URBAN DEVELOPMENT SERIES

What a Waste 3.0

Global Snapshot of Solid Waste Management toward Circularity until 2050

Ed Cook, Kremena Ionkova, Perinaz Bhada-Tata, Sonakshi Yadav, and Frank van Woerden

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With Nikola Doychinov, Heather Nichole Hogan, Costas Velis, Tanzir Chowdhury, Caroline Bradley, Silpa Kaza, Rieko Kubota, Ali Abedini, Shiko Hayashi, Nuru Lama, Gianluca Forlani, and Konstantinos Verganelakis

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Purpose and Audience

What a Waste 3.0 is the third edition of the World Bank Group's *What a Waste* series, following the 2012 and 2018 publications. It updates and expands these earlier publications and provides a global reference dataset on municipal solid waste in the context of a transition toward circularity, drawing on the most recent publicly accessible data from 217 countries and economies and 262 cities. This edition consolidates data on waste generation, composition, collection, treatment, and disposal, and presents trends by region and income group. It also includes information on legislation, institutional arrangements, plastics management, private sector participation, employment, environmental impacts, and the costs and financing of municipal waste services.

The publication is intended as a technical reference, offering structured data to inform planning, benchmarking, and analyses. It does not provide policy recommendations or endorse specific approaches. Instead, by making prevailing data and trends widely accessible, it supports evidence-based decision making and informed dialogue across the waste sector. Against the backdrop of a mounting global waste crisis—with rising volumes, environmental degradation, and widening service gaps—*What a Waste 3.0* underscores the scale and urgency of the challenge. By presenting the most comprehensive and contemporary publicly accessible dataset on municipal waste, it offers a common foundation for coordinated action.

What a Waste 3.0 is designed for national and local governments, development institutions, researchers, private sector, and practitioners working in solid waste management, the circular economy, and broader urban development. The publication is intended to be used alongside the accompanying online datasets, which provide open access to detailed country- and city-level data for further analysis and application.

With decades of engagement in the sector, and as the largest provider of development financing for solid waste management globally, the World Bank Group is pleased to offer *What a Waste 3.0*. The report was developed with input from partners, technical experts, and data contributors worldwide—as a contribution to the global knowledge base and to support countries and economies in building more effective and sustainable waste systems that enable greater resource recovery and advance the transition toward circularity.

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Foreword

Solid waste is one of the most visible by-products of human prosperity—and one of the most underestimated threats to our shared future.

Trash discarded on a city street or a neighborhood dump does not remain local. Plastic carried by rivers reaches the ocean; methane from decomposing food escapes into the atmosphere; and open burning pollutes the air we all breathe. Waste is a municipally managed issue with consequences that are both local and global.

In 2022, the world generated 2.6 billion tonnes of municipal solid waste. This new edition of our *What a Waste* report reveals that total volumes could soar to 3.9 billion tonnes by 2050—a 50 percent increase—with the fastest growth projected in Sub-Saharan Africa (124 percent) and South Asia (99 percent). Today, about 30 percent of global waste is still either openly dumped or left uncollected, compounding risks to local economies, public health, and the environment.

Meeting this challenge will demand significant, sustained investment. Achieving universal and sustainable waste collection and management will require steady public spending in the range of 0.3–0.8 percent of GDP. Yet the costs of inaction—from worsened flooding and pollution, to declining property values and tourism losses, to foregone jobs and missed economic opportunities—are far higher.

But a different future is within reach. With strategic action, countries can cap total waste generation even as economies grow; expand collection coverage and improve service quality; reduce system costs relative to business as usual; and unlock millions of good jobs across the value chain. Waste services, resource recovery, and circular economy industries already employ millions of workers. With the right policies, investments, and support for small- and medium-sized enterprises and the informal workforce, they can create many more jobs.

The World Bank Group stands ready to help countries and cities turn this waste challenge into an opportunity for resilient, inclusive growth. As the world's largest official development financier of solid waste management, the World Bank pairs deep sector knowledge with concessional finance and private capital solutions to support reform and investment—from waste reduction and collection to treatment and recovery.

What a Waste 3.0 offers the most comprehensive and publicly accessible global dataset on municipal solid waste, covering 217 countries and economies and 262 cities. Building on the 2012 and 2018 editions, it consolidates data on waste generation, composition, collection, treatment, and disposal; tracks trends by region and income; and maps legislation, institutions, private participation, employment, environmental impacts, and costs and financing.

Although solid waste is generated locally, its impacts—and opportunities—are global. By aligning data with ambition and finance with reform, we can turn the mounting waste crisis into an opportunity to build cleaner, more resilient, and livable cities—creating jobs today while safeguarding resources for tomorrow.

Ming Zhang
World Bank Group Director
Global Department for Urban, Subnational Finance,
Tourism and Disaster Management
Infrastructure Vice Presidency
The World Bank Group

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Nikola Doychinov, Heather Nichole Hogan, Costas Velis, Tanzir Chowdhury, Caroline Bradley, Silpa Kaza, Rieko Kubota, Ali Abedini, Nuru Lama, Gianluca Forlani, and Konstantinos Verganelakis authored specific sections of the study as detailed below.

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Each section of the report was written by the following individuals:

- Executive Summary and Chapter 1 (Introduction) were written by Kremena Ionkova and Frank van Woerden.
- Chapter 2 (At a Glance: A Global Picture of Solid Waste Management) was written by Ed Cook and supported by Costas Velis.
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- Chapter 6 (Waste Administration, Operations, and Jobs) was written by Kremena Ionkova, Sonakshi Yadav, and Heather Nichole Hogan who developed the section on EPR and deposit return schemes.
- Chapter 7 (Costs and Financing for Waste Management Systems) was written by Nikola Doychinov and Kremena Ionkova, with contributions from Frank van Woerden, Sonakshi Yadav, Nuru Lama, Gianluca Forlani, Konstantinos Verganelakis, Adriaan Korthuis, and Anna Kovács.

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Abbreviations and Acronyms

AD	anerobic digestion
CO2e	carbon dioxide equivalent
COED	cost of environmental degradation
DRS	deposit return scheme
EPR	extended producer responsibility
EU	European Union
GDP	gross domestic product
GHG	greenhouse gas
GNI	gross national income
IMF	International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change
IQR	interquartile range
KWh	kilowatt hour
MBT	mechanical biological treatment
MRF	material recovery facility
Mt	million tonnes
NDC	Nationally Determined Contribution
OECD	Organisation for Economic Co-operation and Development
PPP	purchasing power parity
RDF	refuse-derived fuel
SDG	Sustainable Development Goal
UNFCCC	United Nations Framework Convention on Climate Change
WEEE	waste electrical and electronic equipment

©Alamy/Mohamad. Waste workers at a municipal solid waste materials recovery facility.

Summary of Findings

The world is at a critical juncture in managing its growing waste. Rapid population growth, accelerating urbanization, rising incomes, and increased consumption are driving a surge in municipal solid waste[1] generation that is outpacing the capacity of local systems and municipal budgets. As a result, cities and communities worldwide are struggling to keep up with mounting quantities of waste. When waste is not managed well, the consequences are far reaching: environmental pollution intensifies, greenhouse gas (GHG) emissions rise, and valuable natural resources are wasted. These threaten public health and the environment and undermine economic development and the livability of cities. Yet, within the crises lies an opportunity. By investing in more efficient, inclusive, and sustainable waste management systems, countries can unlock new avenues for economic growth, job creation, and innovation. Improved waste management systems that embrace circular economy principles, where materials are reused and value is retained, can transform waste from a burden into a driver of sustainable development, benefiting both local communities and the global environment. To fully grasp the scale and urgency of today's challenges, as well as the opportunities they present, this *What a Waste* report offers the most up-to-date data and statistical analytics on global solid waste management performance levels and trends.

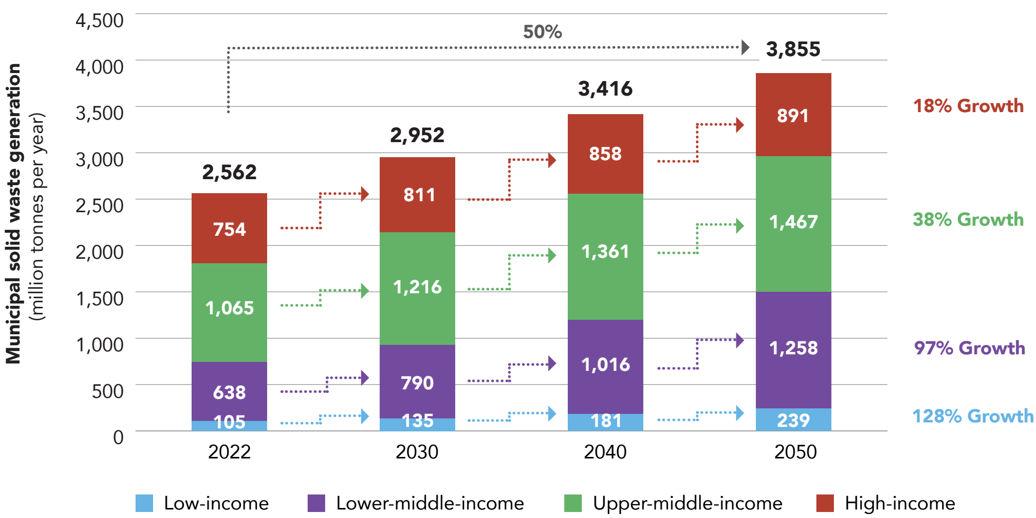
Global Picture of Solid Waste Management toward Circularity

What a Waste 3.0 estimates that global waste generation is rising faster than previously projected. While the 2018 *What a Waste 2.0* report estimated that the world would generate 2.59 billion tonnes of waste by 2030 (Kaza et al. 2018), the most current figures show that 2.56 billion tonnes were already produced by 2022.[2]

The distribution of waste generation is uneven across country income groups and regions. High-income countries, while comprising 16 percent of the global population, generated 29 percent of the world's waste in 2022 and had the highest per capita waste generation. Upper-middle-income countries, accounting for 36 percent of the population, produced the largest share of global waste at 42 percent. Lower-middle-income countries represented about 40 percent of the population and generated 25 percent of global waste, whereas low-income countries, with 9 percent of the population, produced 4 percent of the waste. Regionally, East Asia and the Pacific generated the largest share of global waste at 33 percent, whereas the Middle East and North Africa produced the least at 6 percent.

Under a business-as-usual scenario, global waste generation is expected to grow from 2.56 billion tonnes in 2022 to 3.86 billion tonnes by 2050, a 50-percent increase. The increase in low-income countries is expected to more than double by 2050, with the fastest growth projected in Sub-Saharan Africa and in South Asia (figure S.1).

Figure S.1 Projected waste generation by income group



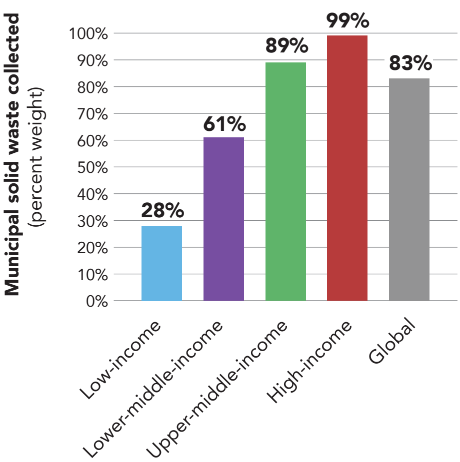
Source: Original figure for this report.
Note: Growth rates in colored text show proportional increase in waste generation between 2022 and 2050.

Food and garden waste account for the majority of municipal waste composition in low-income countries, making up 52 percent of the total waste generated. By contrast, higher-income countries see their waste streams dominated by dry recyclable materials, textiles, and waste electrical and electronic equipment (WEEE), which together comprise about 50 percent of their municipal waste. Plastics constitute approximately 12.5 percent of municipal solid waste globally, with the proportion ranging from 8.1 percent in low-income countries to 13.1 percent in upper-middle-income countries. Single-use plastics are estimated at 65 percent of all municipal solid waste plastics generated worldwide each year.

Waste collection rates show stark disparities across income levels and regions (figure S.2). High- and upper-middle-income countries achieve high collection rates, with high-income regions such as North America reporting rates close to 100 percent and upper-middle-income countries reaching about 89 percent. By contrast, lower-middle-income countries collect 61 percent and low-income countries collect only 28 percent of their waste. These gaps are also evident regionally, with South Asia and Sub-Saharan Africa having the lowest collection rates worldwide at 67 and 31 percent, respectively.

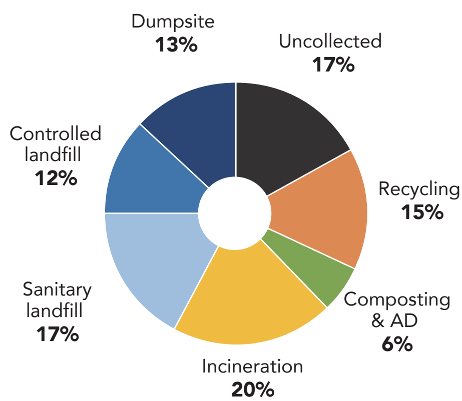
Global waste management practices differ markedly by income level and region. Although nearly 100 percent of municipal solid waste in high-income countries is managed in controlled facilities[3]—meeting the Sustainable Development Goal (SDG) target for safe waste management (UN-Habitat and UNSD 2018)—only 3 percent of waste in low-income countries is managed in controlled facilities, with most waste either uncollected or disposed of in dumpsites. Globally, landfills remain the most common method of waste management, accounting for 29 percent of all waste, followed by materials recovery through recycling, composting, and anaerobic digestion[4] at 21 percent, and incineration with energy recovery at 20 percent. The remaining 30 percent of waste generated worldwide is either openly dumped or not collected at all (figure S.3), a challenge most acute in low-income countries and rapidly growing regions such as Sub-Saharan Africa and South Asia (figure S.4).

Figure S.2 Municipal solid waste collection rates by income group



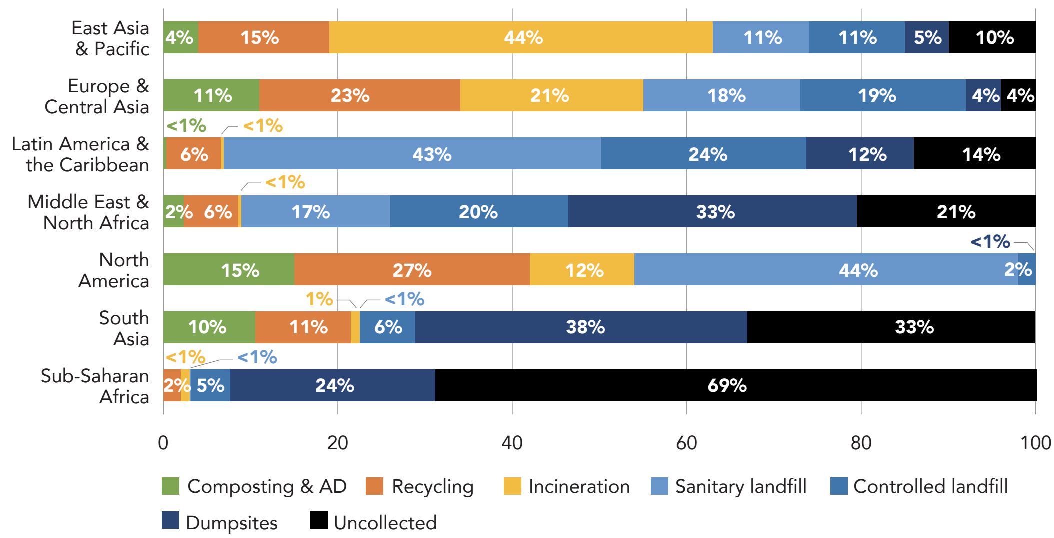
Source: Original figure for this report.
Note: Mean collection coverage (percent, weighted by the total mass of waste collected in each income group in 2022).

Figure S.3 Global municipal solid waste treatment and disposal



Source: Original figure for this report.
Note: Mean treatment and disposal (percent, weighted by the total mass of waste generated in 2022).
AD = anaerobic digestion.

Figure S.4 Municipal solid waste treatment, disposal, and uncollected waste by region



Source: Original figure for this report.
Note: Proportion of uncollected and treated waste multiplied by the weight of waste generated in 2022. AD = anaerobic digestion.

Food waste presents a unique challenge due to its widespread prevalence, culturally determined practices, and the complexities involved in collecting uncontaminated organic waste. It constitutes the largest share of municipal solid waste globally, accounting for 38 percent. Although composting and anaerobic digestion are the most sustainable treatment options, their adoption remains limited. Globally, only 6 percent of waste is composted or processed through anaerobic digestion. In low-income countries, this figure drops to less than 1 percent.

Plastic waste is of significant concern. Nearly 29 percent of all plastic waste—or 93 million tonnes per year—is mismanaged; 13 percent is poorly managed in uncontrolled facilities such as dumpsites, and 16 percent remains uncollected. Middle-income countries are the leading source of unmanaged plastic waste, generating 87 percent of the global total. Sub-Saharan Africa, South Asia, and East Asia and the Pacific produce the largest quantities of unmanaged plastic waste—15 million tonnes, 14 million tonnes, and 12 million tonnes, respectively.

Nearly all countries have legislation governing solid waste management and 70 percent of countries report having national solid waste management strategies. Local governments often introduce additional regulations, such as requirements for source segregation, to strengthen national laws.

Globally, 88 percent of countries have national policies targeting plastics, with upstream measures like taxes, bans, and fees on imports and production being the most widespread. Extended producer responsibility[5] is commonly adopted to engage producers and suppliers of plastic materials in the management and recycling of plastic products (OECD 2016). However, its practical implementation to date has largely been limited to high-income countries. Challenges such as limited regulatory capacity, data availability and reliability, and insufficient enforcement mechanisms hinder the widespread impact of such instruments. Measures such as deposit return schemes for beverage containers are less common.

Solid waste management is predominantly a local responsibility, with municipal or metropolitan authorities overseeing most waste services. Direct central government involvement in waste operations is uncommon and generally limited to smaller countries and island states. About half of waste management operations are publicly run, whereas the rest is split between private and mixed public–private arrangements. Private sector participation is most prevalent in treatment and disposal, often through concession contracts, with service and franchise contracts also playing a role. Despite the potential benefits, cooperation between municipalities for shared service provision remains limited, which can hinder the achievement of greater efficiency and cost savings.

Waste management and recycling activities are important sources of employment, estimated to engage about 18 million urban waste workers, equivalent to about 0.3 percent of the global urban population. In lower-income countries, most of these jobs are concentrated in waste collection, sorting, and recycling, with the informal sector playing a particularly critical role. In lower-income countries, informal waste workers are essential to the functioning of solid waste management systems, yet they often operate under precarious conditions, facing social stigma, limited legal protections, and significant health risks. By contrast, in high-income countries, a growing share of employment is generated indirectly through industries that supply goods and services to, or benefit from, the waste sector. Indirect employment is not captured in the employment estimates within this report. Systematic public reporting on employment remains largely confined to high-income and some middle-income countries, contributing to concerns about data reliability and the visibility of informal sector contributions.

Costs and Financing

The global cost of municipal waste management already exceeds US$250 billion annually and is projected to rise to US$426 billion by 2050 if existing practices continue. These costs vary significantly across countries, shaped by factors such as collection and treatment methods, community participation, labor and fuel expenses, and the degree of automation. While basic waste management systems in lower-income countries cost at least US$40-US$45 per tonne, depending on local conditions, advanced systems that incorporate recycling and landfill diversion often exceed US$120 per tonne. This places substantial financial pressure on local authorities, with implications for the sustainability and effectiveness of service delivery.

Municipal waste management is an expensive service that local governments provide, placing significant fiscal pressure on public budgets especially in low- and middle-income countries. This *What a Waste* reports that solid waste management absorbs, on average, 6 percent of municipal budgets, with cities in lower-income countries spending a higher than average share. Despite this expenditure, many cities struggle to achieve full service coverage, maintain basic infrastructure, or recover operational costs. Full cost recovery through user fees is predominantly achieved in high-income countries, whereas most low- and middle-income countries supplement financing with support from local, regional, and central government budgets. User fees for waste management services vary widely, ranging from as little as US$10 per household per year in low-income countries to over US$500 in high-income countries, with average fees of US$30 and US$260, respectively. Actual costs frequently exceed available financing from user fees, budget allocations, and other sources combined, resulting in underinvestment and persistent service gaps that reinforce one another.

This report estimates that, in middle-income countries, establishing basic but universal systems of collection and environmentally sound management of municipal waste, would require approximately 0.3 percent of gross domestic product (GDP), with more advanced systems approaching 0.5 percent. In low-income countries, achieving basic universal coverage may require close to 0.8 percent of GDP, reflecting lower baseline service levels and smaller economies. High-income countries would need at least one-third of a percent of their GDP.[6] By comparison, reported public expenditure on solid waste management is less than 0.15 percent of GDP in about three-quarters of low- and middle-income countries and about 0.3 percent in high-income countries. While reported public spending in low- and middle-income countries falls well below estimated financing needs, actual outlays are likely higher, as budget data often exclude expenditures by private providers and state-owned enterprises.

In a business-as-usual scenario, low- and lower-middle-income countries face substantial investment needs, estimated at US$556 billion between 2022 and 2050. Mobilizing investments at this scale is likely to require a mix of domestic fiscal resources, development assistance, and private capital; between 2003 and 2021, official development finance commitments to the sector totaled only US$14.5 billion, including US$1.0 billion for low-income countries and US$5.9 billion for lower-middle-income countries (Lerpiniere, Wilson, and Velis 2025). While the public sector remains central to planning, regulation, and core service provision, additional financing from private sources is likely to play an increasingly important role, particularly for advanced treatment and recovery facilities. Private sector participation in waste management depends on predictable revenue streams, underpinned by tariff policies, fee collection systems, and policy and regulatory frameworks that create conditions attractive to private operators. Reliable sector financing therefore remains essential to provide the foundation for private participation and to ensure continuous, high-quality service delivery.

The waste sector has benefited from innovative financial mechanisms. It has established a strong presence in carbon markets, particularly through its engagement with the earlier Clean Development Mechanism,[7] and is now poised to benefit from new opportunities under Article 6 of the Paris Agreement. Participation in these markets allows waste operators to attract investment for waste treatment technologies, such as landfill gas capture and utilization, composting, and waste-to-energy, which help reduce GHG emissions. Good governance, transparent monitoring and reporting systems, and alignment with national climate objectives to ensure environmental integrity and maximize the impact of carbon finance are required to access climate financing and realize sought objectives (World Bank Group 2024; 2025).[8]

As waste quantities continue to grow—especially in low- and lower-middle-income countries where existing service coverage and infrastructure remain below adequate levels—the challenge is to address existing shortfalls and meet future demand. Without accelerating investments, existing service gaps will widen, leaving countries further behind and locking in higher environmental, health, and economic costs. The urgency is therefore twofold: to expand systems fast enough to keep pace with rising waste volumes, and to raise performance well above prevailing baselines to avoid compounding the broader economic costs of inaction and damages from unmanaged waste.

Impacts and Opportunities

Solid waste management lies at the nexus of local service delivery, livability, and economic development, and is increasingly central to global environmental sustainability. At the local level, it is essential to public health, environmental quality, climate resilience, and the functioning of cities. Effective, reliable, and inclusive waste services reduce the spread of disease, prevent contamination of water, soil, and air, mitigate flooding caused by blocked drainage, and support a safe, dignified urban environment. Clean cities contribute to local economic development by enhancing competitiveness and strengthening the overall business environment. As cities transition toward more circular economies, where waste-derived materials are reintegrated into productive use, solid waste management is firmly established as a driver of investment, private sector participation, and job creation.

Globally, how waste is managed has significant implications for climate change, pollution, and the sustainable use of finite natural resources. Open burning and unmanaged organic waste release GHGs including methane and black carbon, which contribute to climate change and deteriorating air quality. The Global Methane Assessment identified the waste sector as the third-largest global source of methane, responsible for approximately 20 percent of global anthropogenic methane emissions and prioritized the sector for mitigation action (UNEP and CCAC 2021). Inadequate waste systems are also the primary source of plastic waste leakage into rivers and oceans, which severely damages marine ecosystems and threatens livelihoods and biodiversity (World Bank 2022a; 2022b). Poor waste practices result in the permanent loss of valuable materials, including metals, minerals, and nutrients, undermining efforts to conserve finite natural resources and transition to more resource-efficient economies.

These wide-ranging impacts underscore the need to view waste management as both an urgent public good challenge and a strategic opportunity to unlock significant local economic, social, and ecological benefits.

Economically, the case for effective waste management is compelling, as the costs of inaction considerably exceed costs required for sound waste systems. The economic costs of uncollected waste that is burned, dumped, or discharged into waterways, and of damage from flooding caused by blocked drains and reduced stormwater capacity, have been shown to surpass the financial costs of properly operating waste management systems. Broader societal and opportunity costs—such as the erosion of trust in local authorities and impacts on community dignity and pride—are rarely quantified but remain critical for local development and societal well-being. Investing in sound waste management avoids these costs and delivers broader benefits: cleaner, livable cities that attract talent and investment, higher property values, jobs, and growth in related industries, such as recycling and manufacturing.

Social benefits include greater inclusivity and expanded employment opportunities, with jobs generated in waste services and resource recovery across formal and informal sectors. Integrating informal workers is critical for advancing social equity and strengthening communities. Additional employment is also created upstream through research, redesign, and remanufacturing for recyclability. As cities embrace circular economies, waste management drives secondary job creation and broader economic benefits.

Environmental benefits relate chiefly to pollution reduction and climate change mitigation. Opportunities are substantial and span both upstream and downstream interventions for plastic pollution. Upstream, redesigning products, reducing unnecessary packaging, and adopting alternative materials can prevent plastic waste at its source. Downstream, achieving universal waste collection, and eliminating open dumping are essential to prevent plastics from leaking into the environment. Strengthening integrated waste management systems and investing in circular economy approaches are also critical to protect ecosystems and reduce pollution.

The waste sector offers significant opportunities in climate mitigation. In 2022, GHG emissions from solid waste management activities were estimated at approximately 1.28 billion tonnes of carbon dioxide equivalent per year, with methane accounting for the vast majority at 1.15 billion tonnes of carbon dioxide equivalent annually. If existing practices continue, GHG emissions from solid waste management are projected to rise sharply, reaching 1.84 billion tonnes of carbon dioxide equivalent by 2050, a 43-percent increase from 2022 levels.

Food loss and food waste[9] are major contributors to these emissions, with possibly one-third of all food produced globally lost or discarded each year (FAO 2011). Addressing food loss and food waste is essential for reducing emissions but also improving food security, protecting natural resources and achieving climate goals. It remains among the most complex issues facing the world today.

Reflecting the urgency and potential for impact, it is notable that 156 countries have recognized the climate mitigation potential of improved waste and plastic management by including the waste sector in their Nationally Determined Contributions (NDCs).[10] Prioritized measures include composting and methane capture as well as recycling. However, financing and regulatory challenges constrain implementation, with most commitments reported as dependent on international support.

Scenarios for Municipal Solid Waste Management toward Circularity to 2050

What a Waste 3.0 has developed alternative scenarios for municipal solid waste management through 2050, providing a framework for understanding how different policy choices and levels of ambition could shape the future of global waste.

This report presents three scenarios: business as usual, low ambition, and high ambition. The business-as-usual scenario extends prevailing trends, projecting a significant increase in global waste generation—from 2.56 billion tonnes in 2022 to 3.86 billion tonnes in 2050. By contrast, the high-ambition scenario models a future where waste generation is capped at prevailing levels, despite ongoing population and economic growth, through a combination of targeted interventions and improved waste management practices. The low-ambition scenario represents a middle path, achieving half the reduction of the high-ambition scenario, with global waste reaching 3.12 billion tonnes in 2050. Importantly, these scenarios are designed to support long-term planning and policy development, by considering waste reduction and improvements in waste collection and management.

Across all scenarios, waste collection coverage expands significantly, with the most notable gains in low-income countries. Waste treatment and disposal practices also see substantial progress while the share of uncollected and openly dumped waste declines sharply. These achievements vary by income group, with high- and upper-middle-income countries increasing recycling and composting, whereas low- and lower-middle-income countries eliminate open dumping and expand access to recycling, composting, and sanitary landfilling. Collectively, the scenarios highlight the scale of the challenge and the significant potential for progress in waste management toward circularity.

The financial costs and GHG emissions were estimated for the three scenarios. The low-ambition and high-ambition scenarios result in lower overall costs compared to the business-as-usual scenario, primarily owing to reduced waste volumes.[11] Conversely, in low- and lower-middle-income countries, investment and annual costs rise under all scenarios, driven mainly by low baseline conditions with widespread uncollected waste and open dumping. The scenarios demonstrate the substantial climate benefits in GHG emissions that can be achieved through improved waste management. Both the low- and high-ambition scenarios project a decline in global GHG emissions from the waste sector between 2030 and 2050, with estimates of 1.33 billion tonnes of carbon dioxide equivalent and 0.91 billion tonnes of carbon dioxide equivalent, respectively, by 2050.

The scenarios are intended to inform and guide discussion and policy action on alternative future pathways for the waste sector. Redirecting a modest share of GDP into well managed, essential systems can lock in basic service reliability, avert escalating economic losses and pollution, support job creation, and improve urban livability. The scenarios highlight how greater ambition, where waste prevention and minimization are paired with upstream measures toward substantially higher reuse, recycling and recovery rates, can deliver further climate, environmental, and resource efficiency benefits, generate additional opportunities for job creation and economic development, and contribute to the achievement of global sustainability goals.

Notes

1. Municipal solid waste is defined to include waste from households and residential establishments, including bulky waste, similar to household waste from commerce and trade, office buildings, institutions, and small businesses; yard and garden waste; street sweepings; the contents of litter containers; and market waste, if managed as household waste. The definition excludes waste from municipal sewerage networks and treatment, as well as waste from construction and demolition activities.
2. This surpassing of earlier projections is partly due to improved data quality and updated methodologies that now include previously unmeasured waste streams, such as uncollected waste.
3. The term "controlled" is defined by the Waste Wise Cities Tool through a set of ladders of control applied for land disposal, incineration, and other recovery facilities. In this edition of *What a Waste*, "controlled" refers specifically to all collected waste that is treated in facilities other than dumpsites. The Waste Wise Cities Tool is available at: https://unhabitat.org/wwc-tool.
4. It should be noted that while presented together with composting, anaerobic digestion does not necessarily result in material recovery.
5. The Organisation for Economic Co-operation and Development (OECD) defines extended producer responsibility as follows: "Extended producer responsibility is a policy approach that makes producers responsible for their products along the entire lifecycle, including at the post-consumer stage. By doing so, it helps achieve environmental goals such as recycling targets. At the same time, EPR generates funding from producers that help to pay for the collection, sorting and recycling of waste products, as well as generates detailed information on production, products, waste generation and treatment." OECD 2016.
6. All estimates were conducted at the country income-group level using combined 2022 GDP.
7. The Clean Development Mechanism (CDM) is a UN program under the Kyoto Protocol that allows emission reduction projects in developing countries to earn tradable carbon credits. For more information, see https://cdm.unfccc.int/.
8. For a discussion on waste sector projects accessing carbon finance through the Clean Development Mechanism and opportunities under Article 6 of the Paris Agreement, see https://hdl.handle.net/10986/43183. For an overview of the growth of carbon markets, the operationalization of Article 6, and implications for sectors including waste, see https://hdl.handle.net/10986/42016.
9. Food loss occurs along the supply chain, especially in regions lacking infrastructure, cold storage, and efficient logistics, while food waste happens at retail and consumer levels due to spoilage, over-purchasing, aesthetic standards, or expiry dates. FAO 2013.
10. Nationally Determined Contributions (NDCs) are country-owned climate action plans required under Article 4.2 of the Paris Agreement. They set out each country's commitments to reduce GHG emissions and adapt to climate change and are updated every five years to reflect increased ambition and progress. NDCs serve as stepping stones toward the global goal of limiting temperature rise and achieving climate resilience.
11. The estimates focus only on direct waste management costs and do not account for additional expenses associated with upstream prevention and minimization measures. Such measures will require further investments from producers and distributors involved in diverting materials and products.

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©iStock/Nikada. Accumulation of solid waste in an open drainage channel.

1. Introduction

The global challenge of managing solid waste is more pressing than ever. Cities, towns, and rural communities are grappling with rapidly increasing waste volumes, changing waste composition, and mounting pollution pressures that threaten environments and public health, reduce urban competitiveness and livability, and strain municipal budgets. Population growth, urbanization, and evolving consumption patterns intensify these pressures.

