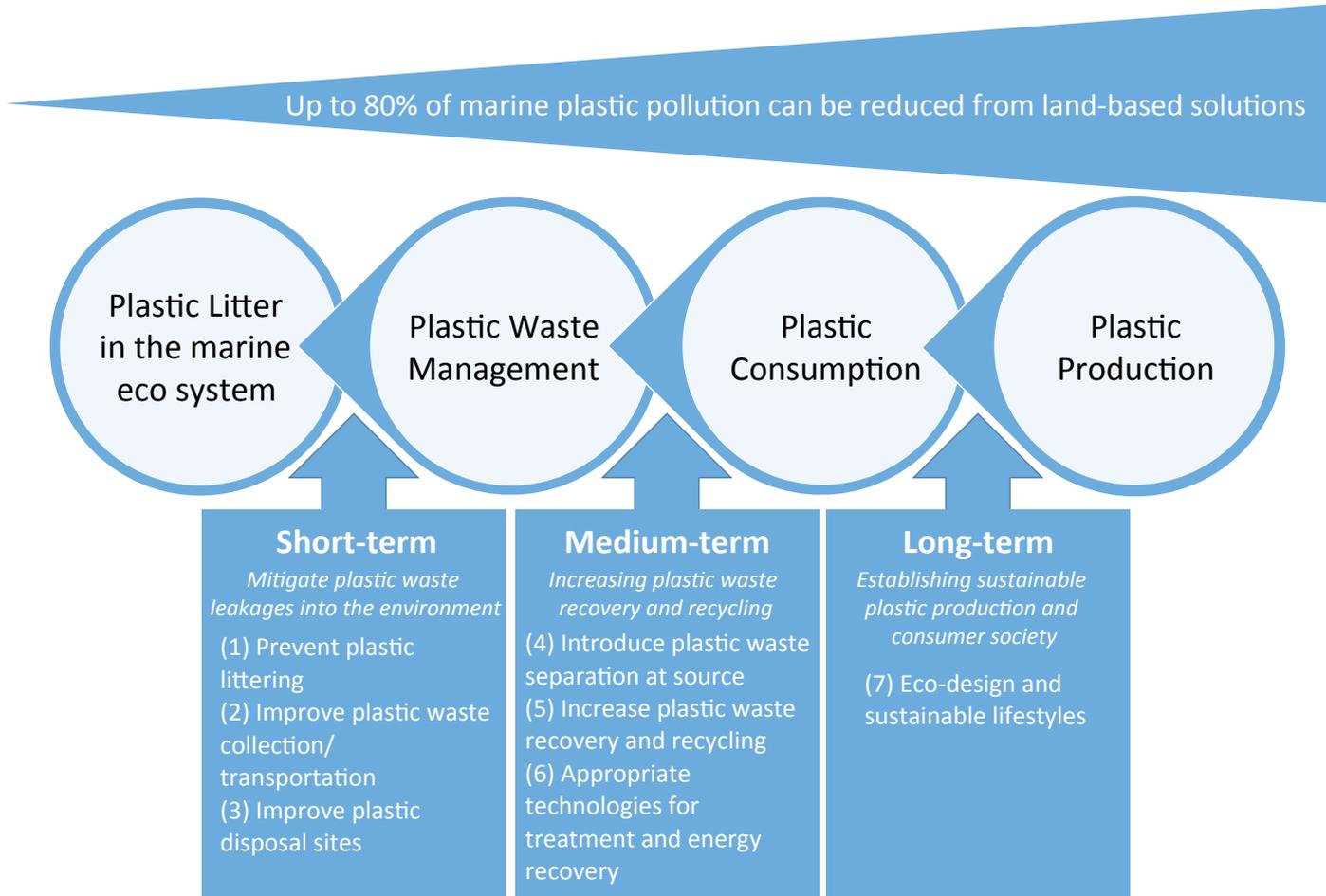


Figure 7: Proposed strategic actions to reduce marine waste from land-based sources through sustainable waste management approach. Source: Authors by 2019

⁸⁷ Such as; A Roadmap to 2025 - The UK Plastics Pact; Malaysia's Roadmap towards Zero Single-use Plastics, 2018-2030; Canada-wide Action Plan on Zero Plastic Waste; National Strategy - Plastic Waste Management and Recycling in Albania; Plastic Waste Management in Singapore; A Plastics Roadmap for Finland.

3.1 Short-term strategy - mitigate plastic waste leakages into the environment

Context

Plastic waste leakage into the environment occurs due to unsustainable waste management systems, such as littering of plastic waste by residents, poor waste collection and transportation methods and unsanitary waste disposal. Plastic waste littering is one of several serious issues in low and middle-income countries. Due to poor street sweeping and waste collection services, discarded plastics often end-up in drains and, in due course, streams and rivers or in the case of coastal areas, directly into the sea. The utilisation of extensive, efficient street sweeping and waste collection services, including a number of suitability located public bins and street cleaning operations, will therefore be necessary to prevent littered plastic. However, street sweeping and litter clearing is not an easy task without cooperation of the public. It also poses a huge financial burden on local governments – a recent study in the UK indicated that it costs local authorities about 800 million GBP, with a wider economic cost of over 1 billion GBP⁸⁸.

