WWF

REPORT

INT

2019

SOLVING PLASTIC POLLUTION THROUGH ACCOUNTABILITY

WARNING: Plastics are polluting nature, endangering wildlife and taxing natural systems. It is entering the food we eat and the air we breathe.

ACKNOWLEDGEMENTS

The report was written by Dalberg Advisors, and the team comprised of Wijnand de Wit, Adam Hamilton, Rafaella Scheer, Thomas Stakes, Simon Allan.

Special thanks to Alona Rivord, a conservationist and a campaigner.

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WWF

WWF is one of the world's largest and most experienced independent conservation organizations, with over 5 million supporters and a global network active in more than 100 countries.

WWF's mission is to stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature, by conserving the world's biological diversity, ensuring that the use of renewable natural resources is sustainable, and promoting the reduction of pollution and wasteful consumption.

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Dalberg

WWF International
Avenue du Mont-Blanc
1196 Gland, Switzerland
www.panda.org

Dalberg
Rue de Chantepoulet 7
1201 Geneva, Switzerland
www.Dalberg.com

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WWF'S CALL FOR COLLECTIVE GLOBAL ACTION

Plastic is not inherently bad; it is a man-made invention that has generated significant benefits for society. Unfortunately, the way industries and governments have managed plastic, and the way society has converted it into a disposable and single-use convenience, has transformed this innovation into a planetary environmental disaster.

Nearly half of all plastic products littering the world today were created after 2000. This issue is only decades old, and yet over 75 per cent of all plastic ever produced is already waste.

Based on the findings from this study, WWF urges governments, industries, and members of the public to acknowledge that the current global approach to addressing the plastics crisis is failing. The absence of an effective systemic response—at either the national or international levels—hinders progress, threatens sustainable economic growth, and has direct consequences on the environment, species and people.

While the current trajectory for plastics growth shows that the crisis is expanding, we can change this with a single approach taken across all sectors: accountability.

WWF CALLS ON ALL GOVERNMENTS TO:

- **Agree to a legally binding international treaty** to eliminate plastic pollution from leaking into the oceans, thereby significantly contributing to Sustainable Development Goal 14.1.
- **Establish national targets** for plastic reduction, recycling and management in line with global treaty commitments, including transparent reporting mechanisms that recognize the trans-boundary nature of the problem.
- **Deploy appropriate policy instruments** to incentivize the creation and use of recycled plastics over new plastics, and the innovation of viable alternatives to plastics that have smaller environmental footprints.
- **Collaborate with industries and civil society groups** to ensure a systems-based approach that addresses plastic production, consumption, waste management and recycling as a single system, and refrain from individual, fragmented or symbolic policy actions.
- **Invest in ecologically sound waste management systems** domestically and in countries where national plastic waste is exported for disposal, thereby locking in long-term economic social and environmental benefits.
- **Legislate effective extended producer responsibility** as a policy mechanism for all plastic-producing sectors to ensure the greater accountability of companies in the collection, reduction, reuse, recycling and management of the plastic waste originating in their trade chains.
- **Implement sufficient monitoring and compliance measures** for all policies related to the production, collection and management of waste by all stakeholders in the plastic system.
- **Work at appropriate subnational levels and invest in city approaches** to establish robust management plans and transparent accounting mechanisms that prevent plastic leakage into water systems or other mismanaged waste disposal mechanisms.

WWF CALLS ON ALL COMPANIES AND INDUSTRIES INVOLVED IN PRODUCING, PROMOTING AND SELLING PLASTIC GOODS TO:

- **Reduce excessive and unnecessary plastic** to prevent it from becoming mismanaged waste or plastic pollution.
- **Commit to sourcing recycled plastics or sustainable plastic alternatives** for product packaging.
- **Innovate and seek out sustainable alternatives to plastics** that promote circular economy models and do not have severe negative social or environmental impacts.
- **Leverage individual and collective influence** to shift industries away from harmful economic models that endanger wildlife, pollute natural systems, and create long-term social and environmental problems.
- **Invest in ecologically sound waste management systems** in end-use markets and countries where plastic waste is imported for disposal.
- **Support the development of legislation** and best practices to ensure a sector-wide shift and the effective implementation of government policies.

WWF CALLS ON CIVIL SOCIETY GROUPS TO:

- **Work together with industries and government** to identify systemic solutions that avoid negative environmental and social consequences.
- **Provide the public with mechanisms that empower** their voices as advocates.
- **Hold accountable international institutions, national governments, and private sector entities** that fail to take action or to work in good faith in addressing the systemic drivers that perpetuate the plastic crisis.

WWF CALLS ON THE PUBLIC TO:

- **Engage with government representatives** to ensure that they take action to reduce, recycle and manage plastic waste in a transparent and accountable manner.
- **Use your power as consumers** and call on industries to demonstrate leadership through reducing dependency on single-use and unnecessary plastics while investing in environmentally sound alternatives.
- **Reduce your consumption** of unnecessary plastics, reuse and recycle what you do use.

BY TAKING ACCOUNTABILITY OF OUR ACTIONS, AND WORKING TOGETHER, WE WILL SOLVE THE PLANETARY PROBLEM OF PLASTIC.

EXECUTIVE SUMMARY

Since 2000, the world has produced as much plastic as all the preceding years combined. Production has grown rapidly this century as plastic is cheap, versatile and reliable[1]. These traits support the development of disposable plastic products, and almost half of all plastic becomes waste in less than three years. Most of these throwaways are consumed in high and upper-middle income countries. This issue is only decades old yet already over 75 per cent of all plastic ever produced is waste[2].

Due to waste mismanagement, one-third of plastic waste is estimated to have entered nature as land, freshwater or marine pollution[3]. Rapid consumption practices generate huge amounts of plastic waste that the world is ill-equipped to handle; 37 per cent of plastic waste is currently managed ineffectively. Mismanaged plastic waste is a critical concern as it is more likely to become pollution than waste managed through a controlled waste treatment facility. Mismanaged waste refers to plastic left uncollected, openly dumped, littered, or managed through uncontrolled landfills[4]. The majority of this mismanaged plastic waste is believed to have polluted land-based ecosystems, and 80 per cent of ocean plastics are estimated to come from land-based sources[5].

Plastic has become ubiquitous in nature creating a serious challenge for the natural world, society and the global economy. The planet's soil, freshwater and oceans are contaminated with macro, micro and nano-plastics[6]. Each year, humans and other animal species are ingesting more and more nano-plastic from food and drinking water, with the full effects still unknown[7]. Plastic pollution kills wildlife, damages natural ecosystems, and contributes to climate change[8]. Carbon dioxide emissions are growing each year from increased production and incineration of waste plastic. Plastic production consumes four per cent of total oil and gas demand annually[9]. The UN Environment Programme (UNEP) estimates the natural capital cost of plastic at US$8 billion per year, with fisheries, maritime trade and tourism directly and adversely impacted by plastic pollution. It is also estimated that there is four times more plastic pollution on land than in the oceans, suggesting that the total economic impact of plastic pollution is actually much greater. Plastic also has severe human impacts. Local communities are affected by airborne pollutants from the open burning of plastic, and from unregulated waste incineration and recycling, which is a common occurrence in regions with underdeveloped waste management capacity[10,11].

Plastic pollution comes at a cost that is not carried by all stakeholders that are profiting from plastic production and usage. The plastics life cycle does not have a global feedback loop to hold upstream stakeholders accountable for their products after the point of sale[12]. Falling production costs have resulted in the accelerated production of virgin plastics[13], reaching 396 million metric tons in 2016, and an associated drop in their sale price[14]. Yet, plastic producers are not held accountable for the negative impacts of production, as the market price of virgin plastic today does not represent its full life cycle costs to nature and society[15]. In the United States, China and Europe, petrochemical production is not deemed sufficiently energy intensive and is exempt from carbon regulation[16]. Manufactures of products made out of virgin plastic, known as plastic converters, have limited responsibility for the impacts of their actions on plastic waste and pollution; these factors are largely ignored during product design[17]. Insufficient incentives exist to ensure plastic waste is managed properly, let alone re-captured for recycling or reuse[18].

Mismanaged waste is a direct result of underdeveloped waste management infrastructure. Effective plastic waste management performance is correlated to the income status of a nation[19]. This is a major challenge in low and middle-income countries, leading to low collection rates and high rates of open dumping and uncontrolled landfilling. Collection rates are generally higher, but issues remain in high-income counties, such as low levels of recycling and preference for landfilling and incinerating plastic waste[20]. Constraints on waste management capacity create challenges for end-users. Failure to properly sort or dispose of plastic leads to waste being discarded directly into landfills or dumped into nature[21]. The world's inability to manage plastic waste results in one-third of plastic, 100 million metric tons of plastic waste, becoming land or marine pollution[22].

X3

CO_2 EMISSIONS

CARBON DIOXIDE EMISSIONS FROM INCINERATION OF PLASTICS CAN TRIPLE BY 2030

Closing the loop of plastics is hindered by an unprofitable recycling industry unable to scale, and by limited consumer choices for environmentally sound alternatives to plastic. Currently, only 20 per cent of plastic waste is collected for recycling. In Europe, material loss during recycling is almost half of total collected, much of the plastic collected for recycling cannot be recycled for health, safety, or qquality and contamination reasons[23]. Furthermore, most secondary plastic materials created from recycled plastic are of inferior quality to virgin plastic, and therefore trade for a lower price. Yet, the scaling of recycling is a real possibility by improving the quality issues stemming from high levels of mixed and contaminated plastic waste, and by increasing economies of scale. Operating costs for recycling ventures are prohibitively high due to waste collection and separation costs, and a limited supply of recyclable plastic[24]. Environmentally-sound alternatives to virgin plastics remain sparse, and limited mechanisms are in place to encourage upstream actors to support the development of alternatives[25].

If business continues as usual, by 2030 the plastic system is expected to double the amount plastic pollution on the planet, with oceans the most visibly affected. The systemic failures along the plastic trade chain make it cheaper to discharge plastic into nature than to effectively manage plastic to the end-of-life stage. Although existing initiatives to combat plastic pollution are in place in many regions, they are not enough as the current plastics system is locked into polluting the planet[26]. Annual ocean plastic leakage will remain above nine million metric tons per year until 2030, because the growth in plastic consumption outstrips the growth in waste management capacity. This plastic debris is a threat to wildlife – more than 270 species have been harmed by entanglement in discarded fishing gear and other plastic – and 240 species have been recorded living with ingested plastic; this is both a marine health and human health issue. Annual waste generation could increase by 41 per cent over the next 15 years due to accelerated production of plastics driven by the falling costs of production[27,28,29]. Carbon dioxide emissions from plastic waste management could triple by 2030 as other waste treatment infrastructure remains more economically attractive than recycling. Unmonitored, an incineration-lead waste-to-energy approach to the plastic pollution problem risks creating other pollutant issues for nature and society beyond carbon dioxide emissions. The likelihood of this outcome is a concern given varied regional environmental regulations and incineration plant performance, coupled with incineration capacity predicted to grow by 7.5 per cent a year until 2023 in Asia[30].

Plastic's negative externalities are tied to a fragile global waste trade system that is struggling to adapt to national trade policy reforms. In 2016, four per cent of global plastic waste was exported, amounting to roughly 13 million metric tons, of which G7 countries were the source for nearly 50 per cent of this export waste. China recently increased quality standards for plastic waste imports into the country resulting in these G7 nations unable to export to China due to their highly contaminated domestic waste[31]. Given that two-thirds of all plastic waste exports had previously arrived in China, further changes to trade patterns could have a significant impact on plastic pollution. Without China's waste management system, it is estimated that 111 million metric tons of plastic waste would be displaced by 2030[32]. Unless plastic exporters heighten their contamination standards, or countries invest in their own recycling capacity, the international plastics trade will remain fragile, and will risk exacerbating the damage that plastics have on the environment.

Immediate action is needed to stop the uncontrolled growth of plastic pollution, and coordinated initiatives are required to hold each stakeholder accountable for resolving the plastics tragedy of the commons. In the business as usual scenario, each actor remains unaccountable for ensuring that the plastic value chain is sustainable. Current efforts to improve waste management capacity across the planet are insufficient to stop a predicted 104 million metric tons of plastic at risk of leakage into nature in 2030. The current trajectory for plastic pollution results from: consumption patterns that support single-use business models for plastic products; waste mismanagement leaking plastic into nature; and a supply chain currently producing five times more virgin plastic than recycled plastic.

104M
METRIC TONS

CURRENT EFFORTS TO IMPROVE WASTE MANAGEMENT CAPACITY ACROSS THE PLANET ARE INSUFFICIENT TO STOP A PREDICTED 104 MILLION METRIC TONS OF PLASTIC AT RISK OF LEAKAGE INTO NATURE IN 2030.

A systems approach, deploying tactical and strategic interventions across the plastic life cycle, is needed to create a path to no plastic in nature. To stop the growth of plastics, tactics should include building on and reinforcing existing initiatives, such as banning problematic single-use plastics, and upgrading national waste management plans. At the same time, to tackle underlying issues, a global accountability mechanism should be created featuring a multilateral agreement with clear on the ground plans, robust domestic laws, and commercial devices to distribute responsibility appropriately across the plastic life cycle. Measures should be put in place to ensure the global price of plastic reflects its full life cycle cost to nature and society. Additionally, consumers must be persuaded to change their behaviours and provided with alternative choices and products that cause plastic pollution.