This third edition of the World Bank Group's *What a Waste* series builds on the foundational work of the first edition (Hoornweg and Bhada-Tata 2012) and the expanded analyses of the second edition (Kaza et al. 2018). *What a Waste 3.0* presents the most comprehensive global assessment to date of municipal solid waste generation, management, and costs, and describes their economic and climate impacts, highlighting opportunities for waste minimization and better resource management toward circularity.

Over the past decade, the *What a Waste* series has become a primary reference for understanding the state of municipal solid waste management globally. *What a Waste 3.0* updates and broadens the evidence base, incorporating enhanced datasets, refined methods, and a clearer lens on how policy and investment choices could shape outcomes across regions and income groups.

Compared with *What a Waste 2.0*, this edition adds important data points related to plastic waste and collates data and information on extended producer responsibility and deposit return schemes. It also highlights self-managed waste reported in national sources, estimates prevailing waste management costs and required financing levels, and estimates jobs in the urban waste sector, comparing results with literature outside the World Bank Group.

A principal advancement of this edition is the development of three forward-looking scenarios through 2050 that reflect different ambition levels and policy pathways for waste prevention and management: a business-as-usual scenario, a low-ambition scenario, and a high-ambition scenario. These scenarios allow readers to compare projected waste generation, service coverage, treatment pathways, GHG emissions, and cost implications under varying levels of ambition. They underscore the risks of inaction.

As in the case of the earlier publications, *What a Waste 2.0* and *What a Waste 3.0* differ methodologically. To improve comparability for statistical analyses, this edition makes conservative adjustments to capture previously unrecorded flows, including uncollected waste and waste handled by the informal sector. The results indicate that global waste generation is increasing faster than previously anticipated. Eight years after the release of *What a Waste 2.0*, the world has not achieved the improvements in waste management that are urgently needed. Conditions in many low- and lower-middle-income countries remain particularly serious and a matter of concern.

The publication is a stark reminder of the urgent global waste management situation and its implications for local constituencies: deteriorating environmental and social conditions and missed opportunities for economic development and job creation.

This report is organized as follows:

Chapter 2: Global Picture of Solid Waste Management toward Circularity. Chapter 2 provides an overview of global solid waste management trends in waste generation, composition, collection, treatment, and disposal.

Chapter 3: Regional Snapshots. Chapter 3 provides analyses of waste generation, composition, collection, treatment, and disposal across seven regions.

Chapter 4: Scenarios for municipal solid waste management and circularity to 2050. Chapter 4 presents projections for municipal solid waste under three scenarios: business as usual, low ambition, and high ambition.

Chapter 5: Waste and Climate. Chapter 5 estimates GHG emissions in the baseline and under the three scenarios to 2050 and discusses country Nationally Determined Contributions as they relate to waste management.

Chapter 6: Waste Administration, Operations, and Jobs. Chapter 6 discusses legal, institutional, administrative, operational, and contractual aspects of how the sector is organized.

Chapter 7: Costs and Financing of Solid Waste Management Services. Chapter 7 presents typical costs for waste management services, estimates waste management costs under the business-as-usual, low- ambition, and high-ambition scenarios, and discusses sector financing sources and levels.

Each chapter is followed by an extended, focused text box that deepens the discussion on a particular topic, including construction and demolition waste in post-disaster situations; stakeholder participation and behavior change; waste reduction; food wastage and regulatory approaches for institutional food waste generators; waste management technologies; and the role of the private sector in sustainable waste management.

Appendix A provides waste generation data and projections by country and economy.

Appendix B presents waste treatment and disposal data by country and economy.

Appendix C summarizes the methodology followed.

Readers are invited to use the global datasets, available online, which serve as comprehensive repositories of data and information.

Please note that:

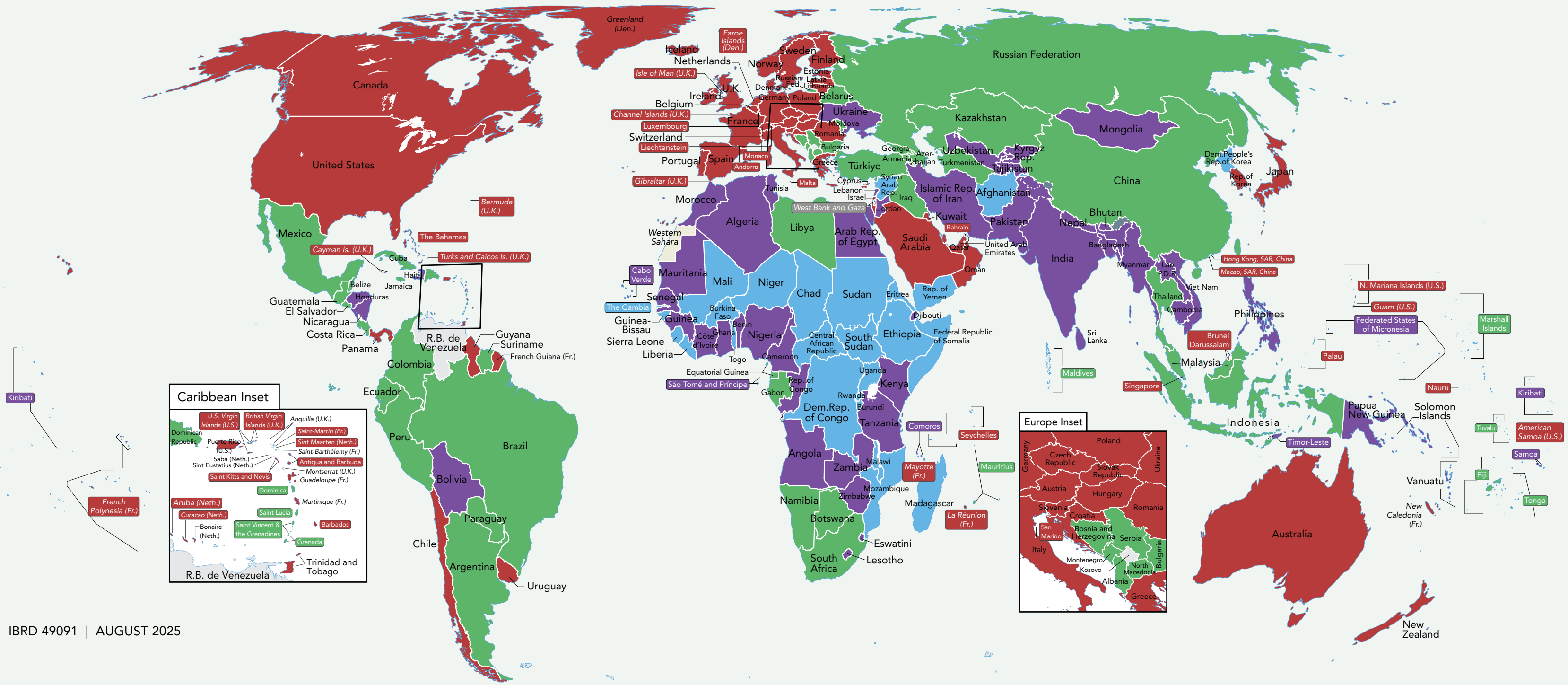
"Municipal solid waste", "solid waste", and "waste" are used interchangeably in this document, unless otherwise specified.

"Incineration" should be understood as waste incineration with energy recovery.

1.1

Definition of Regions and Income Groups

Map 1.1 Definition of income groups



IBRD 49091 | AUGUST 2025

Classification according to World Bank estimates of calendar year 2022 GNI per capita. GNI per capita (Atlas methodology US$).

Low-income: ≤ US$1,135 **Lower-middle-income:** US$1,136-US$4,465 **Upper-middle-income:** US$4,466-US$13,845 **High-income:** > US$13,845

Source: World Bank.
Note: The color-coding on this map for Taiwan, China represents the income group for China, which is upper-middle-income The income group for Taiwan, China is high-income.

Map 1.2 Definition of regions per World Bank analytical classifications

Classification according to World Bank analytical grouping for calendar year 2022.

North America | Europe & Central Asia | Latin America & the Caribbean | East Asia & Pacific | Middle East & Noarth Africa | South Asia | Sub-Saharan Africa

Source: World Bank.

1.2

A Note on Data

This edition of *What a Waste* comprises municipal solid waste management data for cities and countries from various sources and provides analyses, which can be used by policy makers and researchers. Data for this report were collected through a joint effort by the World Bank, Eunomia Research and Consulting Ltd, University of Leeds, and Institute for Global Environmental Studies, Japan. Data were gathered online, prioritizing official government sources, namely official statistical data and formally published public sector data. Where official data were not available, information was gathered from documents published by international organizations, multilateral and bilateral agencies, and academic journals. Data were obtained in the original language and translated where necessary. Data collection primarily took place during 2024 and early 2025. Additionally, regional World Bank solid waste experts and urban development practitioners provided insights beyond the data collected, which are included in the regional snapshots to provide further context for each region.

For the purposes of this report, the definition of municipal solid waste encompasses residential, commercial, street cleaning, and institutional waste.[1] Occasionally, this is referred to as "waste" for brevity, unless otherwise specified. Throughout this report, references to incineration refer to incineration with energy recovery. To the greatest extent possible, data on industrial, medical, hazardous, electrical and electronic, construction and demolition, and mining wastes were collected in parallel with municipal solid waste data and are reported separately from total waste generation. Every effort was undertaken to verify sources and find the most recent information available.

Solid waste data should be considered with a degree of caution because of inconsistencies in definitions, data collection methodologies, the point at which measurements are taken, and the availability of reliable data. The reliability of solid waste data is influenced by several factors, including: undefined words or phrases; incomplete or inconsistent definitions; lack of dates, methodologies, or original sources; inconsistent or omitted units; and estimates based on often assumptions that were not clear. In this report, where possible, measured values are recorded rather than estimates or projections, even if that meant using older data. In addition, in a few cases where a source only provided a range for a data point, the mean of the range was used for this study and is noted as such. Given the variety of methodologies used by the different sources, caution should be exercised on the direct comparison of data points for individual countries and cities. Where available, the most recent measurements are recorded. However, where the data pedigree[2] was judged to be insufficient, older data are occasionally recorded in preference to more recent, but less robust alternatives.

The data reported are predominantly from the years 2020–24, although earlier years are used in some cases depending on data availability. The year 2022 was selected as the base year, as it is the most commonly reported year across the dataset. When a single data point within a country or city, such as waste generation, represents a total accumulated over multiple years, the data were proportionally allocated across the relevant years. The reference year for the different indicators—for example, waste composition, waste treatment—may vary within a country or city. When the reporting year of data was not available in the original source, the year of publication was recorded and used in its place for data analyses. When a year range was reported in the original source, the final year of the range is provided in this report's dataset.

To enable data to be compared, data for waste composition, collection rates, and treatment and disposal methods are presented as percentages in this report. Therefore, data originally reported using different units, such as waste composition by weight, are converted to percentages using the respective sources wherever possible, with any modifications noted in the comments. Minor rounding differences may occur in both percentages and whole numbers, which may result in totals not adding up to 100 percent or to the stated sums.

Three datasets were created, which are referred to throughout the report:

1. Country dataset: Includes a repository of data for 217 countries and economies collected during the research in its original or partially harmonized format.
2. Projected country dataset: Country level waste generation data only are projected for 2022 to enable comparability in consistent year and then projected for 2030, 2040, and 2050. It enables comparison of waste generation according to consistent years and is available in appendix A. For more information on the methodology, see appendix C (Summary Methodology).
3. City dataset: Includes a repository of data for 262 selected cities collected during the research conducted for this study in its original or partially harmonized format.

These datasets are available at https://www.worldbank.org/en/publication/what-a-waste/.

Readers are advised that the country and city datasets are data repositories. Users should always consult the original sources and accompanying notes for each data point before undertaking further analyses.

Statistical analyses: To present the most realistic aggregate appraisal—at global, income group, and regional levels—data on waste generation, collection coverage, treatment, and disposal are conservatively adjusted. The adjustments are applied solely for aggregate calculations. The adjustments were made to account for flows of waste that are not typically recorded or measured, such as the amount of uncollected waste, the waste collected by the informal sector, and nonhousehold municipal solid waste, where explicitly reported as such. Waste composition was adjusted to harmonize categories and assumptions were made to distribute waste reported under categories, such as "other". The adjusted data were then projected for 2022, 2030, 2040, and 2050 using growth rates linked to a regression function and either gross domestic product (GDP) per capita, purchasing power parity (PPP) (constant 2021 international $), or gross national income (GNI) per capita, Atlas method (current US$).[3] Adjustments were made on a highly conservative basis, meaning that it is possible that some flows are still unaccounted for and that, for example, waste generation may be even higher than the adjustments indicate.

The adjusted data are used to develop three scenarios, at global, country group and regional level: business-as-usual scenario, low- and high-ambition scenarios. A summary of the methodology is presented in appendix C.

It is important to note that since modeled, the adjusted data are a departure from data reported by individual countries and economies in official statistics.

Beyond the core data metrics, which include municipal waste generation, composition, collection and treatment, this report also provides information on the following categories, where available:

- Plastic waste that includes estimates of mismanaged and poorly managed[4] plastic wastes and single-use plastics—at global, country income group, and regional level;
- Self-management of uncollected waste that consolidates data, mainly from national census and surveys, in which individuals and households report the main method of management of waste that is uncollected;
- Special wastes that include waste from nonmunicipal sources, such as mining, electrical and electronic equipment e-waste, construction and demolition, medical or healthcare, and hazardous waste;
- Estimated GHG emissions from solid waste management activities that incorporate waste generation, composition, treatment and disposal, including projections;
- Public expenditure on waste and costs that includes city scale waste management budgets, user fees, and collection cost recovery;
- Waste administration that includes legal and planning frameworks, administrative and operating models, investment financing, and jobs in waste and resource recovery; and
- Extended producer responsibility schemes that include deposit return schemes, types of materials included, and scheme modality.

Notes

1. Municipal solid waste is specifically defined to include waste from households and residential establishments, including bulky waste similar waste from commerce and trade, office buildings, institutions, and small businesses; yard and garden waste; street sweepings; the contents of litter containers; and market waste if managed as household waste. The definition excludes waste from municipal sewerage networks and treatment, as well as waste from construction and demolition activities.
2. "Data pedigree" refers to the documented origin, history, and quality of a dataset. It encompasses consideration of the methods used to process and validate that data. It includes metadata on the methods, instruments, sampling protocols, temporal and spatial resolution, data transformations, and the degree of uncertainty or error. A robust data pedigree enables reproducibility, supports the evaluation of data reliability, and informs the suitability of the data for specific analyses or models.
3. World Bank Group. 2024. "GNI Per Capita, Atlas Method (Current US$)." https://data.worldbank.org/indicator/NY.GNP.PCAP.CD.
4. The term "mismanaged waste" is used in this report to refer to: (i) "poorly managed waste", that is, collected waste deposited in uncontrolled facilities or dumpsites and (ii) "unmanaged waste", that is, waste that is not collected.

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©iStock/ArtMarie. Open dumpsite on the urban periphery.

2.

At a Glance: A Global Picture of Solid Waste Management toward Circularity

KEY INSIGHTS

- Global waste generation is 0.88 kilogram per capita per day on average, with most values ranging from 0.57 kilogram per capita per day to 1.38 kilograms per capita per day across individual countries and economies. Waste generation quantities generally correlate with income levels and urbanization rates.
- It is estimated that 2.56 billion tonnes of municipal solid waste was generated in 2022. This is expected to grow to 3.86 billion tonnes by 2050 under a business-as-usual scenario.
- Waste generation quantities in low-income countries are expected to more than double by 2050. The East Asia and Pacific region generates the majority of the world's waste at 33 percent, whereas the Middle East and North Africa region generates the least at 6 percent. The fastest growing regions in waste generation are Sub-Saharan Africa and South Asia, where total waste generation is expected to approximately double by 2050, under a business-as-usual scenario.
- Food and garden waste make up most of the municipal solid waste in low-income countries at 52 percent of waste generated, whereas the waste in higher-income countries is dominated by dry recyclable materials, textiles, and waste electrical and electronic equipment at 50 percent of waste generated.
- Plastics make up approximately 12.5 percent of municipal solid waste globally. This ranges from 8.1 percent in

KEY INSIGHTS (CONTD.)

low-income countries to 13.1 percent in upper-middle-income countries. Single-use plastics represent an estimated 65 percent, or 208 million tonnes, of all municipal solid waste plastics generated globally every year.

- Waste collection rates vary widely by income level. High- and upper-middle-income countries typically provide almost universal waste collection. Low-income countries tend to collect approximately 42 percent of waste in cities, but outside urban areas, waste collection is much lower at about 5 percent.
- Globally, approximately 29 percent of waste is disposed of in some type of landfill, 13 percent is openly dumped, 21 percent undergoes materials recovery through recycling and composting, 20 percent is treated through modern incineration with energy recovery, and 17 percent is uncollected.
- Adequate waste disposal or treatment, such as controlled landfills or more stringently operated facilities are predominantly found in high- and upper-middle-income countries. Low-income countries generally rely on open dumping, with 25 percent of municipal waste being dumped after collection and 72 percent remaining uncollected.
- Nearly 29 percent of all plastic waste, or 93 million tonnes, is mismanaged. Of this, 13 percent is poorly managed in uncontrolled facilities such as dumpsites, and 16 percent remains uncollected. Middle-income countries are the leading source of unmanaged plastic waste, generating 87 percent of the global total. Sub-Saharan Africa, South Asia, and East Asia and the Pacific produce the largest quantities of unmanaged plastic waste at 15 million tonnes, 14 million tonnes, and 12 million tonnes, respectively.

2.1 Waste Generation

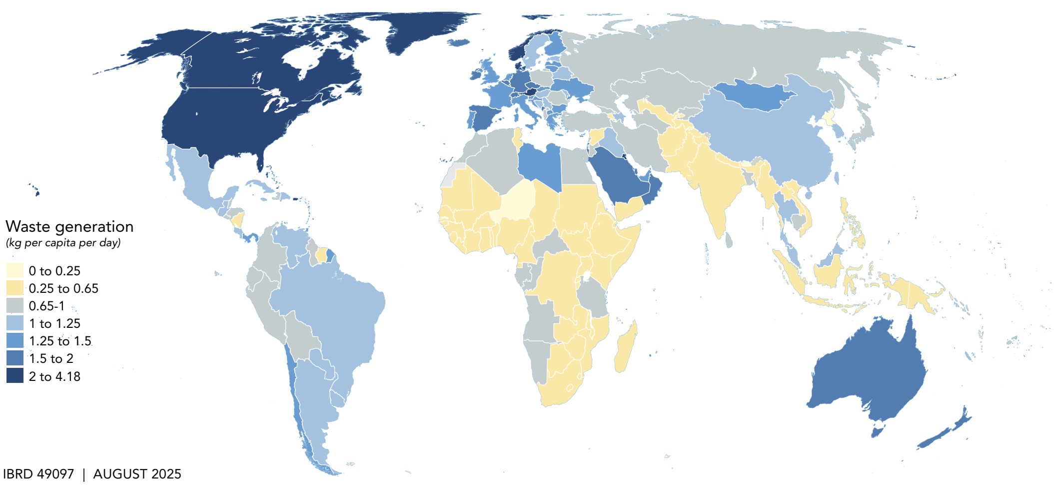
Waste generation follows rates of urbanization, economic development, and population growth. As nations and cities grow more populated and affluent, products and services are more accessible to residents, and nations have more opportunities to engage in global trade and exchange. This corresponds with increased amounts of waste that must be managed through treatment and disposal.

The 2012 and 2018 reports of *What a Waste* estimated global waste generation levels to be 1.3 billion and 2.1 billion tonnes, respectively (Hoornweg and Bhada-Tata 2012; Kaza et al. 2018). This latest version of *What a Waste* finds that waste generation appears to have increased faster than was anticipated in the last version, which used 2016 as a baseline year. The *What a Waste 2.0* report predicted 2.59 billion tonnes of waste generation by 2030 but according to the most up-to-date information available in this report, global waste generation had already reached an estimated 2.56 billion tonnes in 2022. It is possible that waste generation is increasing more rapidly.

However, in this report, the quality of the data has improved, and the projection methodology updated to include unrecorded and unmeasured waste flows that are often excluded from waste generation, such as uncollected and nonhousehold waste (appendix C).

The world's waste, by weight, is not evenly generated across geographical regions. The East Asia and Pacific region has the largest proportion of global population at approximately 30 percent and account for an equivalent amount of the world's waste at 33 percent—849 million tonnes estimated for 2022—of total global waste generation. The Middle East and North Africa region contains approximately 6 percent of the global population and generates the least amount of waste, accounting for 6 percent of the world's waste at 161 million tonnes (map 2.1). As a region, North America has the smallest proportion of global population at 5 percent but generates nearly 12 percent of global waste.

Map 2.1 Waste generation by country



Source: Original map for this report.
Note: Country dataset. National mean waste generation in kilograms per capita per day, projected to 2022.

Although high-income countries only accounted for about 16 percent of the world's population in 2022, they generated 29 percent, or 754 million tonnes, of the world's waste (figures 2.1a and 2.1c) and have the highest per capita generation of the income groups (figure 2.1e). Upper-middle-income countries account for 36 percent of the global population and produce the largest absolute tonnage of waste at 42 percent of global waste—1,065 million tonnes of waste per year (figure 2.1a). Lower-middle-income countries account for approximately 40 percent of the global population and generate about 25 percent of global waste or 638 million tonnes per year (figure 2.1a). Low-income countries account for 9 percent of the world's population and generate only approximately 4 percent of global waste or 105 million tonnes per year (figure 2.1a).

The highest waste generation per capita across global regions is in North America, which produced 2.25 kilograms of waste per capita per day (figure 2.1f). All three countries in North America—Bermuda, Canada and the United States—are high-income countries. The regions with the lowest waste generation per capita are Sub-Saharan Africa and South Asia, with a weighted mean of 0.52 kilogram and 0.49 kilogram of waste per capita per day, respectively; these regions contain a high proportion of countries that are low- to middle-income. Owing to the population size, South Asia is the third largest waste generating region globally (figures 2.1b and d).

Figure 2.1 Municipal solid waste generation

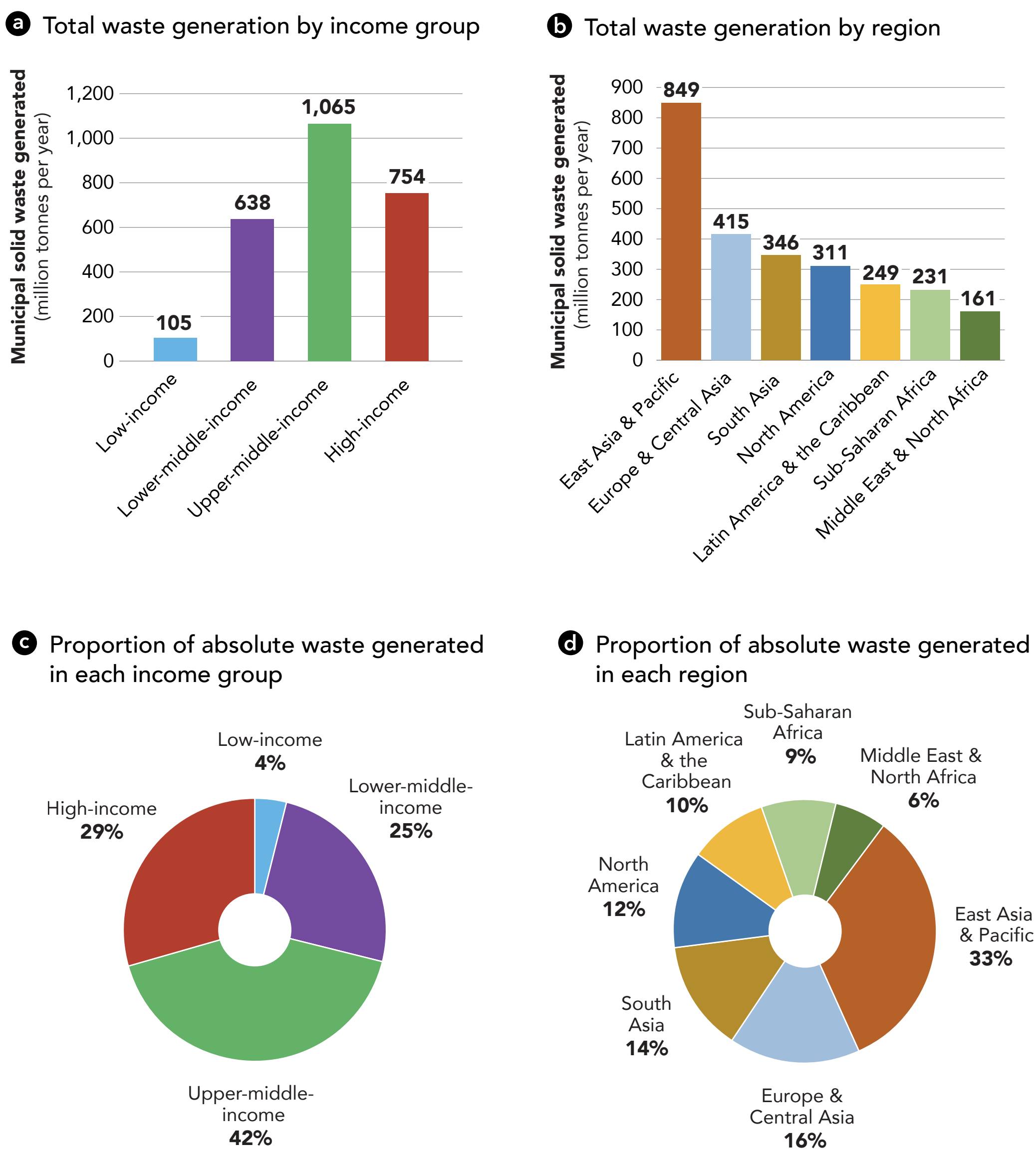
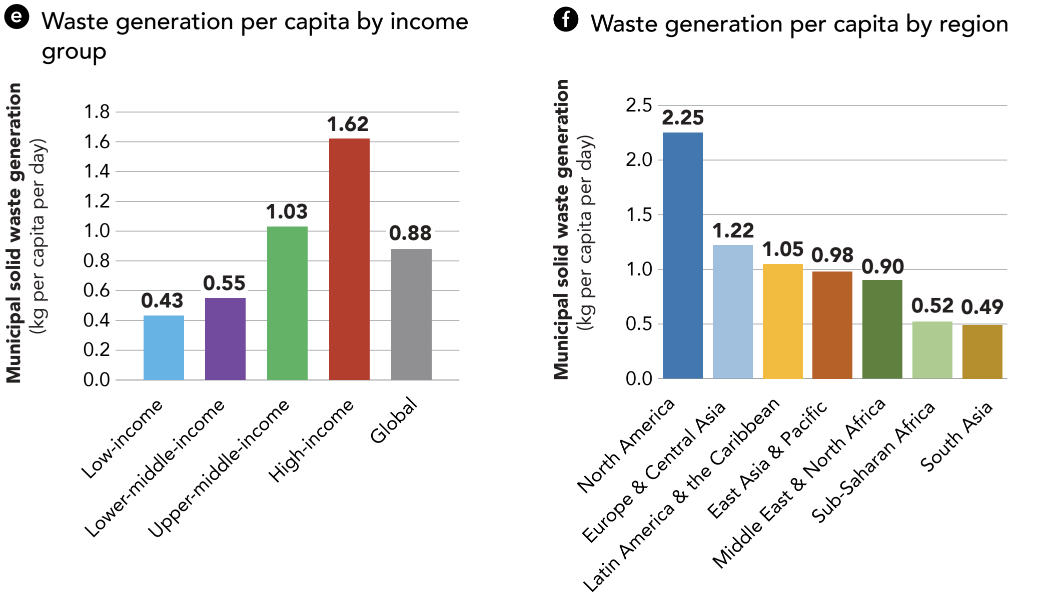


Figure 2.1 Municipal solid waste generation *(contd.)*



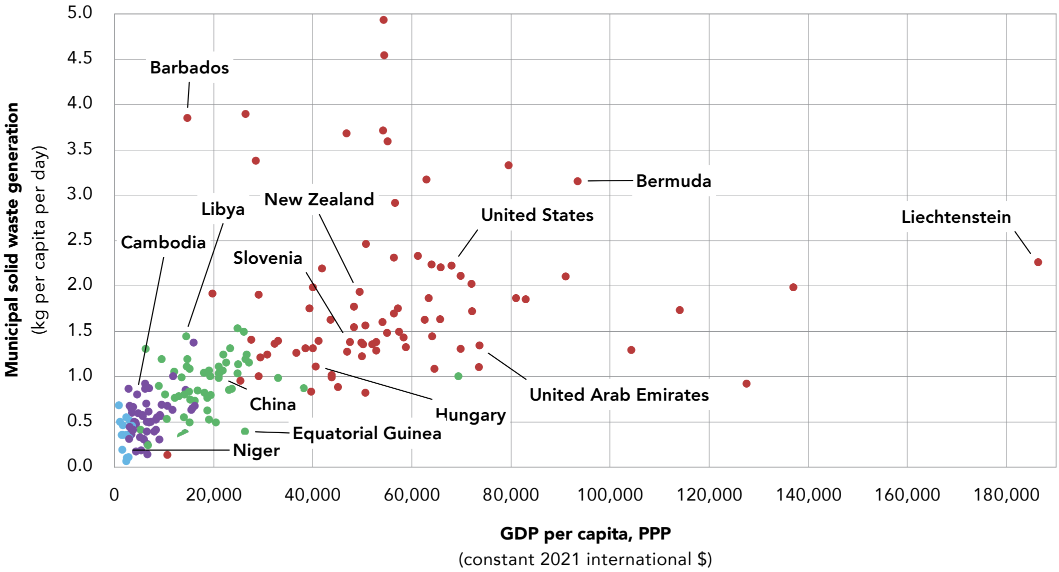
Source: Original figure for this report.
Note: Municipal solid waste generated, projected to 2022.

The mean global waste per capita for 2022 is 0.88 kilogram per day, an increase from the 2016 mean of 0.74 kilogram per capita per day reported in the 2018 edition of *What a Waste*. The mean waste generation per capita across individual countries and economies varies widely, from 0.16 kilogram per day to more than 3 kilograms per capita per day.

Waste generation overall has a positive relationship with economic development, particularly in countries that are at a low to moderate level of development (figure 2.2). With incremental income changes from low- to high-income levels, waste generation increases (figure 2.3). Higher-income regions such as North America and Europe and Central Asia show a high gross domestic product (GDP) per capita and high waste generation rate, whereas regions that are experiencing peaks in economic growth such as East Asia have rising GDPs and are expected to show higher levels of waste generation overtime (figure 2.4). The slowing of the growth of waste generation at higher income levels could be due to reduced marginal demand for consumption, and therefore, reduced waste.

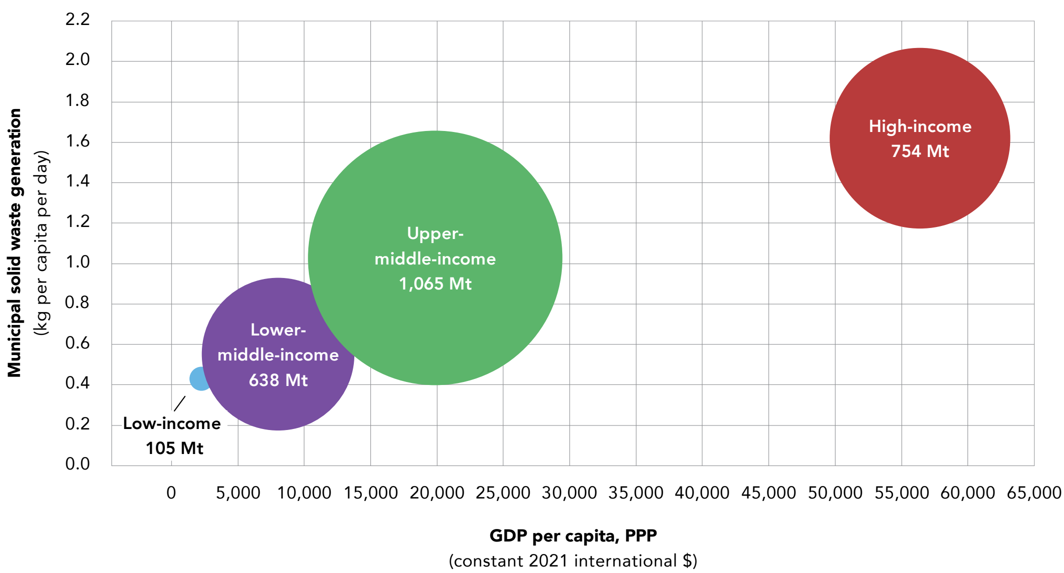
Waste generation also increases with urbanization. High-income countries tend to have higher levels of urbanization and generate more waste per capita (figure 2.3). At a regional level, North America generates about 2.25 kilograms per capita per day with the highest urbanization rate of 82.6 percent, whereas South Asia generates 0.52 kilogram per capita per day (figure 2.5) with a 36.6 percent urbanization rate (UNDESA 2018).