Plastic waste also leaks into the environment through the operation of waste collection and transportation, such as disorderly collection practices, unmanaged transfer or temporary collection points or use of uncovered vehicles to transport the waste to treatment facilities or disposal sites. Providing effective and adequate waste collection services in low- and middle-income countries could significantly reduce quantities of plastic wastes leaked into the marine environment. The estimation shows that if a municipal waste collection rate of 80% could be achieved in Asia, the yearly worldwide contribution of plastic into the ocean could be reduced by more than 45%⁸⁹. In general, waste collection involves the responsibilities related to street sweeping, primary waste collection from households, secondary collection from temporary disposal points or transfer stations and transport to final disposal sites. The two main systems exist for collection of the majority of municipal waste including single use packaging are kerbside collection (house-to-house) and communal collection. However, while respective local governments are responsible for providing waste collection services to their residents, most local governments in low- and middle-income countries have failed to carry out these duties due to the lack of capacity in terms of waste collection and transport vehicles, equipment and staff.

The informal, micro-enterprises or community-based organisations play a key role in the plastic waste collection in low and middle-income countries. These groups collect plastic waste by visiting door-to-door or temporary collection points and purchase them for

recycling. In addition, there are some cases where households are educated to bring the separated plastic wastes to specified centres, such as Waste Banks in Indonesia and Dry waste Recycling Centres in India. However, the informal sector is often marginalized and encounters many challenges. Informal waste collectors often work in extremely hazardous environments and unhealthy conditions. In addition, these groups only collect high-value and marketable (easy to sell materials) such as PET bottles while ignoring low-value materials such as single-use plastic packaging, which are disposed and thus increases littering around containers or open disposal sites. Plastic waste management policies and planning in low and middle-income countries therefore need to consider integration of the informal sector by creating more sustainable organisational structures such as co-operatives, small enterprises or social businesses and establishing related infrastructure, such as sorting platforms at transfer stations or landfill sites to raise the level of participation of the informal sector in preventing plastic marine litter.

Plastic waste also require consolidation and transport before it is processed. Plastics are comparatively lightweight, and in the case of packaging, contain trapped air, which reduces the efficiency of collection vehicles. Baling is a common method following delivery of loose material to an intermediate local transfer station. This allows articulated bulk road vehicles to become a cost-effective method of transport. In low and middle-income countries where transfer stations with compaction may not be available, or where the distance to reprocessing facilities is far, plastics are often not collected and transport is not cost effective, meaning waste plastics may be leaked into the environment or burned openly.

At the final stage of waste management systems, plastic can leak into the environment from disposal sites. In the majority of low- and middle-income countries, final disposal sites are open dumpsites, which are located near to low-lying areas or waterways considering the low price and availability of adequate land for disposal when compared to availability of lands within the city limits for final disposal. According to the International Solid Waste Association (ISWA), more than 50% of all plastic waste collected ends up in final disposal sites that are often open dumpsites in many low- and middle-income countries. Out of them, about 38 of the world's largest dumpsites are located less than 20 km from the coastline and contribute an estimated 30% of the plastic waste disposed of into the ocean⁹⁰.

⁸⁸ C. Sherrington, C. Darrah, and S. Hann (2014): Exploring the Indirect Costs of Litter in England, pp. 1–92,

⁸⁹ Velis C., Lerpiniere D., Tsakona M. (2017). How to prevent marine plastic litter – now, ISWA, Vienna, <http://marinelitter.iswa.org/marine-task-forcereport-2017/>

⁹⁰ Velis C., Lerpiniere D., Tsakona M. (2017). How to prevent marine plastic litter – now, ISWA, Vienna, <http://marinelitter.iswa.org/marine-task-forcereport-2017/>

Proposed strategies and policy interventions

To mitigate plastic waste leakages into the environment and to

prevent marine plastic litter, a set of short-term strategies and policy interventions are identified as in Table 1.

Table 1: Short-term strategies and policy interventions

Strategic Action	Policy Interventions				
	Regulatory	Economic	Technology	Data/ Information	Voluntary
Short-term strategy - mitigate plastic waste leakages into the environment (1) Prevent plastic littering	<ul style="list-style-type: none"> - Introduce anti-litter regulations, laws and enforcement - Specify plastic litter into the anti-litter regulations if not available in existing regulations - Plastic littering will be included in the overall waste management policy and planning. 	<ul style="list-style-type: none"> - Set plastic litter innovation funds - Set fixed penalties for plastic littering 	<ul style="list-style-type: none"> - Better infrastructure planning and implementation (design, number and location of public litter bins and other street items to catch plastic litter) 	<ul style="list-style-type: none"> - Develop a baseline and an affordable methodology for assessing and monitoring the extent of plastic litter 	<ul style="list-style-type: none"> - Though prevention is the best option, cleaning-up campaign is required to clean the existing litter - Implement anti-plastic littering campaigns - Raise awareness of the environmental and economic costs of plastic littering - Develop voluntary code and anti-litter messaging on plastic packaging - Document and share good practices on street cleaning and reducing plastic littering
(2) Improve waste collection, handling transfer stations and proper transportation	<ul style="list-style-type: none"> - Set plastic waste collection targets, strategies and policies - Strengthen informal/community-based systems for collecting plastic waste - Introduce take-back systems - Standardise plastic waste collection systems - Enforcement action to reduce illegal plastic waste disposal 	<ul style="list-style-type: none"> - Charge waste producers for collection of non-recyclable plastic (collection fees/ EPR system) - Mobilise investment for developing collection, sorting and processing systems - Set incentives for informal, community-based and private sector involvement for plastic waste collection and transportation 	<ul style="list-style-type: none"> - Development of better and more cost-effective systems for collecting, transporting and sorting waste plastics - Introduce baling and shredding equipment at the transfer stations 	<ul style="list-style-type: none"> - Develop a baseline and an affordable methodology for assessing and monitoring the extent of plastic waste management data - The monitoring indicators described above will need to link clearly to the SDGs, particularly SDG 14, but also other SDGs where plastic waste and resource management has a key contribution to make, including SDG 11 and 12 	<ul style="list-style-type: none"> - Share best practice on all aspects of the collection, sorting and reprocessing supply chain. - Create voluntary standards for collection, sorting and reprocessing