This approach could cut plastic waste generation by 57 per cent and reduce virgin plastic production by nearly half, compared with business as usual. Phasing out single-use plastics, those that have a one-year lifespan, has the potential lower plastic demand by up to 40 per cent by 2030. Reducing plastic consumption, coupled with growing secondary plastic material production, could half virgin plastic production by 2030. Phasing out single-use plastic usage lessens the plastic burden placed on the waste system and is estimated to lower plastic waste generation to 188 million metric tons, a 57 per cent reduction from the business as usual scenario.

Eliminating waste mismanagement and reusing plastic can create a plastic pollution-free system, and create over a million jobs in plastic recycling and remanufacturing. As an alternative to the business as usual scenario, the no plastic in nature scenario calls for developing capacity to recycle 60 per cent of plastic waste, or about 113 million metric tons. Cleaner sorting of waste into specific types of plastic, coupled with designing products for ease of reuse, would create a consistent volume of high-quality plastic waste to support the development of increased recycling capacity. Over a million new jobs could be created through recycling and remanufacturing plastic[33]. This job creation potential is dependent on the scale of recycling growth in a closed loop plastic system and on operating efficiencies within each plant. Improving waste collection rates to 100 per cent would enable all plastic waste to enter a formal waste management system stopping an estimate 50 million metric tons from being mismanaged. The final step to eliminate plastic pollution requires ending open dumping and uncontrolled landfilling to stop a predicted 54 million metric tons of plastic from being mismanaged.

All stakeholders in the plastic system must be aligned to the common goal of ending plastic pollution and fixing the plastic value chain. This systemic solution can achieve this goal, but bold action from a broad range of stakeholders is needed to implement strategic and tactical interventions. Beyond current initiatives, a pathway to reach this common goal requires critical action.

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Boys compete with their hand made boat by plastic waste during the official voyage launch of the dhow made by recycled plastic at Lamu Island, northern coast of Kenya. Flipflopi, the worlds first 100% recycled plastic dhow, embarked on its 500 km maiden voyage from Lamu, Kenya to Tanzania's Zanzibar, visiting schools, communities and government officials, sharing solutions and changing mindsets along the way.

POLLUTION FROM PLASTICS - A THREAT TO NATURE AND SOCIETY

Since 2000, the plastics industry has produced as much plastic as all the preceding years combined. The production of virgin plastic has increased 200-fold since 1950, and has grown at a rate of 4 per cent a year since 2000[34]. In 2016, the most recent year for which data is available, production reached 396 million metric tons. That is equivalent to 53 kilograms of plastic for each person on the planet. Production of plastic in 2016 resulted in approximately 2 billion metric tons of carbon dioxide emissions, which accounts for almost 6 per cent of the year's total global carbon dioxide emissions[35]. If all predicted plastic production capacity is constructed, current production could increase by 40 per cent by 2030[36].

75%

OF ALL PLASTIC EVER PRODUCED IS WASTE

80%

OF OCEAN PLASTICS ARE ESTIMATED TO COME FROM LAND-BASED SOURCES.

1/3 OF PLASTIC

(100 MLN METRIC TONS)

AND 104 MLN METRIC TONS AT RISK OF LEAKAGE INTO NATURE IN 2030 IN BUSINESS AS USUAL SCENARIO

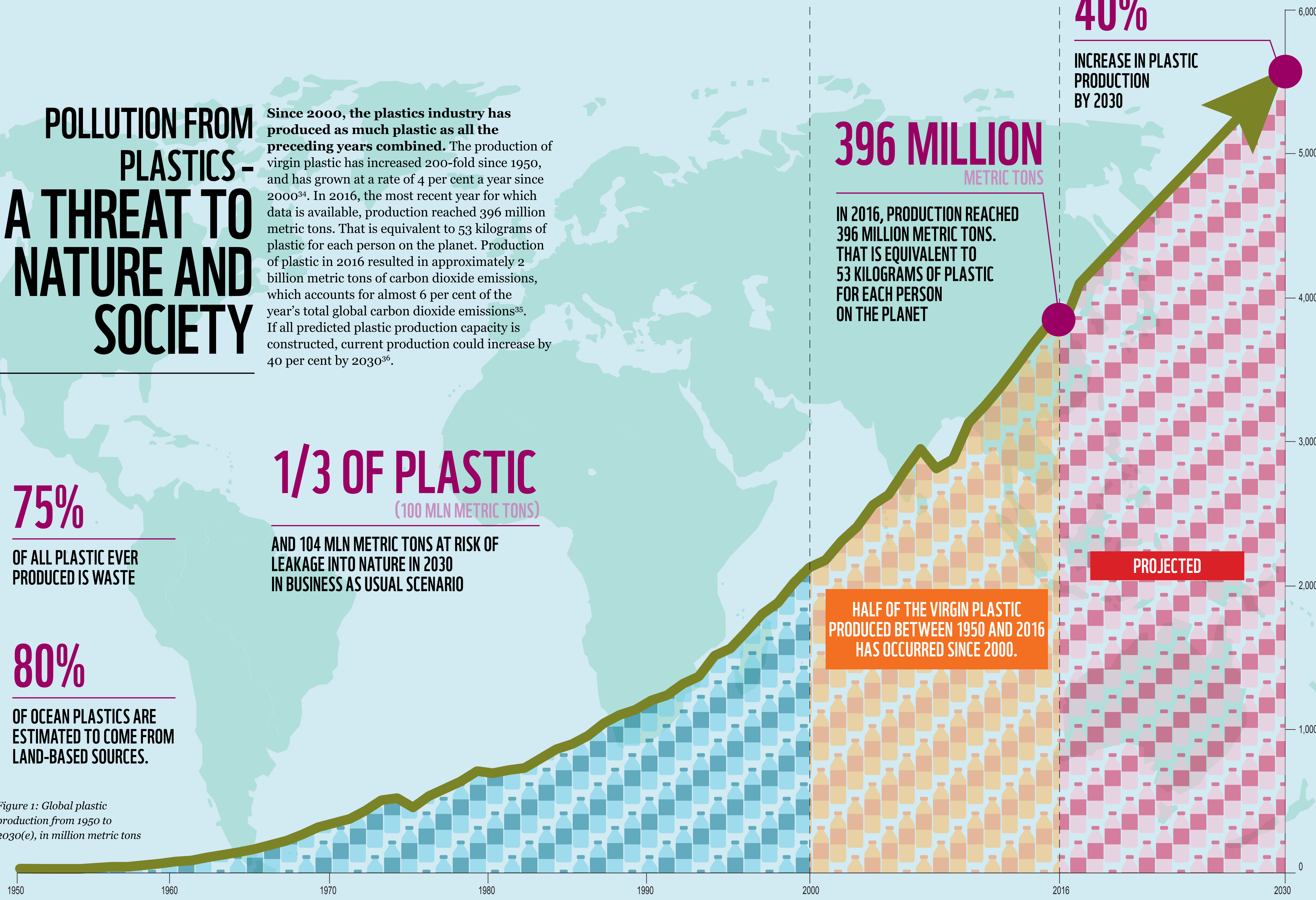


Figure 1: Global plastic production from 1950 to 2030(e), in million metric tons

Source: Dalberg analysis, Jambeck & al (2017)

Almost half of all plastic is used to create throwaway products that have a lifespan of fewer than three years; most of these throwaways are consumed in high and upper-middle income countries. Plastic's low cost and versatility has led to innumerable applications across many industries. The packaging industry is the largest converter of virgin plastics into products and was responsible for converting almost 40 per cent of total plastic produced in 2015[37]. The construction and automotive industries are the second and third largest converters of virgin plastic. Many packaging products are known as single-use plastics, as they are designed to be used only once before disposal. Examples include shopping bags, food packaging and beverage bottles. Most these products are consumed in high income and upper-middle income countries.

Rapid consumption practices generate huge amounts of plastic waste that the world is ill-equipped to handle; 37 per cent of plastic waste is currently managed ineffectively. Almost 310 million metric tons of plastic waste was generated in 2016 or the equivalent of over 2,200 plastic water bottles for every human on earth, with the level of plastic waste growing at more than 3 per cent per year since 2010[38]. However, in 2016, only 63 per cent of plastic waste entered a controlled waste treatment stream with a low risk of creating plastic pollution, as shown in Figure 2.

The most prevalent plastic waste management systems are landfilling, incineration, and dumping. In 2016, 39 per cent of plastic waste was sent directly to landfills where it requires over 400 years to decompose[39]. Industrial incineration is used to treat 15 per cent of plastic waste, which releases 2.7 metric tons of carbon

Figure 2: Overview of main waste management streams for plastic

	Management process	Description	% of 2016 generated plastic waste	
Managed waste	Controlled landfill[1]	• Managed disposal of waste on land with little or no pre-treatment. Site meets requirements for gas monitoring, site compacting and land covering	28	63% of waste was effectively managed
	Recycling	• Plastic collected from the waste stream and reprocessed into a secondary material[2]	20	
	Industrial incineration	• Combustion of plastic in a controlled and closed industrial process with exhaust gases adhering to environmental emission regulations	15	
Mis-managed waste	Open dumping & other	• Discarded plastic directly on land, freshwater or marine areas. Alternatively, littering or any form of unregulated plastic waste management such as open burning	14	37% of waste was ineffectively managed and at risk of becoming pollution
	Uncontrolled or unspecified landfill[3]	• Absence of control of the disposal operations of plastic and lack of management of the landfill site	12	
	Uncollected waste	• Unrecovered plastic from the end-user via a waste collection system and does not enter a formal waste treatment process	11	

Notes: (1) We consider that all landfills on high Income countries are controlled based World Bank data from the "What a Waste 2.0" Report; **(2)** Not accounting for plastic losses during the recovery process; **(3)** Unless explicitly specified as "controlled" or "sanitary"' landfills, we consider landfills in upper middle, lower middle and low Income countries as uncontrolled or unspecified.

Source: Dalberg analysis, Jambeck & al (2015), World Bank (2018), SITRA (2018), European Commission (2001)

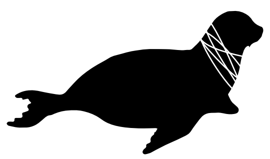
dioxide into the atmosphere for every metric ton of incinerated plastic waste[40]. Only 20 per cent of the planet's plastic waste is currently collected for recycling. Even if plastic is collected for recycling there is no guarantee that it will be reprocessed into new material. For example, less than half of plastic waste collected for recycling in Europe is actually recycled due to high levels of contamination[41].

Mismanaged plastic waste is a critical concern because it is more likely to become pollution than waste managed through a controlled waste treatment facility. Mismanaged waste refers to plastic left uncollected, openly dumped into nature, littered, or managed through uncontrolled landfills.

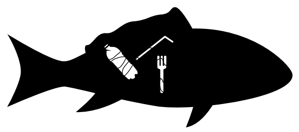
The increasing use of plastic, and the world's inability to manage plastic waste, results in one-third of plastic waste becoming land or marine pollution. An estimated 87 per cent of the plastic that entered a mismanaged waste stream in 2016 was leaked into nature and became plastic pollution[42]. The majority of this mismanaged plastic waste, 90 per cent, is believed to have polluted land-based nature, such as soil and freshwater bodies. The remaining ten per cent has, or is expected to, reach the oceans[43]. Of the plastic waste that reaches the oceans, just one per cent is estimated to accumulate on the surface[44]; the rest is thought to be below the surface or on the ocean floor[45].

PLASTIC HAS BECOME AN UBIQUITOUS MATERIAL CREATING A SERIOUS CHALLENGE FOR THE NATURAL WORLD, SOCIETY AND GLOBAL ECONOMY

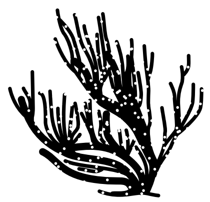
Environmental Impacts



Entanglement: Wildlife entanglement has been recorded in over 270 different animal species, including mammals, reptiles, birds and fish[46]. Entanglement in plastic debris often leads to acute and chronic injury or the death of affected animals. It is estimated that a minimum of a thousand marine turtles die every year due to entanglement in plastic waste, which includes lost or discarded fishing gear[47].



Ingestion: Ingested plastic is damaging to the health of animals. Records have documented more than 240 different animal species ingesting plastic[48]. These animals are often unable to pass the plastic through their digestive systems, resulting in internal abrasions, digestive blockages, and death[49]. Further, toxins from ingested plastic have also been shown to harm breeding and impair immune systems. This is of particular concern for endangered species with small populations that are exposed to multiple stressors in addition to plastic ingestion[50].

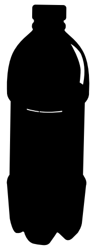


Habitat damage: Plastic waste has been found in soils, rivers and oceans where it can degrade or destroy wildlife habitats. Microplastic pollution has been shown to alter soil conditions, which can impact the health of fauna and increase the likelihood of harmful chemical leaching in the soil[51]. Plastic waste is also accelerating coral degradation. Abandoned, lost, or discarded fishing gear can smother fragile reefs, and the microbial colonies that form on plastic waste can lead to higher rates of disease in corals[52].

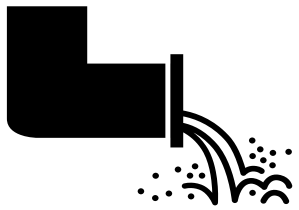
Social Impacts

Plastic pollution has effects on air quality, water systems, and soil conditions. The most common direct impacts are related to unregulated plastic waste management, human ingestion of micro and nano-plastics, and plastic contamination of soils.