Figure 2.2 Correlation between waste generation and GDP per capita, PPP



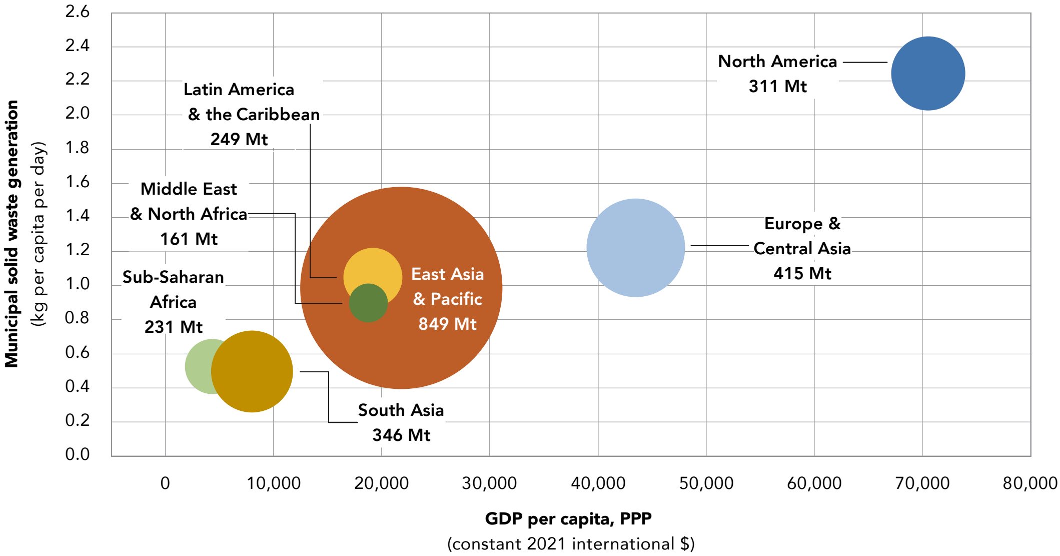
Source: Original figure for this report. World Bank 2024. "GDP Per Capita, PPP (Constant 2021 International $)." https://data.worldbank.org/indicator/NY.GDP.PCAP.PP.KD.
Note: Country dataset. Waste generation is projected to 2022. Colored dots represent country income groups (low-income = blue; lower-middle-income = purple; upper-middle-income = green; high-income = red). Selected countries labeled for orientation. GDP = gross domestic product, PPP = purchasing power parity.

Figure 2.3 Waste generation and GDP per capita, PPP by income group



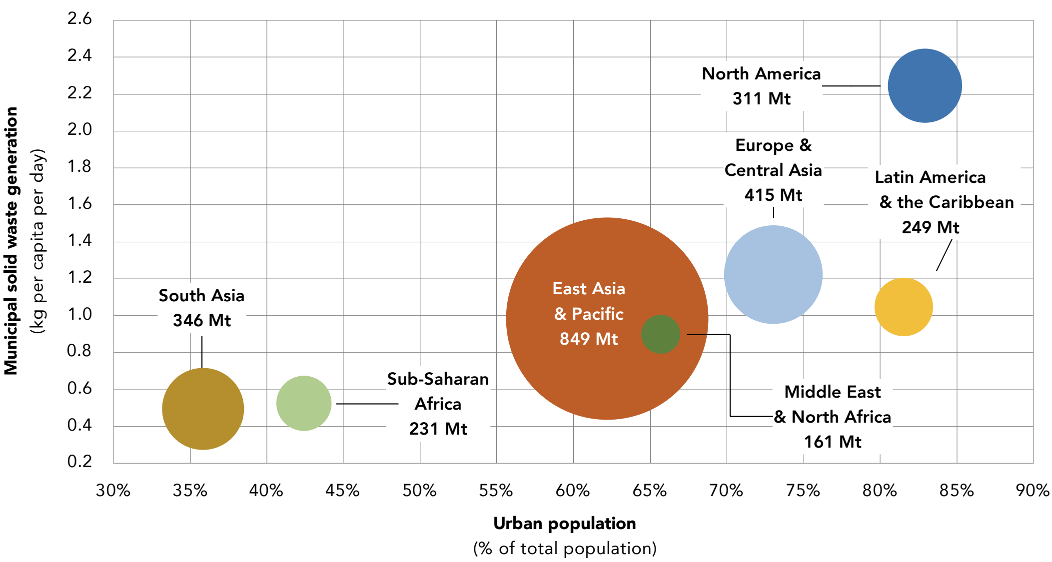
Source: Original figure for this report. World Bank 2024. "GDP Per Capita, PPP (Constant 2021 International $)." https://data.worldbank.org/indicator/NY.GDP.PCAP.PP.KD.
Note: Size of bubble represents the total weight of waste generated in each income level in 2022. GDP = gross domestic product, Mt = million tonnes, PPP = purchasing power parity.

Figure 2.4 Waste generation and GDP per capita, PPP by region



Source: Original figure for this report. World Bank 2024. "GDP Per Capita, PPP (Constant 2021 International $)." https://data.worldbank.org/indicator/NY.GDP.PCAP.PP.KD.
Note: Size of bubble represents the total weight of waste generated in each region in 2022. GDP = gross domestic product, Mt = million tonnes, PPP = purchasing power parity.

Figure 2.5 Waste generation and urban population by region



Source: Original figure for this report.
Note: Size of bubble represents the total weight of waste generated in each region in 2022. Mt = million tonnes.

This study projects changes in municipal solid waste generation to 2050. The methodology is summarized in appendix C.

Total waste generation is not anticipated to change substantially in high-income countries, with just over 137 million tonnes of additional waste expected to be generated in 2050 compared with 2022[1] (figure 2.6a). Although low-income countries have only a small quantity of waste compared with the rest of the world, their waste generation is expected to increase by 128 percent by 2050, the fastest of any group, driven by growth in population and wealth. On an absolute basis, the largest growth is in the upper-middle-income and lower-middle-income countries, where more than 1 billion tonnes of additional municipal solid waste are expected to be generated in 2050 compared with 2022 levels.

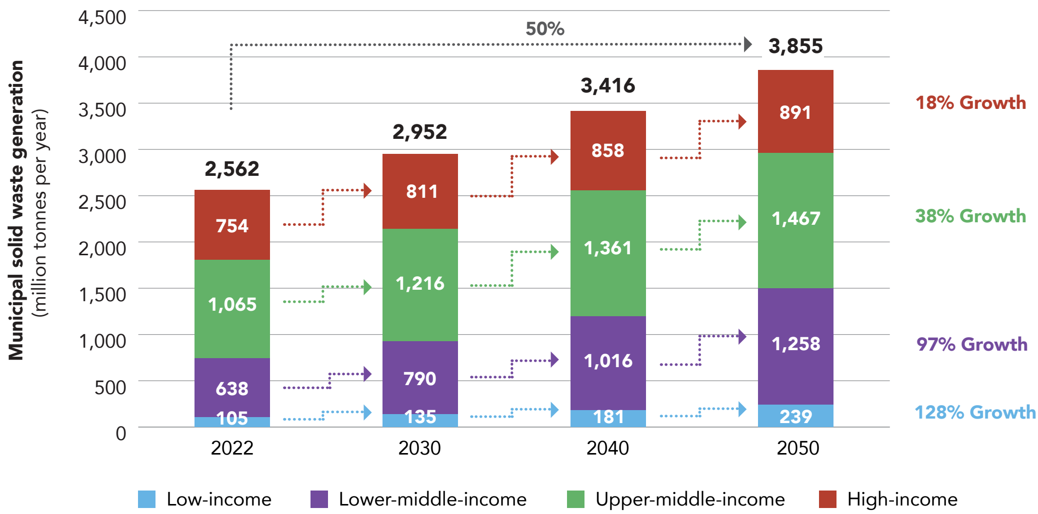
Nonetheless, on a per capita basis, waste generation in low-income countries is anticipated to increase by 21 percent, whereas in the lower-middle-income and upper-middle-income countries it is expected to increase by 51 percent and 37 percent per capita, respectively (figure 2.6b). High-income countries are expected to increase the least on a per capita basis; 14 percent compared with the global mean of 25 percent growth per capita.

Much of the growth in global waste generation over the coming decades will take place in Sub-Saharan Africa, where it will increase from approximately 230 million tonnes to over half a billion tonnes by 2050 (figure 2.7a). This increase is largely driven by population increases as the per capita rate increase in the Sub-Saharan Africa region is 26 percent over the same period (figure 2.7b). South Asia and the Middle East as well as North Africa regions are expected to increase the absolute amount of waste generated by 99 percent and 85 percent, respectively.

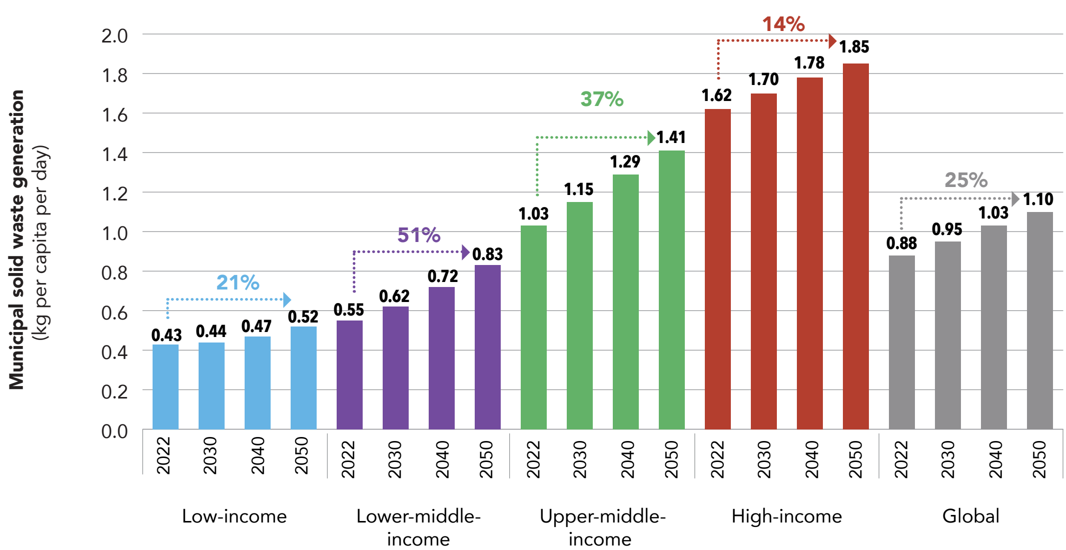
As with the previous edition of *What a Waste* (Kaza et al. 2018), the results of this study show a correlation between waste generation and increasing urban population (figure 2.8). This is likely due to more readily available products and services in urban areas as well as urban citizens being more prosperous overall.

Figure 2.6 Projected waste generation by income group

ⓐ Total waste generation

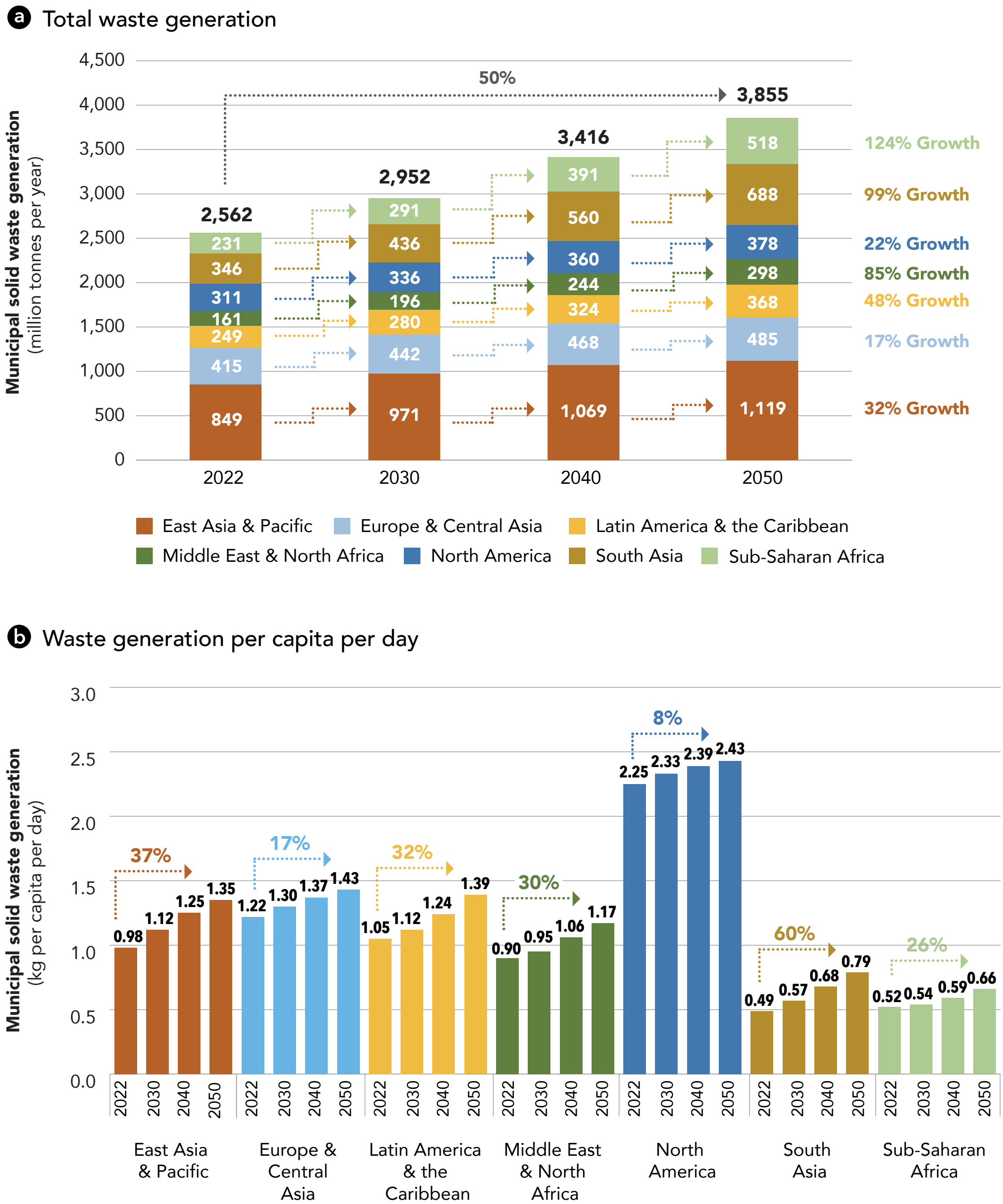


ⓑ Waste generation per capita per day



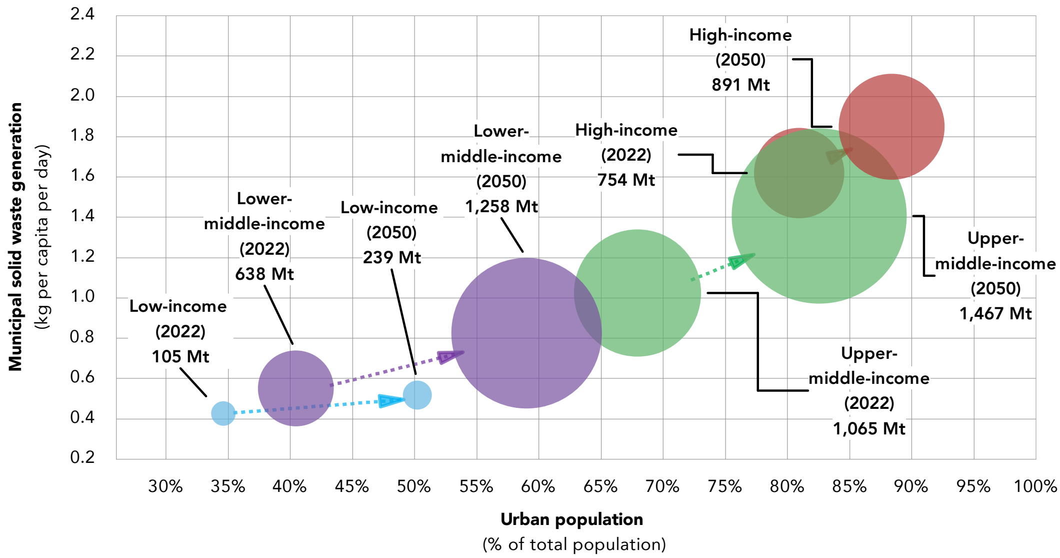
Source: Original figure for this report.
Note: In figure 2.6a, growth rates in colored text indicate proportional increase in waste generation between 2022 and 2050; in figure 2.6b, dashed arrows show the growth in waste generation between 2022 and 2050.

Figure 2.7 Projected waste generation by region



Source: Original figure for this report.
Note: In figure 2.7a, growth rates in colored text indicate proportional increase in waste generation between 2022 and 2050; in figure 2.7b, dashed arrows show the growth in waste generation between 2022 and 2050.

Figure 2.8 Waste generation and urbanization rate by income group



Source: Original figure for this report.
Note: Compares business as usual waste generation in 2022 with 2050. Bubbles represent the total weight of waste generated in each region. Mt = million tonnes.

2.2 Waste Composition

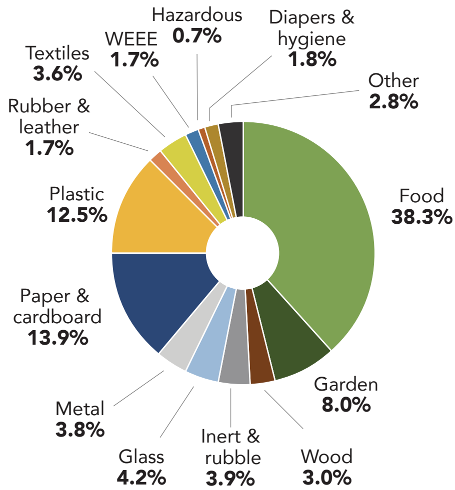
Waste composition refers to the categorization of different material types found in municipal solid waste. The analysis to categorize the waste is typically conducted through a standard waste audit, where samples of waste are collected from the source of generation or disposal sites, categorized into predefined groups, and then weighed.

At an international level, the largest waste category is food waste, making up 38 percent of global waste (figure 2.9) Engineered materials—plastic, paper and cardboard, metal, and glass—amount to another 34 percent of waste.

As income levels rise, the proportion of organic—food and garden—matter in municipal waste decreases, whereas the proportion of some engineered materials[2] increases (figure 2.10). However, upper-middle-income countries show a slightly higher share of organics compared with lower-middle-income countries. Specifically, they have a higher proportion of food and garden waste—53.7 percent by weight compared with 46.6 percent in lower-middle-income and 52.0 percent in low-income countries—and a lower share of engineered materials. This pattern is largely driven by the waste composition in China, which is characterized by high organic content due to cultural factors. As China accounts for the majority of waste generation in the upper-middle-income group, its influence is significant. Without

China, the combined proportion of food and garden waste in this income group would be approximately 46 percent. Additionally, the detail in waste composition data, such as specific quantities of rubber and wood waste, increases with higher income levels.

Figure 2.9 Global waste composition



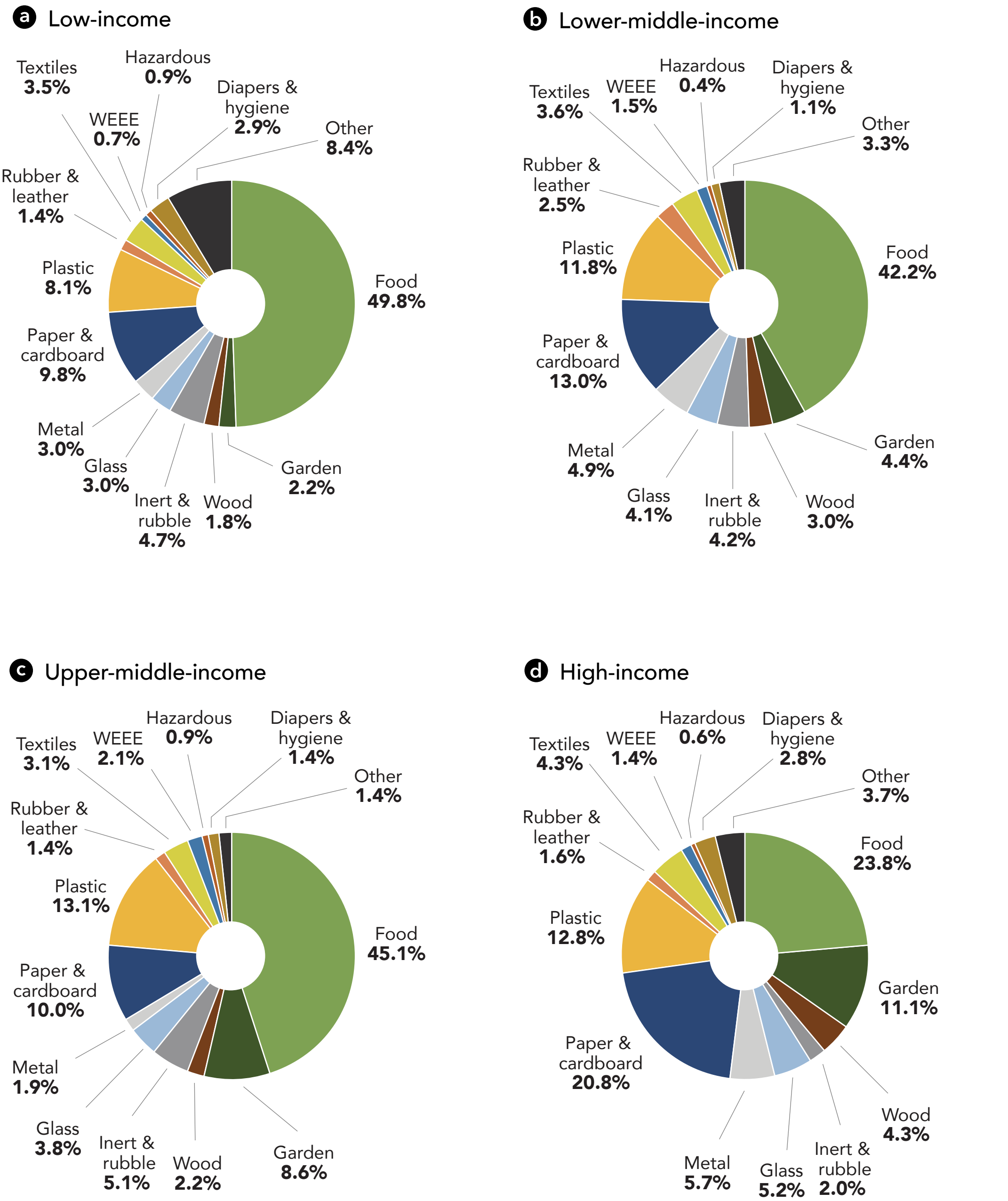
Source: Original figure for this report.
Note: Composition in each country reported for different years, multiplied by waste generation for 2022 and then aggregated to global level to create a weighted mean. WEEE = waste electrical and electronic equipment.

2.3 Waste Collection

A variety of management approaches are in place worldwide to collect and transport the generated waste for treatment. One common form of waste collection is curbside collection, where trucks, small vehicles—or in constrained environments, handcarts, or donkeys—collect waste from households at a predetermined frequency. In some areas, residents deposit waste in communal containers or collection points, which is then collected by the municipality. In regions with less frequent collection, communities might be alerted by a bell or other signal when a collection vehicle arrives. As well as formal collection, many regions have informal collectors of waste. These actors are not employed by the municipality but may collect certain types of waste to sell to recyclers or reprocess or repurpose themselves. In some regions, informal collections can have a considerable impact on the percentage of municipal waste collected overall.

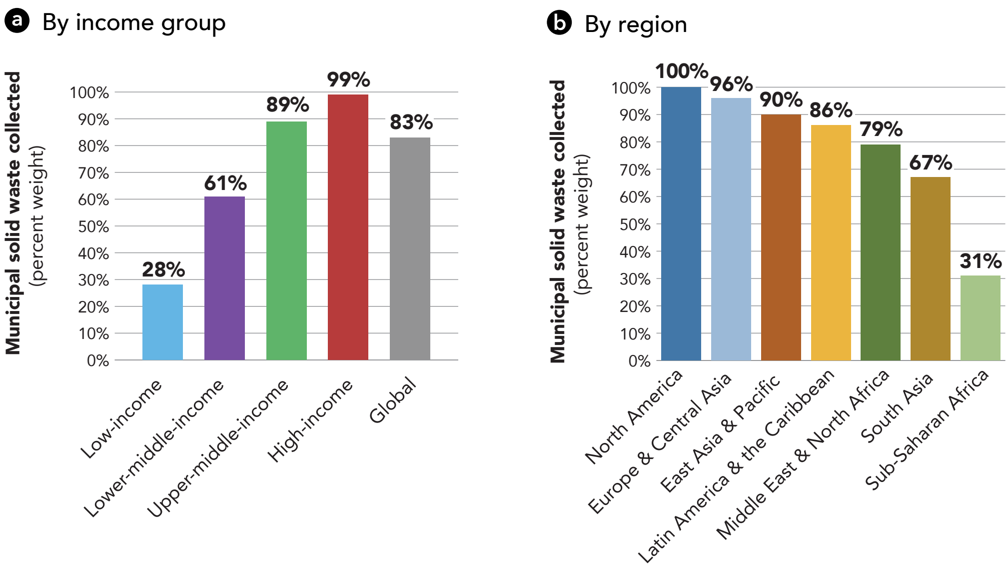
Disparity in municipal waste collection rates depends on country income level (figure 2.11). Waste collection rates in high-income countries are near 100 percent and in North America they are reported as 100 percent. In upper-middle-income countries, collection rates are not far behind at 89 percent. However, in lower-middle-income countries, collection rates are about 61 percent, and in low-income countries, collection rates are approximately 28 percent. In low-income countries, uncollected waste is often managed independently by households, and may be openly dumped, burned, or less commonly, composted. Municipal collection rates also vary between regions, with South Asia and Sub-Saharan Africa having the lowest collection rates of all the regions. All other regions have collection rates close to 80 percent or higher. Improvement of waste collection services is a critical step toward reduction of pollution.

Figure 2.10 Municipal solid waste composition by income group



Source: Original figure for this report.
Note: Composition for each country reported for different years, multiplied by waste generation for 2022 and then aggregated to income level to create a weighted mean. WEEE = waste electrical and electronic equipment.

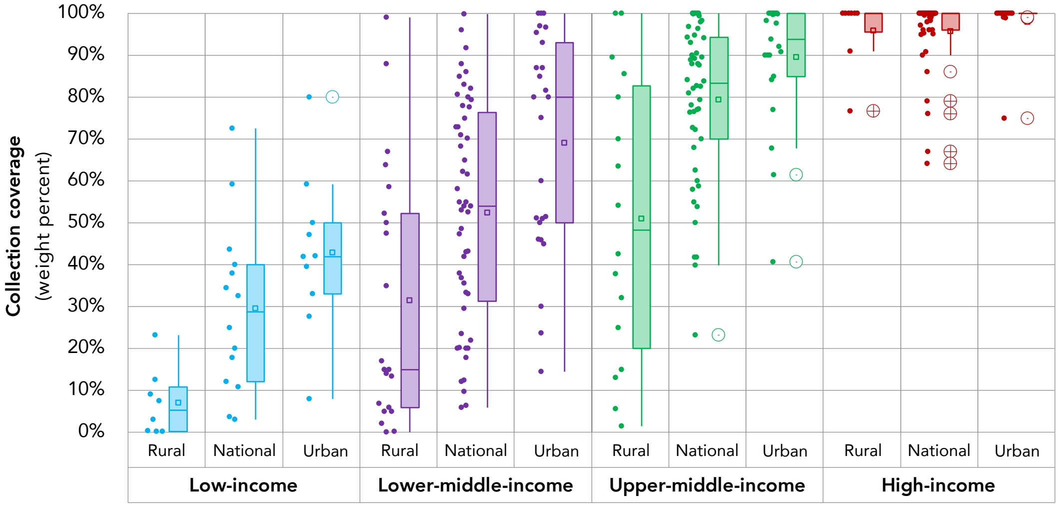
Figure 2.11 Municipal solid waste collection rates



Source: Original figure for this report.
Note: Mean collection coverage (percent, weighted by the total mass of waste collected in each income group in 2022).

Waste collection rates are typically higher for urban areas than for rural areas as authorities focus effort on the areas where population is most dense and the probability of negative interactions between humans and waste is greatest. The nonweighted mean collection rates per country in figure 2.12 show that in low-income countries, lower-middle-income and upper-middle-income countries' median waste collection rates are substantially higher in cities than in rural neighborhoods. High-income countries are the exception, with less variation in waste collection services in rural versus urban areas.

Figure 2.12 Urban, rural, and nonweighted mean national collection coverage by income level



	Low-income Rural	Low-income National	Low-income Urban	Lower-middle-income Rural	Lower-middle-income National	Lower-middle-income Urban	Upper-middle-income Rural	Upper-middle-income National	Upper-middle-income Urban	High-income Rural	High-income National	High-income Urban
Count	8	14	10	21	52	25	16	50	23	8	43	13
Median	5%	29%	42%	15%	54%	80%	48%	83%	94%	100%	100%	100%

25th - 75th percentiles; Range within 1.5IQR; Median Line; Mean; Outliers; Extreme values; • Waste collected as proportion of municipal solid waste generated

Source: Original figure for this report.
Note: Country dataset. Central tendency and spread. Dots represent the mean waste collection coverage in individual countries and economies observed in different and inconsistent years. Summary statistics are not weighted, meaning that each country is represented regardless of its size or population. Therefore, these collection rates are not comparable with the weighted collection rate shown in figure 2.11. Outliers are defined as values lying more than 1.5 times the interquartile range beyond the upper or lower quartiles. Extreme values are values lying more than 3 times the interquartile range beyond the upper or lower quartiles.

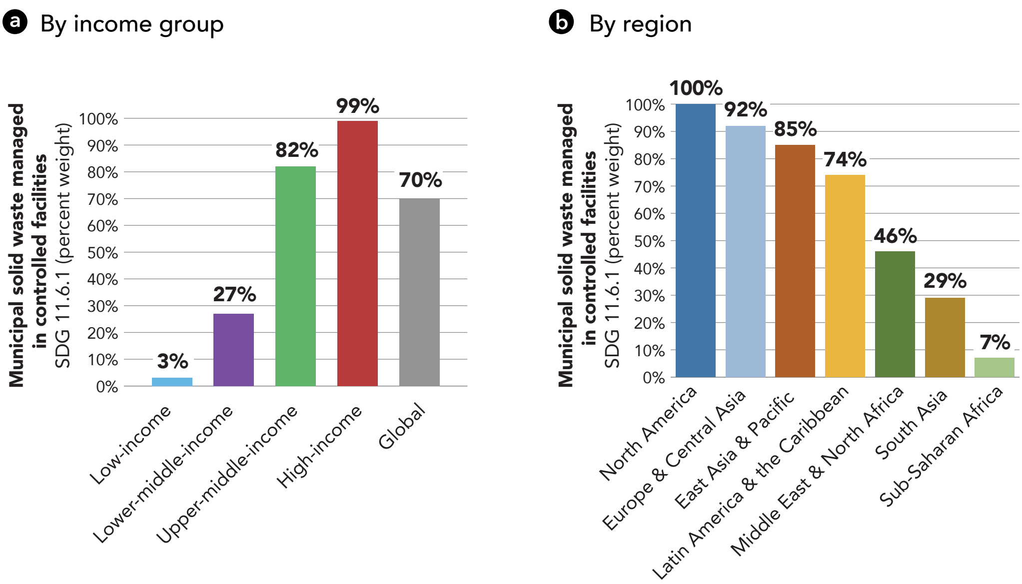
2.4

Progress toward Achieving Sustainable Development Target 11.6.1

Sustainable Development Goal (SDG) indicator 11.6.1 measures the proportion of municipal solid waste managed in controlled facilities. The term "controlled" is defined by the Waste Wise Cities Tool through a set of ladders of control applied for land disposal, incineration, and other recovery facilities (UN-Habitat 2021). In this edition of *What a Waste*, "controlled" refers specifically to all collected waste that is treated in facilities other than dumpsites.