(3) Improve final disposal sites	<ul style="list-style-type: none"> - Ban recyclable plastics disposal at dumpsites - Set targets on zero plastic waste to landfills in overall waste management strategies/ policies - Enforcement of actions to reduce illegal dumping and open burning of plastic waste at disposal sites - Enforcement of legislation requiring the closing of open dumpsites and establishment and operation of sanitary landfills 	<ul style="list-style-type: none"> - Charge waste producers for discharging of non-recyclable plastic (Landfill fees/ disposal fees/ EPR system) 	<ul style="list-style-type: none"> - Introduce plastic waste recovery before disposal (source separation facility for informal sector) - Convert open dumping into controlled sanitary landfills to reduce plastic waste leakage - Study the feasibility and set enabling environment to introduce energy recovery (RDF and Incinerator) 	<ul style="list-style-type: none"> -Develop a baseline and affordable methodology for assessing and monitoring the extent of plastic waste disposal, open dumping and burning 	<ul style="list-style-type: none"> -Set voluntary standards to reduce plastic waste to be landfilled. -Share good practices on managing plastic waste at landfills -Organise waste pickers informal sector to handle plastic waste effectively at landfills
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3.2 Medium-term strategies - increasing plastic waste recovery and recycling

Context

The above short-term strategies and policy interventions can bring some quick impacts to mitigate plastic waste leakage into the environment; however, for establishing a sustainable plastic waste management system towards achieving circular economy, policy makers and practitioners in low and middle-income countries need to establish sustainable (economically viable, environmentally friendly and socially acceptable) plastic waste recovery and recycling models. Some studies have demonstrated the strong environmental impacts from plastic waste recycling rather than landfilling or incineration. Plastic waste recycling into new resins that can be returned into the value chain, reduce the carbon footprint and yields energy savings (recycled plastics can have footprints up to 10 times smaller than virgin equivalents, save about 1-1.5 kg CO₂/kg resin compared to virgin materials and each kg of recycled plastics gives energy savings of 130 000 kJ)⁹¹.

Separation of plastic waste from other bio and non-bio waste or different plastic waste fractions is the most critical prerequisite in transforming plastic waste into resources. Successful waste separation programmes at source make this effort easier, more cost-efficient and provide higher economic value if introduced into plastic recycling activities. However, waste separation at source does not take place in many low- and middle-income countries. Even though some countries and cities have introduced

legislations, policies and time-bound targets to achieve waste separation, they face tremendous challenges during implementation and enforcement.

On the other hand, the separated plastic waste should be properly collected, recovered and processed for recycling. If not, the separated plastic waste will again mix with other wastes and end up at landfill sites. Plastics encompass a wide variety of resins or polymers with different chemical characteristics and belong to two major groups: thermoplastics and thermoset plastics. About 80% of household plastics are considered thermoplastics that can be repeatedly formed into new products by the application of heat, including polyolefins (polyethylene terephthalate (PET), LDPE, HDPE, or PP). In addition, polyolefin is a major type of plastic used throughout the world in applications such as soft-drink bottles, clear film for packaging (PET), packaging, bags, containers, pipes (LDPE), milk and water bottles, housewares, industrial wrappings and film (HDPE), automotive parts, film, battery cases, drinking straws, and electrical components (PP), thus is easily recycled.

However, most low- and middle-income countries lack well-established plastic recycling industries (Table 2). Existing recycling systems in those countries are based on collection, recovery and exporting of recovered plastic materials to neighbouring countries for recycling and import of plastic products from other countries

⁹¹ European Commission (2019): A Circular Economy for Plastics – Insights from research and innovation to inform policy and funding decisions, Brussels

to accommodate domestic needs. In reality, however, this pattern of recycling system has been facing challenges since China, the largest plastic importing hub, and some other countries in Asia (Thailand, Malaysia, and Vietnam) have taken legislative measures to ban the importation of plastic waste⁹². Further, Parties to the Basel Convention at Conference of the Parties to the Basel Convention at its 14th session in 2019 amended Annex II, VIII and IX to strengthen control of transboundary movements of plastic wastes. This helped to establish a global trade in plastic waste more transparent and better regulated, whilst also ensuring that its management is safer for human health and the environment. These recent international actions encourage individual governments to make a switch from outwards plastic recycling systems to establishing country-based plastic recycling mechanisms to cover their domestic needs, which creates a huge potential for circular economy-based systems.

Technologies for recycling plastic waste are in wide use. Among them, mechanical recycling is the predominant technology for recycling plastics in low and middle-income countries. This category includes a variety of mechanical process, including (1) sorting, (2) shredding (flaking), (3) washing and drying, and (4) extrusion/agglomeration. However, recycled plastics re-processors have limited control over the quality of their input materials, which burdens them with additional costs for sorting and disposal, and treatment of rejects. This means strong participation from the public, private and citizens is required. Citizens must perform separation of plastic waste material at source. Due to the chemical properties of plastics, recycling involves inherent technical

complications but efficient separation at source and collection of waste plastics leads to enhanced recycling efficiencies. In order to establish plastics recycling and treatment systems, the private sector needs to invest in setting up pre-sorting, treatment and recycling facilities.