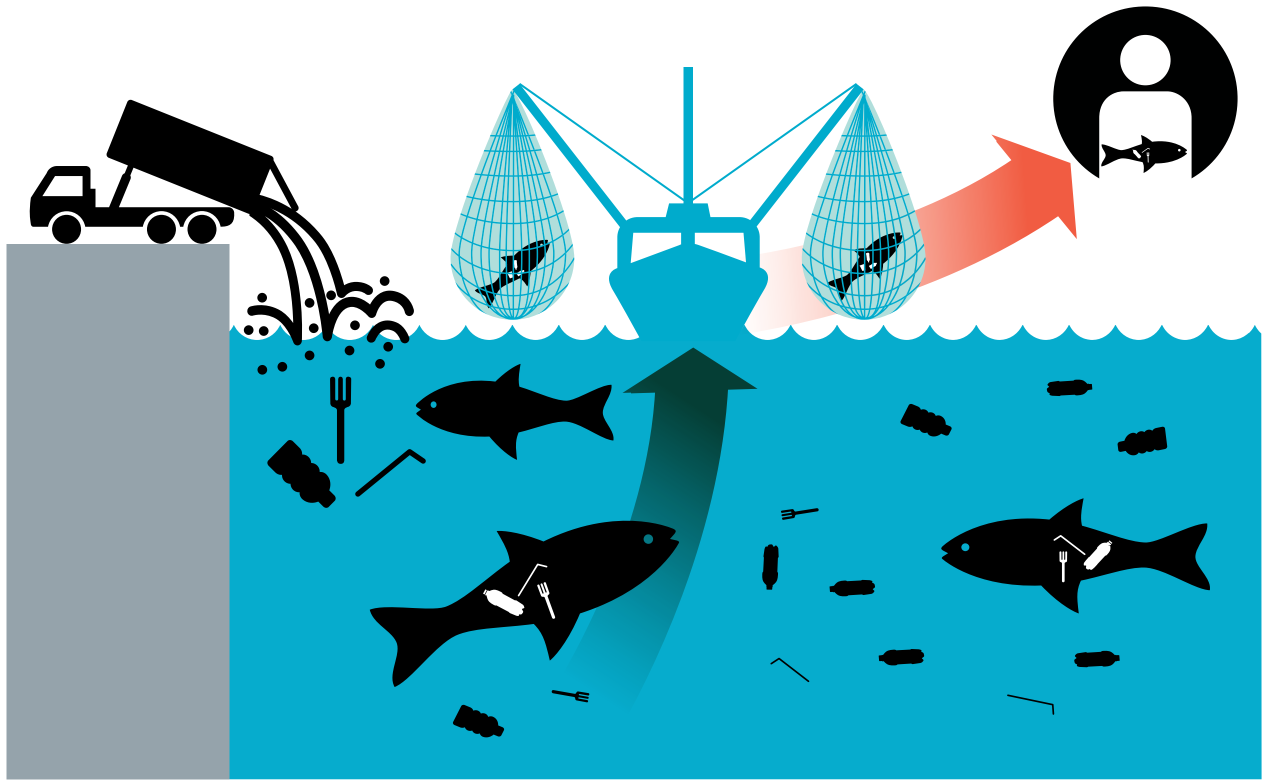
Unregulated plastic waste management: In 2016, 37 per cent of plastic waste was mismanaged through unregulated waste management processes, including open incineration, open dumping, and uncontrolled recycling. These processes, particularly open incineration, release toxic gases, halogens, as well as nitrous and sulphur oxides, all of which can affect air quality[53]. Open dumping also pollutes nearby aquifers, water bodies, and settlements[54]. Additionally, plastic-related compounds associated with poorly regulated incineration or open burning have been shown to heighten respiratory ailments, increase the risk of heart disease, and damage the human nervous system[55]. Communities located close to inadequately controlled waste management facilities are particularly at risk[56].

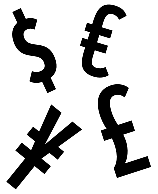


Human plastics ingestion: Although humans are highly likely to ingest micro and nano-plastics, the direct health impacts are unknown. Humans can ingest plastic by consuming foods contaminated with micro and nano-plastics. This is most likely to occur via seafood, particularly shellfish, mussels and oysters[57]. There are many other sources of contamination. A recent study of bottled water found microplastic contamination in 93 per cent of bottles, sourced from 11 different brands across nine countries[58].



Soil and water contamination: Microplastics released during clothes washing and nano-plastics used in cosmetics products can accumulate in wastewater systems. Wastewater treatment processes remove many of these plastic particles as a sewage sludge byproduct[59]. This sludge is often used as field fertilizer causing several thousand metric tons of microplastics to end up in soils each year[60]. Wastewater treatment plants, however, are currently unable to remove all plastic particles from wastewater before it is released back into the environment[61] or municipal water systems[62].

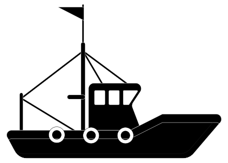




Economic Impacts

The total economic impact of plastic pollution is not yet known, although most research so far has focused on the impact on oceans. The UN Environment Programme (UNEP) estimates the economic impact of plastic pollution on oceans at US$8 billion per year[63]. It is also estimated that there is four times more plastic pollution on land than in the oceans, suggesting that the total economic impact of plastic pollution is actually much greater[64].

While our understanding of the total economic impact is still emerging, below we highlight the existing impact on specific industries.



Fisheries: Oceanic plastic pollution reduces both the supply of, and demand for, seafood due to animal deaths and concerns that animals have ingested plastic. Plastic pollution, including abandoned fishing gear, can also clog boat engines leading to disruption of the fishing industry. Costs from the interruption of business due to plastic pollution in the European Union were estimated at 0.9 per cent of total industry revenues, which amounts to €61.7 million per year[65].

Maritime trade: Commercial shipping vessels are also extremely sensitive to collisions with plastic pollution, as damage to the vessel could endanger human lives. The Asia-Pacific Economic Cooperation (APEC) estimated the cost of litter damage to commercial shipping at US$297 million per year[66].

Tourism: Plastic pollution can reduce income and increase costs in the tourism industry. For example, plastic pollution has led to reduced tourist numbers in Hawaii[67], the Maldives[68] and Korea[69]. Further, removing this plastic pollution imposes additional costs for governments and businesses. The French city of Nice, for instance, spends €2 million each year to keep municipal beaches clean[70].

THE FULL EFFECTS OF MICROPLASTICS ON THE NATURAL WORLD AND SOCIETY ARE STILL UNKNOWN

Many knowledge gaps on the impacts of plastic pollution still exist including the economic impact of land-based pollution and the effects of micro-plastic ingestion on humans and other animal species. Further research is crucial to fully understanding the risks associated with plastic pollution. The findings of the World Health Organization's recently announced review into the effects of the microplastics in drinking water will be an important step toward understanding the health risks of prolonged exposure and long-term ingestion of plastics[71].

Despite limited knowledge of plastic ingestion on human health, the harmful health effects of many additives used in plastic production are well documented. BPA, phthalates, and some plastic flame retardants have been shown to contain substances that, with sufficient exposure, can cause birth defects and development disorders[72]. These findings led the USDA Food and Safety Inspection Service to recommend to the public that several types of plastics should not be heated[73]. Additionally, plastics released into the environment absorb high levels of organic contaminants, potentially making them particularly toxic when ingested[74]. Further research into the health effects of ingestion is urgently needed.

THE ROOT CAUSE OF THE PROBLEM – A TRAGEDY OF THE COMMONS

Plastic pollution comes at a cost that is not carried by the stakeholders that are profiting from plastic production and usage.

The plastics life cycle currently comprises five key steps, as seen in Figure 3. Each step is driven by, and influences, key stakeholders such as producers, plastic converters, end users, governments, and waste management actors*. Much like other forms of pollution, the design of this system does not hold these actors accountable for the negative consequences of their actions[75]. The system's lack of accountability has contributed to the current situation of unsustainable plastics production and increasing plastic pollution[76].

The lack of accountability in the system results in one-third of all plastics waste generated, or 100 million metric tons of plastic waste, polluting nature each year. Plastic pollution and carbon dioxide emissions are a trans-boundary issue, as their impacts are experienced globally. The following section details the failures at each stage in the plastics life cycle and illustrates how these failures lead to a system that leaks a third of all plastic waste into nature.

* See Glossary for a more detailed explanation of each stakeholder and its role within the plastics life cycle

Figure 3: Overview of the plastic life cycle

	1 Plastic Production	2 Plastic Usage	3 Waste Collection	4 Waste Treatment	5 Secondary Markets
Description	• Manufacturing of virgin plastic from fossil fuel chemicals by a process of polymerization or polycondenzation	• Use of plastic from conversion of material into specific products until disposal of product as waste by the end-user	• Recovering disposed plastic waste from end-users and sorting waste into various streams for treatment	• Treatment of sorted plastic waste through various methods such as landfilling, incineration, recycling and dumping	• Reuse of plastic within an economy after reprocessing waste into a secondary material
Keystake holders	• Petrochemical companies • Oil & gas companies	• Plastic converters[1] • End customers (individual, institutional, and commercial)	• End customers • Local or national authorities • Waste management companies • Plastic converters	• Local and national authorities • Regulatory bodies • Plastic producers • Waste management companies • Plastic converters	• Plastic recyclers • Plastic converters

Notes: (1) Manufacturers of plastic products in all plastic markets (e.g., packaging, building and construction, transport) that convert virgin plastic into a specific products for use within the economy. These plastic products can be combined with other non-plastic materials during the conversion process.

Source: Dalberg analysis, Jambeck & al (2014), World Bank (2018), SITRA (2018)

1. Plastic production

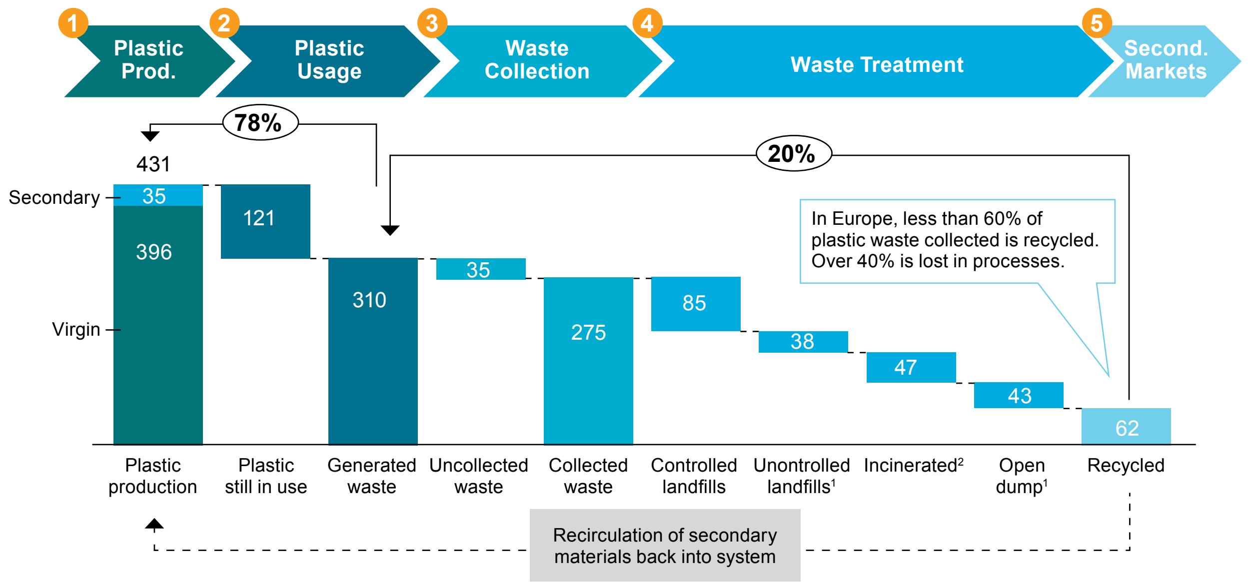
Falling production costs have resulted in the accelerated production of virgin plastics, reaching 396 million metric tons in 2016, and an associated drop in their sale price. The cost of raw materials used to produce plastic, such as natural gas and oil, have declined by almost half over the last decade[77]. U.S. liquid natural gas (LNG) acts as catalyst for changes in the wider energy market [78]. Due to increasing cheap U.S. exports, LNG in Europe and China (the world's largest plastic producers) shifted toward a period of lower prices[79]. As a result of low raw material costs, producing virgin plastic has become increasingly profitable for the petrochemical industry. This contributes to a plastics system that favours virgin plastic over secondary recycled plastic, which is more expensive and laborious to produce.

Plastic producers are not held accountable for the negative impacts of production as the market price of virgin plastic today does not represent its full life cycle costs to nature and society. The regulatory incentives currently in place to curtail virgin plastic production are limited. For example, petrochemical companies located in the U.S., China and Europe do not currently pay for the carbon dioxide emissions resulting from virgin plastic production[80]. Emissions trading schemes exist in Europe[81] and more recently in China[82], but petrochemical production is exempt from carbon emission caps. Unlike aluminium, steel and cardboard production, plastic production is not deemed sufficiently energy intensive to require the purchasing of carbon allowances[83].