In high-income countries, almost 100 percent of waste is already managed in controlled facilities, nearly 30 percent more than the global mean of 70 percent (figure 2.13a). By contrast, in low-income countries, just 3 percent is managed in controlled facilities. Most waste in low-income countries is not collected, and the waste that is collected is almost entirely disposed of in dumpsites.

Figure 2.13 Proportion of municipal solid waste managed in controlled facilities

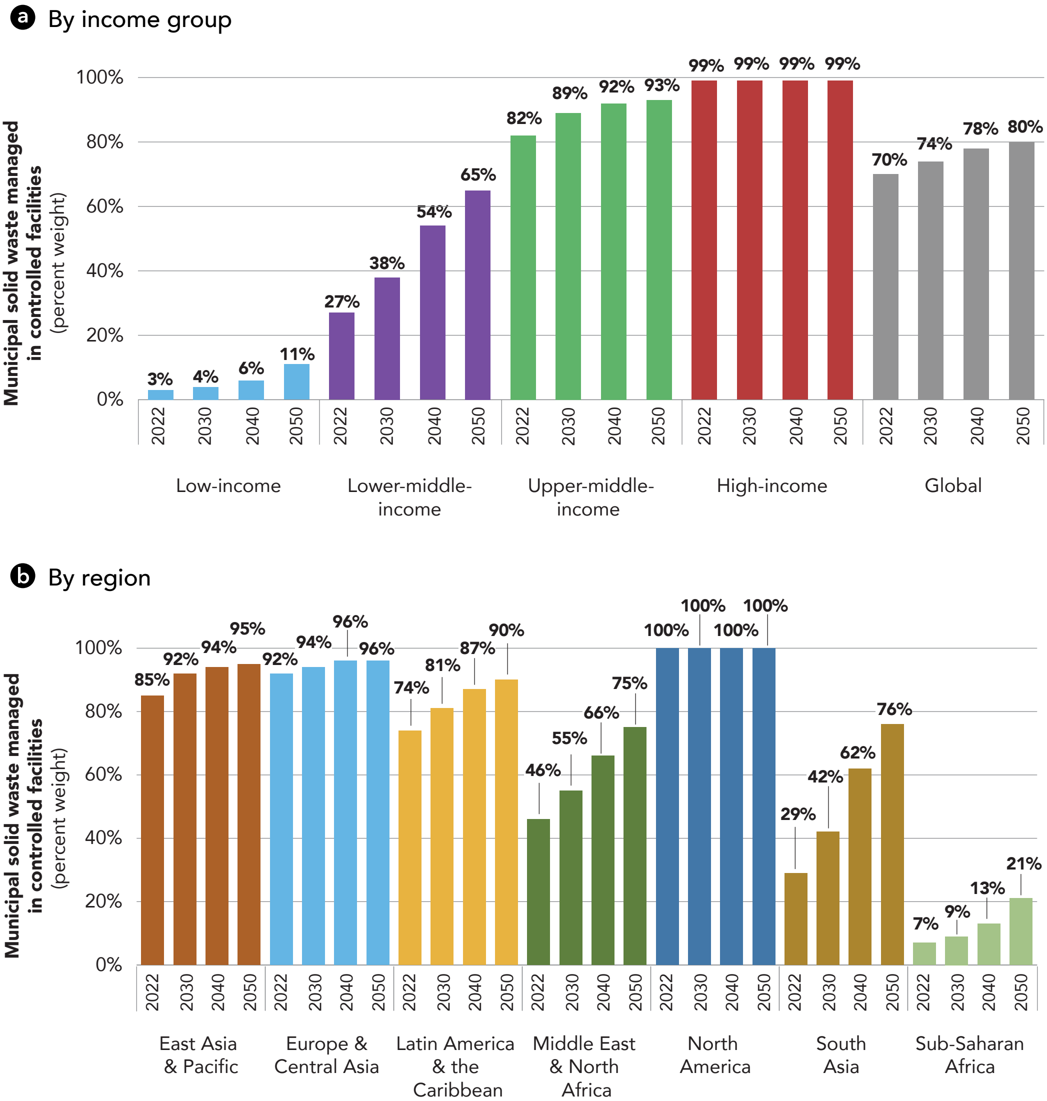


Source: Original figure for this report.
Note: Weighted mean municipal solid waste managed in controlled facilities, projected to 2022, as defined by SDG 11.6.1 target. SDG indicator 11.6.1: Proportion of municipal solid waste collected and managed in controlled facilities out of total municipal waste generated. https://sdgs.unep.org/article/sdg-indicator-1161.

The North America region had already achieved 100 percent of municipal solid waste managed in controlled facilities in 2022, followed closely by Europe and Central Asia where 92 percent of the waste is fully controlled. East Asia has also made strong progress toward achieving SDG 11.6.1 target, driven strongly by China, which has invested consistently in waste management over recent decades. By contrast, the Sub-Saharan Africa region has just 7 percent of its waste managed in controlled facilities.

Under business as usual, global progress toward SDG target 11.6 is anticipated to increase by ten percentage points by 2050, with the largest gains in lower-middle-income countries where the proportion of waste managed in controlled facilities is expected to more than double (figure 2.14a). Regionally, many of these gains are made in the Middle East and North Africa region and in South Asia, which managed just 29 percent of its waste in controlled facilities in 2022, and which is expected to increase that proportion to 76 percent by 2050 (figure 2.14b).

Figure 2.14 Proportion of municipal solid waste managed in controlled facilities to 2050

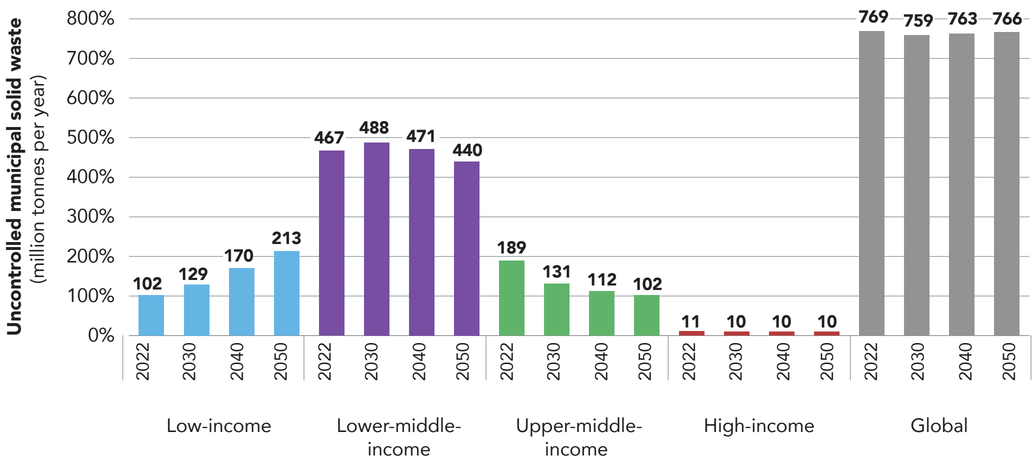


Source: Original figure for this report.
Note: Municipal solid waste managed in controlled facilities as proportion of municipal solid waste generated, projected to 2050.

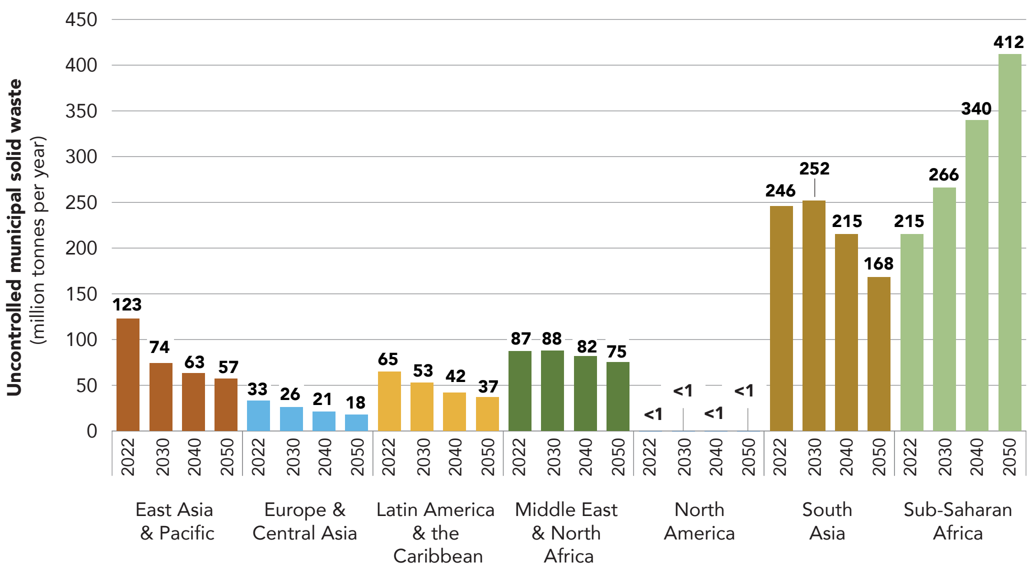
Under business as usual, the uncontrolled fraction of municipal solid waste is anticipated to remain relatively stable at a global level until 2050 (figure 2.15a). This is because the increase in unmanaged and poorly managed waste in low-income countries is likely to negate the anticipated improvements to waste management practices in upper- and lower-middle-income countries. Nearly 60 percent or 461 million tonnes of uncontrolled municipal solid waste was generated in the South Asia and Sub-Saharan Africa regions in 2022 (figure 2.15b). All regions are anticipated to reduce their uncontrolled waste by 2050, however the Sub-Saharan Africa region is expected to nearly double its uncontrolled waste by 2050, canceling out gains on a global scale.

Figure 2.15 Quantity of uncontrolled waste projected to 2050

a By income group



b By region

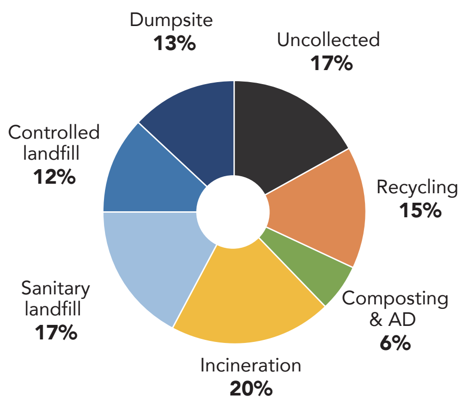


Source: Original figure for this report.
Note: Uncontrolled municipal solid waste, which is not managed in controlled facilities, absolute weight projected to 2050.

2.5
Waste Treatment and Disposal

Waste treatment processes aim to reduce the quantity and hazardousness of waste, recover valuable resources, and ensure safe disposal. Globally, landfills—controlled or sanitary, according to the UN Waste Wise Cities Ladder of Control Tool classification of landfills[3]—are the most common method of waste treatment, with 29 percent of municipal waste being disposed of in this way (UN-Habitat 2021; figure 2.16). Approximately 21 percent of municipal waste undergoes materials recovery through recycling, composting and anaerobic digestion,[4] and 20 percent is treated through modern incineration.[5] Almost a third of waste is not treated at all, either being openly dumped or not collected in the first place.

Figure 2.16 Global municipal solid waste treatment and disposal



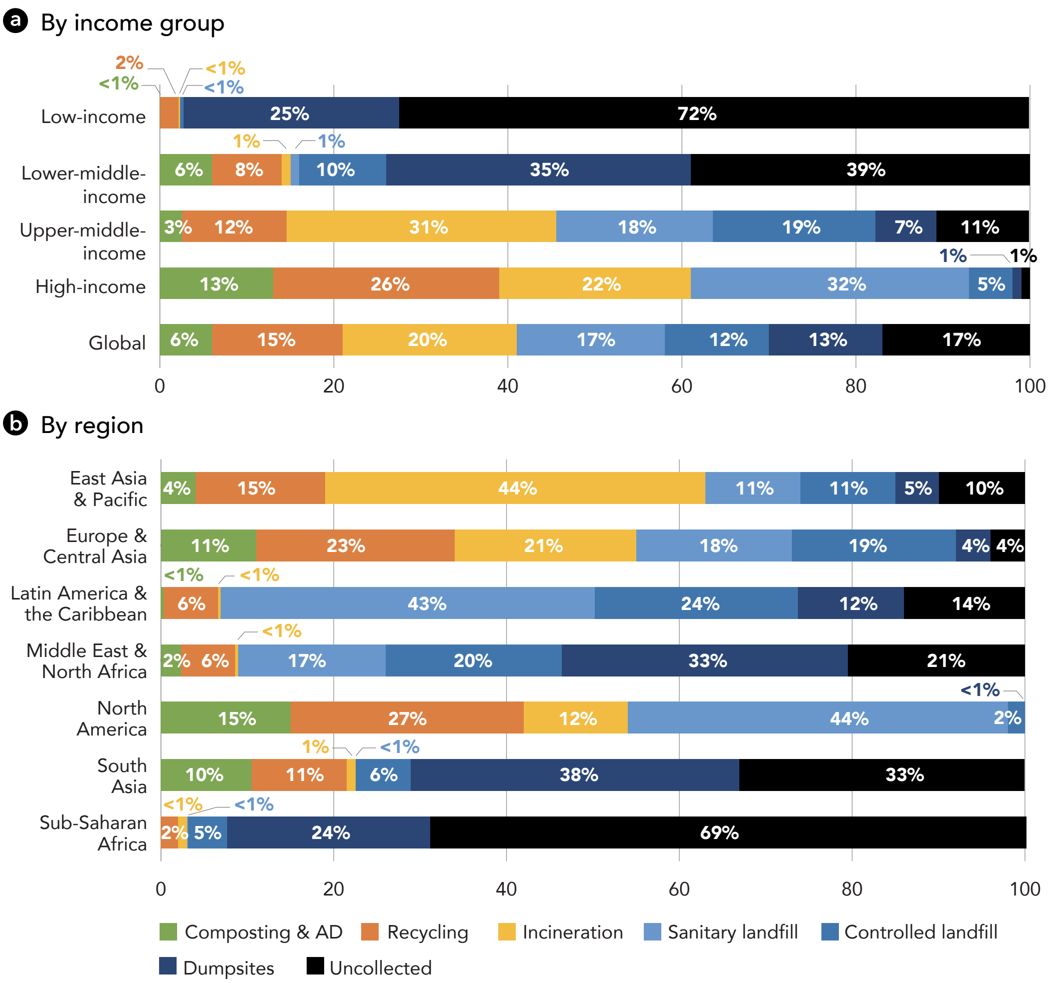
Source: Original figure for this report.
Note: Mean treatment and disposal (percent, weighted by the total mass of waste generated in 2022).
AD = anaerobic digestion.

Food waste represents a major global challenge, accounting for the largest share of municipal solid waste across all regions and income groups. Despite its prevalence, food waste is not always appropriately collected or treated. The most common treatment of municipal solid waste—open dumping or disposal in landfills without landfill gas management—results in methane emissions from food waste, substantially contributing to global greenhouse gas (GHG) emissions. These impacts can be partially mitigated when food waste is disposed of in sanitary landfills equipped with gas capture systems. The most sustainable treatment options for food waste are composting and anaerobic digestion, which reduce methane emissions and recover valuable resources. However, globally, only 6 percent of municipal waste is managed through composting or anaerobic digestion (figure 2.16). This share varies by income group, with 13 percent of collected waste treated via composting or anaerobic digestion in high-income countries, compared with just 0.04 percent in low-income countries (figure 2.18).

Waste disposal practices vary significantly by income group and region (figure 2.17). Open dumping is more prevalent in lower-income countries, where engineered landfills are either unavailable or operating beyond capacity. In low-income countries, approximately 90 percent of formally collected municipal solid waste is disposed of in dumpsites, which have limited or no environmental controls. In Sub-Saharan Africa, 77 percent of collected municipal waste is sent to dumpsites, whereas in South Asia, the figure is 57 percent. These two regions, which rely heavily on dumpsites, are also among the fastest growing globally in waste generation.

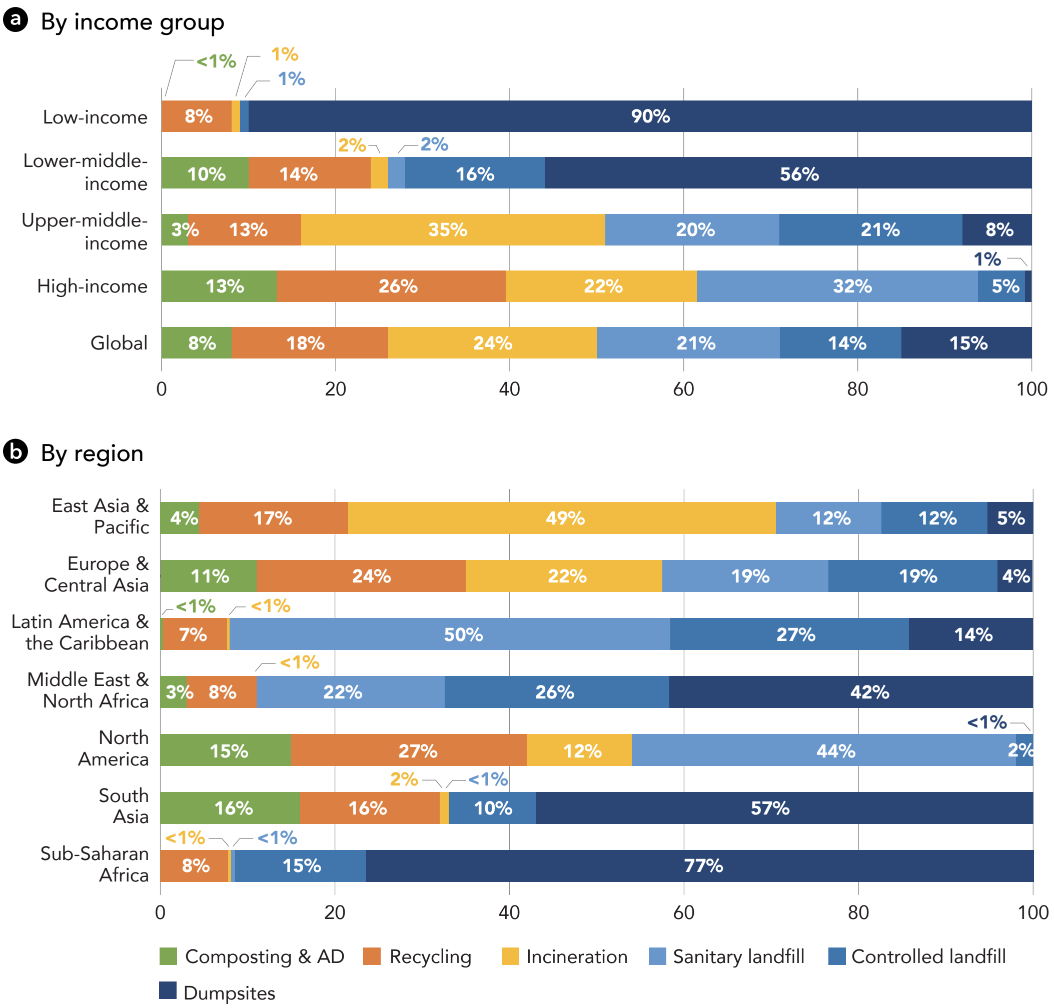
Sustainable waste management practices and treatment methods become increasingly common as national income levels rise. Higher-income countries typically achieve improved waste collection rates and greater reliance on controlled and sanitary landfills, representing an initial step toward more sustainable systems. Incineration with energy recovery also becomes more prevalent with rising income levels; in upper-middle-income countries, nearly one-third of municipal waste is incinerated (figure 2.18a). In high-income countries, by contrast, incineration rates decline to 22 percent as the focus shifts toward material recovery. Recycling and composting—including anaerobic digestion of organics—are prioritized, together accounting for the treatment of nearly 40 percent of municipal waste, reflecting a more sustainable and circular approach than one-time energy recovery through incineration.

Figure 2.17 Municipal solid waste treatment, disposal, and uncollected waste



Source: Original figure for this report.
Note: Proportion of uncollected and treated waste is multiplied by the weight of waste generated in each country in 2022 and then aggregated to income group or regional level. AD = anaerobic digestion.

Figure 2.18 Treatment and disposal of collected municipal solid waste



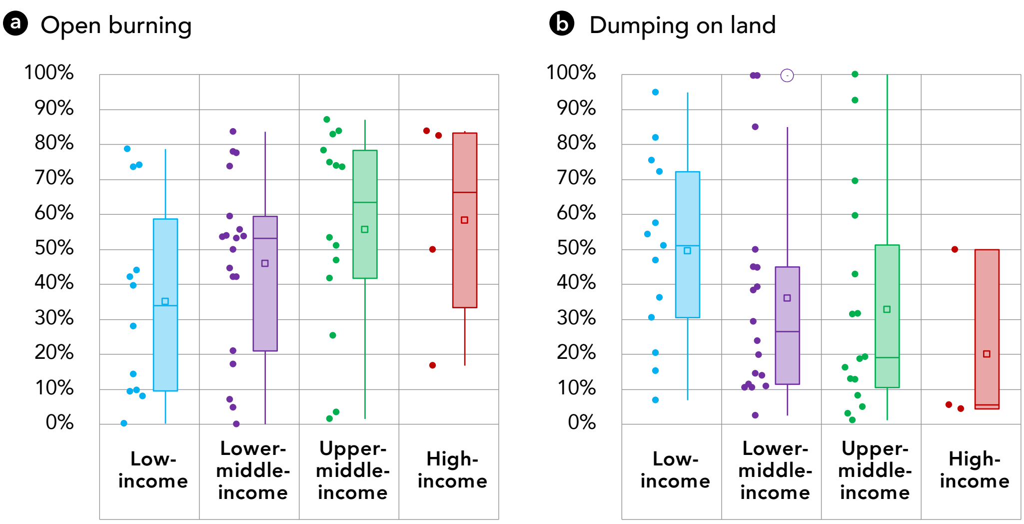
Source: Original figure for this report.
Note: Proportion of treated waste is multiplied by the weight of waste collected in each country in 2022 and then aggregated to income group or regional level. AD = anaerobic digestion.

2.6

Self-management of Uncollected Waste

Limited formal reporting is available on the self-management of uncollected waste. Trends are therefore challenging to identify. In this report, census and survey data that report civilian waste management behavior are identified for 49 countries and economies. Respondents of these surveys were asked to state the main method of waste management for their household. The average (mean) responses for each country are harmonized and illustrated in figure 2.19. The most common methods of managing uncollected waste are burning and dumping on the land for low-income, lower-middle-income and upper-middle-income groups. Open burning and recycling or composting of uncollected waste are the most common methods of waste management for high-income countries. Other methods of dealing with uncollected waste include burying and dumping in waterways.

Figure 2.19 Self-management of uncollected municipal solid waste by income group



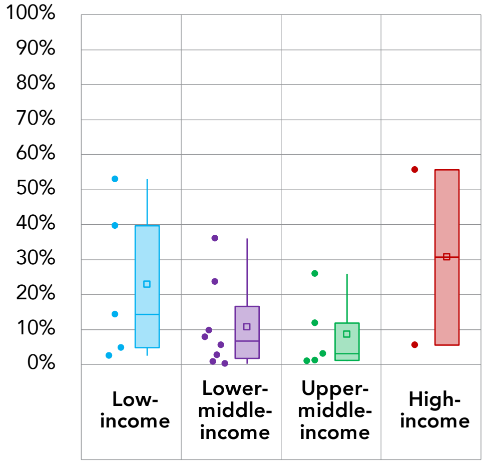
	Low-income	Lower-middle-income	Upper-middle-income	High-income
a Open burning				
Count	12	19	14	4
Median	34%	53%	63%	66%
b Dumping on land				
Count	13	18	16	3
Median	51%	27%	19%	6%

25th - 75th percentiles | Range within 1.5IQR | Median Line | Mean | Outliers

• Waste collected as proportion of municipal solid waste generated

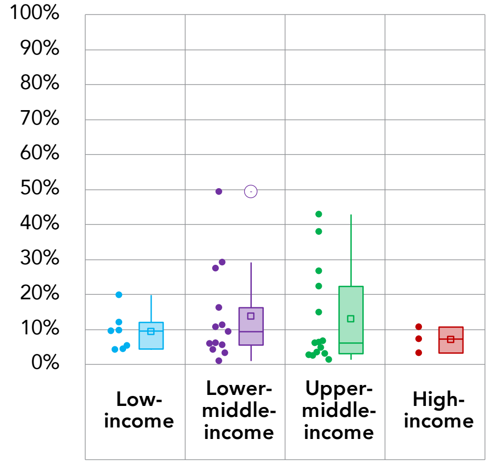
Figure 2.19 Self-management of uncollected municipal solid waste by income group *(contd.)*

c Recycling or composting



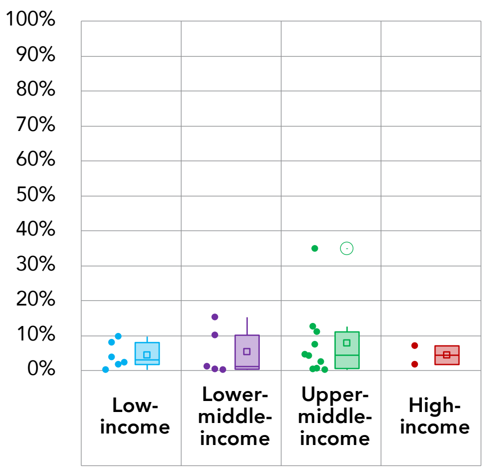
Count	5	8	5	2
Median	14%	7%	3%	31%

d Burying



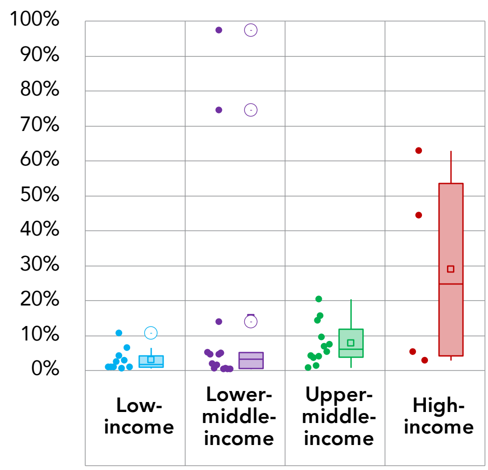
Count	7	13	14	3
Median	9%	9%	6%	7%

e Aquatic environment



Count	6	5	10	2
Median	3%	1%	4%	4%

f Other



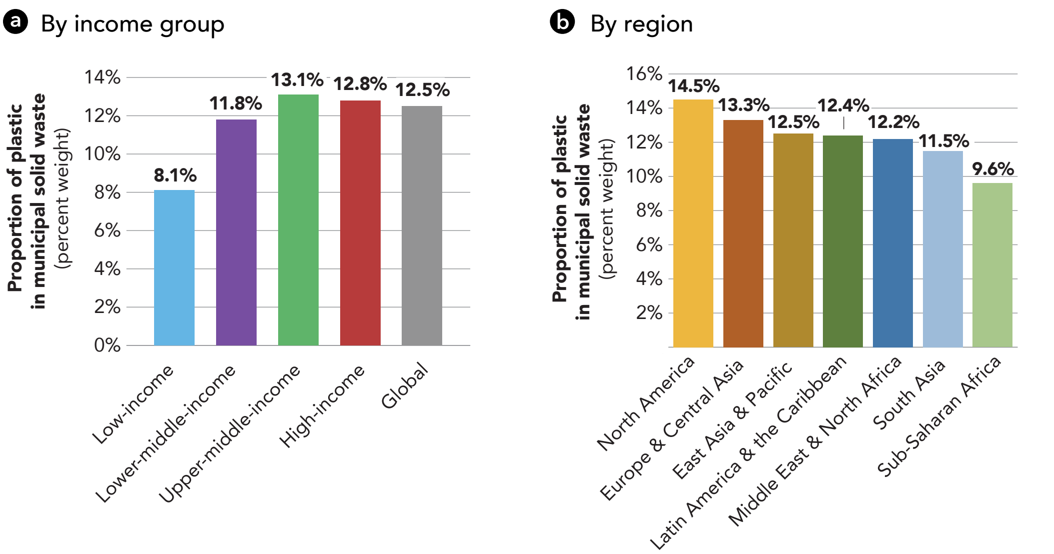
Count	10	14	12	4
Median	2%	3%	6%	25%

Source: Original figure for this report.
Note: Country dataset showing central tendency and spread. Dots represent the mean main method of self-managed waste reported by respondents in national censuses and surveys, who were asked to state their main method of waste management. Outliers are defined as values lying more than 1.5 times the interquartile range beyond the upper or lower quartiles. Categories are harmonized from originally reported results as: (a) Open burning; (b) Dumping on land; (c) Recycling or composting; (d) Burying; (e) Depositing directly into in aquatic environment (lakes, waterways and coastal waters); and (f) Other. Readers are cautioned that datapoints are very few for high-income countries and unlikely to be sufficient for extrapolation. IQR = interquartile range.

2.7
Plastic Waste

Plastic represents approximately 12.5 percent by weight of the municipal solid waste stream worldwide, with the highest proportions in upper-middle-income countries where approximately 13.1 percent of the waste is plastic (figure 2.20a). By contrast, in low-income countries just 8.1 percent of municipal solid waste is plastic, in part driven by the lower monetary capacity of populations to consume products containing or packaged in engineered materials. Regionally, the proportion of plastic in municipal solid waste is highest in the North America region while Sub-Saharan Africa has the lowest proportion of plastic in municipal solid waste, strongly influenced by the large number of low- and lower-middle-income countries in the region (figure 2.20b).

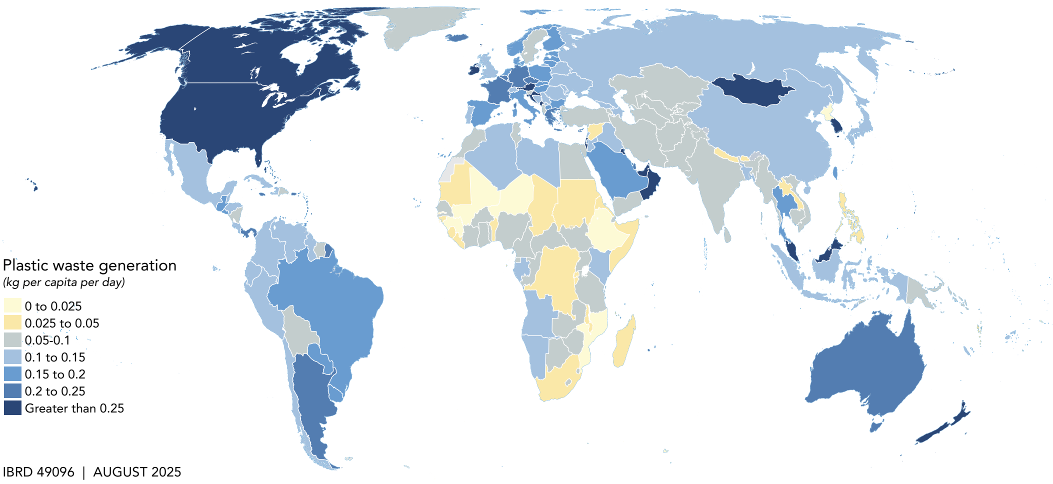
Figure 2.20 Proportion of plastic in municipal solid waste



Source: Original figure for this report.
Note: Mean composition of plastic in municipal solid waste weighted by municipal solid waste generation in 2022.

On a national per capita basis, Canada, Kuwait, Oman, and the United States all generate more plastic waste than 0.35 kilogram per capita per day, whereas many of the countries in Sub-Saharan Africa region generate less than 0.05 kilogram per capita per day (map 2.2).