Compared to the primary plastics market, plastics re-processors (even in high-income countries) are small and fragile and, as a result, vulnerable to market shocks. However, establishment of successful recycling systems requires a good business model that depends on various internal or domestic factors such as costs of recyclables, treatment infrastructure and equipment, personnel, transport, energy use and market prices. The success of recycling business models also depends on external factors such as oil prices, quality and reliability surrounding the material properties of recyclables as well as adherence to health standards. Respective national and local governments also have the responsibility to establish supportive policy frameworks and recycling value chains to accelerate domestic plastic recycling. For example, public authorities can increase demand for secondary plastic materials by developing quality standards for recyclables, which would help guide companies and consumers. They can also increase demand for recyclable plastics through public procurement policies, as well as introduce EPR mechanisms to improve separate plastic waste collection.

Chemical recycling refers to technological processes that convert polymers into their constituent molecules, which can then be used as feedstock for new plastics, fuels or other petrochemicals⁹⁴.

Table 2: Key factors affecting the recycled plastics supply chain in low, middle and high-income country contexts⁹³

Stage	Low-income	Middle-income	High-income
Collection	<ul style="list-style-type: none"> - Collection coverage is low and service is mostly limited to high-income urban areas - Informal sector plays a key role in plastic waste collection - Plastic waste recycling is to be informal or SME-led - Few municipal-led plastics recycling schemes can be observed 	<ul style="list-style-type: none"> - Waste collection rate is high when compared to low-income category, but still main coverage in urban areas - Informal sector often still plays a key role in plastic waste collection and recycling - Some municipal-led recycling schemes, particularly in urban areas 	<ul style="list-style-type: none"> - Formal sector-led (municipal and private sector) plastics recycling schemes are common. - Collection systems are well established and highly mechanised
Primary sorting	<ul style="list-style-type: none"> - Manual sorting is common - If available, mechanical sorting normally limited to balers for compaction 	<ul style="list-style-type: none"> - Some mechanization in sorting - Where informal sector is active, manual separation also likely to be common 	<ul style="list-style-type: none"> - Highly mechanized and capital intensive to maximise recovery of valuable plastics
Recycling	<ul style="list-style-type: none"> - Waste plastics typically exported although there may be some simple recycling process used for plastics (e.g. manufacture of paving slabs from waste plastic bags) 	<ul style="list-style-type: none"> - Waste plastics typically exported for recycling but there may be some local recycling in some contexts 	<ul style="list-style-type: none"> - Waste plastics exported but some local capacity in some countries for high value plastics

⁹² Morita, Y, Hayashi, S (2018): Proposals to strengthen Japan's domestic measures and regional cooperation on stable and environmentally sound plastic scrap recycling: Response to China's ban on imports of plastic scrap, IGES, Hayama. https://pub.iges.or.jp/pub/policybrief_41_e

⁹³ OECD (2018): Improving Markets for Recycled Plastics: Trends, Prospects and Policy Responses, OECD, Paris. <http://dx.doi.org/10.1787/9789264301016-en>

⁹⁴ Al Salem, S.M., Lettieri, P., Baeyens, J (2009): Recycling and recovery routes of plastic solid waste: a review, Waste Management, 2625-43. doi: 10.1016/. <https://www.sciencedirect.com>

Table 3: Medium-term strategies and policy interventions

Strategic Action	Policy Interventions				
	Regulatory	Economic	Technology	Data/ Information	Voluntary
Medium-term strategies - increasing plastic waste recovery and recycling					
(4) Introduce plastic waste separation at source	<ul style="list-style-type: none"> - Introduce mandatory plastic waste separation and collection - Setting targets for plastic waste separation and collection - Standardise separated plastic waste collection and transportation 	<ul style="list-style-type: none"> - Setting incentives to promote waste separation at source (pay-as-you-throw systems, volume-based collection fees) 	<ul style="list-style-type: none"> - Develop more cost effective technologies for sorting waste plastics 	<ul style="list-style-type: none"> - Raise public awareness to separate plastic waste from others, create demand for plastic recycling, and reduce contamination 	<ul style="list-style-type: none"> - Create voluntary standards for plastic waste separation, collection, sorting and reprocessing
(5) Increase plastic waste recovery and recycling	<ul style="list-style-type: none"> - Set statutory targets for recycling of plastic waste - Mandate requirement for recycled content to create demand for plastic waste. - Strengthen informal and SME recycling activities - Use public sector procurement policies to create demand for recycled plastic waste - Ban or reduce hazardous additives in primary plastics - Mandate labelling for biodegradable plastics and improve associated standards and certification for biodegradability (compostable or oxo-degradable) - Enforcement action to reduce illegal waste trafficking. - Regulation and enforcement to ensure consistent environmental standards in recycling systems. - Mandate producers and sellers to establish and audit end destinations for environmental standards. 	<ul style="list-style-type: none"> - Use Extended Producer Responsibility (EPR) - Use financial market mechanisms to increase the resilience of the market to fluctuations in prices of plastic (e.g. futures markets) - Support development of domestic reprocessing capacity to reduce reliance on global markets - Use taxes or trading mechanisms to internalize the externalities associated with primary plastics - Establish direct or indirect government support and incentives for recycled plastics, e.g. through lower VAT rate - Tax additives that cause detrimental effects on recycled plastics (including degradability enhancers) 	<ul style="list-style-type: none"> - Development of better and more cost-effective technologies for sorting waste plastics - Development and demonstration of commercially viable technologies for mixed and/or low value plastics - Develop technologies that can identify or track hazardous additives so that they can be eliminated from recycled plastics - Develop purifying and stabilising technologies that can overcome the physical effects of hazardous additives in recycled plastics 	<ul style="list-style-type: none"> - Introduce mandatory data reporting mechanism for plastics recycling - Develop and share market information to allow actors to expand into new markets - Provide information and training to designers and manufacturers to encourage use of recycled content - Provide information to consumers to encourage purchase of products using recycled content and drive demand - Provide clear and accurate labeling and information, not only will transparency allow consumers to make smarter purchasing decisions, but it will ensure bioplastics are disposed of through the proper channels after end-of-life. - Enhance supply chain awareness of hazardous additives so that the impact on markets for recycled plastics is understood 	<ul style="list-style-type: none"> - Raise public awareness in order to create demand for plastics recycling, reduce contamination, and to reduce littering and dumping - Create voluntary standards for collection, sorting and reprocessing - Industry-led initiative to standardise polymers and additives, and improve information on additives - Industry-led phase out of problematic and hazardous additives from primary plastics - Develop effective voluntary standards for recycling sector to limit need for regulation