2. Plastic usage

Plastic converters, manufactures of products made out of virgin plastic, have limited responsibility for the downstream impacts of their actions causing a prevalence of single-use plastic business models. The rate of plastic consumption has grown by more than 25 per cent since 2010. Plastic products often have a complex blend of additional materials that reduce the costs of production[84]. However, this also reduces the recycling potential of these mixed material products

Figure 4: The five segments of the plastic life cycle, (million metric tons, 2016)



Notes: (1) Plastic at risk of being openly burnt; **(2)** Controlled incineration in plants only; **(3)** Manufacturers of plastic products in all plastic markets (e.g., packaging, building and construction, transport) by converting virgin plastic into a specific plastic item

Source: Dalberg analysis, Jambeck & al (2014), World Bank (2018), SITRA (2018) by introducing impurities and contaminants and increasing the sorting and cleaning costs[85]. As result, more than 40 per cent of plastic waste collected for recycling cannot be profitability recycled, and is instead managed through incineration and landfilling[86].

Plastic converters do not design resource-efficient products that enable effective end-of-life plastic waste management. Decisions taken by plastic converters directly affect the price competitiveness and quality of secondary recycled plastic. This results in an abundance of high quality, low cost virgin plastic products. Downstream waste management companies unfairly carry the financial burden of the decisions made by plastic converters[87]. Due to design and material choices of converters, the cost of plastic waste management increases, and the quality of secondary materials decreases[88].

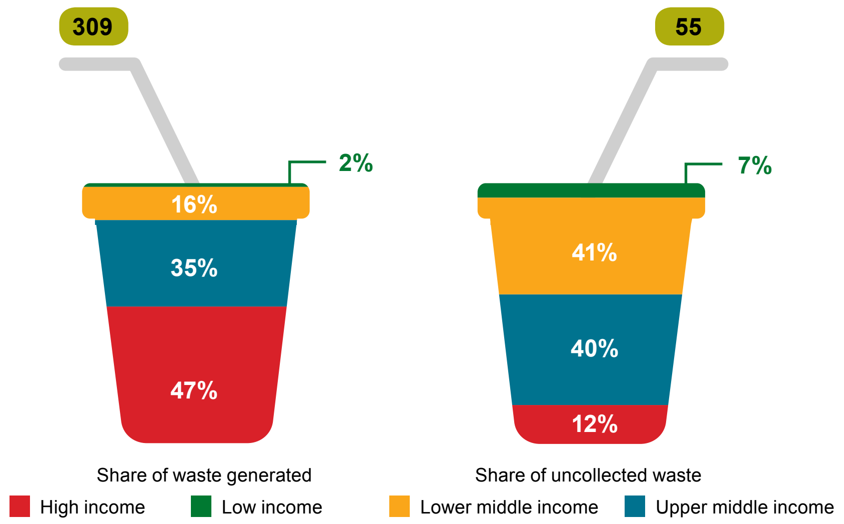
The plastics life cycle does not have a global feedback loop to hold upstream stakeholders accountable for their products after the point of sale[89]. While policies exist such as extended producer responsibility in some OECD countries, many regions with high rates of mismanaged plastic waste have yet to implement similar programs[90]. As of yet, there is no universal policy, governance mechanism, or regulatory body to ensure transparency and accountability of upstream actors, which limits the ability to generate systemic change in the plastics life cycle.

3. Waste collection

Uncollected plastic waste often becomes plastic pollution[91]. In 2016, 11 per cent of plastic waste generated went uncollected, the main causes being underdeveloped waste management infrastructure and barriers that make it difficult for end-users to sort and dispose of their waste. The ability of companies to effectively sort and manage plastic waste varies by country and is negatively impacted by the design decisions of upstream plastic converters.

Underdeveloped waste management infrastructure is a major challenge in low and middle-income countries, and it leads to low collection rates. There is limited investment in waste management infrastructure in low and middle-income countries amid the many competing development priorities. Low-income countries invest three times less into waste management systems than in high-income countries[92]. In 2016, the average collection rate in low-income countries was below 50 per cent.

Figure 5: Share of plastic waste generated and uncollected by income group, (% 2016; million metric tons in bubbles)



Source: Dalberg analysis, Jambeck & al (2014), World Bank (2018), SITRA (2018)

Collection rates are generally higher, but issues remain in high-income counties. Collection rates are above 95 per cent in most high-income countries, but rates are often lower in rural areas as waste collection systems are not modernized in line with urban environments[93]. Unless waste management systems improve across the globe, as the rate of waste generation continues to grow, the amount of uncollected waste and resulting plastic pollution is certain to rise.

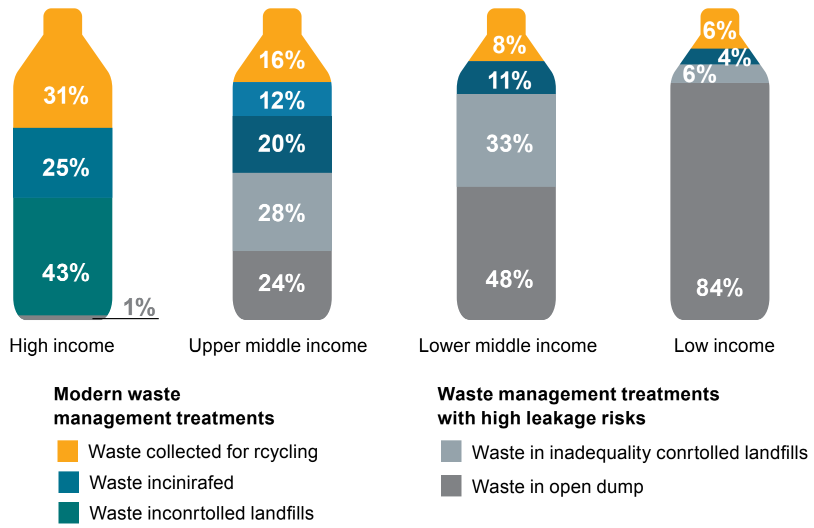
End-users face challenges properly sorting and disposing of plastic waste, which leads to waste being discarded directly to landfills or dumped into nature. Communities in low and middle-income countries often need to travel many kilometres from their homes to dispose of waste in a central container or collection point where it is picked up by their municipality[94]. End-users are often unaware of the importance of effective separation and waste disposal, which often results in substantial littering, particularly in urban centres[95].

4. Waste treatment

Mismanaged waste is a direct cause of plastic pollution. While the mismanagement of waste exists in most regions, it is greatest in low and middle-income countries as a result of inadequate waste management infrastructure (see Figure 6). In countries with limited recycling capacity and fewer effective end-of-life waste management systems, plastic waste is far more likely to end up in inadequately controlled landfills or open dumps[98]. Without improvements to waste management systems, the global volume of plastic pollution is set to increase rapidly.

Scaling recycling capacity remains unprofitable and challenging due to the risky business model. In 2016, less than a 20 per cent of plastic waste was recycled[99]. In Europe, a continent with some of highest recycling rates, plastic recycling economics remain unprofitable. Operating costs are estimated to be €924 per metric ton to recycle plastic, which is significantly less than the average selling price of secondary plastic material, €540 per metric ton[100]. Currently, landfilling and incineration are a more widely utilized form of waste treatment than recycling across all income groups, as seen in Figure 8. A landfill or an incineration plant earns revenue for the storage and treatment of waste[101]. Whereas recycling plants earn an income almost exclusively from the sale of the recycled material they produce[102]. Landfill and incinerator business models are based on a steady supply of raw waste. Plastic recyclers, in contrast, depend

Figure 6: Share of plastic waste treatment by income group



EFFECTIVE PLASTIC WASTE MANAGEMENT PERFORMANCE IS CORRELATED TO THE INCOME STATUS OF A NATION

High income countries produce ten times more waste per person than low income countries, as shown in Figure 7. Over half the plastic waste in 2016 came from high income countries and over a third from upper-middle income countries. However, high income countries have lower waste mismanagement rates, between five per cent and 10 per cent, compared to higher rates other regions. High income countries also export between 10 per cent and 25 per cent of their waste, making their capacity to manage waste sensitive to global trade dynamics. Thus, these rates of mismanagement in high income countries may be underreported as their data assumes all export waste is effectively treated in the importer country[30].

Plastic pollution and carbon dioxide emissions are a transboundary issue, as their impacts are experienced globally, but it is the consumption habits of high-income countries that are driving plastic production. In 2016, carbon dioxide emissions due to plastic consumption was four times higher per kilogram of plastic produced in Italy than in Senegal, as seen in Figure 8. Reducing the consumption of virgin plastics in high-income countries is, therefore, an important step in reducing the carbon footprint of the global plastics life cycle.

As lower middle and low-income countries continue to develop, their rates of plastic waste generation are expected to increase from 11 kilograms toward the 118 kilograms of plastic waste generated per person in high income countries. As a result, larger and larger volumes of global plastic waste will need to be disposed of through plastic waste management systems. Despite middle to low-income countries producing less plastic waste than high income countries, underdeveloped waste management infrastructure leads to higher rates of mismanaged waste. In 2016, over 76 per cent of total plastic waste in low-income countries was mismanaged. Efforts are being made to improve waste management infrastructure. In Sub-Saharan Africa there is a large focus on increasing collection coverage and providing suitable final disposal options[96]. However, challenges with planning, regulation and financing remain[97].

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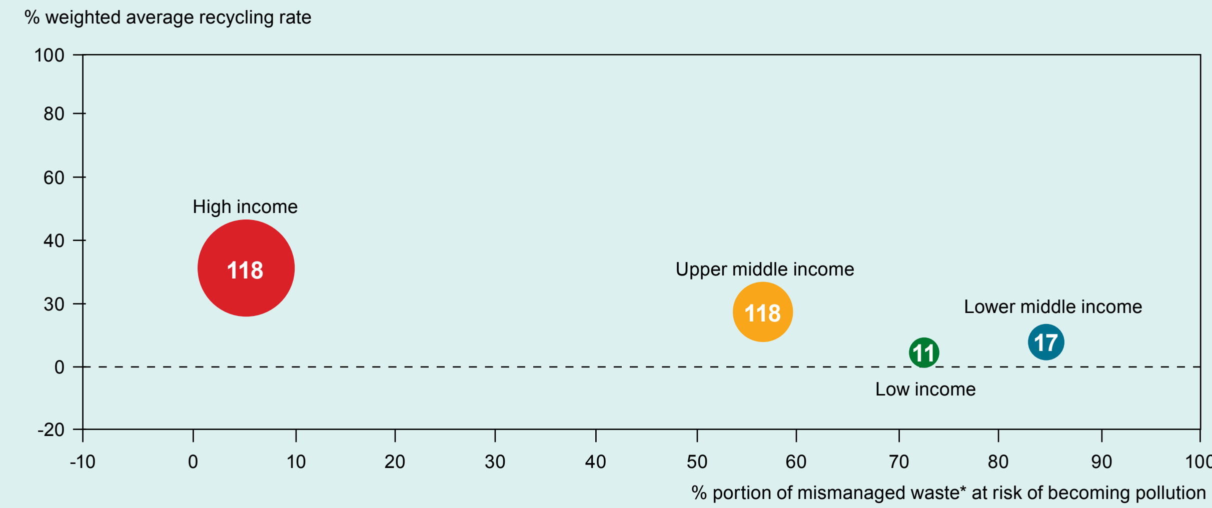
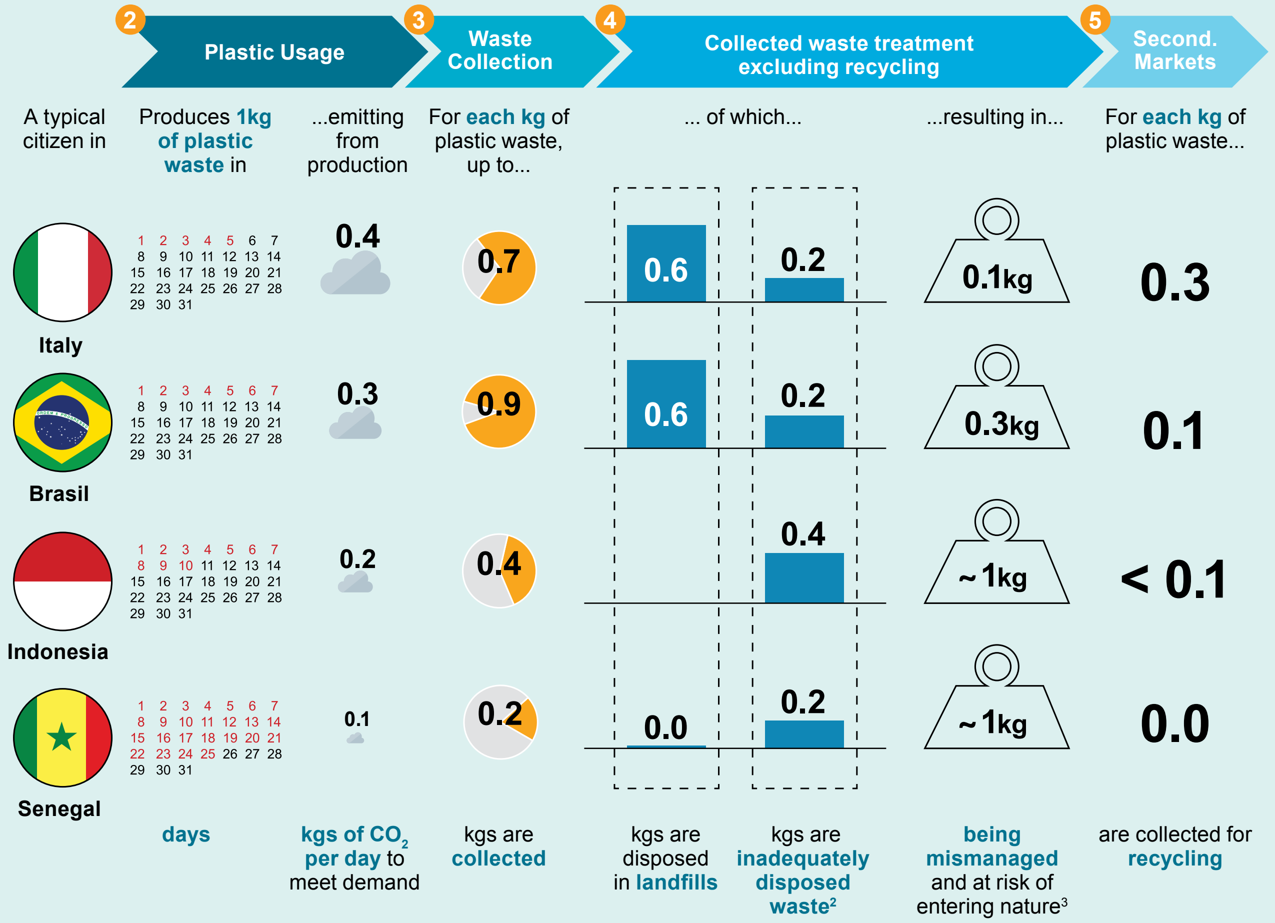
Plastic waste is burning at the side of Burigonga River in Kamrangirchar, Bangladesh.