Map 2.2 Municipal solid waste plastic generation



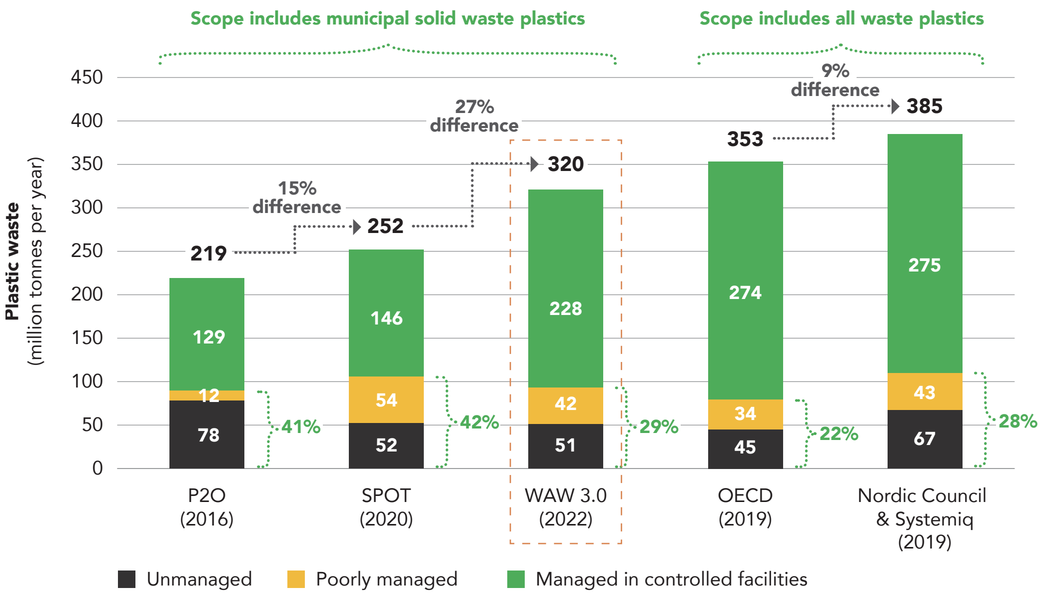
Source: Original map for this report.
Note: Municipal solid waste plastic generation in kilogram per capita per day in 2022.

Global plastic waste generation is estimated at 400 million tonnes per year in 2022 (Plastics Europe 2023), of which 320 million tonnes was municipal solid waste plastic, according to analysis in this report (figure 2.21).[6] Approximately 42 million tonnes or 13 percent by weight were poorly managed, meaning the plastic waste was collected but subsequently deposited in an uncontrolled dumpsite, and 51 million tonnes or 16 percent by weight were unmanaged, meaning it was uncollected. Total plastic waste generation was somewhat higher than other comparable estimates of municipal solid waste plastic in 2020 (Cottom, Cook, and Velis 2024) and 2016 (Lau et al. 2020).

In *What a Waste 3.0*, the combined proportions of poorly managed and unmanaged plastic are 29 percent. These estimates are lower than the two previous modeled estimates of municipal solid waste plastic, which were 41 percent and 42 percent, respectively, of plastic waste generated (figure 2.21). Each of the three studies that investigated municipal solid waste plastic has used a different approach and input dataset, and both the Plastic-to-Oceans (P2O) and Spatio-temporal quantification of Plastic pollution Origins and Transportation (SPOT) models quantify unmanaged waste flows from multiple sources whereas in *What a Waste 3.0*, only uncollected waste is considered to be unmanaged.

Mismanagement of municipal solid waste plastics results in substantially higher emissions to the environment by weight compared with plastic waste from nonmunicipal sources. This is because the municipal fraction contains plastics that have a shorter product lifetime such as single-use plastic packaging, and ephemeral consumer and institutional products such as serveware and personal hygiene products. By contrast, nonmunicipal plastic wastes contain products that remain in the use phase for much longer, such as automotive parts, construction materials, and

Figure 2.21 Comparison of plastic waste generation and management between *What a Waste 3.0* and selected global plastic pollution models



Source: Original figure for this report.
P2O = Plastics-to-Ocean model, https://plasticpollution.leeds.ac.uk/home/toolkits/p2o/. Lau, W.W.Y., Y. Shiran, R.M. Bailey, E. Cook, M.R. Stuchtey, J. Koskella, C.A. Velis, L. Godfrey, J. Boucher, M.B. Murphy, et al. 2020. "Evaluating Scenarios Toward Zero Plastic Pollution" Science, 369:1455-61. https://doi.org/https://doi.org/10.1126/science.aba9475.
SPOT = The Spatio-temporal quantification of Plastic pollution Origins and Transportation model, https://plasticpollution.leeds.ac.uk/home/toolkits/spot/. Cottom, J. W., E. Cook, and C. A. Velis. 2024. "A Local-to-Global Emissions Inventory of Macroplastic Pollution" Nature, 633 (8028):101–08. https://doi.org/10.1038/s41586-024-07758-6.
WAW 3.0 = *What a Waste 3.0*, this report.
OECD = OECD (Organisation for Economic Co-operation and Development). 2022. *Global Plastics Outlook: Economic Drivers, Environmental Impacts and Policy Options*. https://doi.org/10.1787/de747aef-en.
Nordic Council & Systemiq = Shiran, Y., J. d. l. Fuente, C. Ragot, L. v. Boetticher et al. 2023. *Towards Ending Plastic Pollution by 2040: 15 Global Policy Interventions for Systems Change*. https://www.systemiq.earth/downloads/Systemiq_Towards_Ending_Plastic_Pollution_by_2040.pdf.
Note: Each model reports material flows and processes on a slightly different basis. Therefore, the following harmonization assumptions were made to enable comparison:

- *P2O:* Poorly managed = dumpsites; Unmanaged = aquatic, open burning, and dumped on land.
- *SPOT:* Poorly managed = complement of percent weight to controlled facilities minus percent weight plastic emissions; and Unmanaged = plastic emissions.
- *What a Waste 3.0:* Poorly managed = dumpsites; Unmanaged = uncollected.
- *OECD:* Poorly managed = dumpsites; and Unmanaged = open pit burning, terrestrial leakage, and aquatic leakage.
- *Nordic Council and Systemiq*: Poorly managed = dumpsites/unsanitary landfills; and Unmanaged = open burning and released into land or water.

Values above the bars represent total plastic generated. Values marked as "percent difference" provide the proportional difference between two values of total plastic generated. Percent values at lower end of bars represent the proportion of "mismanaged" waste, which comprises "poorly managed" plus "unmanaged" waste.

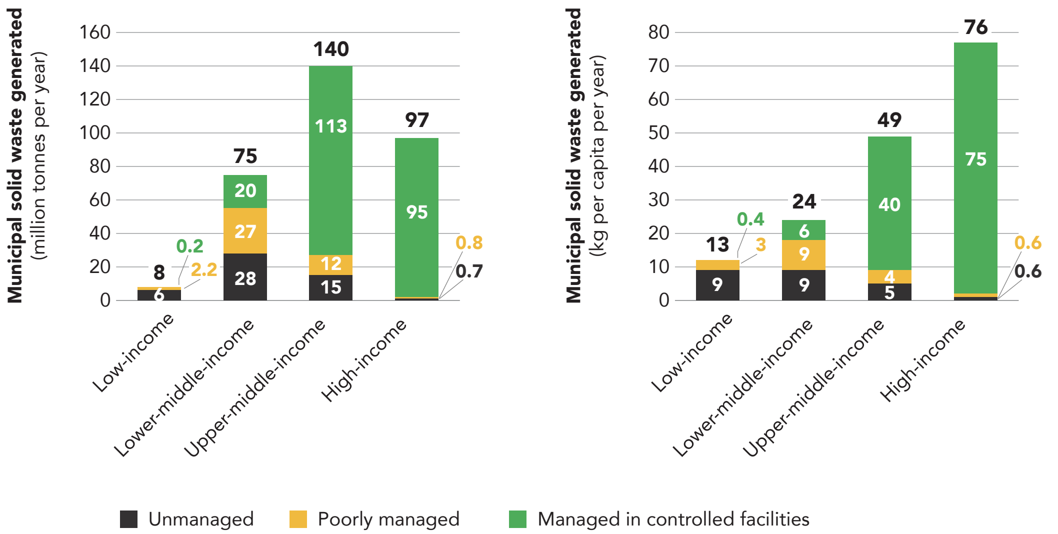
nonmunicipal electrical and electronic goods. The OECD (2022) and Nordic Council of Ministers and Systemiq (2023) studies modeled flows of all plastic waste including from nonmunicipal sources, meaning that the proportion of mismanaged waste would be expected to be lower compared with a municipal solid waste study such as this report (figure 2.21).

On an absolute basis, 55 percent, or 28 million tonnes, of the 51 million tonnes of unmanaged plastic waste worldwide is released in lower-middle-income countries and a further 30 percent, or 15 million tonnes, comes from upper-middle-income

Figure 2.22 Plastic waste generation and management by income group

a Total municipal plastic waste generation

b Plastic waste generated per capita per year



Source: Original figure for this report.

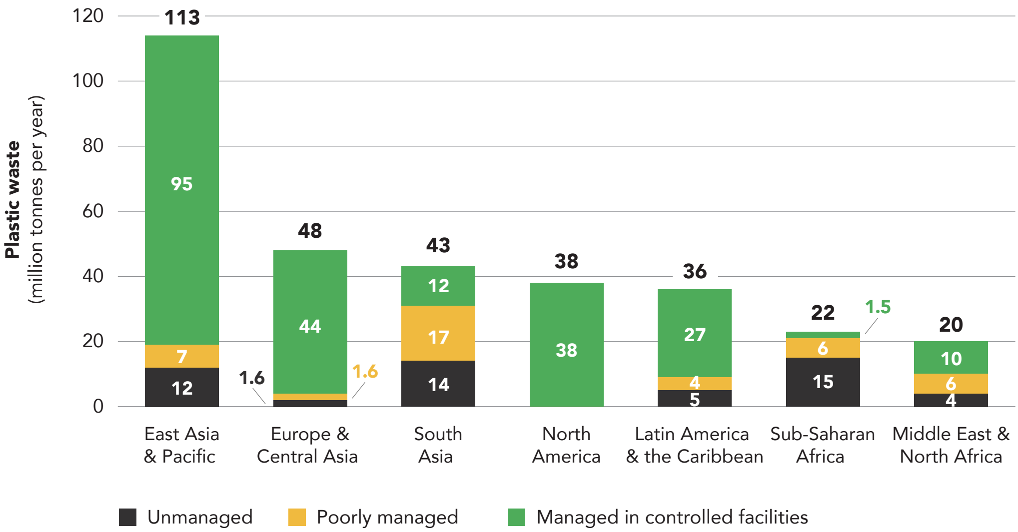
countries (figure 2.22a). Low-income countries release 6 million tonnes of plastic waste to the environment each year, representing 75 percent of all the plastic waste generated in the income group. Conversely, approximately 0.7 percent, or 0.7 million tonnes per year, of plastic waste is unmanaged in high-income countries. The proportion of poorly managed waste in upper- and lower-middle-income countries is similar compared with the unmanaged fraction. However, in low-income countries 2.2 million tonnes, or 28 percent, are poorly managed because the amount of waste that is uncollected or unmanaged is already very high. Just 2.5 percent by weight of plastic waste in low-income countries is managed in controlled facilities, meaning that large quantities of material risk interaction with the natural environment.

The proportion of plastic waste that is generated, poorly managed, and unmanaged is similar across income groups when measured on both absolute and per capita basis. However, the per capita plastic waste generation is substantially lower by weight in upper-middle-income and lower-middle-income countries compared with high-income countries, which generate 55 percent and 200 percent more plastic waste per capita, respectively.

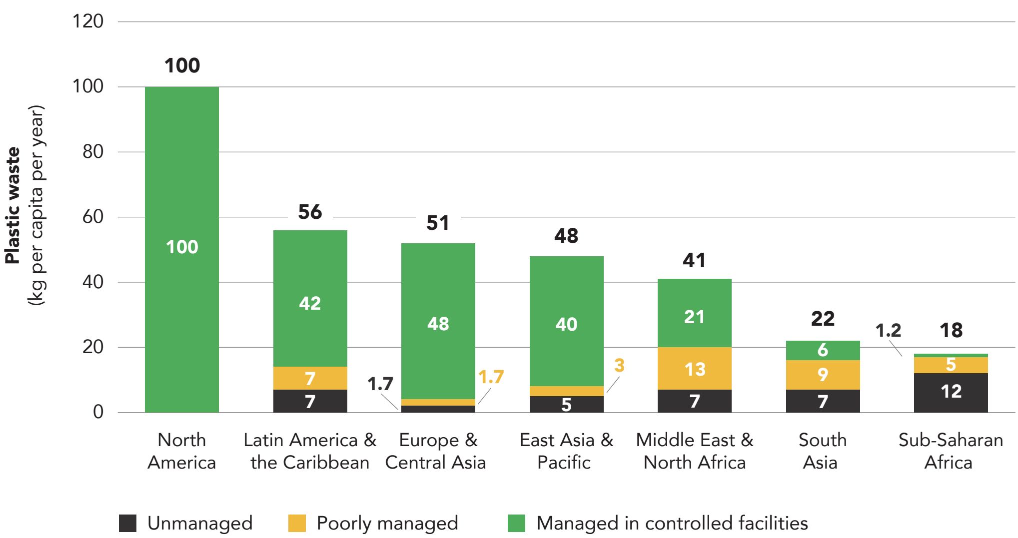
On an absolute basis, the largest quantities of unmanaged plastic are in Sub-Saharan Africa at 15 million tonnes, South Asia at 14 million tonnes, and East Asia and Pacific at 12 million tonnes, accounting for 80 percent by weight of all unmanaged plastic waste (figure 2.23a). The remaining unmanaged plastic is generated in Latin America and the Caribbean, and Middle East and North Africa regions, with negligible quantities generated in North America and 1.6 million tonnes generated in Europe and Central Asia region.

Figure 2.23 Plastic waste generation and management by region

a Total municipal plastic waste generation



b Plastic waste generated per capita per year



Source: Original figure for this report.

Although total quantities of unmanaged waste are comparatively small in the Middle East and North Africa region, on a per capita basis, they are comparable with Latin America and the Caribbean at 7 kilograms per capita per year, East Asia and Pacific Caribbean at 5 kilograms per capita per year, and South Asia at 7 kilograms per capita per year. Only Sub-Saharan Africa region has higher per capita unmanaged waste with approximately 12 kilograms per capita per year (figure 2.23b).

The magnitude of mismanaged municipal solid waste plastics in combination with the high durability of plastics to remain in the environment has resulted in environmental pollution of a scale that is considered a global emergency and has triggered the development of an international treaty (box 2.1).

Box 2.1 Plastic Waste and Pollution

Plastic pollution has emerged as a critical environmental issue, with land-based sources contributing to 80% of all marine litter, of which approximately 85% is plastic (EEA 2023).

The emission of plastics into the environment is closely linked to poor management of plastic waste at various points along the waste management chain. Because plastic items are frequently not properly disposed of or recycled, significant portions are released into the environment. They accumulate on land and at sea (Lebreton 2022) owing to their resistance to natural decomposition. This widespread dispersal of plastics has resulted in their presence in the remotest corners of the globe, from the ocean floor to polar ice caps. (UNEP 2022; 2024).

The mechanisms by which plastics spread are multifaceted. There are ample mechanisms by which plastics, after their use or through wear and tear, are entering the environment. Aquatic systems move both large and smaller particles or microplastics. Atmospheric transport may even disperse tinier particles, micro- and nanoplastics. The aquatic pathway is particularly concerning, as mismanaged municipal solid waste, especially in the form of uncollected waste, often enters rivers and oceans (Mieijer et al. 2021) either through direct dumping, runoff, or because of flooding (Xia et al. 2020). Poorly managed dumpsites contribute further, allowing plastics to escape into ecosystems.

Plastic pollution is most visibly associated with marine debris, which threatens marine life and disrupts delicate ecological balances. However, the problem extends far beyond the oceans. The burning of plastics with the open burning of waste—a common practice in many parts of the world—significantly worsens the release of hazardous chemicals such as furans, dioxins, flame retardants, and heavy metals (Pathak et al. 2024). These substances pose significant risks to both environmental and human health.

The environmental consequences of plastic pollution are vast and profound. Plastics contaminate soil, air, and water, undermines the health of marine and terrestrial ecosystems, endangers wildlife, and threatens fish stocks (Wagner et al. 2025; Gebremedhin et al. 2021). This impacts nature-based economies like fishing, tourism, and recreation, diminishing the quality of life for communities living near polluted areas. Ecosystem disruption and biodiversity loss are further compounded by economic costs, making plastic pollution both an environmental and socioeconomic challenge.

From a human health perspective, exposure to plastic pollution is linked to growing concerns over more than three thousand chemical additives used during plastic manufacturing (UNEP and BRS Conventions 2023). These include flame retardants, plasticizers, colorants, and unintentionally added chemicals, all of which can leach into the environment and into human bodies, with consequences that are only beginning to be fully understood.

In response to these challenges, regulatory frameworks such as the European Commission's REACH[a] (Registration, Evaluation, Authorization, and Restriction of Chemicals) can support the early identification and restriction of hazardous substances and further approaches for simplifying the chemistry of plastics to reduce toxicity, enhance recyclability, and protect health. Increasing the mechanical recycling capacity of plastics is hindered by the complex variety of chemical formulations in plastic products; streamlining these would facilitate safer and more efficient recycling processes.

Globally, the need for coordinated action is recognized. Existing instruments such as the Basel Convention,[b] which addresses the quality and management of plastic waste exports and the Stockholm Convention[c]—which puts requirements to prevent the release of persistent organic pollutants from activities such as waste burning—have distinct but limited scope to stem the broader challenges of plastics pollution. Many countries have introduced policies and regulations to reduce the use of plastics and improve management of plastic waste (Diana et al. 2022), for example through recycling. For instance, the EU Single-Use Plastics (SUPs) Directive came into force in 2019.[d] Before broadening to include packaging products, its initial focus on selected SUPs built on findings that large fractions of plastics in the environment result from a limited range of plastic products, in particular single-use plastics such as plastic bags and beverage containers.

In March 2022, the UN Environment Assembly adopted resolution UNEA 5.2 (UNEP 2022) for the development of an international legally binding instrument on plastic pollution, including in the marine environment. Although the instrument was expected to be implemented by 2025, participating countries or parties in the Intergovernmental Negotiating Committee have yet to finalize negotiation of the terms.

While the instrument is still under development, it is broadly recognized that far-reaching measures are needed to reduce plastic pollution to manageable levels, and that this requires improvements to plastic waste management through collection and recycling, as well as upstream interventions to reduce the generation of plastic waste.

Notes

a. European Commission. 2025. REACH Regulation. https://environment.ec.europa.eu/topics/chemicals/reach-regulation_en.

b. Basel Convention on the *Control of Transboundary Movements of Hazardous Wastes and Their Disposal* under a new rule includes agreement that all waste plastics exported from their jurisdiction achieve a minimum quality standard (entry B3011 of Annex VII) and ensure that all plastic wastes imported into their jurisdiction are received by facilities with verified environmentally sound management according to the Technical Guidelines (Basel Convention n.d.; Basel Convention 2023).

c. Stockholm Convention on *Persistent Organic Pollutants* (POPs) recognizes open burning as a source of chemicals that can persist in the environment, travel long distances, and can lead to serious health effects. The Convention requires Parties to minimize or, if possible, eliminate open burning or, if unavoidable, to improve burning conditions to reduce the formation of persistent organic pollutants in accordance with technical guidelines on best available techniques (BAT) and best environmental practices (BEP). In 2023, 22 new chemical categories were added to the instrument, more than half associated with plastics (Stockholm Convention 2021; Stockholm Convention 2023).

d. Directive (EU) 2019/904 of the European Parliament and of the Council of 5 June 2019 on the reduction of the impact of certain plastic products on the environment. https://eur-lex.europa.eu/eli/dir/2019/904/oj/eng.

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Stockholm Convention, 2023. *The new POPs under the Stockholm Convention*. https://www.pops.int/TheConvention/ThePOPs/TheNewPOPs/tabid/2511/Default.aspx.

UNEP (United Nations Environment Programme). 2022. "UN Environment Assembly 5 (UNEA 5.2) Resolutions." March 2. https://www.unep.org/resources/resolutions-treaties-and-decisions/UN-Environment-Assembly-5-2.

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Wagner, M., Monclús, L., Arp, H. P. H., Groh, K. J., Løseth, M. E., Muncke, J., Wang, Z., Wolf, R., and Zimmermann, L. 2025. State of the science on plastic chemicals - Identifying and addressing chemicals and polymers of concern. *PlastChem.* https://doi.org/10.5281/zenodo.10701705.

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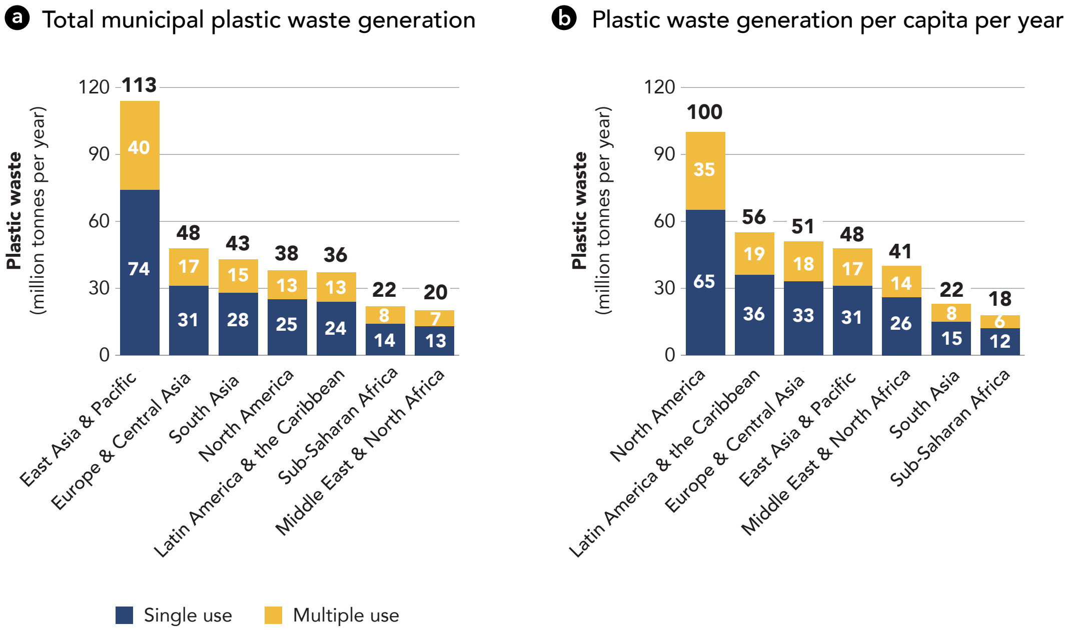
Single-use plastics are a problematic fraction of municipal solid waste stream because they have a short lifespan and are often used in food-grade applications, such as packaging for food, beverages, pharmaceuticals, and cosmetics, which have the greatest limitations for incorporating recycled content into new packaging, thereby limiting closed-loop recycling potential.

The proportion of municipal solid waste plastics that are single use is assumed to be 65 percent[7] in this report. The regional comparison indicates that the East Asia and Pacific region is the largest single-use plastic waste generator, producing 74 million tonnes of single-use plastic waste per year on an absolute basis, nearly 140 percent more than Europe and Central Asia, the next highest plastic waste generating region

Figure 2.24 Plastic waste generation by intended use, frequency, and region



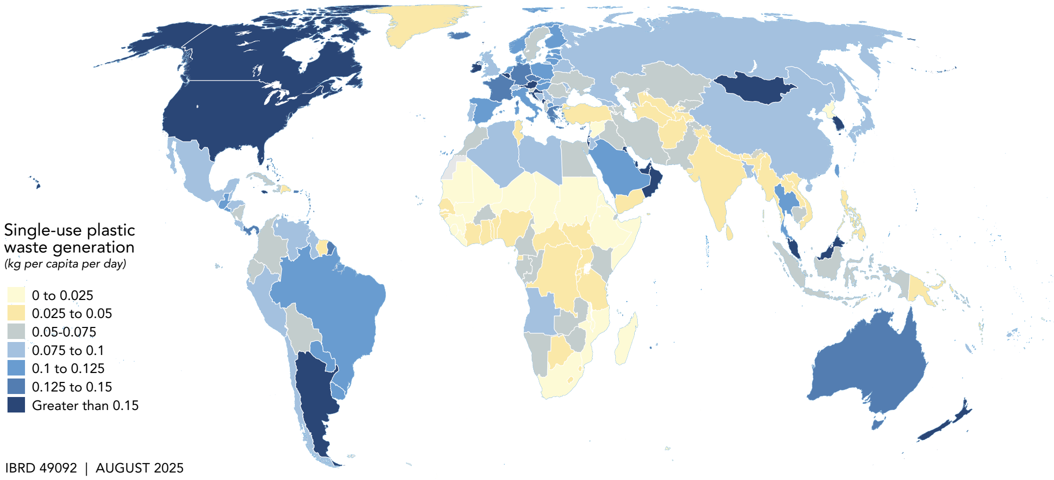
Source: Original figure for this report.
Note: Single-use plastics assumed to be 65% (by weight) of municipal solid waste plastics in 2022.

(figure 2.24a). More than 63 percent, or 47 million tonnes, of the total weight of single-use plastic waste generated in the East Asia and Pacific region is generated in China where, despite the relatively modest per capita waste generation of 33 kilograms per capita per year, the population of nearly 1.4 billion results in a large mass of all materials generated by one country.

On a per capita basis, the North America region generates substantially more single-use plastics, approximately 80 percent more than the next highest generator which is the Latin America and Caribbean region (figure 2.24b). Both South Asia and Sub-Saharan Africa regions generate the least single-use plastic per capita. However, because of the large population in South Asia, it is ranked as the third highest single-use plastic producing region (figure 2.24a).

On a per country basis, the largest quantities of single-use plastics are high-income countries, for example Canada, New Zealand, and the United States, with just a few non-high-income countries with generation rates of more than 0.15 kilogram per capita per day such as Malaysia and Mongolia (map 2.3). On a per capita basis, all countries and economies in the Sub-Saharan Africa region generate less than 0.075 kilogram per capita per day with the majority generating less than 0.05 kilogram per capita per day.

Map 2.3 Single-use plastic waste generation



Source: Original map for this report.
Note: Single-use plastic waste generation, in kilogram per capita per day in 2022.

2.8
Special Wastes

Municipal solid waste is one of several waste streams that countries and cities manage. Other common waste streams include industrial waste, mining waste, construction and demolition waste, agricultural waste, medical waste, hazardous waste, and waste electrical and electronic equipment.

Unlike municipal waste, the definitions of these special waste categories vary and are inconsistent globally. Also, depending on national or local regulatory mandates, these waste streams can be managed by the private or public sector. Owing to these inconsistencies and variations in mandates and reporting requirements, scope for misclassification and miscounting of waste exists.

Some special waste streams, such as industrial waste and construction and demolition waste (box 2.2), will be generated in large quantities in countries and economies where these activities are significant. For example, high-income countries show a median generation of industrial waste at 455 kilograms per capita per year and construction and demolition waste at 894 kilograms per capita per year, respectively, compared with other types of special wastes where the generation is much lower—medical waste at 2.4 kilograms per capita per year, hazardous waste at 84 kilograms per capita per year, and waste electrical and electronic equipment waste at 17 kilograms per capita per year.

Reported figures on industrial waste and construction and demolition waste in low- and middle-income countries are lower than in high-income countries, with median values ranging from 4 to 76 kilograms per capita per year between low-income and upper-middle-income countries for industrial waste and 2 to 143 kilograms per capita per year for construction and demolition waste.

Quantities of mining waste vary considerably among countries, reflecting different levels of mining activity. This variation may also be a result of categorization of this type of waste. For example, in low- and lower-middle-income countries, it is likely that certain byproducts of mining waste are excluded from national waste figures. Reported figures range from near zero to hundreds of tonnes per capita per year, highly subject to the presence and absence of mining activities. One of the limitations of the analysis of special waste is that there are only two observations in low-income countries, thereby reducing the value of comparing mining waste generation data on a volume per capita basis.

Agricultural waste generation is highest in countries and economies with large farming industries, with lower-middle-income countries generating the highest median level at 95 kilograms per capita per year compared with other country income groups.

The quantities of medical, hazardous, and electrical and electronic equipment waste are much lower than the other special waste categories, and they are typically a fraction of municipal solid waste. The generation of these wastes rises as the income level increases. High-income countries generate the highest median levels of medical waste, hazardous waste, and waste electrical and electronic equipment at 2.4, 81, and 17 kilograms per capita per year, respectively, compared with other country income groups at 0.1 to 0.6, 0 to 13, and 19 kilograms per year, respectively. Correct disposal of these waste streams requires specialized facilities that can chemically neutralize, incinerate, or disassemble the waste. Mismanagement of waste with potentially hazardous properties represents a threat to environmental and public safety, particularly in resource constrained lower-income countries.

2.9
Waste Imports

Transboundary waste trade plays an important role in global waste management by enabling recycling and recovery through the transfer of waste to countries and economies with the capacity and infrastructure to process it. However, when recipient countries lack adequate systems and controls to manage imported waste safely, such imports can exceed local system limits, resulting in the emission of waste materials and potentially hazardous substances to the environment, and risking public health. In response to these risks, several international conventions form part of the legal and policy framework governing waste management. For example, the Basel Convention regulates the transboundary movement of hazardous and other wastes and requires their environmentally sound management.[8] The Bamako Convention prohibits the import of hazardous waste into Africa and governs its generation, treatment, and disposal within the continent.[9] The Rotterdam Convention establishes prior informed consent procedures for the international trade of certain hazardous chemicals and pesticides.[10] The Stockholm Convention targets the elimination or restriction of persistent organic pollutants (POPs) due to their long-term environmental persistence, bioaccumulation, and toxicity.[11] The MARPOL Convention regulates pollution from ships, including discharges of oil, noxious substances, sewage, garbage, and air emissions, to protect the marine environment.[12]

Global trade in plastic waste and scrap has undergone a transformation in recent years, driven by increasingly stringent regulations and shifting market dynamics. OECD countries have historically been the primary exporters of plastic waste, with developing countries often serving as importers and processors. However, important policy changes have restricted the international trade in plastic waste. These include China's National Sword policy[13] in 2018, which banned the import of most plastic waste, and the 2021 amendments to the Basel Convention, which brought most plastic waste under international control. The latter now requires prior informed consent for transboundary shipments and limits trade to clean, sorted, nonhalogenated polymers destined for environmentally sound recycling. The European Union's Waste Shipments Regulation (Regulation 2024/1157)[14] further tightened controls on plastic waste exports. From 21 November 2026, exports of plastic waste from the EU to non-OECD countries will be banned. After a 2.5-year transition period, certain non-OECD countries may apply to resume imports if they can demonstrate capacity for environmentally sound management in line with EU requirements.

As a result of these regulatory shifts, global exports of plastic waste have declined sharply, falling from 12.4 million tonnes in 2017 to 6.3 million tonnes in 2022. OECD member countries now account for approximately 87 percent of total exports and 77 percent of imports, with trade increasingly concentrated within regions such as Europe and North America. Southeast Asian countries—including Malaysia, Indonesia, and Viet Nam—remain major destinations for plastic waste, though import quantities have stabilized as domestic recycling capacity expands and further import restrictions are implemented (OECD 2024). Harmonized reporting frameworks, improved traceability, and robust enforcement to ensure that exported waste is managed in an environmentally sound manner have been emphasized as essential by the OECD.

Box 2.2 Construction and Demolition Waste in Postdisaster Debris: Opportunities for Circular Reconstruction

Construction and demolition (C&D) waste,[a] a major global waste stream, is expected to grow as countries and economies continue to urbanize and renew their built environments. *What a Waste* 3.0 estimates that high-income countries have the highest generation rate of C&D at 894 kilograms per capita per year, largely from infrastructure development, building renovation, and demolition. The World Economic Forum (WEF) estimates that between 2023 and 2030, nearly 8 billion tonnes of materials could be required for retrofits alone and that this number is projected to increase to nearly 40 billion tonnes between 2030 and 2050 (WEF 2025).

When managed effectively, C&D waste offers substantial potential as a source of secondary raw materials, including aggregates, metals, and recovered wood. In addition to enhanced material efficiency and reduced demand for virgin resources, reuse, and recycling of C&D waste mitigates GHG emissions associated with raw material extraction and processing. Often one of the largest waste streams in countries, OECD identifies material recovery from C&D waste as essential for achieving climate and resource efficiency goals (OECD 2019; 2021; and 2023). Greenhouse gases from the production and transport of construction materials are estimated to account for up to half of a building's total carbon footprint over its lifecycle, underscoring the importance of material choices and waste strategies in climate mitigation (WorldGBC 2019; WEF and Davos Baukultur Alliance 2025).