	- Obligate manufacturers to buy back recycled plastics				
(6) Appropriate technologies for plastic waste treatment and energy recovery (RDF, incineration, plastic for road construction)	<ul style="list-style-type: none"> - Appropriate treatment options will be considered within waste hierarchy and circular economy concepts in plastic waste management - Review and update waste legislation to include plastic recycling and latest treatment technologies - Set regulatory mechanisms to control or monitor environmental pollution standards 	<ul style="list-style-type: none"> - Set financial incentives for promoting alternative treatment options for plastic waste (tipping fees, feed in tariffs, electricity price) - Potential of getting climate funds 	<ul style="list-style-type: none"> - Development of better and most cost effective technologies for plastic waste treatment - Feasibility study is recommended before selecting the technologies 	<ul style="list-style-type: none"> - Knowledge on plastic waste quantities and characteristics 	<ul style="list-style-type: none"> - Raise public awareness on benefits and environmental/ emission standards of the technologies - Set voluntary monitoring and enforcement mechanisms to assure compliance

Many of the chemical recycling technologies are still at the research stage and require consistent feedstock, which is not always forthcoming in the market for recycled plastics and, if present, is typically processed using mechanical recycling. However, chemical recycling represents a potential solution to the challenges associated with mixed and contaminated plastics waste streams, and could also potentially be used for recycling thermoset plastics, for which there are limited commercially viable options. One of the main advantages of chemical recycling is that it has the potential to treat contaminated and heterogeneous mixtures of polymers with only limited pre-treatment. Conversely, many of the processes produce fuels which, when combusted, contribute to global warming as the raw materials are derived from fossil carbon sources. Some commercial scale pyrolysis and gasification plants have been constructed and others are reportedly under construction. However, these technologies have not yet entered mainstream application and are still considered to be marginal. However, it is relatively well-established, albeit at a small level, in Japan. Chemical recycling has not yet been demonstrated to be commercially viable for recycling post-consumer plastics waste.

In addition to mechanical and chemical plastic recycling methods, other technologies and treatment methods have been evolving for treating and recovering energy from plastic waste, such as co-processing and energy recovery through refuse-derived fuel (RDF) and incinerators. In addition, both case study countries have experimented and applied some new methods for utilising plastic waste such as plastic waste for road construction. Co-processing refers to the utilization of waste materials in industrial processes such as cement, production of lime or steel and power stations or any other large combustion plants. Co-processing helps replace

primary fuel and raw materials through the waste recovery industry and removing materials from waste. RDF that is comprised of the combustible portion of MSW (low-value plastic waste) and generally produced through shredding and sorting relatively uniform segments has the advantage that cement plants already exist in low- and middle-income countries.

In addition, there is growing discussion as well as experimentation in applying thermal methods, i.e. incineration (direct combustion) in municipal solid waste management in low- and middle-income countries as an alternative to open disposal. Gasification is the partial oxidation of plastic waste to produce syngas (synthesis gas), which can potentially be used for electricity generation and production of chemical fuels. Making gasification profitable requires high local-market prices for electricity, a government-set feed-in tariff for electricity, or high tipping fees for traditional waste disposal – conditions that are sometimes but certainly not always present in low- and middle-income countries. However, gasification can process very large quantities of mixed waste with relatively little pre-treatment or sorting, so has the potential to be utilized at scale.

Proposed strategies and policy interventions

Given the diversity and scale of the challenges facing markets for recycled plastics, the following strategic measures and policy interventions are proposed under the mid-term framework (Table 3). This requires close partnerships amongst all stakeholders, including policy-makers, regulators, municipalities, industry and communities. Neglecting to engage a key part of the supply chain (e.g., product designers or primary resin producers) could jeopardise the effectiveness of any future policy interventions. A

wide range of potential regulatory, economic, technology, data/information or voluntary interventions could be deployed to address the barriers to properly functioning markets for recycled plastics. However, no single intervention represents a solution. For the successful application of the technologies to suit local conditions, decision-makers should carefully assess different aspects, such as current system of waste management, including plastic waste,

waste composition, its calorific value and quantities of suitable waste. Decision-makers also need to consider the capacity, level of experience, efficiency of the operation and environmental risks such as potential for hazardous residues like toxic ash. Other key aspects for consideration are cost-benefits, legal frameworks, and additional revenues from energy recovery.

3.3 Long-term strategies - creating sustainable plastic production and consumer society

Context

Although the short- and medium-term strategies and actions discussed in the previous sections could create a clean environment and marine ecology, reducing plastic leakage and increasing resource recovery and recycling, long-term strategies and policy interventions are required to promote sustainable plastic production and consumption society to move from a linear to more sustainable

plastic waste management from land-based to protect marine ecosystem (Figure 8). Such initiatives should include the design of products for reuse and recyclability as well as resource efficient production processes. They should also include business models that favour reuse, repairing and sharing as well as a respective consumption behaviours of citizens.