Figure 7: Country income status comparison by kilograms of plastic waste generated per person, mismanaged plastic waste at risk of pollution, and plastic recycling rates (2016)



* Mismanaged plastic waste includes all uncollected plastic waste and waste disposed in an inadequately managed landfills or open dumps
Source: Dalberg Analysis, World Bank "What a Waste 2018" database; UN Basel Convention (2002); SITRA (2018); Plastics Europe (2017)

Figure 8: Deep dive into 1 kilogram of plastic waste in different countries



Source: **(1)** Extrapolation based on figures for LDPE. Production of 1 kg of LDPE requires the equivalent of about 2 kg of oil (raw material and energy). **(2)** Disposed in inadequately controlled landfills or in open dumps; **(3)** Excludes plastic waste arising from littering and assumes all exported waste is correctly treated in importer country on largely unreliable supplies of separated waste. Recycling businesses also exposed to material losses during the recycling process, and the low quality and low selling price of the secondary material they produce[103]. The profitability of recycling is affected by changes to any of these parameters, which are currently beyond the control of recycling businesses themselves.

Recycling operating costs are prohibitively high due to high collection and separation costs, and a limited supply of recyclable plastic. Collecting and sorting is a time consuming and labour-intensive process due to the high levels of mixed and contaminated plastic waste. Together, collecting and sorting constitute approximately 40 per cent of recycling costs[104]. In many cases, the inclusion of different materials or harmful substances to virgin plastic products means that the plastic waste cannot be recycled for health, safety, or quality control reasons[105].

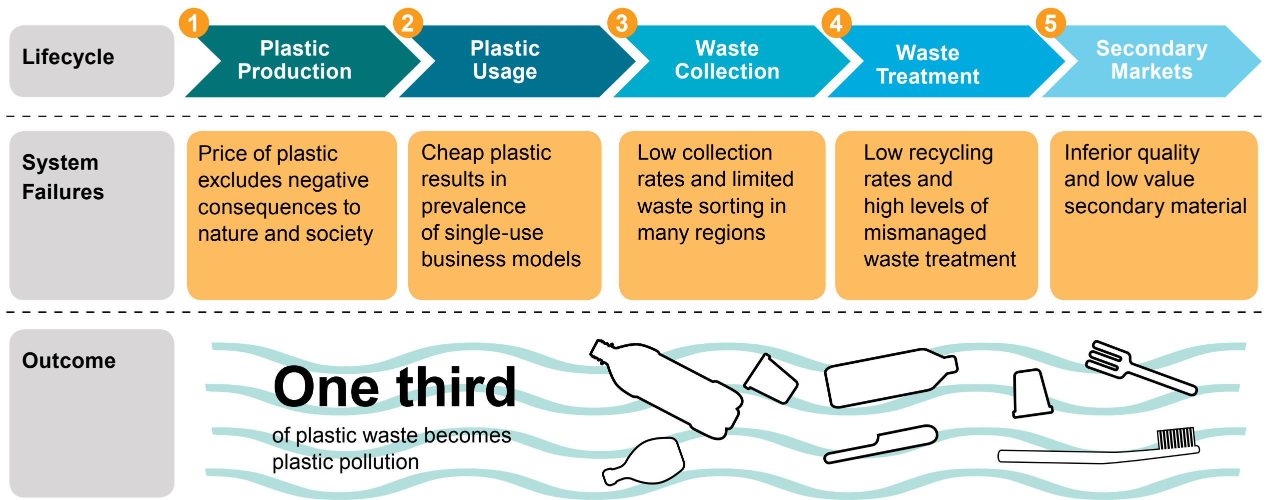
5. Secondary markets

Secondary plastic materials are of an inferior quality than virgin plastic, and therefore trade for a lower price. Due to its lower quality, recycled plastic has more limited reuse applications, reducing its demand, its price, and therefore the revenues of recycling companies. Secondary recycled plastic can trade for as little as a third of the price of the virgin plastic[106].

There are limited mechanisms in place to encourage upstream actors to support the development of environmentally sound alternatives to virgin plastics[107]. Secondary materials, unlike virgin plastics, carry the cost and consequences of poor upstream product design and weak waste management infrastructure. However, there are currently a lack of incentives in many regions to improve the costs, technical capabilities, and quality of secondary materials and other alternatives[108].

The failures of the current plastic system make it cheaper to discharge plastic into nature than to effectively managing plastic to the end-of-life stage. Since these economics are true for all actors in many locations around the world, the current plastics system is locked into polluting the planet[109]. In this broken system, decisions taken by upstream stakeholders, like multinational corporations, can have profound deleterious effects on the scale of global plastic pollution. For example, in 2015, a leading global beverage company changed its packaging from glass to plastic bottles in Tanzania[110]. Current estimates of Tanzanian plastic waste mismanagement are above 90 per cent[111]. Compared to glass, plastic does not have a circular deposit recovery system[112]. This corporate decision is expected to cause higher plastic consumption, to increase the amount of pollution generated, and to disrupt the glass circular value chain.

Figure 9: Summary of failures across the plastic system driving plastic pollution



Without systemic change to the plastic life cycle, the current plastic pollution crisis risks spiralling out of control. The plastics industry has produced more plastics since 2000 than all the preceding years combined. Over 75 per cent of this plastic is already waste. In fact, a third of this plastic waste is estimated to have become plastic pollution due mismanaged waste management processes. As result, plastic has contaminated the planet's soils, freshwater bodies and oceans. Additionally, humans are ingesting more plastic from their food and drinking water, and carbon dioxide emissions from plastic production and incineration are growing each year. To reverse this tragedy of the commons, the plastic life cycle needs urgent systemic change.

© Jamie Lamb / Getty Images

Seal pup choking on plastic fishing line.

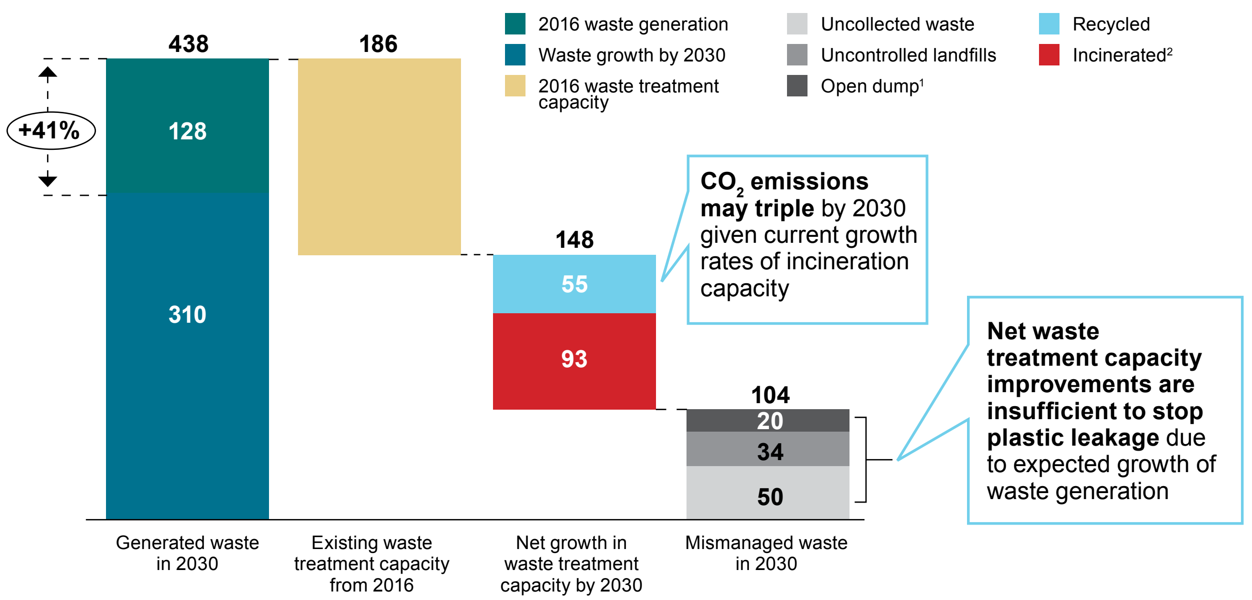
BUSINESS AS USUAL – POLLUTION WILL DOUBLE BY 2030

The plastic system is expected to double plastic pollution by 2030, with oceans the most visible affected by this pollution. Within the next 15 years, the current plastic life cycle is expected to result in almost double the amount of plastic accumulated in the ocean between 1950 and 2015. Ocean plastic pollution could reach 300 million metric tons by 2030, based on current population growth forecasts, GDP per capita projections, and current plastic waste generation per capita. This is enough waste to make the equivalent of 11 trillion 500ml plastic bottles.* Annex 2 provides more detail on the methodology used for this projection. Furthermore, land-based pollution could be much higher by 2030 given that recent evidence suggests there is potentially four times more plastic in terrestrial ecosystems than in the oceans[113].

Annual ocean plastic leakage will remain above nine million metric tons per year until 2030 because the growth in plastic consumption outstrips the growth in waste management capacity. The plastic system is producing waste faster than it can be managed. If business continues as usual, improvements to waste management capacity are unlikely to stop plastic leakage into nature. The growth of total plastic waste from uncontrolled consumption counteracts the net improvements in waste management capacity, resulting in a small reduction in mismanaged plastic as seen in Figure 10. In absolute terms, mismanaged waste is expected to decrease from 115 million metric tons to 104 million metric tons over the next 15 years. As a result, plastic leakage will remain similar to current levels. Over nine million metric tons of plastic - equivalent to around 1.4 million 500ml plastic bottles leaking into the ocean every minute.

* See Glossary. Mass of plastic pollution was converted into equivalent number of a standard 500ml PET plastic bottle, with a mass of 12.7 grams. Calculation based on 90,000 seating capacity football stadium with volume of 4,000,000m³. 1m³ is equal to 1,000 litres.

Figure 10: Plastic leakage consequences from plastic growth in the business as usual scenario, (million metric tons, 2030)



Notes: (1) Plastic at risk of being openly burnt; **(2)** Controlled incineration in plants only

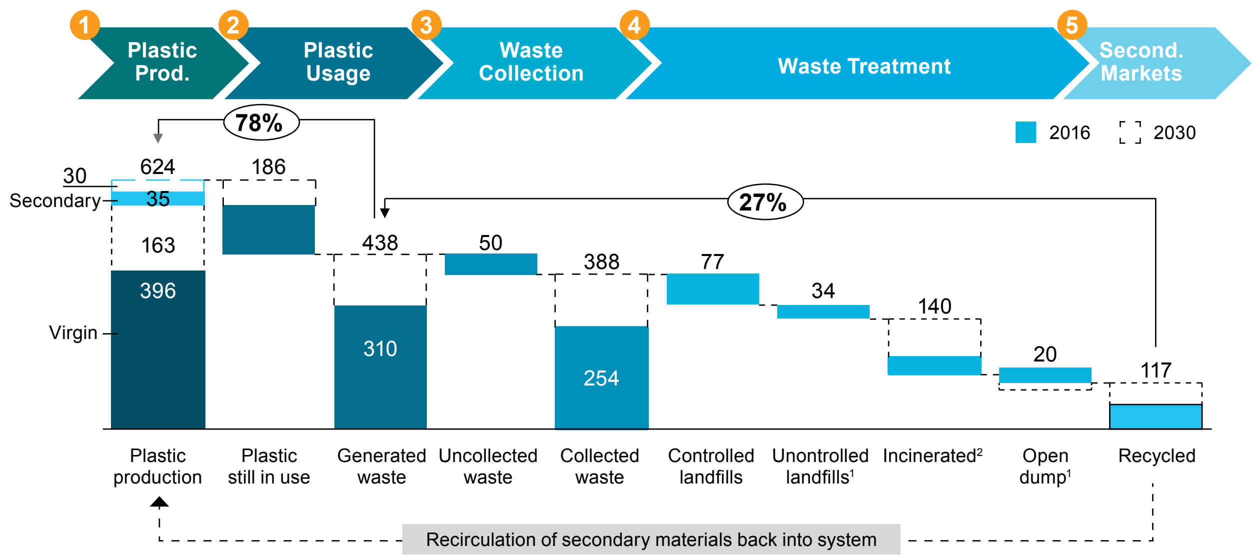
Source: Dalberg analysis, Jambeck & al (2014), World Bank (2018)

Annual waste generation could increase by 41 per cent over the next 15 years due to accelerated production of plastics driven by the falling costs of production. With business continuing as usual, plastic waste generation is to expected increase by 128 million metric tons, and plastic consumption will continue to grow at a recent rate of above three per cent. Most plastic is made from byproducts of natural gas exploration or crude oil refinement, and plastic production capacity is expected to increase given supply surplus over the coming years from additional Liquefied Natural Gas capacity in the US[114]. On its current trajectory, China could consume 90 per cent more crude oil in the production of petrochemicals by 2030 than in 2015[115]. Additionally, UK multinational chemical company INEOS is planning the first major investments in European chemicals capacity in over 20 years by expanding two ethylene facilities and constructing a new propylene production plant[116]. If all predicted plastic production capacity is constructed, it may lock in an expansion of virgin plastic production for decades[117]. Driven by the growth in consumption, reliance on virgin plastic remains analogous to today as shown in Figure 11.