Recognition is growing that prevailing approaches to how cities are built and rebuilt must evolve. Emerging policy frameworks, such as the World Economic Forum's Baukultur initiative,[b] emphasize the need for a cultural shift toward more resource-conscious construction practices. This includes moving beyond conventional demolition-and-replacement models toward approaches that prioritize reuse, selective deconstruction, and material recovery.

This shift is particularly relevant in postdisaster reconstruction where large quantities of debris[c] are generated in a short timeframe alongside urgent demand for rebuilding. Applying circular principles to the recovery process creates an opportunity to rebuild with a lower environmental footprint, reduces future C&D waste, and lays the foundation for more resilient and resource-efficient urban development.

Disaster debris, typically comprising structural rubble, timber, asphalt, metals, and sediments, substantially overlaps with C&D waste in composition, management requirements, and recovery potential. This alignment presents opportunities to apply circular economy principles to recovery efforts, including material separation, reuse, and recycling. Predisaster planning, regulated sorting and storage, and clear protocols for recovery and reuse are essential to enable circular outcomes in the compressed, high-pressure conditions of postdisaster response.

This text box presents examples from the United States, Japan, and Ukraine—each offering structured approaches to postdisaster debris management and demonstrating how integration with C&D frameworks can enable circular and resilient recovery.

US EPA guidance on predisaster debris management planning

The U.S. Environmental Protection Agency (EPA) offers a comprehensive framework for disaster debris preparedness, centered on the importance of planning before crises occur (US EPA 2019). Although developed for U.S. states and municipalities, this approach offers transferable lessons for countries aiming to strengthen debris readiness, reduce environmental risks, and accelerate recovery.

At the core of EPA's guidance is the development of Pre-Incident Debris Management Plans (US EPA 2013). These plans define roles and responsibilities, estimate potential quantities of debris, identify material types, and lay out operational procedures. Effective debris management plans include waste characterization protocols to distinguish recyclable, hazardous, and inert materials, ensuring appropriate handling and routing.

The EPA emphasizes early material segregation and diversion to maximize reuse and reduce environmental impacts. Sorting debris, at source or at staging areas, supports recovery of concrete, clean wood, asphalt, and scrap metals. Plans are encouraged to pre-identify viable end markets and recycling facilities to enable timely diversion. Identifying and securing debris management infrastructure in advance, including temporary storage sites and permitted disposal or processing facilities, are considered a critical requirement.

Logistical preparedness is another key theme. EPA recommends mapping transport routes, identifying potential access constraints, and outlining haul distances from damage zones to storage or treatment sites. Tools such as the Disaster Debris Recovery Tool[d], which maps over 20,000 U.S. facilities, and the All-Hazards Waste Planning Tool,[e] which supports regulatory and capacity planning, are used to fill infrastructure gaps and streamline debris flows. These tools help authorities coordinate across jurisdictions and improve real-time decision making during emergencies.

Worker safety and environmental compliance are essential elements of the plans. Plans are expected to include personal protective equipment guidance, health risk communication strategies, and procedures for managing asbestos, lead-based paint, and other hazardous substances.

Disaster management plans also improve access to postdisaster financing. EPA advises alignment with the Federal Emergency Management Agency's (FEMA) Public Assistance Program and Policy Guide,[f] which governs reimbursement for debris removal. Compliance requires detailed volume estimates, tracking systems, approved contractor use, and cost documentation. These financial mechanisms accelerate recovery timelines and improve budget predictability for local authorities.

Importantly, EPA also underscores the role of community outreach in debris planning. Plans are expected to include risk communication for residents, signage templates for active sites, and engagement strategies to build public understanding and trust.

Taken together, the EPA's framework illustrates the value of structured, pre-incident debris planning with a focus on material segregation, infrastructure mapping, operational logistics, and transparent communication. Countries facing frequent disasters or large-scale reconstruction can adopt and adapt these practices to reduce landfilling, enhance environmental safeguards, and enable more efficient recovery.

Japan's postdisaster debris recycling

During the Great East Japan Earthquake in March 2011, about 31 million tonnes of debris was generated, equivalent to about 70% of Japan's annual municipal solid waste (Takezaki 2015). The largest share came from building pillars and crushed concrete. Japan achieved a recycling rate of 80% for debris and 99% for tsunami silt, with only 12% incinerated. Recycled materials were used as construction inputs, supporting the reconstruction of affected areas.

Since the Great East Japan Earthquake, Japan has strengthened its postdisaster debris management policies and regulations, applying them in subsequent disasters. These efforts have reduced disposal quantities, ensured safe removal of hazardous materials like asbestos, and maximized reuse of recovered debris in reconstruction.

Institutional framework at the national level: Japan's national government promotes recycling of construction waste through several legislative instruments. The Regulation for Enforcement of the Basic Act on Disaster Management[g] serves as the overarching framework guiding disaster management planning and implementation across all types of disasters. It requires central, prefectural, and local authorities to prepare disaster management plans and business continuity plans tailored to events such as earthquakes, tsunamis, volcanic eruptions, and other emergencies.

Complementing this framework are two key legislative instruments: (1) the Waste Management and Public Cleansing Law of 1970[h] establishes the principle that waste generated from emergencies and disasters must be managed in a manner that safeguards public health and the environment, and (2) the Construction Material Recycling Law of 2000,[i] which further strengthens the regulatory framework by introducing a registration system for demolition contractors and mandates the recycling of materials generated during demolition activities.

Following the Great East Japan Earthquake, the Ministry of the Environment of Japan issued a notification[j] specifically targeting the use of postdisaster debris in public works. The notification set out criteria under which eligible materials could be repurposed for reconstruction. Temporary transfer of local responsibilities to higher administrative bodies was also allowed to enable rapid response. While local authorities are typically responsible for debris management, the scale of destruction severely disrupted municipal operations. Under the Local Autonomy Act of 1947,[k] prefectural governments were allowed to temporarily assume debris management responsibilities and coordinate recovery efforts across affected municipalities.

Key drivers and enabling factors in Miyagi Prefecture: Miyagi Prefecture was among the areas most severely affected by the earthquake and tsunami. The 2012 special notification outlined six criteria for recycling postdisaster debris in public works: (1) debris must be presorted and treated; (2) it must contain no hazardous substances; (3) use of recycled materials must not result in environmental harm; (4) materials must be used exclusively for reconstruction-related public works; (5) material use and destination must be documented, and (6) recycled products must meet structural and safety standards.

Local and prefectural governments were required to conduct conformity testing to enforce these criteria. For example, to verify the absence of hazardous substances, sampling tests had to be carried out on each identifiable batch of debris. Recognizing that recycled debris would not gain market traction without support, the government proactively diverted these materials to public reconstruction projects. A Guidance Note[l] was issued to encourage local governments to use recycled debris in public works and document best practices. Based on the guidance, disaster-derived concrete was processed into aggregate for civil works, while recovered wood was repurposed into biomass fuel or engineered wood products for housing. The guidance placed strong emphasis on quality control, particularly the testing of materials for hazardous substances. With support from academic institutions, the government developed and issued detailed protocols outlining testing methods and acceptable thresholds.

Asbestos contamination was a major concern in the aftermath of the disaster. When buildings containing asbestos collapse, the resulting debris poses significant health risks and is difficult to recycle. Temporary storage sites for asbestos-containing materials were required to be clearly marked, regularly wetted by spraying to suppress dust, and managed under strict safety protocols. Immediate response measures included public alerts through local media, signage, and radio broadcasts; distribution of protective equipment to residents and emergency responders; and clear delineation of temporary storage zones.

To prevent health impacts, authorities were also required to label, cover, and document asbestos-contaminated waste. To support these efforts, the Ministry of the Environment has developed a national manual[m] outlining step-by-step procedures and risk-based priority actions for the safe management of asbestos waste during disaster response.

The experience of managing postdisaster debris after the Great East Japan Earthquake influenced the development of national regulations and technical guidance. Lessons learned from this large-scale emergency response informed the creation of more robust procedures for debris management planning, debris recycling, hazardous material handling, and predisaster coordination across government levels. As a result, Japan has since strengthened its institutional preparedness, enabling local governments to respond more effectively and efficiently to subsequent disasters with clearer protocols, improved technical capacity, and better-integrated recycling practices.

Debris management in conflict-affected Ukraine: Toward a phased and scalable approach

The full extent of destruction from the Russian Federation's full-scale invasion of Ukraine remains unknown owing to the lack of official data on damaged and destroyed assets, making debris generation estimates unavailable. However, total damage to housing and infrastructure is estimated at nearly US$170 billion—based on replacement costs—including losses to residential buildings, industrial facilities, and critical infrastructure (KSE 2024). The World Bank's Third Rapid Damage and Needs Assessment (RDNA3) estimated US$11 billion in demolition and debris removal needs nationwide in 2024 (World Bank Group 2024). Local governments, particularly in conflict-affected areas, face the immense challenge of managing this debris with limited financial resources, institutional capacity, and technical guidance.

In this context, Ukraine has been working to develop a phased debris management framework that, while grounded in local realities, offers broader relevance for other postcrises settings (World Bank 2025). The approach reflects key priorities: safeguarding health and the environment, reducing open dumping, enabling recycling, and aligning with European Union accession goals (European Commission 2024).

Institutional framework: Ukraine's legal framework for debris and construction waste management has been evolving to address recovery needs and support the country's European Union (EU) integration objectives.[n] The Waste Management Law,[o] in effect since July 2023, establishes a unified waste classification system, formally defines C&D waste, and incorporates circular economy principles. Supporting regulations include Cabinet Resolution No. 1102,[p] which outlines the national waste list, and Cabinet Resolution No. 1073,[q] which governs demolition waste generated as a result of armed conflict. Under martial law conditions, Procedure No. 474[r] assigns responsibility for demolition and debris management of war-damaged structures to local self-governments. Local authorities and particularly the oblasts, or regions, are responsible for identifying, permitting, and managing disposal sites, as well as overseeing debris handling and promoting reuse.

Phases of debris management in Ukraine: Given Ukraine's size and the varying intensity of military activity, under current martial law, local governments are progressing through debris management at different paces and capacities. Some municipalities remain under active military threat, while others have moved toward debris clearance, sorting, and reuse.[s] As such, the phases described below are not to be interpreted as strictly sequential, but rather as a flexible and scalable framework to guide evolving local responses.

Phase 0 – Risk communication and planning preparation: During the emergency phase under martial law, the primary objective is to do no harm. The national government supports the development and dissemination of safety awareness campaigns and risk communication materials related to debris removal and the handling of hazardous materials. Local government, or hromadas, ensure that debris storage areas are clearly marked, that appropriate protective gear is provided for workers and residents, and that asbestos warnings are widely communicated.

The national government is also to begin preparing simplified templates for debris management plans. These templates would include guidance on estimating debris generation, defining debris ownership, managing asbestos, designing storage and disposal sites, and incorporate recycling and other relevant details to facilitate planning by hromadas. At the same time, oblast, or regional, and hromada authorities would start estimating the quantity of debris within their respective jurisdictions to determine the necessary capacity for debris recycling and the appropriate size of disposal sites.

Phase 1– Strategic planning and risk mitigation: Planning responsibilities are divided among four levels of government. At the national level, ministries lead on legal frameworks, financing strategies, and coordination with international partners. An interinstitutional coordination mechanism has been set up to facilitate structured engagement with donors.

At the regional level, the oblast coordinates reconstruction efforts across municipalities. At the hromadas level, local governments prepare and implement municipal-level debris management plans and support localities through technical expertise and intermunicipal coordination. Municipal plans are guided by draft national templates and include debris quantification, site planning, asbestos risk identification, and health and safety procedures. Since much of the building stock in Ukraine contains asbestos, particularly in roofing, insulation, and siding, attention is given to health risks during demolition and debris handling. Public campaigns, safety guidance, and targeted training for public workers and contractors aim to mitigate these risks. The absence of technical specifications for recyclable debris remains a significant barrier for debris reuse.

Phase 2 – Emergency clearance and temporary storage: At the national level, security agencies and the state emergency services lead safety-related clearance operations, including the removal of explosive ordinance. Regional authorities coordinate logistics and oversee priority areas, while local governments manage temporary debris clearance, public communication, and site operations. Emergency efforts focus on securing high-risk zones, clearing access routes, and establishing temporary debris storage sites. Identifying suitable storage locations that are sufficiently distant from populated areas and environmentally sensitive zones remains a significant challenge. Despite ongoing efforts, many municipalities continue to face uncontrolled dumping due to limited funding and regulatory ambiguity. Given that debris is often contaminated with hazardous materials, separation during removal and storage is essential to preserve its recycling potential. However, equipment, standardized procedures, and supervisory capacity remain limited. Pilot initiatives in cities such as Lviv and Kharkiv are testing the use of sorted debris in road base layers to support reconstruction. In parallel, local governments are undertaking debris quantification to inform planning, guide site identification, and enable targeted allocation of national and regional funding.[t] Debris quantification by local governments is also underway to support planning, site identification, and prioritization of funding allocations by national and regional authorities.

Phase 3 – Establishment of authorized sites and recycling infrastructure: Designation of authorized debris storage and recycling sites is underway. Technical specifications for recycled materials are under development, particularly for applications in public sector construction works. Oblast governments are anticipated to play a coordinating role—identifying potential sites, aligning with environmental requirements and facilitating inter-municipal collaboration. Local governments may be tasked with temporary site upgrades and the initial organization of material separation. A phased approach is being considered to gradually transition from temporary to more permanent infrastructure, potentially supported by donor-funded pilots and capacity-building efforts. Materials with promising reuse potential are being determined, including concrete for road foundations, brick and aggregate for fill, and uncontaminated wood for engineered wood products. The eventual transformation of select temporary sites into long-term C&D waste recycling hubs is also being considered, aligned with EU circular economy principles and the development of local markets.

Phase 4 – Long-term systematization and market development: At the national level, regulatory and policy reforms are under preparation. These include clearer permitting procedures for waste management, improved data systems, updated classifications of waste types, and producer and contractor accountability frameworks (OECD 2025). Oblast governments are expected to support market development through inter-municipal cooperation, regional data collection, and technical services. Local governments are expected to integrate recycling into planning processes and enforce waste management standards. The Ministry for Development of Communities and Territories is expected to champion the use of recycled debris in public construction, with fiscal incentives supporting uptake. Adoption of national recycling targets is under discussion, referencing the EU Waste Framework Directive's target of 70% recovery of nonhazardous C&D waste.[u] While this process is in early stages, it is expected to gradually contribute to Ukraine's alignment with EU environmental directives and broader recovery goals. In the medium term, exploration of fiscal instruments to promote circularity in the construction sector is underway, including support for entities establishing recycling infrastructure. Longer-term reforms are expected to transition debris management policy into a broader C&D waste management framework, aligned with EU accession objectives.

Emerging lessons for broader contexts: While challenges persist, Ukraine's emerging debris management model offers preliminary lessons for other post-crisis settings. A phased and risk-informed approach centered on public health protection, environmental safeguards, and the potential for material recovery improve local government preparedness and support more circular recovery pathways over time. Early efforts at the national level to develop policy guidance, planning templates, and technical protocols represent important first steps. In parallel, some regional authorities have begun facilitating coordination among municipalities, while donor-supported pilots and guidance documents are helping to inform future practices. An interinstitutional coordination mechanism is also being established to steer national efforts and provide structured engagement with international donors. Although implementation remains at an early stage, Ukraine's experience suggests that establishing clear roles, early planning structures, and a phased operational framework can gradually enable more organized and sustainable debris management—even in highly constrained environments.

Notes

a. The US Environmental Protection Agency defines construction and demolition waste as "the waste generated by all activities carried out during the construction, maintenance, demolition, and deconstruction of any type of building and civil work, or during natural disasters" (US EPA 2018).

b. For more information about the Davos Baukultur Alliance, see https://centres.weforum.org/centre-for-urban-transformation/davos-baukultur-alliance.

c. The UN Office for Coordination of Humanitarian Affairs (OCHA) defines debris as "mixture of building waste and rubble typically arising from damaged buildings and their demolition. This waste stream can include natural materials such as clay and mud, trees, branches, bushes, etc." (UN OCHA 2011).

d. For more information about the Disaster Debris Recovery Tool (DDRT) developed by the US EPA, see https://www.epa.gov/large-scale-residential-demolition/disaster-debris-recovery-tool.

e. For more information about the All-Hazards Waste Management Planning Tool developed by the US EPA, see https://www.epa.gov/homeland-security-waste/all-hazards-waste-management-planning-tool.

f. FEMA. *Public Assistance Program and Policy Guide.* Version 4. FP 104-009-2. https://www.fema.gov/sites/default/files/documents/fema_pappg-v4-updated-links_policy_6-1-2020.pdf.

g. Regulation for Enforcement of the Basic Act on Disaster Management, Prime Minister's Office Order No. 52 of 1962 (Last version: Cabinet Office Order No. 30 of 2021). https://www.japaneselawtranslation.go.jp/en/laws/view/4173/en.

h. Waste Management and Public Cleansing Law No. 137 of 1970. https://www.env.go.jp/en/recycle/basel_conv/files/Waste_Management_and_Public_Cleansing.pdf.

i. Laws and Support Systems for Promoting Waste Recycling in Japan. https://gec.jp/gec/en/Publications/LawSupport-Systems.pdf.

j. 東日本大震災からの復旧復興のための公共工事における災害廃棄物由来の再生資材の活用について（通知） Utilization of post-disaster waste derived recycled materials for public works related to the reconstruction for Great East Japan Earthquake (English translation). https://www.env.go.jp/content/900481570.pdf.

k. 地方自治. Local Autonomy Act of Japan. (English translation). https://laws.e-gov.go.jp/law/322AC0000000067.

l. 災害廃棄物の再生利用事例集. Guidance on recycling of post-disaster debris (English translation). https://policies.env.go.jp/recycle/disaster_waste/guidance/reclamation_case_studies/index.html.

m. 災害時における石綿飛散防止に係る取扱いマニュアル. Manual for preventing asbestos dispersion during disasters. (English translation).https://www.env.go.jp/air/asbestos/saigaiji_manual.html.

n. Ukraine applied for EU membership in 2022, and the EU Council opened accession negotiations in 2024. Despite the ongoing Russian Federation's invasion, Ukraine has made notable progress in aligning its legislation with the EU acquis, including commitments under the European Green Deal, such as circular economy and waste management policies.

o. Ukraine Law No. 2320-IX "On waste management" (English translation). https://www.fao.org/faolex/results/details/fr/c/LEX-FAOC217724/.

p. Ukraine Cabinet of Ministers Resolution No. 1102 (2011), *On approval of the Waste Classification Procedure and the National Waste List.* https://zakon.rada.gov.ua/laws/main/1102-2023-п.

q. English Outline of Cabinet Resolution No. 1073. https://www.lexology.com/library/detail.aspx?g=70dd0af4-ee58-42e7-b917-da22a398873b.

r. Ukraine Cabinet of Ministers Resolution No. 474 (2022), *On approval of the Procedure for performing work on dismantling objects damaged or destroyed as a result of emergencies, military operations or terrorist acts.* https://zakon.rada.gov.ua/laws/main/474-2022-п.

s. Outlined in *Recommendations Toward a Policy Note: Municipal Debris Management in Ukraine.* http://documents.worldbank.org/curated/en/099053025113533353.

t. UNDP Ukraine. 2023. Circular Recovery Pilot Projects in Lviv and Kharkiv.

u. European Union. Waste Framework Directive 2008/98/EC. https://eur-lex.europa.eu/eli/dir/2008/98/oj/eng.

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Notes

1. Income groups for countries and economies are kept constant at their 2022 classifications. That is, potential changes in income group are not considered in projections.
2. Specifically referring to plastic, paper and cardboard, metal, and glass.
3. Controlled: Some use of cover; waste is compacted; sufficient equipment for compaction exists; site is fenced and control of access; no fire/smoke existence; site staffed; weighing and recording conducted; slope of the landfill is stable, landslides not possible; protection of workers' health and safety. Sanitary: waste periodically covered; waste compacted; site fenced and control of access; leachate containment and treatment; landfill gas collection (depending on landfill technology); site staffed; weighing and recording conducted; protection of workers' health and safety (UN-Habitat 2021).
4. It should be noted that while presented together with composting, anaerobic digestion does not necessarily result in material recovery.
5. Occasionally, "incineration with energy recovery" is referred to as "incineration" for brevity. In all cases "incineration" should be understood as incineration with energy recovery, unless otherwise specified.
6. In this report, composition, treatment, and waste generation data from 217 countries and economies have been used to estimate the amount of municipal solid waste plastic (a subset of overall plastic waste generated) that is 'poorly managed' (collected but not managed in controlled facilities) and unmanaged waste (uncollected).
7. The estimate of 65 percent is based on expert judgment and corroborated by findings from Changing the Way We Use Plastics (European Commission, 2018), which states that more than 60 percent of plastic waste originates from packaging. https://op.europa.eu/en/publication-detail/-/publication/e6f102e3-0bb9-11e8-966a-01aa75ed71a1/language-en.
8. For more information on the *Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal* (1989), see https://www.basel.int.
9. For more information on the *Bamako Convention on the Ban of the Import into Africa and the Control of Transboundary Movement and Management of Hazardous Wastes within Africa* (1991), see https://au.int/en/treaties/bamako-convention.

10. For more information on the *Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade* (1998), see http://www.pic.int.
11. For more information on the *Stockholm Convention on Persistent Organic Pollutants* (2001), see http://www.pops.int.
12. For more information on the *International Convention for the Prevention of Pollution from Ships (MARPOL)* (1973/1978/1997), see https://www.imo.org/en/About/Conventions/Pages/International-Convention-for-the-Prevention-of-Pollution-from-Ships-(MARPOL).aspx.
13. China's National Sword policy, enacted in January 2018, banned the import of most plastic waste and other materials, closing the market for exporting nations and causing a global shift in plastic waste flows.
14. European Union. *Regulation (EU) 2024/1157 of the European Parliament and of the Council of 11 April 2024 on shipments of waste and amending Regulations (EU) No 1257/2013 and (EU) No 2020/1056.* Official Journal of the European Union L, no. 6 (20 May 2024): 1–120. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32024R1157.

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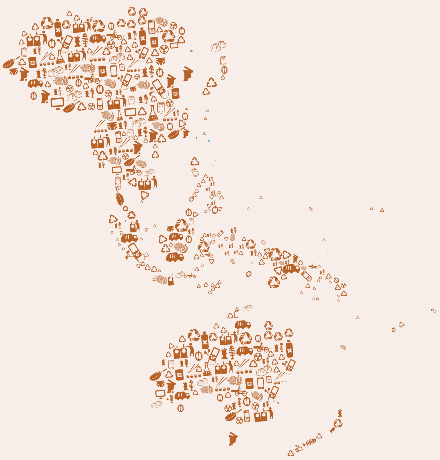
©iStock/yilmazsavaskandag. Municipal solid waste fragments polluting a coastal shoreline.

3.

Regional Snapshots



3.1

East Asia and Pacific

KEY INSIGHTS

- The East Asia and Pacific region generated the most municipal solid waste globally at 849 million tonnes in 2022, a mean of 0.98 kilogram per capita per day.
- Waste collection rate in the region is relatively high, with a weighted average of 90 percent. In urban areas, the median waste collection coverage is 100 percent, compared to 64 percent in rural areas.
- The region has the highest proportion of organic waste such as food, garden, and wood among all regions at 57 percent by weight, whereas engineered materials like plastic, paper and cardboard, glass, and metal make up 29 percent of the waste stream.
- Despite the high proportion of organics, composting and anaerobic digestion remain low, at 4 percent overall.
- Incineration accounts for approximately 44 percent of municipal solid waste treatment in the region, primarily driven by China, with Japan contributing to a lesser extent. Twenty-two percent of the waste is disposed of on land, and 15 percent is recycled.
- The uncollected waste, a tenth of the generated waste in the region, is reported to be mainly openly burned.

KEY INSIGHTS (CONTD.)

- China, one of the most populous countries in the world, heavily influences regional performance, generating approximately 60 percent of the municipal solid waste in the region. Over the past decade, China has made outstanding progress in managing its municipal solid waste, setting a powerful example of what is possible and achievable in the sector within a relatively short time. Given the scale of its waste generation, China significantly influences the overall performance and defining characteristics of waste management in the East Asia region.

3.1.1 Background and Trends

The East Asia and Pacific region spans the Asian mainland, Australia, and Pacific Island states. It comprises 37 countries and economies, including 15 high-income, nine upper-middle-income, and 13 lower-middle-income countries, as of 2022. China, an upper-middle-income country, is the second most populous in the world, with a population of 1.4 billion, representing 60 percent of the region's total population of 2.4 billion in 2022 (UNDESA 2024).

High-income economies in the region have near universal waste collection and some of the highest material diversion rates globally; for example, 60 percent recycling and composting in the Republic of Korea (KEC 2022) and over 50 percent in Singapore (Singapore NEA n.d.; IGES 2017). Japan processes 77 percent (Japan MoE 2024) of its municipal solid waste in over 1,000 waste-to-energy plants (Japan MoE 2025), reflecting decades of experience with a range of treatment technologies and capacities. Japan has successfully decoupled waste generation from economic growth through a combination of targeted policies, economic incentives, and strong citizen participation. Japan reports per capita waste generation of 0.88 kilogram per day, lower than in many other high-income countries (Japan MoE 2024). Cost recovery practices vary across high-income countries. In the Republic of Korea, the polluter-pays principle has played a key role in achieving high recycling rates. Other countries in the region set waste charges below the cost of service, with the shortfall primarily covered through property taxes. Service costs are generally high, reflecting investments in advanced technologies and the implementation of multistream source separation. Governments actively support capital investment in waste infrastructure by co-financing waste facilities alongside local authorities. National and local planning processes for waste management are well aligned and coordinated, providing a strategic framework for long-term progress.

In contrast to high-income economies, most middle-income countries in the region face challenges in managing their solid wastes. In many cases, more than 20 percent of waste remains uncollected whereas the majority of collected waste is disposed of in controlled landfills or open dumpsites. A substantial number of waste workers operate outside the formal system, recovering recyclable materials before they enter the municipal stream. Indonesia has implemented a waste bank model, enabling households to exchange recyclables for cash or goods. Waste banks are present in other East Asian countries as well. Despite significant optimism, the overall impact on the quantity of recycling has been limited, with many waste banks dormant or only partially operational due to insufficient financial support.

Many municipalities introduced bans on some types of single-use plastic, and some—such as in the Philippines—have adopted ordinances requiring households to separate waste. Some municipalities require households to manage organics at home, thereby reducing pressure on municipal services. Refuse-derived fuel is being produced in many locations in this and other regions, but long-term offtake agreements remain difficult to secure. Refuse-derived fuel quality is often low due to high moisture content, a large share of inert materials, and the presence of polyvinyl chloride (PVC), limiting its commercial viability. Black soldier fly composting and vermicomposting are also being explored quite commonly but to date remain limited in scale. The absence of source separation—at minimum into wet and dry streams—limits feedstock quality for both composting and refuse-derived fuel, thereby restricting viable treatment options. The sector remains underfunded, with most financing directed toward collection and transport, whereas treatment and disposal receive limited resources.

China is estimated to have generated approximately 502 million tonnes of municipal solid waste in 2022,[1] excluding recyclable materials collected through channels, such as the national network of supply and marketing cooperatives, which are not accounted for in official statistics on waste management (Liu, Yu, and Yuliang 2020). Nearly 75 percent of urban waste is incinerated (appendix B). Waste collection coverage is universal in cities and approximately 90 percent in rural areas (China MoHURD 2024; Wang, Zhang, and Xu 2024). Due to China's large population, these figures significantly influence regional averages. When China is excluded from regional calculations, the mean rate of uncollected waste in the East Asia and Pacific region increases from 10 percent to 19 percent, whereas the share of waste disposed of through dumping rises from 5 percent to 15 percent, and incineration with energy recovery decreases. Over the past decade, China has made substantial progress with its municipal solid waste management, showcasing the potential for rapid improvements. These advancements serve as practical examples of what can be achieved in the sector when strong commitment, political attention, and sufficient resources are in place.

Among the 13 Pacific Island countries, Nauru is the only one classified as high income, while the rest are evenly split between upper- and lower-middle-income categories. In addition to common solid waste management challenges, Pacific Island countries face added constraints due to limited land availability, geographic remoteness, rising consumption, and import-oriented economies with large quantities of packaging waste. As popular tourist destinations, some Pacific Island countries experience seasonal spikes in waste generation. Most lack systems for source segregation and diversion rates remain low—only three countries report recycling levels of 8 to 10 percent by weight. Waste is primarily landfilled or dumped. In five of the countries, more than 60 percent of the waste remains uncollected.

Efforts to reduce waste generation and improve solid waste management are ongoing, including single-use plastic bans, container deposit schemes, and waste-related taxation in countries such as Fiji, Kiribati, Palau, Samoa, Tonga, and Vanuatu. The *Cleaner Pacific 2025: Pacific Regional Waste and Pollution Management Strategy* (SPREP 2016), developed jointly by Pacific Island countries, promotes regional cooperation, including shared recycling hubs and harmonized policies. A proposed regional recycling network envisions central hubs in select countries, supported by feeder systems from neighboring Pacific Island countries. The objective is to consolidate material flows and increase volumes of material to enhance the financial viability of recycling efforts across the region (box 3.1).

Box 3.1 Solid Waste Management in Small Island States

In small island states such as those in the Pacific Ocean and Caribbean Sea, waste management brings unique challenges posed by their geography and economies. Remoteness and reliance on imported goods often increase the share of packaging materials in the waste stream. Domestic recycling markets are further constrained by small operational scales and low quantities of recyclables, hindering economies of scale and access to external markets. Offshore transport requirements increase costs.

Many islands' popularity as global tourist destinations aggravates waste management difficulties, as seasonal influxes of visitors significantly increase waste quantities. Tourism typically leads to higher per capita waste generation and introduces materials requiring specialized treatment, such as plastics from food service, textiles, and bulky items. Island economies often depend on fisheries, which produce substantial waste from discarded gear and nets. Additionally, marine litter from other regions frequently washes ashore, increasing the burden on local communities for cleanup and disposal.

Land scarcity and complex geographies such as for atoll archipelagos are persistent obstacles, complicating the identification and development of suitable sites for waste management facilities. Legacy disposal sites are often located near coasts, making them vulnerable to storm surges, rising sea levels, and saline intrusion. These sites are frequently unlined or poorly managed, posing significant risks to fragile coastal ecosystems. Climate change exacerbates these issues, as small islands are highly susceptible to hurricanes and typhoons, which can generate sudden surges of debris and construction waste that overwhelm existing infrastructure and quickly exhaust limited landfill capacity.

Financial sustainability is a major concern, with service fees typically insufficient, inconsistently applied, or poorly collected. Many islands depend on government subsidies or donor support to cover operational costs. Although innovative financing mechanisms are being introduced, such as advancing disposal fees on imported goods, dedicated environmental funds, and allocating part of tourism taxes for waste management, many islands continue to struggle with financial sustainability.

As a result, solid waste management in small island states involves distinct and often more complex challenges than those faced by other countries. These difficulties arise from

constrained land resources, heightened climate risks, the economic importance of tourism, and the distance to off-island markets for secondary materials. Addressing these challenges requires a mix of interventions, regional collaboration, and targeted investment in resilience. Waste minimization is critical, particularly through reducing single-use plastics and packaging. Policies that promote source separation of organics, recyclables, and residuals are essential to reduce the high costs of waste transport—for example, by local composting of organics—and for improving treatment options and attracting offtakers for better quality secondary materials. Local separate collection and composting of organics significantly reduces the amount of waste requiring further treatment and facilitates the process of transporting recyclables from islands. Tourism-linked economies should internalize waste management costs, with hospitality and cruise sectors contributing to full cost recovery for the waste they generate.

It is important to pursue economies of scale both within individual islands and among island groups. For individual islands, economies of scale can be achieved through coordination among local communities and, for larger islands, regionalization of waste services, including joint procurement and shared transportation and treatment. Coordination among island groups can enhance bargaining power with national and international suppliers and producers, enabling stronger negotiation on producer responsibility for packaging, electronics, and fishing gear.