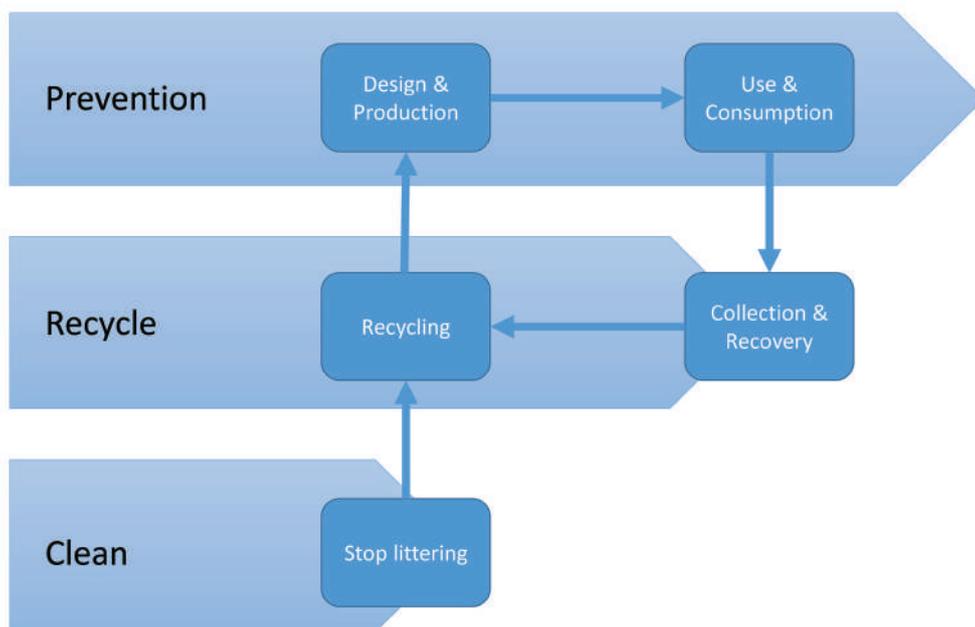


Figure 8: Integrated solutions to plastic waste pollution⁹⁵

Future plastic production should take into account the full lifecycle, including end-of-life recycling. Thus, it is important to assess the lifecycle resource efficiency of plastic products within the circular economy. This leads to the most environmentally friendly, cost-effective and socially acceptable products. However, eco-designing is often not the uppermost concern of designers who need to focus on optimising product protection and aesthetics for marketing purposes. Adequate incentives, appropriate policies, guidelines or

regulations from political decision-makers at the national level are thus required.

Plastics exist to serve many different purposes and make things happen and enable access to a broad range of products that people use in their everyday lives. It is therefore essential that consumers understand that resource efficient products lead to lower environmental impact and should be responsible for

⁹⁵ European Commission (2019): A Circular Economy for Plastics – Insights from research and innovation to inform policy and funding decisions, Brussels

Table 4: Long-term strategies and policy interventions

Strategic Action	Policy Interventions				
	Regulatory	Economic	Technology	Data/ Information	Voluntary
Long-term strategies – establishing sustainable plastic production and consumer society					
(7) Eco-design and sustainable lifestyles	<ul style="list-style-type: none"> - Phase out or ban single use plastics - Minimise input of virgin materials/ resins - Standardise labelling of materials to enable plastic recycling 	<ul style="list-style-type: none"> - Set incentives (tax rebates) and national/local funds/ subsidies to support R&D into new design and materials as alternatives to plastics. 	<ul style="list-style-type: none"> - Design/ produce longer lasting products - Avoid use of hazardous/ toxic chemicals in plastics - Plastic design for environment, easy to reuse, repair and recycle - Reduced packaging materials - R&D into potential to substitute with biodegradable materials 	<ul style="list-style-type: none"> - R&D into identifying alternative materials for plastic (single-use plastics) - Prioritise alternative packaging materials - Awareness raising/ information sharing on repair/reuse opportunities 	<ul style="list-style-type: none"> - Voluntary targets to reduce single use plastics - Voluntary actions to refuse single-use plastics and choose products that can be reused and recycled - Voluntary actions in the neighbourhoods/ communities for public cleaning (street, beach etc.,)