Carbon dioxide emissions from plastic waste management could triple by 2030 as other waste treatment infrastructure remains more economically attractive than recycling. Over 350 million metric tons of carbon dioxide could be emitted in 2030 by continuing to pursue a waste-to-energy (WtE) incineration approach for dealing with plastic waste. Global incineration capacity may continue to grow faster than recycling given the lower risk "pay as you store" waste management business model and the current financial support mechanisms for WtE plants[118].

Unmonitored, an incineration lead WtE solution to the plastic pollution problem risks creating other pollutant issues for nature and society beyond carbon dioxide emissions. Furthermore, additional health and safety concerns for local communities are raised by pursing this path, given varied regional environmental regulations and incineration plant performance. Asia is expected to be the fastest growing region for incineration capacity until 2023, with annual growth of 7.5 per cent[11]. Incineration capacity in China has doubled since 2012, with 28 plants in operation, and capacity growth is expected due to increasing waste generation

Figure 11: Projection of plastic life cycle 2030, (Million metric tons, BAU scenario)



Notes: (1) Plastic at risk of being openly burnt; **(2)** Controlled incineration in plants only

Source: Dalberg analysis, Jambeck & al (2014), World Bank (2018)

INCINERATION RISKS TURNING A PLASTIC POLLUTION CRISIS INTO AIR QUALITY AND GREENHOUSE GAS ISSUE

Of the 275 million metric tons of waste collected globally in 2016, 47 million metric tons was incinerated. In a business as usual scenario, this is projected to increase to 140 million tons of plastic waste incinerated in 2030. Currently, incineration of plastic waste makes a small contribution to global carbon emissions. Without improved technologies or regulations, however, incineration of larger quantities of waste will lead to equivalent increases in carbon emissions.

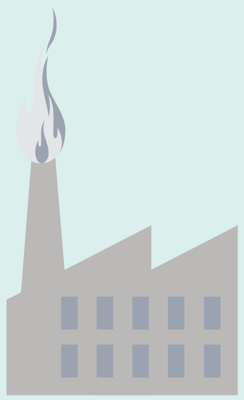
Alternative technologies to incineration are available but remain unproven and are surrounded by environmental uncertainties. Waste-to-energy has the potential to offset some of the carbon dioxide emissions by reducing the energy supplied by burning fossil fuels. To reduce these emissions, Norwegian waste-to-energy facilities are piloting the implementation of carbon capture and storage (CCS) technology[121]. However, this is the exception and not the norm, and further research is required to fully understand the environmental impacts of CCS. Other technologies such as gasification, or using enzymes for bio-chemical processing, are available, but are in their infancy and are not commercially viable.

There are concerns that incinerators will be chosen as a short-term solution to deal with stockpiling of plastic waste[122]. This has the potential to "lock in" demand for incinerators for years to come, rather than focusing on reducing usage and scaling recycling to build a circular value chain[123].

International standards for incineration are non-homogenous, and the issues associated with incineration as a means of plastic disposal vary globally. Local environmental effects such as air pollution are felt more keenly in emerging markets due to a lack of adherence to regulations, improper sorting of waste prior to incineration, and lack of space available for landfills[124].

For example, the emission standards for mercury in China are lower than those found in Europe and the U.S. Environmental laws and regulations are also often poorly enforced in China[125]. Consequently, the solid waste incineration sector in China is a leading source of the national mercury emission growth. Additionally, 78 per cent of China's waste-to-energy facilities fail to meet European Union standards for dioxin emissions[126]. This is a result of poor waste classification which leads to a high moisture content and high concentrations of organic matter in the incinerated waste[127].

In India, plastics make up around 12 per cent of municipal solid waste. When burnt, plastic releases toxic gases such as dioxins and furans[128]. The practice of open burning in India is seen to be a significant contributor to urban air pollution[129]. The government intends to increase support for waste-to-energy facilities, which has raised concerns relating environmental compliance and flue gas scrubbing for these plants[130]. Non-compliant waste incineration will exacerbate the negative health effects associated with existing open burning practices[131].



275 MILLION TONS OF WASTE COLLECTED GLOBALLY IN 2016, 47 MILLION TONS WAS INCINERATED. IN A BUSINESS AS USUAL SCENARIO, THIS IS PROJECTED TO INCREASE TO 140 MILLION TONS OF PLASTIC WASTE INCINERATED IN 2030

and favourable government initiatives[12]. The government in India also supports WtE facilities. Continuing on this waste management path means China and India will "lock-in" this infrastructure for the duration of the investment cycle, typically 30-40 years, and are unlikely to pursue recycling opportunities.

Plastic's negative externalities are tied to a fragile global waste trade system that is struggling to adapt to national trade policy reforms. Today, roughly 13 million metric tons of plastic waste is traded, but China recently increased quality standards for plastic waste imports into the country. Further changes to trade patterns could be have a significant impact on plastic pollution. Without China's waste management system, for example, it is estimated that 111 million metric tons of plastic waste would be displaced by 2030[132]. Unless plastics exporters heighten their contamination standards, or countries invest in their own recycling capacity, the international plastics trade will remain fragile, and will risk exacerbating the damage that plastics have on the environment.

Urgent tactical action and strategic adjustments to the plastic system are needed to stop leakage, and further accumulation, of plastic in nature. In the business as usual scenario, each actor remains unaccountable for ensuring the plastic value chain is sustainable. Current efforts to improve waste management capacity across the planet are insufficient to stop plastic leakage, given growth trajectories for plastics. The current trajectory for plastic pollution results from: consumption patterns that support single-use business models for plastic products; waste mismanagement leaking plastic into nature; and a supply chain currently producing five times more virgin plastic than recycled plastic. Immediate action is needed to stop the uncontrolled growth of plastic pollution, and coordinated initiatives are required to hold each stakeholder accountable for reversing the plastics tragedy of the commons.

Children have fun in the water, after school in Lamu, Kenya. The Ocean is full with plastic waste.

© Shutterstock / Kiki Dohmeier / WWF

NO CHINA, NO TRADE: THE FRAGILE STATE OF THE GLOBAL PLASTIC WASTE TRADE SYSTEM

In 2016, four per cent of global plastic waste was exported, of which G7 countries made up nearly 50 per cent of export trade[133] as seen in Figure 13. In Japan, more than 20 per cent of plastic waste was exported for treatment in another country. For France, Germany and the United Kingdom, exports were above 10 per cent. China and Hong Kong were the largest importers of plastic waste. Almost two-thirds of plastic waste exports were received by these two nations. This made China and Hong Kong the centre of the global plastic waste trade in 2016.

In December 2017, China made the decision to enforce a significantly higher purity standard on plastic waste imports to improve performance of the country's waste management system[134]. China implemented the new import requirements in 2018 under its National Sword policy. However, the global waste management system was unprepared and unable to meet the new regulations. Thus, this policy reform is forcing global exporters to send higher quality waste to China, and to lower their amounts of contaminated export waste.

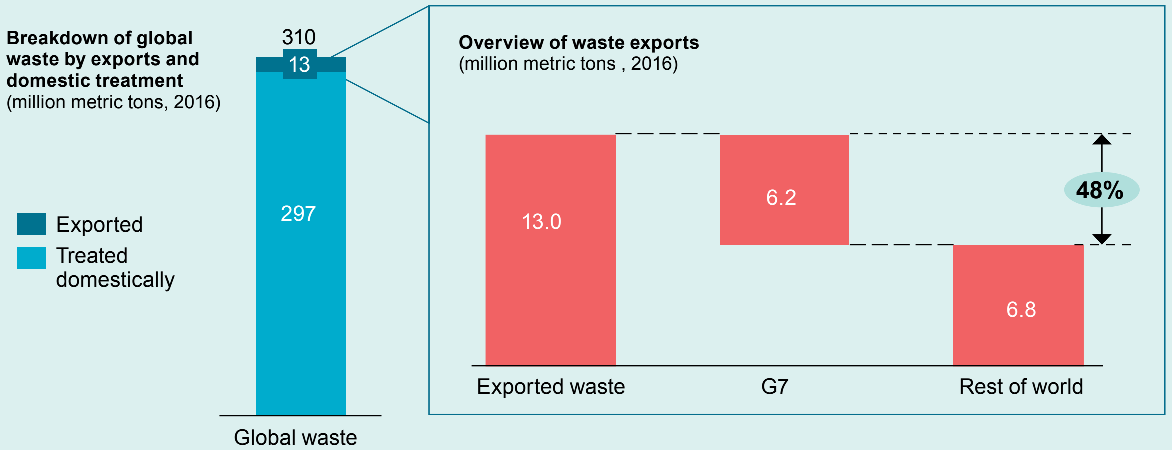
The net result of this policy change was a plastic waste exports decrease of over 20 per cent between 2017 and 2018. Additionally, South East Asian countries picked up a larger share of the remaining plastic waste exports. In Korea, plastic waste imports tripled the month after the reform, while exports experienced a ten-fold reduction[135]. Recycling become unprofitable given this change in the market, which caused forty-eight private Korean recycling companies stop accepting domestic waste. This left government facilities struggling to meet demand despite operating beyond their capacities[136].

China's reform also led to a five-fold increase in plastic waste exports to Vietnam and Malaysia in the first half of 2018. These nations were already having challenges with effective waste management prior to the ban by China and Hong Kong.

As a result, they were ill equipped to handle the sudden influx of imports. Therefore, plastics collected and exported for recycling since China's policy change may have ended up in landfills, incinerators or dumped in the open[137]. Furthermore, hundreds of new recycling facilities have appeared around the Thai port of Laem Chabang, leading to complaints about associated pollution. Raids on the port have also found that 95 per cent of imports violate the rules and contamination standards set out by Thailand's Department of Industrial Works[138].

Concerns have also emerged related to the additional costs needed to solve this trade issue. For waste collection companies in the U.S., transportation costs to new plastic waste importers are higher[139], and the price of contaminated plastic has fallen to below zero. There is speculation that some cities and towns may opt out of recycling services as they are too expensive[140].

Figure 12: Overview of 2016 global plastic waste trade



Source: Dalberg analysis, Jambeck & al (2014), World Bank (2018), SITRA (2018)

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A Bangladeshi child works in a plastic bottle recycling factory in Dhaka, Bangladesh. Recycling workers in Bangladesh, one of the world's poorest countries, make recycling of plastics in primitive working conditions and are paid per day $2. Even child laborers work under these conditions and risk their lives.

A SYSTEMS APPROACH TO RESOLVE THIS TRAGEDY OF THE COMMONS

As seen in previous chapters, the present plastics system is enabling uncontrolled growth of plastic waste, and current initiatives are unable to prevent plastic pollution from doubling by 2030. Stopping plastic pollution requires developing a global system that makes treating plastic waste more economical than discharging plastic directly into nature. At present, actors in the plastic system find it more cost effective to discharge their waste into nature than to effectively manage plastic to its end-of-life. Since this is true for all stakeholders across the trade chain, the plastics system is locked into polluting the planet. Downstream interventions, currently the singular focus of plastic waste reduction efforts, are severely limited and ineffective.

To resolve this tragedy of the commons, a systems approach, deploying tactical and strategic interventions across the trade chain, is needed to create a path to no plastic in nature. To stop the growth of plastics, tactics should include building on and reinforcing existing initiatives, such as banning single-use plastics and upgrading national waste management plans. At the same time, a global accountability mechanism should be created featuring multilateral agreement with clear on the ground plans, robust domestic laws, and commercial devices to distribute responsibility appropriately across the plastic life cycle. Additionally, consumers must be persuaded to change their behaviours and provided with alternative choices to plastic.

Tactical interventions toward stopping plastic pollution should build on and reinforce existing initiatives including:

- **Banning problematic single-use plastics to reduce consumption and to force actors to design products for reuse.** Transitioning away from single-use plastic should start by focusing products with the shortest lifespan, as these plastics are the main drivers of consumption and waste generation. Currently, 40 per cent of plastic is single-use and has a lifespan of one year. Phasing out these products is the first step toward reducing consumption. The phaseout of single-use plastic can include bans of certain single-use products, such as straws or shopping bags, as seen in many countries. Importantly, these initiatives cannot exist in a vacuum. They must have supporting legal frameworks at the global, regional, national and local levels that create the conditions for a no plastic in nature future. These conditions include incentivizing reuse business models, recycling, and sustainable alternatives to plastic. A consumption reduction will lower demand for virgin plastic, and will lessen the overall management burden placed on the downstream waste system. Plastic producers and converters must design plastic products for beyond point of sale focusing on reuse. Increasing the reusability of plastic requires shifting supply chains from single-use to reuse business models, designing products with single-source materials, and phasing out harmful additional substances that are blended with plastic inhibiting their reprocessing for health and safety reasons.