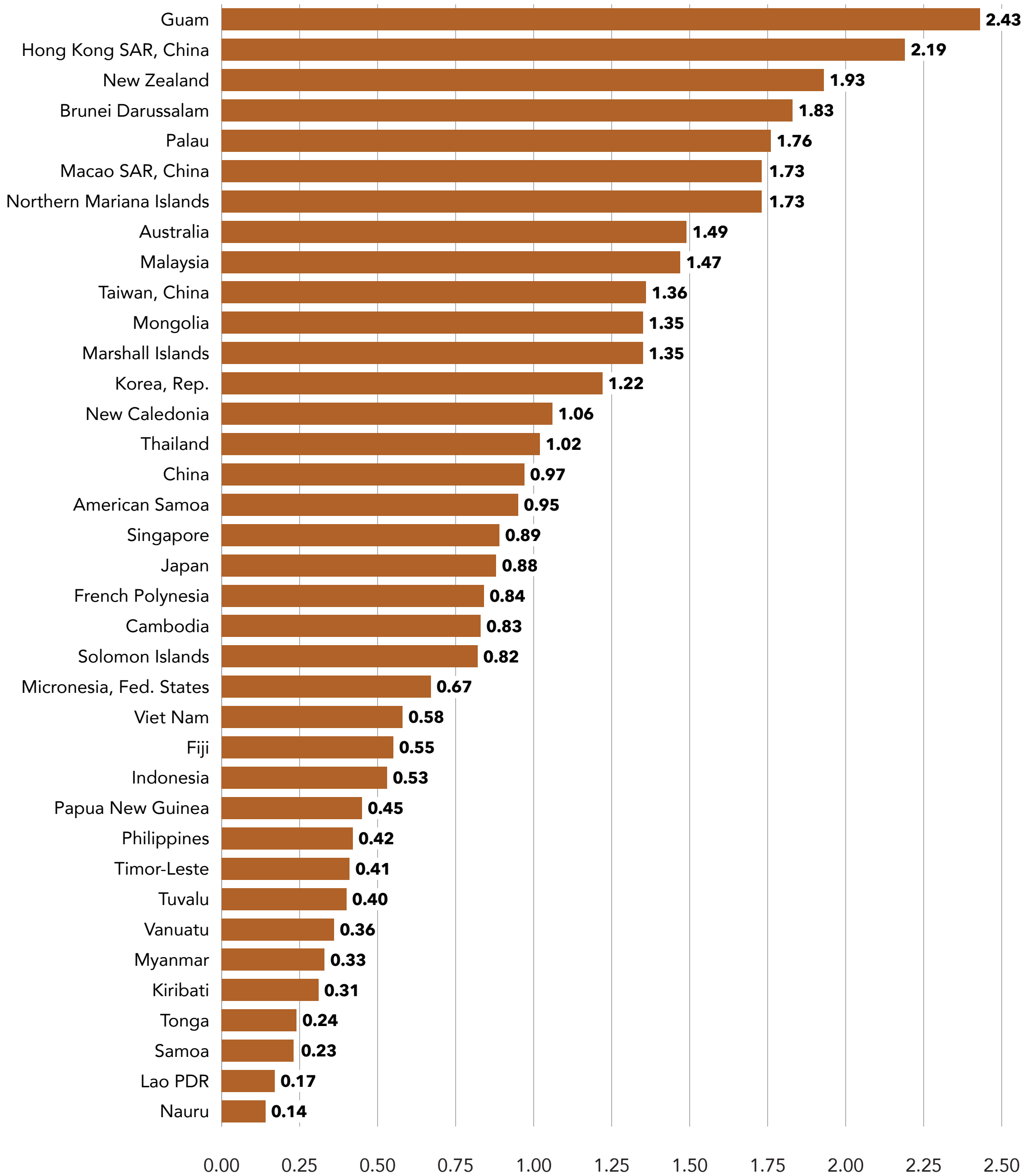
Preparedness for disaster waste should be integrated into solid waste management planning. Natural disasters routinely generate large volumes of debris, including construction waste, vegetation, and hazardous materials. Emergency debris management plans, including temporary storage sites and rapid contracting mechanisms, are critical for maintaining continuity of services and protecting infrastructure.

3.1.2 Waste Generation and Composition

The East Asia and Pacific region is home to 2.4 billion people and in 2022, generated an estimated 849 million metric tonnes of municipal solid waste, at a mean of 0.98 kilogram per capita per day (figure 3.1). This is the most waste produced by any region. Generation rate per capita per day ranges from 0.14 kilogram in Nauru to 2.43 kilograms in Guam. Similar to other regions, the countries generating the most waste per capita are high-income economies.

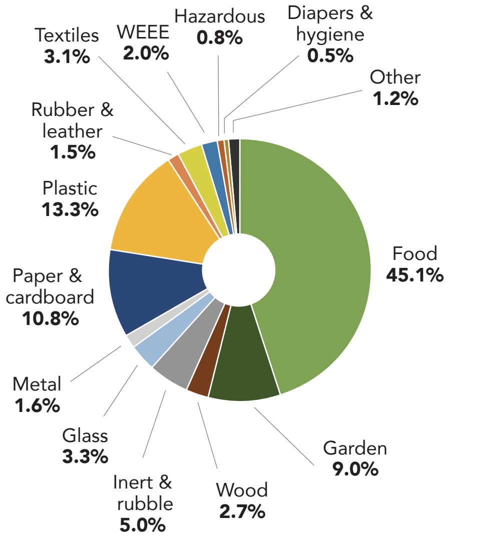
Approximately 57 percent of municipal solid waste in the region consists of food, garden, green waste, and wood, while engineered materials[2] account for 29 percent (figure 3.2). China's waste stream contains a higher proportion of food waste at 59 percent (Kemao 2023) compared to 45 percent in most other upper-middle-income countries, due to cultural habits and consumption patterns. When China is excluded, the share of food and garden waste in the regional average drops from 54 percent to 42 percent.

Figure 3.1 Municipal solid waste generation in East Asia and Pacific countries



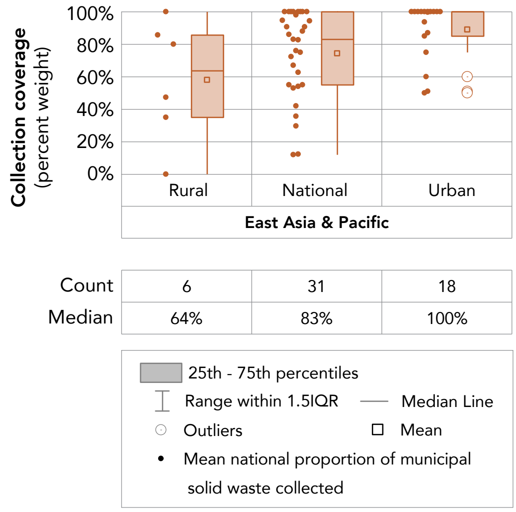
Source: Original figure for this report.
Note: Mean waste generation in kilogram per capita per day projected to 2022.

Figure 3.2 Composition of municipal solid waste in East Asia and Pacific



Source: Original figure for this report.
Note: Weighted mean based on 2022 waste generation. WEEE = waste electrical and electronic equipment.

Figure 3.3 Waste collection coverage in countries from East Asia and Pacific



Source: Original figure for this report.
Note: Country dataset. Central tendency and spread of waste collection coverage in weight percent. Each dot refers to mean waste collection coverage at national, national urban, and national rural levels, based on data from different and inconsistent years. The summary statistics presented are not weighted, meaning that each country is counted equally regardless of its population size. As a result, these collection rates are not directly comparable to the regional weighted collection rate. Outliers are defined as values lying more than 1.5 times the interquartile range beyond the upper or lower quartiles. IQR = interquartile range.

3.1.3 Waste Collection

The weighted mean national waste collection rate in the East Asia region is 90 percent, the third highest across all regions (figure 2.11). As with other regions, collection rates are higher in urban areas than in rural ones, with median values of 100 percent and 64 percent, respectively (figure 3.3). Urban collection rates vary widely, ranging from 50 to 100 percent. Data on rural areas are limited, with only six countries reporting in the East Asia and Pacific region. Of those countries where rural collection rates were reported, data vary from 100 percent collection in Guam to no reported rural collection services at all in Papua New Guinea (SPREP 2016).

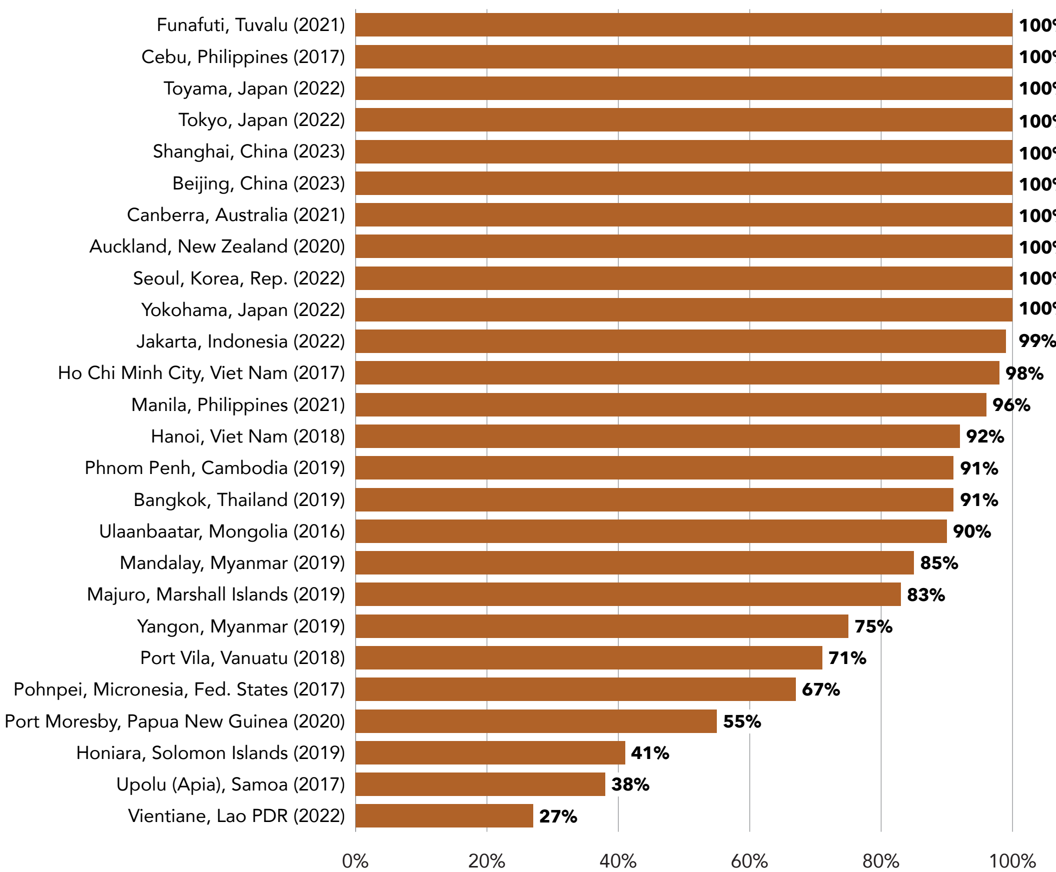
Collection rates in selected cities across the region range from 100 percent in high-income countries, capital cities, and large metropolises, to under 50 percent in places like Apia on Upolu Island, Honiara in the Solomon Islands, and Samoa (World Bank Group 2021; MRA Consulting Group 2023). Where reported, cities in this region (figure 3.4) tend to use either a curbside collection system, where the waste is left outside the property for collection, or a centralized drop-off system, where households and businesses take their waste to a specified location, as is the practice in Tokyo, Toyama, and Yokohama in Japan.

3.1.4 Waste Treatment and Disposal

The most common treatment route for municipal solid waste in this region is incineration, with 44 percent of the waste being treated in this way (figure 3.5). Just over 20 percent of the waste goes to landfill and about 15 percent is recycled. Given China's large population and waste generation rates, regional figures are heavily influenced by its waste treatment and disposal practices, particularly its reliance on incineration as the primary method. If China is excluded from the regional treatment mix, the share of landfilling increases to 24 percent, and the share of waste treated through incineration drops from 44 percent to 19 percent.

Among the countries in the region, Macao SAR, China, has the highest rate of incineration in the region at 99 percent (Macao SAR, China EPB 2022). Incineration is also frequently practiced by other higher-income countries with limited land availability, such as Japan at 77 percent (Japan MoE 2024), Singapore at 43 percent (IGES 2017; Singapore NEA n.d.), and the Republic of Korea at 24 percent (KEC 2022).

Figure 3.4 Municipal solid waste collection coverage for selected cities in East Asia and Pacific

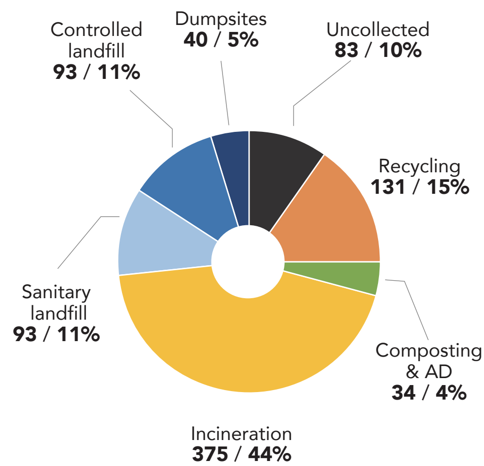


Source: Original figure for this report.
Note: City dataset. Bars refer to the proportion of waste collected by weight in cities. Bracketed years indicate year that the measurement refers to.

The highest rates of material recycling in the region are in high-income countries with Taiwan, China (Taiwan, China MoE 2024), Singapore (IGES 2017; Singapore NEA n.d.), and the Republic of Korea (KEC 2022). Lower-middle-income countries continue to depend on landfills, with some nations such as Lao People's Democratic Republic (Borongan and Huno 2020), Myanmar (IGES 2020), and Vanuatu (Vanuatu DEPC 2019) practicing open dumping of between 18 and 55 percent of their waste, and other countries such as Papua New Guinea (SPREP 2023b) and Micronesia (SPREP 2023a), which formally collect less than half of their waste.

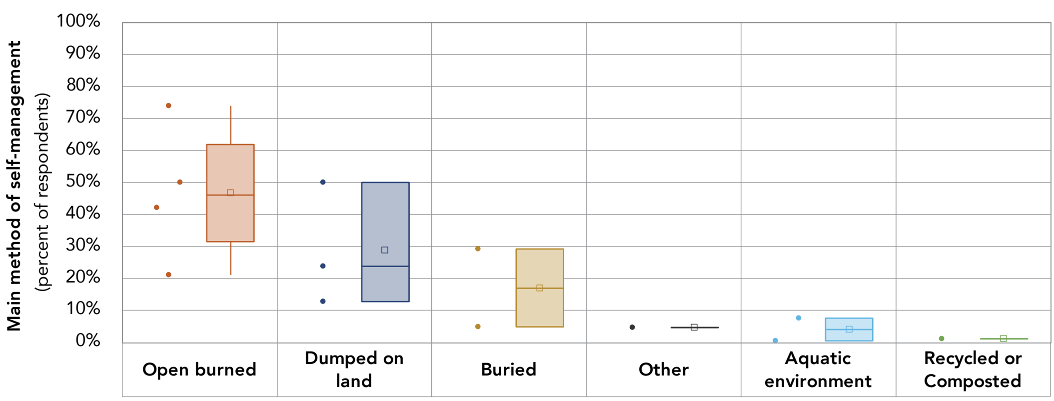
The most common disposal method for uncollected waste is to burn it, followed by dumping it on the land or burying it (figure 3.6).

Figure 3.5 Waste treatment and disposal in East Asia and Pacific



Source: Original figure for this report.
Note: Numbers refer to the amount of waste treated or uncollected in millions of tonnes per year. AD = anaerobic digestion.

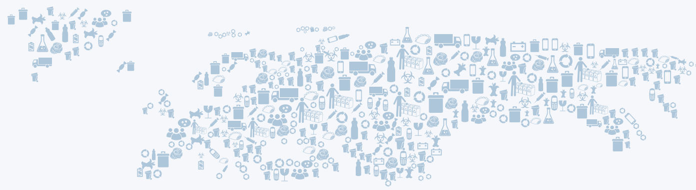
Figure 3.6 Self-management of uncollected municipal solid waste in East Asia and Pacific



	Open burned	Dumped on land	Buried	Other	Aquatic environment	Recycled or Composted
Count	4	3	2	1	2	1
Median	46%	24%	17%	5%	4%	1%

25th - 75th percentiles; Range within 1.5IQR; Median Line; Mean
• Mean national proportion of municipal solid waste main method of self-management

Source: Original figure for this report.
Note: Country dataset. Dots refer to the mean main method of self-management as reported by respondents in national surveys and censuses. IQR = interquartile range.



3.2

Europe and Central Asia

KEY INSIGHTS

- Europe and Central Asia generated 415 million tonnes of municipal solid waste in 2022, with a mean of 1.22 kilograms per capita per day.
- Waste collection rates in the region are high, with a weighted mean of 96 percent. In urban areas, the median waste collection coverage is 98 percent, compared to 77 percent in rural areas.
- Thirty-four percent of waste materials are recovered through recycling and composting, one of the highest proportions of material recovery across all regions.
- Incineration is used to process 21 percent of the region's waste, and 37 percent continues to be landfilled.
- High-income economies in Western Europe lead the region in recycling rates and waste diversion from disposal, driven by rigorous environmental legislation developed under the European Commission's waste legislation.
- Even though overall performance across European Union countries is high, Member States vary considerably, with newer members lagging behind in service performance levels.
- Elsewhere in the region, middle-income countries are working actively to modernize their waste management systems, strengthen regulatory frameworks, and promote recycling and resource recovery.

3.2.1 Background and Trends

The Europe and Central Asia region comprises 58 countries, including 38 high-income, 16 upper-middle-income, and four lower-middle-income countries as of 2022. Twenty-seven countries are members of the European Union, all but one of which is classified as high income.

In 2022, the region had a population of over 931 million, with 56 percent residing in high-income countries that generated the majority of the region's solid waste (UNDESA 2024).

The European Union (EU) is a global leader in municipal solid waste management policy development and in establishing fundamental guiding frameworks for the sector. The legislative framework guiding the sector is primarily based on the Waste Framework Directive[3] that sets the basic concepts and definitions related to waste management, including Waste Hierarchy, which prioritizes prevention, reuse, recycling, and recovery before disposal. Member States are subject to binding targets for recycling, material-specific packaging targets, and reduction in landfilling, as well as other requirements, such as the adoption of national waste management plans and standardized and mandatory data reporting. This framework ensures a harmonized approach to waste management across the EU toward established objectives.

Actual performance across countries within the EU varies. Germany, for example, has achieved one of the highest recycling rates globally, reaching nearly 50 percent recycling and 22 percent composting.[4] Despite the presence of strict regulations and ambitious recycling targets, some Member States have faced challenges in implementation, resulting in uneven progress across the region. A target to reuse or recycle 55 percent of municipal waste and 65 percent of packaging waste by 2025 may not be met by all EU Member States, with 10 Member States at risk of missing both targets. Some of the newer Member States have a high reliance on landfilling, and many need to significantly step up their efforts and better monitor the effectiveness of policy measures (EEA 2023). Additional challenges include improving waste separation at source, as well as increasing public awareness and participation in recycling programs especially in some of the newer Member States.

Countries outside the European Union, including those on the Balkan Peninsula and in the Caucasus and Central Asia, generally align their waste management approaches with EU practices and have incorporated Waste Hierarchy into their sector plans. For example, Armenia, Bosnia and Herzegovina, and Kosovo follow regional waste–shed approaches for waste treatment and disposal facilities servicing multiple municipalities. Azerbaijan, Serbia, and Türkiye have developed material recovery facilities along with waste-to-energy plants for some of their urban waste, whereas Kazakhstan and Uzbekistan plan to diversify their treatment mix from predominantly disposal toward increased recycling and energy recovery.

Waste management performance in these countries lags that of the EU. Separation at source is often present in urban centers, but public participation remains low. Compliance and enforcement are also an issue especially in semi-urban and rural areas. Other challenges across the middle- and low-income countries in the region include outdated infrastructure, low recycling rates, low levels of cost recovery, and limited public awareness. Many East European countries continue to rely heavily on landfilling without sufficient environmental controls, and many existing facilities date back to the Soviet Union era. Waste fees are generally low, not reflective of actual costs, and are below the established affordability threshold of 1 to 1.5 percent of disposable income or household expenditure. Despite these challenges, in most of these countries there are ongoing efforts to modernize waste management systems, improve regulatory frameworks, and promote recycling initiatives toward more sustainable practices.

Across the Europe and Central Asia region, solid waste services are the responsibility of municipalities in nearly all countries. Exceptions include Baku in Azerbaijan and Tbilisi in Georgia, where state-owned enterprises manage waste treatment and disposal. Waste collection systems vary; some cities use a contract model, where municipalities provide the service directly or through service contractors and collect waste fees; others adopt a franchise model, delegating both service provision and fee collection to private providers. In some cases, such as in Veneto, Italy, both systems coexist within the same region. In the ECA context, where affordability is generally good and service provision is well-monitored, no significant difference exists in service quality between the two models.

3.2.2 Waste Generation and Composition

The Europe and Central Asia region generated 415 million tonnes of municipal solid waste in 2022, a mean of 1.22 kilograms of waste per capita per day, which is the second highest per capita generation rate after the North America region (figure 3.7). This ranges from 3.27 kilograms per capita per day in Faroe Islands to 0.33 kilogram in Turkmenistan. Higher-income countries typically have higher waste generation rates.

Population growth in the region is slow, with many countries experiencing declining fertility rates, and in some cases, overall population decline (UNECE 2023). Additionally, the region is 73 percent urbanized,[5] meaning that changes in waste generation rates linked to population growth and urbanization are expected to occur at a slower pace compared to regions with higher projected growth and urbanization rates.

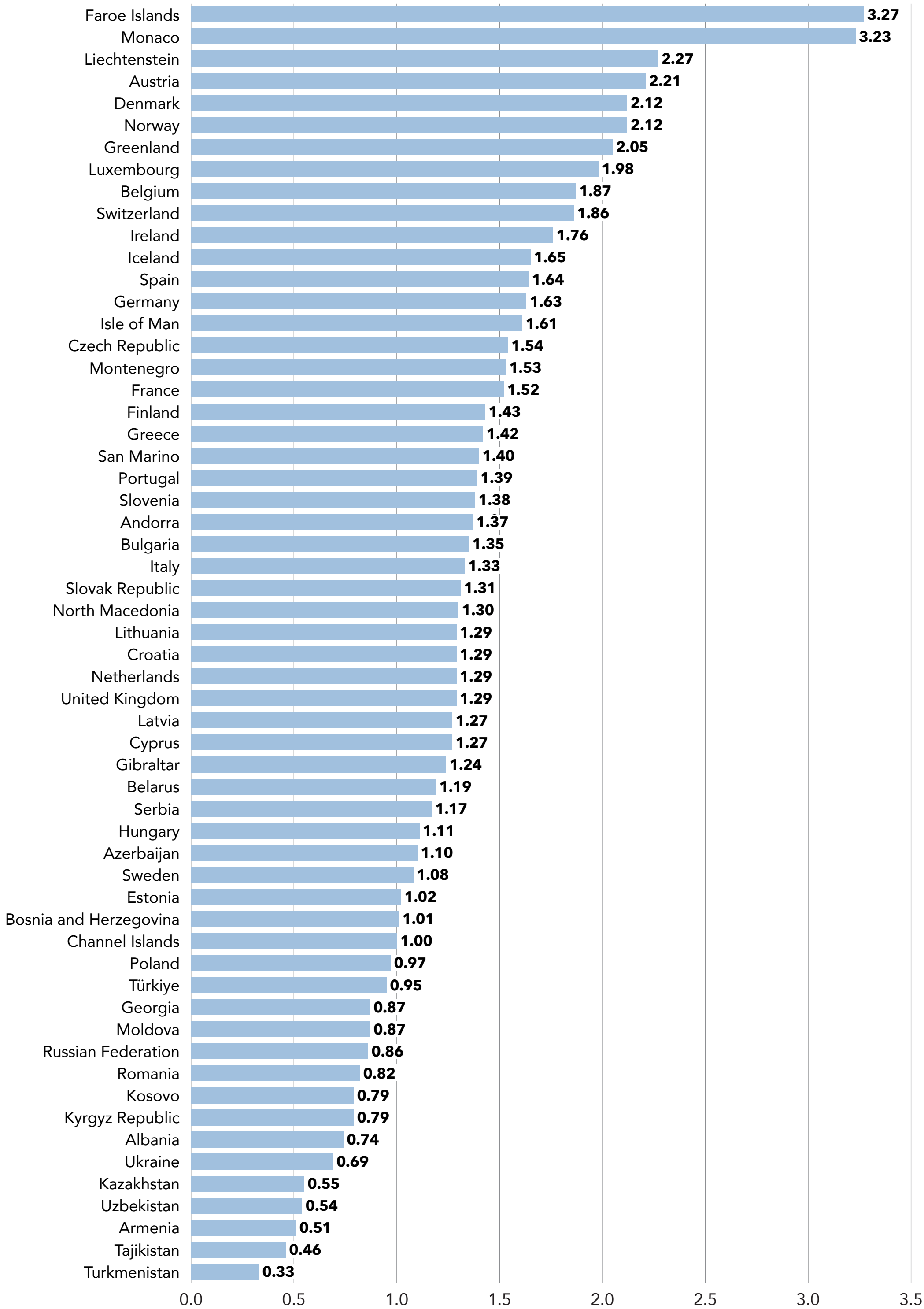
In the Europe and Central Asia region, organic waste—food waste, garden green waste and wood—comprises 41 percent of municipal solid waste (figure 3.8) which, alongside North America at 40 percent, is lower than the other regions. Proportions of other materials in the waste, including paper and cardboard at 18 percent and glass at 7 percent are among the highest across all regions. Taken together, materials typically used in packaging such as paper, plastics, and glass are 37 percent.

3.2.3 Waste Collection

The weighted average national waste collection rate in the Europe and Central Asia region is 96 percent, among the highest in the world (figure 2.11). Collection rates are higher in urban areas than in rural ones, with median values of 98 percent and 77 percent, respectively (figure 3.9). Rural collection rates vary widely, ranging from 13 percent to 100 percent, while urban rates range from 77 percent to 100 percent.

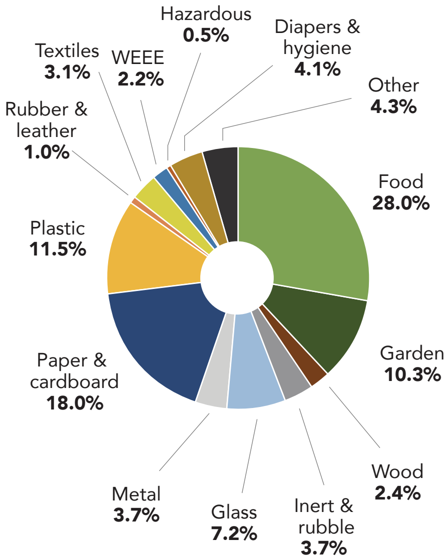
Collection rates across selected cities in the region are high, in most cases above 90 percent (figure 3.10). This reflects relatively strong municipal capacity, established service provision systems, and active municipal involvement in urban areas across the region. This high coverage may mask disparities in service quality and consistency, particularly in peri-urban or informal settlements.

Figure 3.7 Municipal solid waste generation in Europe and Central Asia



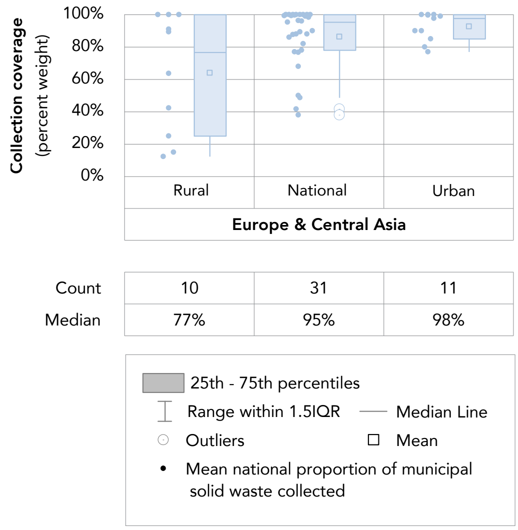
Source: Original figure for this report.
Note: Mean waste generation in kilogram per capita per day projected to 2022.

Figure 3.8 Composition of municipal solid waste in Europe and Central Asia



Source: Source: Original figure for this report.
Note: Weighted mean based on 2022 waste generation.
WEEE = waste electrical and electronic equipment.

Figure 3.9 Waste collection coverage in countries from Europe and Central Asia



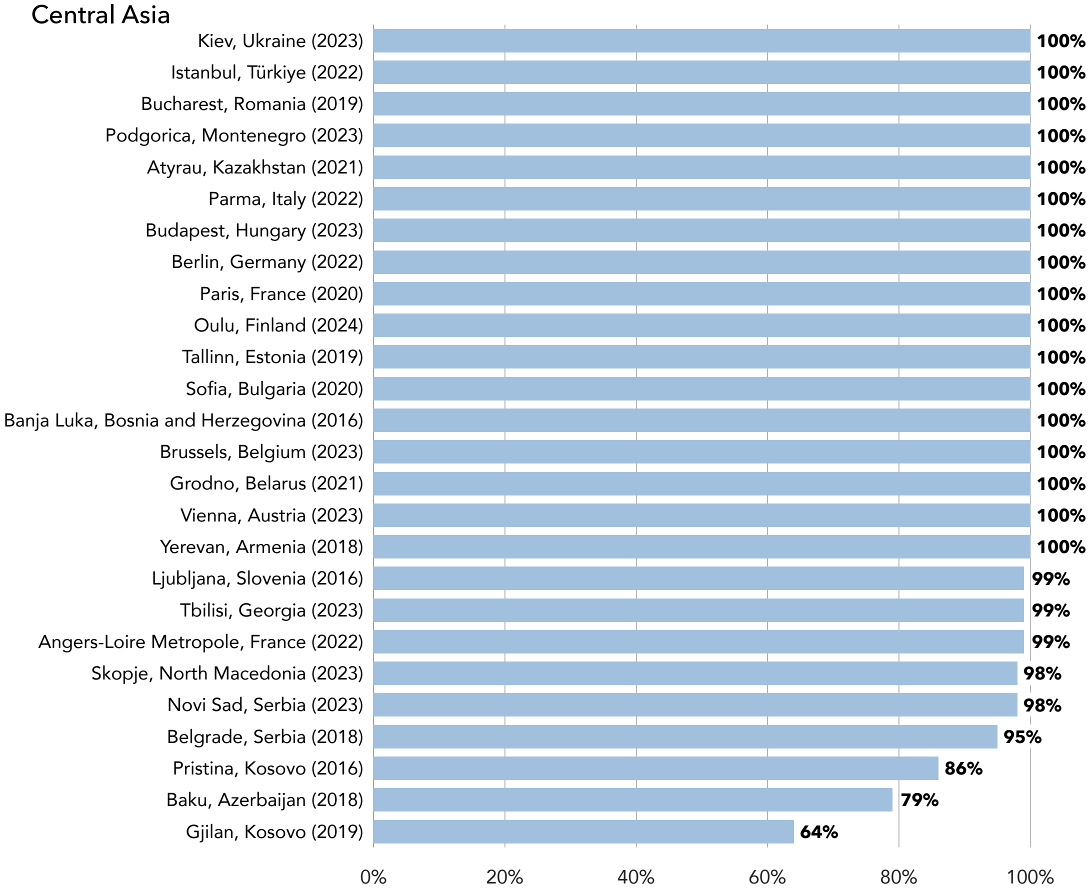
Source: Original figure for this report.
Note: Country dataset. Central tendency and spread of waste collection coverage in weight percent. Each dot refers to mean waste collection coverage at national, national urban, and national rural levels, based on data from different and inconsistent years. The summary statistics presented are not weighted, meaning that each country is counted equally regardless of its population size. As a result, these collection rates are not directly comparable to the regional weighted collection rate. Outliers are defined as values lying more than 1.5 times the interquartile range beyond the upper or lower quartiles. IQR = interquartile range.

3.2.4 Waste Treatment and Disposal

The majority of the 415 million tonnes of municipal solid waste generated annually in the region in 2022 was collected and sent to formal treatment or disposal facilities. However, an estimated 16 million tonnes remained uncollected, and 17 million tonnes were disposed of at dumpsites (figure 3.11). Europe and Central Asia treat a high proportion of their waste through recycling, composting, and anaerobic digestion—the highest share globally after North America. This strong performance is driven by legally binding recycling targets and restrictions on landfilling applied to EU Member States.