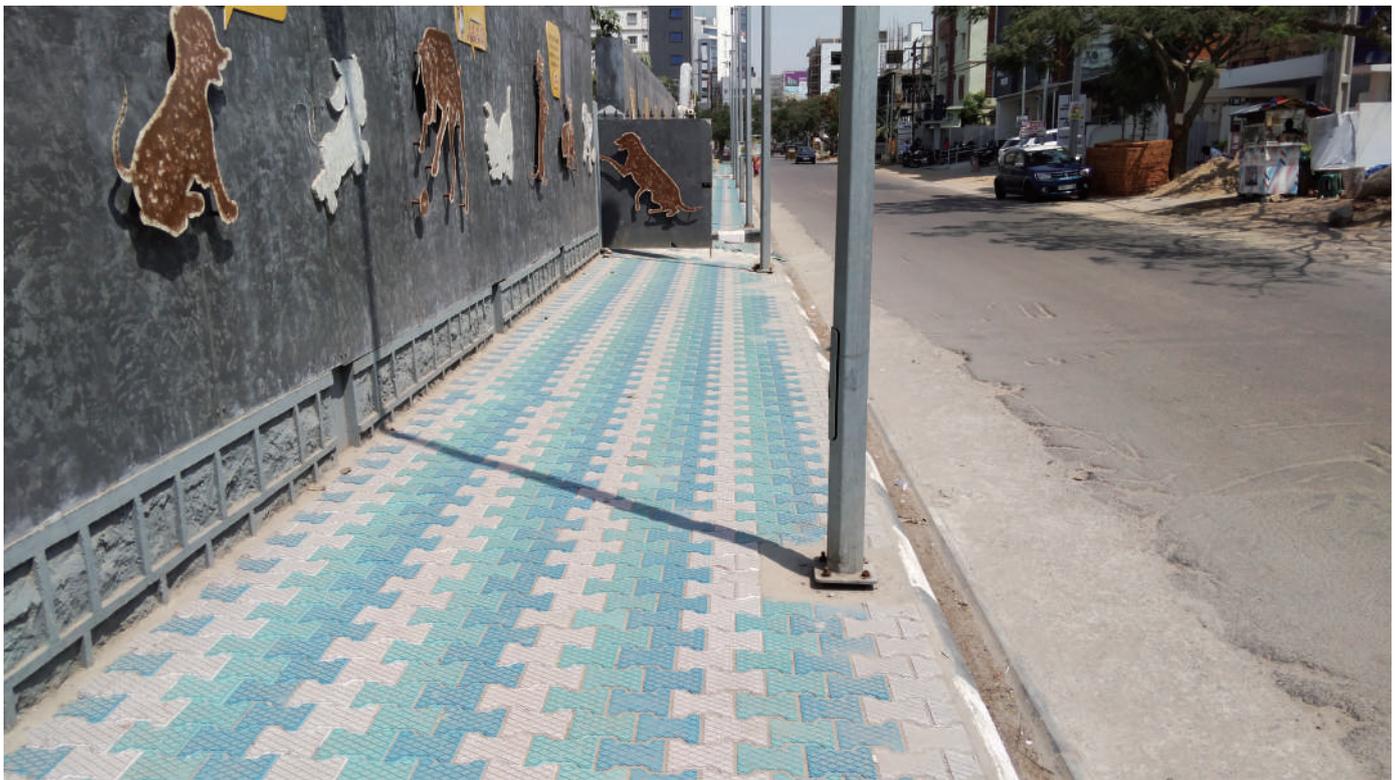


Photo 4: Plastic waste recycle for pavement construction in India

properly managing such products at the end of their use phase. In addition, consumers should be informed about the benefits of correct waste separation, appropriate recycling methods and be aware of the negative consequences of littering behaviour. Installing well designed, high functionality waste management systems and ensuring the separate collection of all packaging waste is a prerequisite for maximising the recovery of resources and preventing their escape into the environment. Awareness raising campaigns have an important role to play in changing behaviours

for the proper and responsible management of goods and services. It is also important to build greater awareness throughout the value chain, to create the most resource efficient products, and to help advocate for improved waste management, mindful product design and changes in human behaviour.

Proposed strategies and policy interventions

Table 4 proposed a set of strategies and policy interventions to move towards sustainable plastic production and consumer society.

4. Conclusions and Recommendations

Today, plastic is one of the widely used materials that believe to deliver a range of important benefits to society. At the same time, due to the rapid growth of plastic production, particularly single use plastics, their use and mismanagement, significant pollution has been caused in the natural environment, including marine eco-system. As a result, there are growing international efforts to address plastic pollution by reducing plastic leakage into the ocean. According to data, land-based sources are responsible for 80% of marine debris while the remaining only 20% of ocean plastic is thought to originate from marine-based sources. At the same time, due to the lack of waste management policy and infrastructure to keep pace with urban growth and economic development, low- and middle-income countries in Asia and the Pacific, particularly in Southeast and South Asia regions are experiencing some of the highest rates of mismanaged plastic waste in the world.

This report therefore identifies and discusses the importance of developing sustainable plastic waste management policies and infrastructure along with the overall waste management systems in the respective national and local governments to promote circular economy and sustainable plastic production and consumer society in low- and middle-income countries. Based on the literature review and some fieldwork in two selected Asian countries, Indonesia (Southeast Asia) and India (South Asia), it also proposed a set of priority strategies and policy interventions in the short, medium and long-term to decision-makers and practitioners in low- and middle-income countries on how to reduce marine plastic pollution from land-based pathways.

In the short-term, preventing plastic littering, improving plastic waste collection service, including waste collection coverage and efficiency as well as improving final disposal (stopping open disposal and burning plastic waste) were identified for implementation. Although the above short-term strategies can bring about a swift impact to substantially reduce plastic waste leakage into the environment and marine eco-system, the report identified the importance of more appropriate (economically viable, environmentally friendly and socially acceptable) alternative treatment and recycling methods in the medium-term to optimise plastic waste as a resource and for energy recovery before final disposal. It also proposes that while the short- and medium-term strategies and actions make impacts in reducing plastic leakage in the business-as-usual context, long-term strategies and actions to promote circular economy and sustainable lifestyles would be necessary in order to bring about radical changes from linear to more sustainable plastic production and consumer society. Governments, companies, business associations and civil

society should create initiatives to strengthen resource efficient consumption and production patterns. Such initiatives should include the design of products for reuse and recyclability as well as resource efficient production processes.

Transitioning to a more eco-friendly and sustainable plastic production and consumer society is not an easy task for low and middle-income countries and can be a lengthy process and need more resources, capacities as well as common understanding and actions among all stakeholders in the respective cities or countries. In this regards, CCET in partnership with UN Environment-IETC and the Ministry of Environment (MOEJ), Japan assist national/ local governments and other interested parties in low and middle income countries in Asia in conducting a road mapping process, which aims at developing a strategy for reducing waste plastics through more and better waste prevention and recycling. Road mapping is a method for developing strategies designed to meet a given overall aim as well as providing support for local innovation processes and acting as a focal point between the various partners. The work with road maps should be seen as both a process of information collection and analysis, and a networking. This implies that both the road mapping – the process of developing the road map – and the road map itself are important towards achieving sustainable plastic production and consumer society (Figure 9).