40%

CURRENTLY, 40 PER CENT OF PLASTIC IS SINGLE-USE AND HAS A LIFESPAN OF ONE YEAR. PHASING OUT THESE PRODUCTS IS THE FIRST STEP TOWARD REDUCING CONSUMPTION.

- **Eliminating waste mismanagement by eradicating plastic waste dumping, littering and uncontrolled landfilling, and reaching 100 per cent waste collection rates.** Plastic is a globally produced, traded, and polluting material. Plastic pollution is experienced around the world, and affects the environment, society and the economy. Global support is needed to eliminate waste mismanagement in places with highest rates of occurrence, namely lower middle and low-income countries. These countries can't eliminate waste mismanagement alone, given the competing development priorities grappling for finite public resources. Financial and technical support will be required to help under-resourced countries to develop waste management capacity, governance and regulation, as well as to lower the physical barriers for end-users to effectively dispose of waste.
- **Scaling up environmentally sound alternatives to plastic and supporting additional research into the behaviour, fate and effects of these materials in the natural world.** Implementing measures to scale opportunities to replace plastic with alternative materials should be encouraged. Policy support at national level is needed to remove the barriers to scale commercially viable alternatives, with a net positive environmental impact. Improving material competition with conventional plastic requires innovation and entrepreneurship. Encouraging policy implementation for more sustainable products should be pursued. The use of alternatives must be part of a broader strategy towards more sustainable production and consumption patterns. Understanding the full life cycle effects of alternative to plastic is a high priority as many of these materials may have environmental trade-offs. Replacing plastics must only be done with materials with a net positive impact on the environment.

Strategic interventions should focus on holding plastic system stakeholders accountable in all nations by:

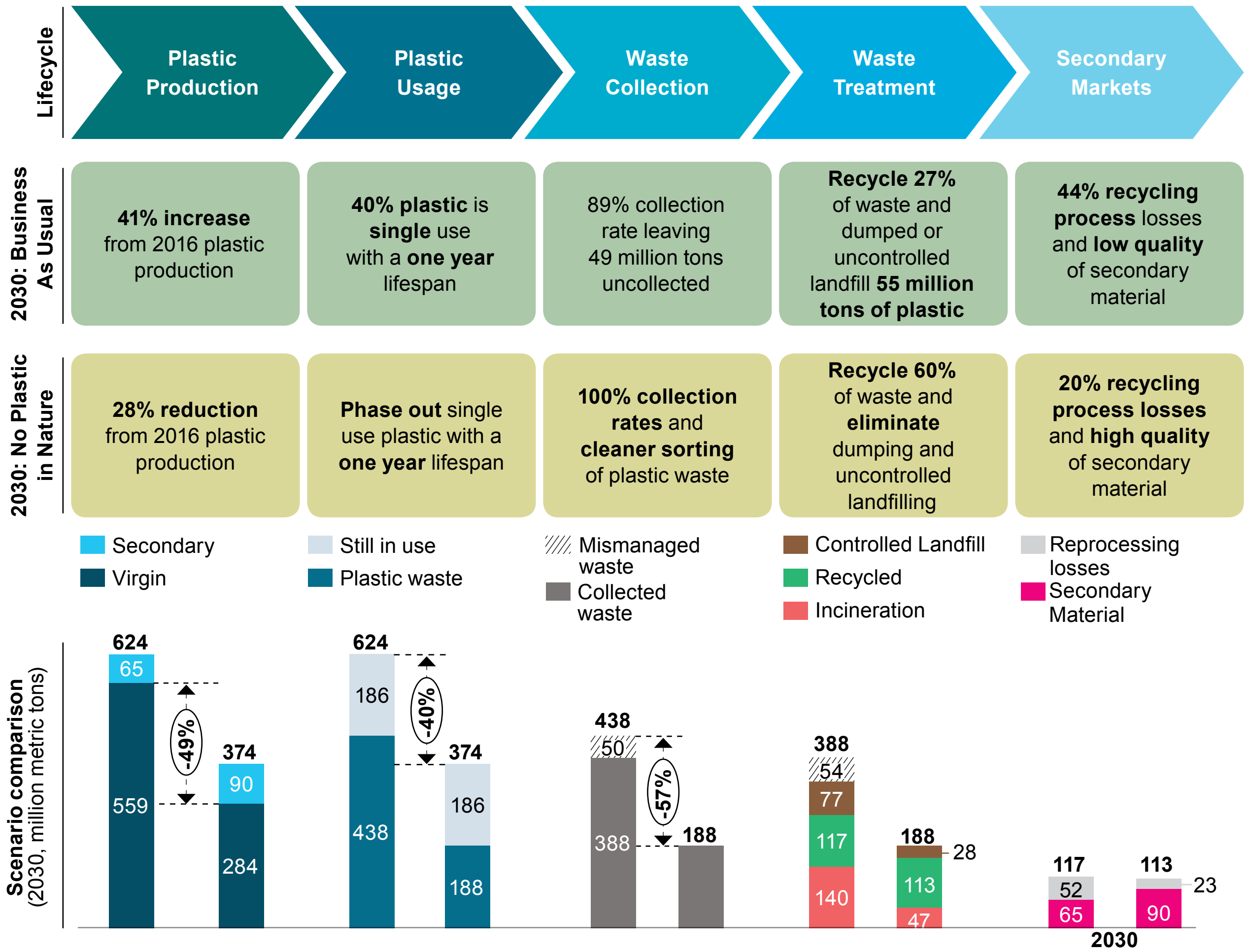
- **Create global commitment through a multilateral agreement to protect nature from plastic pollution and to resolve this tragedy of the commons.** Steps have been taken in some geographies to ban single-use plastic. The European Union circular economy package and national level plastic bag bans are just a few examples, but global level commitments to transition away from single-use plastics are necessary to stop plastic pollution. These legally-binding commitments should not only address short term issues with plastic waste growth, but also the longer term issues linked to fixing the plastic system. To stop plastic pollution, a comprehensive global agreement must set out this international goal to fix the plastics system and outline the pollution reduction targets to eliminate all plastic pollution and further leakage of plastics into nature.
- **Developing policy measures to ensure the price of plastic reflects its full life cycle cost to nature and society.** Robust laws and commercial schemes must ensure that the price of plastic accounts for: carbon dioxide emissions; the harmful environmental, economic and social impacts of leakage; and the use of plastic additives preventing waste from being recycled. A plastic price reflective of natural and societal costs may improve the economics, and demand for alternative materials or secondary plastics. Critically, scaling recycling capacity requires investment into what is currently an unprofitable industry in most parts of the world. Improving recycling profitability entails increasing revenues by growing demand for recycled plastic, and improving the quality of secondary material to attract a higher market price. Reducing operating costs can also boost profits. Increasing secondary material production volumes at recycling facilities can lower the cost per metric ton, and

uncontaminated flows for all types of plastic are needed from product design to waste treatment to lower collection and sorting costs. Extended producer responsibility mechanisms share these costs with actors involved in the system, and incentivize designing a system for reuse and make recycling a more attractive prospect.

- **Changing consumer behaviour with regard to plastic by providing environmentally sound alternatives, and supporting reduced use of unnecessary plastics.** Consumers should be encouraged to phaseout usage of unnecessary plastics, and seek proven environmentally sound alternatives as substitutes for remaining plastics. Legislation and financial incentives should support usage of environmentally sound alternative usage over conventional plastic, to maximize opportunities to scale for commercially viable alternatives. Additionally, policy, regulation and education programs should be put in place to help consumers create cleaner and separated plastic waste to facilitate scaling recycling capacity.

Implementing tactical and strategic interventions could cut plastic waste generation by 57 per cent and reduce virgin plastic production by nearly half compared with the business as usual scenario. Phasing out single-use plastics that have a one-year lifespan has the potential to lower plastic demand by up to 40 per cent by 2030, as seen in Figure 13. Reducing plastic consumption, coupled with growing secondary plastic material production, could half virgin plastic production by 2030. Compared to the business as usual scenario, phasing out single-use plastic usage lessens the plastic burden placed on the waste system and is estimated to lower plastic waste generation to 188 million metric tons, a 57 per cent reduction from the business as usual case.

Figure 13: a systemic solution to enable no plastic in nature by 2030



Source: Dalberg analysis, Jambeck & al (2014), World Bank (2018), SITRA (2018)

Eliminating waste mismanagement and reusing plastic can create a plastic pollution-free system and create over a million jobs in plastic recycling and remanufacturing. As an alternative to the business as usual scenario, the no plastic in nature scenario calls for developing capacity to recycle 60 per cent of plastic waste by 2030, or about 113 million metric tons. Existing incineration capacity is assumed to be operational in 2030 given the effect of infrastructure investment "lock-in." Cleaner sorting of waste into specific types of plastic, coupled with designing products for ease of reuse, would create a consistent volume of high-quality plastic waste to support the development of increased recycling capacity. Over a million new jobs could be created through recycling and remanufacturing plastic[141]. This job creation potential is dependent on the scale of recycling growth in a closed loop plastic system and on operating efficiencies within each plant. Improving waste collection rates to 100 per cent would enable all plastic waste to enter a formal waste management system stopping an estimate 59 million metric tons from being mismanaged. The final step to eliminate plastic pollution requires ending open dumping and uncontrolled landfilling to stop a predicted 545 illion metric tons of plastic from being mismanaged.

All stakeholders in the plastic system must be aligned to the common goal of ending plastic pollution and to reversing this tragedy of the commons. A systems approach can deliver a solution using tactical and strategic interventions to achieve this goal, but bold action from a broad range of stakeholders is needed to implement these interventions. Beyond current initiatives, a pathway to reach this common goal requires:

- **A global treaty setting the international goal to eliminate all plastic pollution and further leakage of plastics into the ocean.** Like the successful Montreal Protocol to protect the ozone layer, a bold multilateral convention is needed to protect people and nature from plastic pollution. To reach this ambitious goal, commitments should be put in place to: phaseout problematic single-use plastic usage; transition business models to reuse frameworks; establish a global waste manage performance standard; and support lower middle and low-income countries in developing waste management capacity. The global standard to eliminate waste mismanagement should target 100 per cent collection rates, including cleaner flows of plastic from product design to waste treatment, and should mandate the eradication of open dumping and uncontrolled landfilling. A new technology framework for reuse waste treatment methods and the boundaries of acceptable alternatives to plastic should be outlined in the treaty. Further, a capacity building framework should be included in treaty to amplify support to lower middle and low-income countries to improve waste management capacity in line with their own national objectives.
- **Regional and national implementation plans to execute upon the objectives of the global treaty to stop plastic pollution.** Governments must develop implementation plans to stop plastic pollution by developing governance and policy mechanisms to lower plastic consumption and eliminate waste mismanagement. Local regulators must create plastic waste standards and regulation to deliver upon these policies. Additionally, financial flows will be needed to tackle waste mismanagement by building local technical capacity and developing reuse waste management infrastructure. Public-private partnerships can support this

transition and reduce the funding burden placed on the state. Creating an enabling environment for these partnerships will be critical.

- **Enhanced transparency and a governance system to hold every nation accountable for implementing treaty obligations.** All governments must put forward their best efforts through nationally determined contributions, and commit to strengthening these efforts in the years ahead. All parties should report regularly on the plastic consumption, waste management performance, and plastic reuse within their economies. These results should measure against their implementation efforts and be made publicly available. There should also be a global review every five years to assess the collective progress toward achieving the purpose of treaty. Accountability will be achieved primarily through tracking progress made by countries in implementing and achieving their commitments. These reports will be subject to an independent review by technical experts. The transparency framework should apply to all countries but provide built-in flexibility to accommodate varying national capacities. The aim should be for all parties to work toward the same standards of accountability as their capacities strengthen over time. Meeting the objectives of the treaty is of the utmost importance, and a mechanism to should be put in place to help countries falling behind on their commitments get back on track. Penalties for noncompliance can be considered as a last resort.
- **Robust laws and commercial schemes to hold plastic producers and converters accountable for reversing this tragedy of the commons.** The responsibility for effectively managing plastic must be shared by all the actors within a plastics system. Implementing commercial schemes at regional, national and sub-national levels, such as extended producer responsibility, for all industries benefiting from plastics is a method to achieve this objective. Phased legislation is also needed to transition all industries with plastic supply chains from single-use to reuse business models. The industries affected by this legislation may require incentives to invest

Figure 14: Life cycle interventions needed to transition onto a no plastic in nature path at regional and national level.

Value Chain	Today	No Plastic in Nature Future
Plastic Production	Price of plastic excludes negative consequences to nature and society	Price of plastic reflective of true cost to nature and society
Plastic Usage	Cheap plastic results in prevalence of single-use business models	Plastic products designed to be reused or recycled
Waste Collection	Low collection rates and limited waste sorting in many regions	100% collection rates and sophisticated waste sorting, globally
Waste Treatment	Low recycling yields and high levels of mismanaged waste	High recycling yields and zero tolerance for mismanaged waste
Secondary Markets	Inferior quality and low value secondary material	High quality secondary material cheaper than virgin plastic

Source: Dalberg analysis, Jambeck & al (2014), World Bank (2018), SITRA (2018)

into reuse business models. A portion of the proceeds from these commercial schemes could be used to bridge the funding gap for this transition. Creating a plastic price reflective of its true cost to nature and society will improve the economics of recycling. Measures such as market-based pollutant trading schemes or taxes can help rectify some of these price distortions. The European Union Emission Trading Scheme is an example of such an intervention.