In conclusion, this report recommends to consider the following key points for the successful design and implementation of sustainable plastic waste management plans/strategies and actions in low- and middle-income countries.

- Leadership and meaningful commitments are needed from the respective national governments, local authorities, governors, and mayors to develop holistic and integrated plastic waste management strategies and actions including ambitious plastic waste reduction, reuse and recycle targets, and to accelerate the installation of effective institutional and financial systems to address plastic waste pollution from land-based sources. National and local leaders can be motivated and encouraged to take actions through facilitation of the global/regional voluntary commitments related to the United Nations, G7, G20, Association of Southeast Asian Nations (ASEAN), Asia-Pacific Economic Cooperation (APEC), South Asia Cooperative Environment Programme (SACEP) and South Asia Regional Cooperation (SARC).
- The plastic waste management strategies and action plans should be a part of overall waste management system in the



Figure 9: 6 steps to consider in developing a roadmap for plastic waste management in cities or countries
Source: Adopted from UNEP, 2018⁹⁶

respective national and local governments and based on local contexts, such as political, environmental, social and economic aspects. Respective government authorities (either national or local) can lead the development of strategy, but need to involve all key stakeholders, including citizens, academics, and businesses (both formal and informal). This is critical to ensuring implementation is as smooth as possible after the strategies are ready.

- While there are many methods and technologies available as regards plastic waste management, identification and facilitation of appropriate technologies that are technically, socially and financially viable to the local context are important. Thus, municipal decision-makers should carefully assess some of the key aspects, such as plastic waste volume, plastic waste characteristics, level of experience and development of technology, commercial feasibility in terms of the overall capital, including operational and maintenance costs, capabilities, and environmental and social acceptability of new technology at the local level before selecting the most appropriate technology for application.
- Recovering the costs is a prerequisite for an effective plastic waste and resource management system. Due to the lack of budget availability, many cities face the challenge of financing recurrent operational costs of staff and equipment as well as investment for plastic waste collection, processing, treatment and final disposal. Local decision-makers should thus find ways to base local service provision on financially sustainable

fundamentals such as an increase in share of property taxes, sale of products from plastic waste streams, tourist taxes, fees for disposal at landfills and user charges. In addition, the ‘polluter pays principle’ can be introduced in terms of ‘pay-as-you-throw’ charges or flat-rate charges.

- Promotion of favourable project-finance investment conditions for the private sectors is another possibility for increasing the investment capital that is essential and required for plastic waste recycling and treatment. However, risk-management mechanisms need to be set up to encourage such private sector investment, including first-loss provisions, shared equity pools with (multilateral) lenders, and insurance pools, among others. The national governments can also introduce EPR as a key fiscal measure to involve the packaging, plastics and retail industry in waste management and marine litter prevention. Multilateral institutions and regional bodies (e.g., ASEAN, APEC, UN), aid organizations and development banks (ADB, World Bank, GEF) can also provide financial support for addressing plastic waste management at national and local levels.
- Comprehensive data on plastic waste throughout the lifecycle including from generation, collection, treatment, leakage to marine and final disposal is required for evidence-based planning, decision-making on effective waste management policies and systems as well as for monitoring management performance. Thus, establishing the necessary institutions, resources and capacities at local, national and global scales to

⁹⁶ UNEP (2018): Single-Use Plastics: A Roadmap for Sustainability. https://wedocs.unep.org/bitstream/handle/20.500.11822/25496/singleUsePlastic_sustainability.pdf?sequence=1&isAllowed=y

collect accurate and reliable data, agree on voluntarily agreed baselines, protocols on the quality and type of data and data collection and reporting is necessary. This enables setting priorities and effective deployment of land-based plastic waste management strategies and monitoring. In addition, well-designed data management systems can serve as a baseline for testing the effectiveness of programmes, and for reporting on the impact of current and new legal instruments such as banning of single-use plastics as they come into effect. The monitoring indicators can also link in reporting to the global commitments on plastic such as SDGs and other international agreements.

- Effective institutional mechanisms is the prerequisite for environmentally sound plastic waste management and marine litter prevention. National, regional and local decision-makers need to develop and adapt respective policy frameworks and decision-making processes in an ongoing manner. At the national level, ministries related to environmental protection need to set standards, determine levels of monitoring and control as well as set national policies, strategies and master plans for addressing plastic waste management. However, considering the responsibility of different ministries at the

national level, such as Ministry of Environment, Ministry of Marine, Ministry of Economic and Trades, Ministry of Urban Developments, and Ministry of Technology, establishment of a national coordinating body to address the plastic waste issue is an important prerequisite for effective implementation.

- Municipalities are the key players for plastic waste management. They are generally in charge of implementing the above-mentioned regulatory framework and for providing waste collection and transport services at the local level. Local waste management authorities thus need to be sufficiently equipped with qualified staff, resources and capacity to organize and supervise service provision. They need to monitor waste related data in their municipality, ensure the application of environmental, health and safety standards, organize financial flows and conduct tendering processes for private service providers. Local waste management plans help to define objectives and actions for a given timeframe. However, waste management authorities need to develop them in close cooperation with political decision-makers as well as stakeholders of civil society, science and the private sector. In some cases, inter-municipal cooperation can help in sharing treatment and disposal facilities.



Photo 5: Voluntarily actions taken by community groups to reduce single-use plastics in India



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