- **Appropriate government policy instruments to incentivize the use of recycled plastics over new plastics.** Reuse business models need recycling to be profitable and scalable. Increasing secondary material demand could be achieved by offering tax-rebates to companies for a higher volume of secondary material usage in their products. Legislating for a minimum volume of secondary material could be effective, and less costly to governments. Improving the quality of the secondary materials requires investment in research and development to support recycling innovations. Lowering the cost of recycling requires creating standards, policies and regulations for cleaner flows of all types of plastic from product design to waste treatment. Finally, policies should support a consistent volume of uncontaminated plastic waste using financing mechanisms to increase the production capacity of recycling facilities in order to create economies of scale that lower the unit cost of recycled plastic.
- **Industry to innovate and scale environmentally sound alternatives and to offer consumers product choices beyond plastics.** Legislation and financial incentives should support industry to develop environmentally sound alternatives to conventional plastic, and to maximize opportunities to scale commercially viable alternatives. Governments and multilateral institutions should develop grant schemes for research and development to innovate scalablee alternatives to plastic with net positive environmental impacts. Industry should support consumers to phaseout usage of unnecessary plastics and to embrace reuse business models.

Fisherman using tiffins after plastic bags ban at Dadar, in Mumbai, India.

ANNEX 1: PLASTICS 101 - WHAT IS THIS MATERIAL?

The term plastic applies to a wide range of materials capable of flow during the manufacturing process[142]. Plastic polymers are typically prepared by polymerization of monomers derived from oil or gas, and plastics are usually made from these by addition of various chemical additives[143]. Polymerization is a process of chemically bonding identical monomers, such as ethylene and propylene, together to form a polymer of plastic. Polycondensation is a condensation reaction of a monomer having two functional groups to create a polymer of plastic. Both reactions require a catalyst[144].

Plastic is inexpensive, lightweight, corrosion-resistant, and has electrical insulation properties[145]. More than 30 types of plastics are produced with a vast array of properties[146]. The various types of plastics can be divided into two overarching material groups requiring completely different recycling processes: thermoplastics, which are generally mechanically recyclable[147], and thermosets plastics, which are only chemically recyclable[148]. In fact, six plastics constitute over 80 per cent of plastic produced between 1950 and 2015[149]. Five thermoplastics and one thermoset make up this group as seen in Figure 15 and 16.

Figure 15: Overview of the five most common thermoplastics

Type of plastic material	Common uses
1 • **Polyethylene**	• Plastic bags and bin bags • Food containers • Computer hardware casing • Playground fixtures and equipment
2 • **Polypropylene**	• Carpeting, rugs and upholstery • Laboratory equipment • Automotive parts • Medical devices
3 • **Polyvinyl-chloride**	• Plumbing products, • Electrical cable insulation, • Clothing • Medical tubing
4 • **Polyethylene Terephthalate**	• Bottles • Foods containers • Polyester clothing • First-aid blankets
5 • **Polystyrene**	• Food and liquid containers • Building insulation • Packaging materials • CD cases

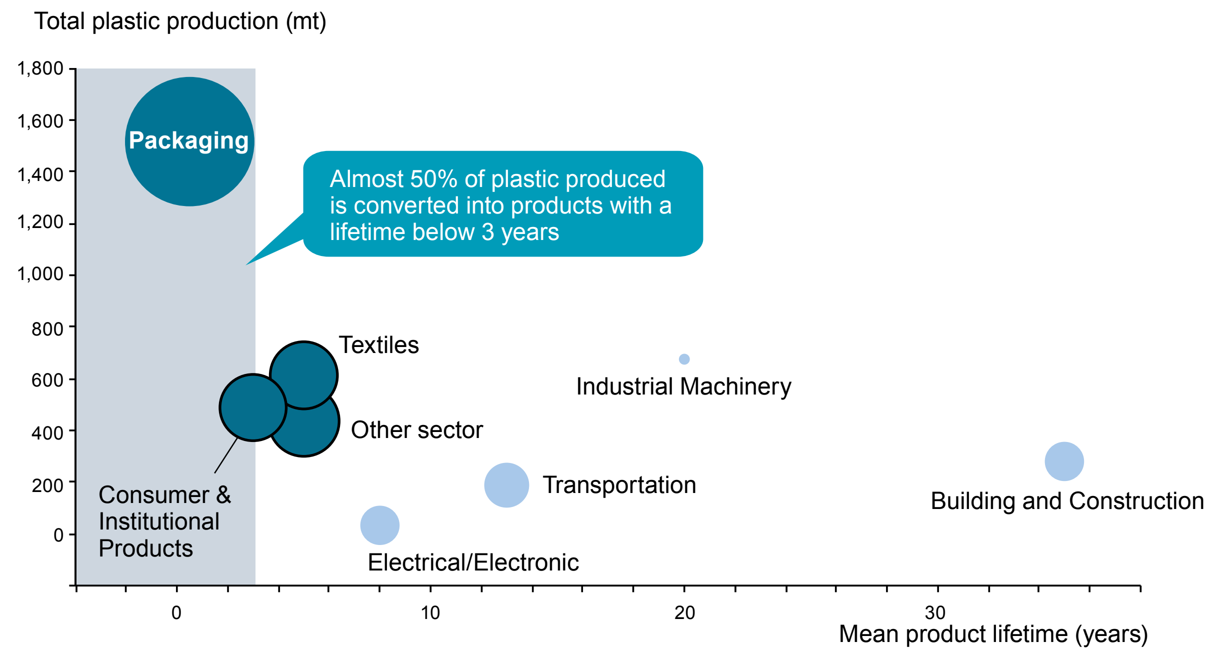
Source: Dalberg analysis, Jambeck & al (2017), The American Chemistry Council (2018), PlasticsEurope (2018)

Figure 16: Overview of the most common thermoset

Type of plastic material	Common uses
1 • **Polyurethane**	• Coatings, adhesives, sealants and elastomers • Bedding and furniture • Building insulation • Electronics

Virgin plastics have different properties and applications in many sectors. The packaging, building and construction, and automotive industries are the three largest converters of virgin plastic into various products[150] seen in Figure 17. Durability of plastic is valued by industries, with half the plastic produced in 2016 expected to have a single use life span of above three years[151]. Yet, the remaining plastic is produced for short-term, single usage[152]. Almost all the plastic produced by the packaging industry fall into this category, which was almost 40 per cent of plastic produced in 2016[153].

Figure 17: 2016 plastic production segmented by converter industry and mean life cycle time of converted plastic product



ANNEX 2: MODELLING METHODOLOGY

The modelling methodology followed three key steps:

1. Collect data from comprehensive, reputable and validated sources
2. Standardize data to allow for valid comparisons
3. Analyse data to assess the current state of the plastics system and to forecast to 2030

Specific actions within each of these steps are illustrated in Figure 18.

A global plastic pollution estimation was made using aggregate data from 216 countries instead of summing regional forecasts by income level. Limited data was available in low income groups. Country level data inconsistencies raised concerns about forecasting at regional level using per capita regression forecasting given low income countries are expected to have the greatest growth rates in the next 15 years. Waste generation data per country came from the World Bank's "What a Waste 2.0" database. This larger sample size helped to improve the model's accuracy. An estimate of plastic production until 2030 was developed based on historical growth rates over the last 15 years, current new-build commitments for new petrochemical production capacity across the global, and benchmarked against existing plastic production forecasts.

During the process of data collection and cleaning there were some issues regarding data validity availability, outlined in Figure 19.

Figure 18: Overview of methodology for report analysis

Collect	Standardize	Analyse
• Dalberg developed a plastic waste life cycle dataset based on waste management data from 216 countries from the World Bank, and the 135 countries involved in global waste trade from UN Comtrade data • The plastic dataset includes a 2016 actuals and 2030 estimates for: - Total waste generated - Waste collection rate - Waste disposal by treatment method - Import and export of plastic waste	• Dalberg cleaned some of the waste data as some countries have not published data across each section of the plastic waste life cycle • Dalberg aggregated countries by income level as almost 70% of 2016 waste was generated in high and upper middle income countries, which are also the countries with the most comprehensive waste management datasets • For missing country-level data, Dalberg developed a proxy on a per capita basis for each income band and extrapolated up for each country based on the respective population size • Dalberg benchmarked the model outputs for 2016 with results from existing research to ensure validity	• Using the cleaned, standardized data, Dalberg assessed overall waste generation, waste collection and recycling rates to determine income status regions (and countries) with the worst performing plastic waste management system • Dalberg also showed regions responsible for import and export of plastic waste and highlighted plastic waste loss in the system into nature • Predictions for 2030 were developed based on a "business-as-usual scenario" by analysing trends in the plastic life cycle over the last 15 years • Sensitivity analysis was performed on the predictions for 2030 to show impact of system change across the plastic value chain

Figure 19: Overview of databases used for report analysis

Database	Description	Considerations	Solutions
World Bank "What a Waste 2.0" Database	• Breakdown of Municipal Solid Waste (MSW) for each country by type of waste and by treatment type	• Waste management categories were not aligned with technologies specific to plastic • Underreporting bias in low income countries	• The World Bank categories were regrouped into the appropriate waste treatment technologies • The missing data was adjusted using a proxy value specific to the income group, which was scaled by population
UN Comtrade Data	• A database of the total plastic imported and exported by country	• Lack of data for trade flows between Hong Kong and China make it difficult to determine where the waste was imported and where it was treated	• Trade inflows and outflows were balanced and verified against World Bank waste generation data. If there was a discrepancy the data was adjusted based on the more accurate data source
Jambeck Research Group – University of Georgia	• Selection of data used for production growth forecast, benchmarking leakage data, and waste management technology segmentation	• Predictions were up to 2025, not 2030	• Trade inflows and outflows were balanced and verified against World Bank waste gene Jambeck data was used to benchmark the production projection made by Dalberg Advisors up until 2025 • An additional 2030 forecast from Material Economics, and an extrapolation of Jambeck data to 2030, were used to calibrate estimate from 2026 to 2030

GLOSSARY

1. **Country level income status** are classifications by income level determined by the World Bank. As of 1 July 2016, income status was defined as a Gross National Income (GNI) per capita of: i. US$1,025 or less in 2015 for low-income economies; ii. US$1,026 and US$4,035 for lower middle-income economies; iii. between US$4,036 and US$12,475 for upper middle-income economies; and US$12,476 or more for high-income economies.
2. **Mismanaged waste** refers to plastic left uncollected, openly dumped into nature, littered, or managed through uncontrolled landfills.
3. **Producers of virgin plastic** are petrochemical companies such as Dow, Exxon Mobil Chemical, and INEOS[154]. These companies are often integrated with upstream oil and gas facilities, as oil and gas by products form the raw materials for over 30 plastics[155].
4. **Plastic converters** manufacture products from virgin plastic. These companies include fast moving consumer goods companies, retailers, and building and construction material manufacturers. Critically, the decisions made by plastic converters have substantial impacts on downstream stakeholders[156].
5. **End-users** are the final consumers of plastic products. These consumers can be individuals, institutions and/or commercial vendors; however, they collectively play a role in shaping the consumption patterns for plastic products[157]. End-users are the starting point for the waste management system. Ensuring that plastic ends up in a formal waste management system relies on end-users disposing of plastic waste at appropriate collection points for waste management.
6. **Government authorities and regulatory bodies** are responsible for providing the governance, regulations, and resources for the plastics system. At a local and national level, these stakeholders play a pivotal role in setting performance targets, setting regulation, drafting legislation, developing and enforcing accountability mechanisms to ensure adequate performance, and shaping strategies to develop technology innovations.
7. **Waste management companies** develop, operate, and maintain waste management infrastructure. These entities are responsible for plastic waste from the point at which it is disposed by the end-user at a collection point until the end of the waste treatment process[158]. Waste treatment can take many forms, but the most common methods in use today are landfilling, incineration, mechanical recycling, chemical recycling, and dumping[159].
8. **Recycling firms** reprocess plastic waste into a secondary material for reuse[160]. These actors create the circular feedback loop within the plastic value chain.
9. **Incineration businesses** are responsible for burning waste materials at very high temperatures. In some cases, energy recovery from the incineration process is possible. The burning of plastics can release toxins into the air and the surrounding environment. These plants operate in controlled and regulated conditions, but evidence exists showing that conditions are not held to consistent standards globally[161]. Open burning of plastic waste is not classified as incineration and is seen as a form of opening dumping in this report.
10. **Single-use plastic** often also referred to as disposable plastics, are commonly used for plastic packaging and include items intended to be used only once before they are thrown away or recycled. These include, among other items, grocery bags, food packaging, bottles, straws, containers, cups and cutlery. In most cases they have a lifespan of less than one year and in all cases less than three years.

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Solving plastic pollution through accountability

100% RECYCLED

41%

Increase in plastic waste generation by 2030

104

Million metric tons of plastic at risk of leakage in 2030

50%

Increase in CO_2 emissions across plastics value chain by 2030

111

Million metric tons of displaced plastic waste by 2030 without China's waste management system

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To stop the degradation of the planet's natural environment and to build a future in which people live in harmony with nature.

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