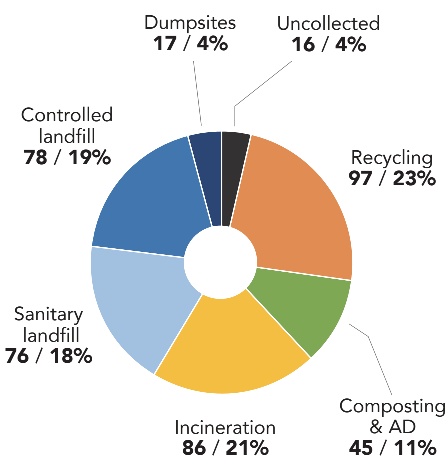
Despite the region's overall strong performance, significant disparities remain between high-income and middle-income countries. While EU Member States benefit from advanced infrastructure, robust policy frameworks, and enforcement mechanisms that support waste diversion, many non-EU countries still rely heavily on landfilling due to limited investment in waste treatment facilities and weaker regulatory oversight. Controlled landfills and even dumpsites remain prevalent in some parts of the region, particularly in rural areas, contributing to environmental and public health risks. Addressing these challenges will require targeted investments, capacity building, sustained financing, and public involvement, including improved environmental awareness, to enhance waste management practices across the entire region.

Figure 3.10 Municipal solid waste collection coverage for selected cities in Europe and Central Asia



Source: Original figure for this report.
Note: City dataset. Bars refer to the proportion of waste collected by weight in cities. Bracketed years indicate year that the measurement refers to.

Figure 3.11 Waste treatment and disposal in Europe and Central Asia



Source: Original figure for this report.
Note: Numbers refer to the amount of waste treated or uncollected in millions of tonnes per year. AD = anaerobic digestion.

3.3
Latin America and the Caribbean

KEY INSIGHTS

- Latin America and the Caribbean region generated 249 million tonnes of municipal solid waste in 2022, with a mean of 1.05 kilograms per capita per day.
- Some 48 percent of the waste generated is classified as organic—food, garden, wood—waste.
- Waste collection rates in the region are above the global average, with a weighted mean of 86 percent. In urban areas, the median waste collection coverage is 98 percent, compared to 38 percent in rural areas.
- Sixty-eight percent of the waste generated is disposed of in some form of landfill, and about 44 percent of waste is disposed of in sanitary landfills with environmental controls, suggesting a general focus on sustainable disposal methods.
- The region recycles six percent of waste, with the informal sector likely to play a large role in regional recycling rates. The informal waste sector contributes significantly to waste management in the region, and recognition and support are growing for informal workers as a part of overall waste management systems.

3.3.1 Background and Trends

Latin America and the Caribbean region consists of 42 countries across South and Central America and the Caribbean islands. The region had a population of 651 million in 2022 (UNDESA 2024) and consists of middle- and high-income countries, with four lower-middle-income, 20 upper-middle-income, and 18 high-income, as of 2022.

Waste management in the region is largely handled by local governments. However, many small island states have centralized systems, with national governments providing all waste services due to their size and limited local administrative capacity. Countries such as Antigua and Barbuda, Dominica, Grenada, Jamaica, and Saint Lucia have national waste management authorities or corporations.

In urban areas, a trend is growing toward source separation, separate collection, and waste recovery, particularly in cities with higher population density and stronger economic development. Land constraints, driven by population pressure and geographic features such as mountains or rainforests, have increased the urgency of identifying sites for final disposal. In rural areas and smaller cities, challenges persist with service coverage, continuity, quality, and informal practices within the system. In the Caribbean, awareness is growing about recycling and organic waste treatment as are strategies to ease pressure on limited disposal infrastructure. However, large scale, successful implementation remains limited, with only a few cases in island states, such as Aruba and Grenada.

South America is predominantly composed of upper-middle- and high-income countries, with diverse geographies. While waste generation has risen in recent years, collection systems have also improved, with most countries collecting over 80 percent of waste and only three falling below that threshold. Disposal practices vary, but where data are available, waste primarily goes to sanitary or controlled landfills. These landfills are increasingly being reimagined as waste treatment centers to reduce final disposal. Private sector involvement through concession systems is common, except in Bolivia and Uruguay, where state-owned companies or mixed public–private models are used. Extended producer responsibility for packaging is widely adopted across the subregion, with more materials being added, and most countries have national waste management plans in place.

Brazil, the largest country in the region, has a strong legislative framework with policies aimed at expediting landfill closures, increasing waste reutilization and recycling, preventing food waste, promoting composting, and reducing methane emissions from waste, which is the country's second largest source of methane. Extended producer responsibility for packaging materials is a key component of Brazil's National Solid Waste Policy, supported through partnerships between private actors and waste picker cooperatives. Brazil is considered a global reference for integrating informal waste pickers—*catadores*—into formal recycling systems, combining legal recognition, social inclusion, and environmental benefits. According to WIEGO (2021), *catadores* represent over a quarter of a million workers and are concentrated at the bottom of the income distribution, yet they drive Brazil's high recycling rates despite limited public infrastructure. The International Alliance of Waste Pickers estimates that 90 percent of recycling in urban areas is carried out by *catadores*, and Brazil's National Movement of Waste Pickers estimates their numbers may reach up to 800,000 (IAWP 2025). While many have been incorporated into more formal systems, many still work under informal and precarious conditions.

Central American countries range from lower-middle- to high-income. Waste collection coverage varies widely, from 42 percent in Guatemala (Alarcón Montero et al. 2023) to 89 percent in Costa Rica (Solid Waste and Circular Economy Hub 2021). Collected waste is primarily managed through some form of landfill—sanitary, controlled, or unspecified—with the remainder mostly disposed of in open dumpsites. Interest in organic waste management is growing, with all countries promoting it and Costa Rica and Mexico leading on initiatives. These two countries are also advanced in implementing extended producer responsibility programs, while others are exploring scalable models. In nearly all countries, private sector participation has been critical to waste operations, using varied delivery models.

The island states are predominantly upper-middle- and high-income but face distinct challenges due to limited land and frequent natural disasters. They generate the highest waste per capita, driven by high tourism and import dependency. This increases their vulnerability, especially during frequent hurricanes, and places added emphasis on resilience. The waste sector faces mounting pressure from high per capita generation, the need for debris management, and intensified marine pollution, including plastic washed ashore by sea currents. These challenges are compounded by small populations, limited land, and constrained manpower. With most development concentrated along the coast, landfills are often located there to reduce transportation costs and use flatter terrain for disposal. However, coastal landfills pose environmental risks, including contamination of beaches, reefs, wetlands, and groundwater—resources critical to local communities and the tourism sector (Phillips and Thorne 2023).

Within the Caribbean, Haiti faces additional political and institutional challenges as a fragile state. Waste is largely managed at the municipal level, with minimal government oversight or coordination. The sector is marked by weak regulation, limited infrastructure, and poor public management. In many urban areas informal waste pickers are the main providers of waste collection, serving households and businesses at low cost. In larger cities, some private companies manage collection, but most waste is illegally dumped in rivers and drainage canals, with little to no treatment or proper disposal. In other cases, waste is openly burned or buried, contributing to severe environmental pollution and greenhouse gas emissions (US ITA 2024).

Recycling has evolved unevenly throughout the region. Some countries with higher population densities and volumes of waste and with established regulatory frameworks and active secondary markets, such as Colombia, see higher recycling rates. While some smaller South American and Caribbean countries have found outlets, most have more nascent or limited recycling systems and face logistical, market and commercial constraints. The Caribbean also faces higher exposure to marine debris, especially plastics, due to its geographical location and tourism activity.

Although many countries in the region have implemented laws to govern waste management activities, effectively enforcing these laws remains a serious challenge. Weak institutional operation can be partly attributed to overlapping or lack of clearly defined responsibilities needed to support the legislative frameworks and compliance with the law often goes unmonitored, and noncompliance goes unpenalized. A common driving factor in countries including extended producer responsibility in their legislation is the ascension process to the OECD.

3.3.2 Waste Generation and Composition

Latin America and the Caribbean generated 249 million tonnes of municipal solid waste in 2022, at a mean of 1.05 kilograms per capita each day (figure 3.12); slightly higher than the global per capita mean. The Caribbean exhibits the highest mean daily generation of waste per capita, at 1.91 kilograms per capita per day, followed by South America at 1.01 kilograms—driven mainly by countries such as Argentina, Brazil, and Chile—and Central America at 0.91 kilogram. The British Virgin Islands, Barbados, and the Bahamas produced the greatest amounts of waste at 4.18, 3.95, and 3.59 kilograms per capita per day, respectively. Many of the highest waste generators are high-income Caribbean Island states with active tourist economies, whereas the lowest generators tend to be lower- or upper-middle-income countries.

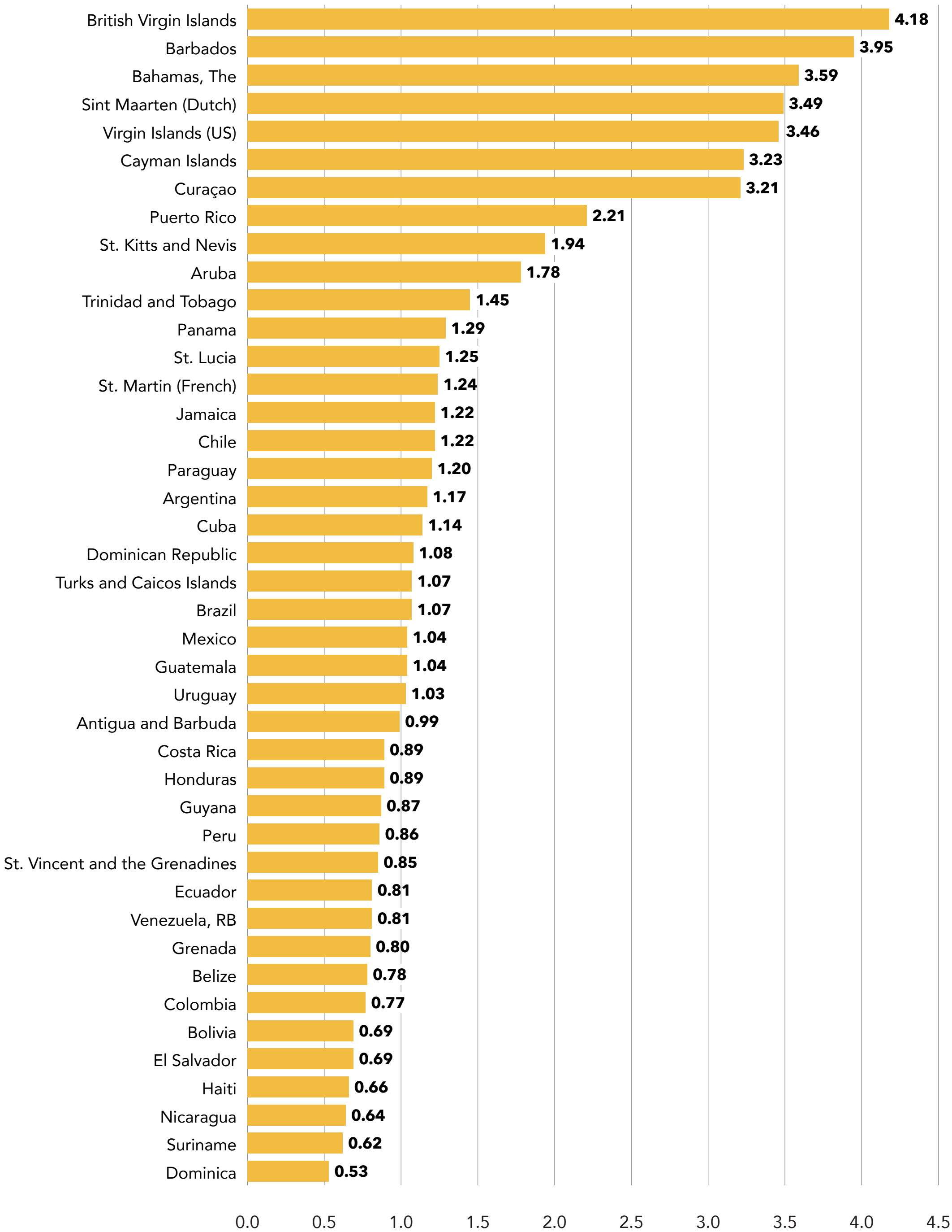
Just under half of the municipal solid waste generated in Latin America and the Caribbean region is food and garden waste. Food content tends to be higher in lower-income countries. Countries of Latin America and the Caribbean have the highest proportion of plastic waste at nearly 15 percent compared with the other regions, and it is followed by paper and cardboard at 11 percent. The rest is composed of materials such as glass, metals, electronic items, textiles, rubber and leather, inert waste, hazardous waste, wood, and diapers and hygiene waste ranging from less than 1 percent up to less than 5 percent (figure 3.13).

3.3.3 Waste Collection

The weighted mean national waste collection rate in the Latin America and the Caribbean region is relatively high at 86 percent (figure 2.11b). Collection rates are higher in urban areas than in rural ones, with median values of 98 percent and 38 percent, respectively (figure 3.14). Rural collection rates vary, ranging from 14 percent to 54 percent, while urban rates range from 61 percent to 100 percent.

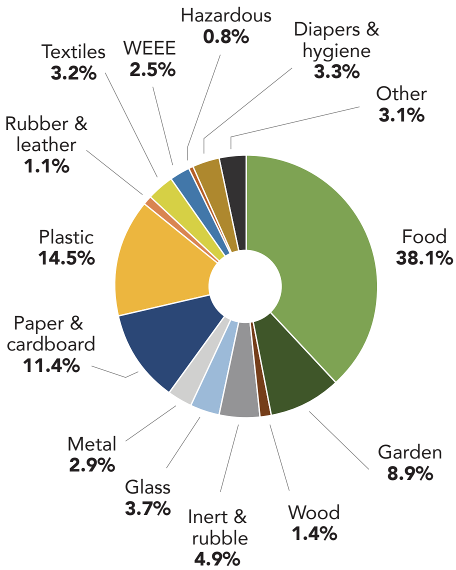
The total percentage of the waste collected is over 95 percent in Argentina (Alarcón Montero et al. 2023), Aruba (Aruba 2023), Chile (Alarcón Montero et al. 2023), Trinidad and Tobago (Alarcón Montero et al. 2023), and Uruguay (Solid Waste and Circular Economy Hub 2021) that are high- or upper-middle-income countries. At below 50 percent is Guatemala (Alarcón Montero et al. 2023), an upper-middle-income country, and Haiti (Solid Waste and Circular Economy Hub 2021), a lower-middle-income country (figure 3.14). Collection coverage varies considerably with rurality. The majority of cities studied had collection rates of over 90 percent (figure 3.15).

Figure 3.12 Municipal solid waste generation in Latin America and the Caribbean countries



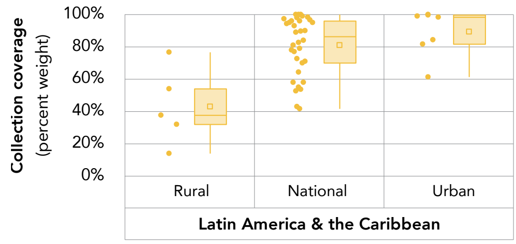
Source: Original figure for this report.
Note: Mean waste generation in kilogram per capita per day projected to 2022.

Figure 3.13 Composition of municipal solid waste in Latin America and the Caribbean



Source: Original figure for this report.
Note: Weighted mean based on 2022 waste generation. WEEE = waste electrical and electronic equipment.

Figure 3.14 Waste collection coverage in countries from Latin America and the Caribbean



	Rural	National	Urban
Count	5	34	7
Median	38%	86%	98%

25th - 75th percentiles
Mean
Range within 1.5IQR
Median Line
Mean national proportion of municipal solid waste collected

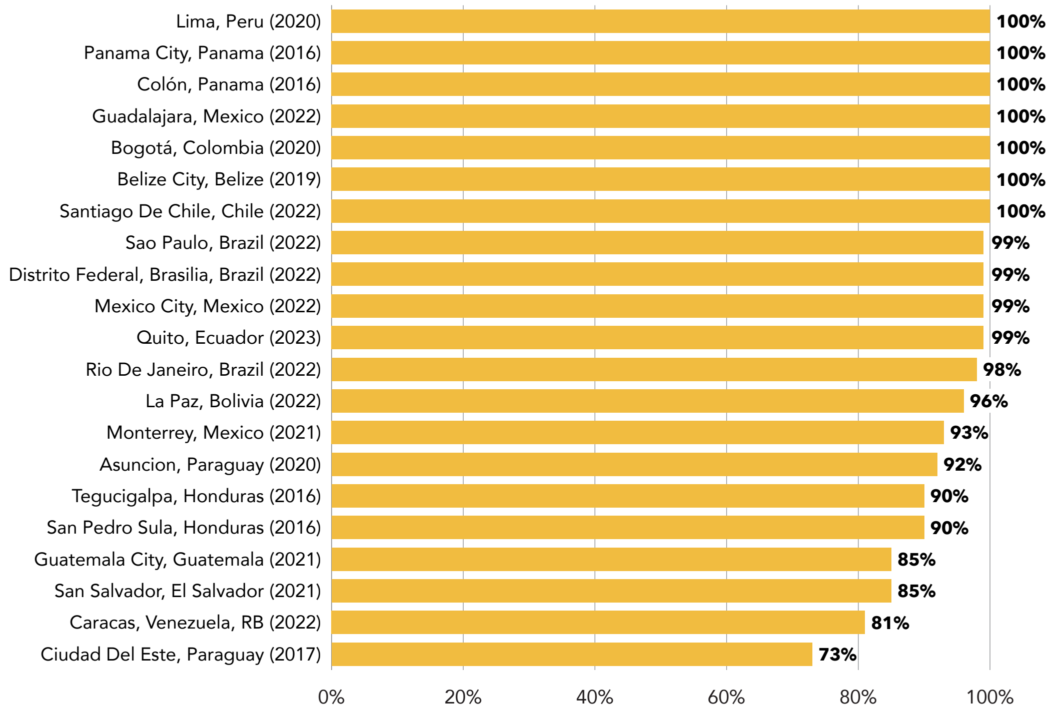
Source: Original figure for this report.
Note: Country dataset. Central tendency and spread of waste collection coverage in weight percent. Each dot refers to waste collection coverage at national, national urban, and national rural levels, based on data from different and inconsistent years. The summary statistics presented are not weighted, meaning that each country is counted equally regardless of its population size. As a result, these collection rates are not directly comparable to the regional weighted collection rate. IQR = interquartile range.

3.3.4 Waste Treatment and Disposal

Two-thirds or 166 million tonnes of municipal solid waste in Latin America and the Caribbean is disposed of in sanitary or controlled landfills (figure 3.16). Sanitary landfills have environmental controls and account for about 44 percent of waste disposal and treatment at 108 million tonnes. Twelve percent or 30 million tonnes of waste is disposed of in dumpsites that lack basic controls. Uncollected waste accounts for 14 percent at 35 million tonnes of total municipal solid waste generated. The most common form of self-management is open burning (figure 3.17). Other forms of self-management of municipal waste include dumping on land or in water bodies, burying, and home composting.

Formal recycling systems in Latin America and the Caribbean region are beginning to be implemented. Six percent or 16 million tonnes of municipal solid waste is recycled; this is likely to be almost entirely from the informal sector. Forty-seven percent of generated municipal solid waste in Latin America and the Caribbean is food and garden waste, but only 0.3 percent or one million tonne of the waste is composted

Figure 3.15 Municipal solid waste collection coverage for selected cities in Latin America and the Caribbean

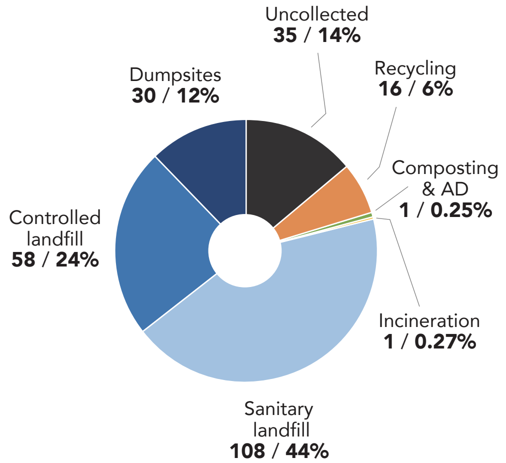


Source: Original figure for this report.
Note: City dataset. Bars refer to the proportion of waste collected by weight in cities. Bracketed years indicate year that the measurement refers to.

or disposed of by anaerobic digestion. Of the 39 selected Latin America and the Caribbean cities, eight had recycling systems in place. Of these, two also composted their waste. Mexico City, for example, recycles about 21 percent and composts about 13 percent of its waste (Government of Mexico City 2018).

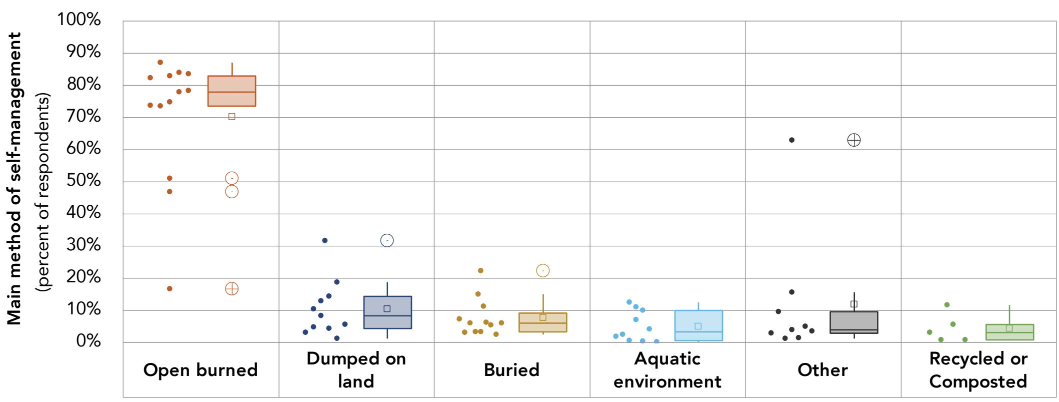
The data for uncollected waste are from respondents' reported data, primarily from surveys and census data (figure 3.17). Nearly 80 percent of respondents reported that the uncollected and self-managed waste is openly burned. Other forms of informal self-management are reported much less frequently, such as dumping on land at a median of 8 percent, burying of waste at 6 percent, disposal in water bodies at 3 percent, recycling or home composting at 3 percent, and miscellaneous other methods at 4 percent. These findings show continued reliance on informal methods, underscoring the need to strengthen collection systems and continue transitioning to safer, more inclusive and environmentally sustainable systems.

Figure 3.16 Waste treatment and disposal in Latin America and the Caribbean



Source: Original figure for this report.
Note: Numbers refer to the amount of waste treated or uncollected in millions of tonnes per year. AD = anaerobic digestion.

Figure 3.17 Self-management of uncollected municipal solid waste in Latin America and the Caribbean



	Open burned	Dumped on land	Buried	Aquatic environment	Other	Recycled or Composted
Count	13	11	12	10	9	5
Median	78%	8%	6%	3%	4%	3%

25th - 75th percentiles; Range within 1.5IQR; Median Line
Mean; Outliers; Extreme values
Mean national proportion of municipal solid waste main method of self-management

Source: Original figure for this report.
Note: Country dataset. Dots refer to the mean main method of self-management as reported by respondents in national surveys and censuses. Outliers are defined as values lying more than 1.5 times the interquartile range beyond the upper or lower quartiles. Extreme values are values lying more than 3 times the interquartile range beyond the upper or lower quartiles. IQR = interquartile range.

3.4
Middle East and North Africa

KEY INSIGHTS

- The Middle East and North Africa region generated 161 million tonnes of waste in 2022, the lowest total of any region, at a mean value of 0.90 kilogram per capita per day.
- The largest per capita waste generators are high-income countries and include countries from the Gulf Cooperation Council.
- The proportion of generated waste that is organic—food, garden, wood—is among the largest of global regions at 57 percent.
- National waste collection in the region is below global average with a weighted mean of 79 percent. Countries in the Gulf Cooperation Council (GCC) have waste collection rates of nearly 100 percent.
- The region is still heavily reliant on land disposal with some 70 percent of generated waste being disposed of in this way. One-third of total generated waste is disposed of in uncontrolled dumpsites.
- Recycling and composting occur on a small scale across many countries in this region including in both high- and lower-income countries. Despite the high fraction of organic waste, only 2 percent of generated waste is composted or anaerobically digested. Part of the GCC countries have more advanced recycling strategies, achieving up to 30 percent recycling levels.

3.4.1 Background and Trends

The Middle East and North Africa region consists of 21 countries spanning Morocco in the West to the Islamic Republic of Iran in the East. The region was home to a population of 493 million people in 2022 (UNDESA 2024).

The region is characterized by wide-ranging differences in income levels and political stability. About one-third of the countries are high-income countries, the vast majority are middle-income countries, whereas Republic of Yemen and Syrian Arab Republic are low-income countries. The differences in income levels translate into varied performance levels from universal waste collection and treatment or disposal in most high-income countries to significantly lower collection rates and the near absence of controlled disposal in some middle-income and low-income countries.

Six countries in the Middle East and North Africa region have fragile, conflict, and vulnerable status due to postconflict instabilities. Quite unique among global regions is that income levels among fragile, conflict, and vulnerable countries range from low-income to upper-middle-income levels. This creates conditions in some countries of relatively high waste generation levels combined with limited governance capacities.

The region is still heavily reliant on open dumping and landfilling for the disposal of municipal solid waste, with variation primarily in whether countries are using controlled landfills, sanitary landfills, or dumpsites (Thabit, Nassour, and Nelles 2023).

Nearly all countries have sector strategies that aim at diverting waste from disposal and enhancing waste recycling beyond existing levels, which are mostly achieved from private and informal sector activities. Consequently, most countries in the region stay below recycling rates of 10 percent. However, some countries are leading the way in recovering materials; for example, Oman has a 30-percent recycling rate (Oman NSCI 2022). A recent trend has been for countries to pursue incineration as a waste treatment option, with Algeria, Kuwait, Oman, Saudi Arabia, and the United Arab Emirates (UAE) having incinerator projects in the planning phase, although operational incineration capacity is still very limited (Thabit, Nassour, and Nelles 2023). For selected products, extended producer responsibility systems have become operational in some of the Gulf Cooperation Council (GCC) countries. Middle-income countries such as the Arab Republic of Egypt and Jordan are taking steps to introduce extended producer responsibility.

Waste management from collection to treatment and disposal typically is the responsibility of municipalities. Exemptions are Oman and UAE where state-owned companies provide collection, treatment and disposal services.

Collection services are commonly outsourced to private sector operators and increasingly involved in public–private partnership (PPP) arrangements such as in Qatar and Kuwait. In the Arab Republic of Egypt, the informal sector plays an important role in providing waste services, including in the capital city of Cairo.

3.4.2 Waste Generation and Composition

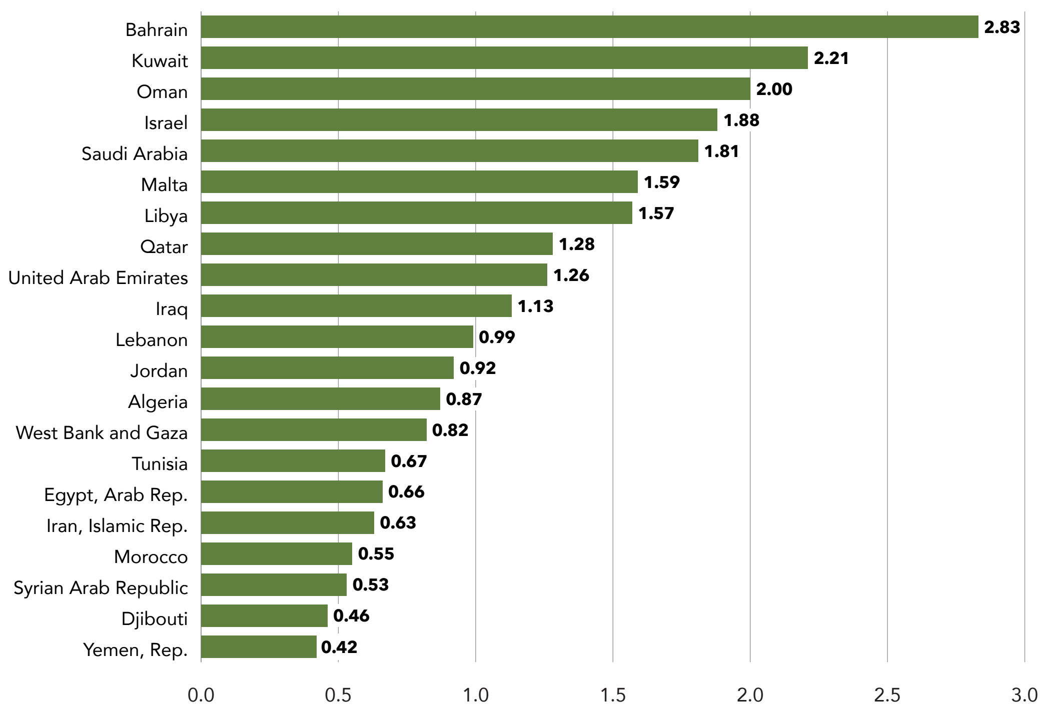
The Middle East and North Africa region generated the lowest amount of municipal solid waste in 2022 of any region at 161 million tonnes. The per capita waste generation is not the lowest however, at 0.90 kilogram per capita per day (figure 3.18). The highest waste generating countries in the region are high income and include the countries that make up the GCC—Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the UAE. The lowest generating countries are low- or lower-middle-income, for example, the Republic of Yemen, Djibouti, and the Syrian Arab Republic.

Organic waste from food, gardens, and wood waste account for 57 percent of municipal solid waste in Middle East and North Africa, the largest proportion of organic waste compared to other regions (figure 3.19) except for East Asia and Pacific. Food waste alone is 50 percent. Food waste accounts for nearly half of waste generated in the low-, lower-middle-, and upper-middle-income countries at 50 percent, 42 percent and 45 percent, respectively. The proportion is lower in high-income countries at 24 percent. Part of this difference is caused by the relatively higher quantities and, thus, fractions of nonorganic waste such as packaging waste in high-income countries but can also be attributed to higher consumption of ready-to-serve food and fast food, and so producing less food waste compared to lower-income countries where residents are more likely to cook at home (Thabit, Nassour, and Nelles 2023).

3.4.3 Waste Collection

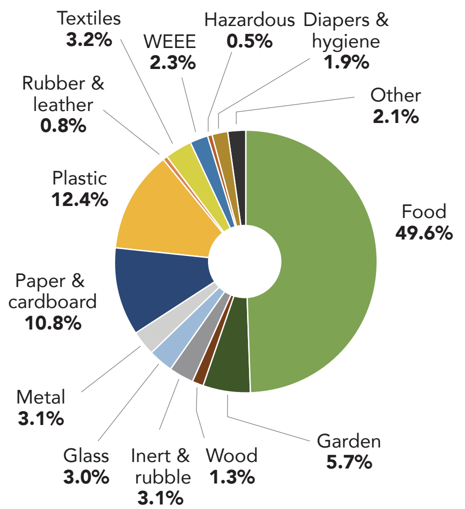
Municipal solid waste collection coverage is relatively high in the Middle East and North Africa region (figure 3.20). On a national level, the mean weighted waste coverage is about 79 percent (figure 2.11). Coverage is highest in urban areas, with a median waste collection coverage of 93 percent (figure 3.20). Rural coverage varies considerably. For example, five percent of waste is collected in rural Tunisia (GIZ and SWEEP-Net 2014), while 100 percent of rural populations and households have access to collection services in Kuwait,[6] Qatar (Qatar PSA 2022), and Malta (EEA 2022).

Figure 3.18 Municipal solid waste generation in the Middle East and North African countries



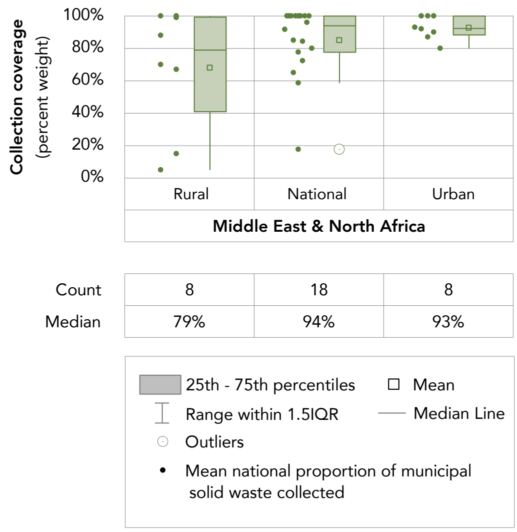
Source: Original figure for this report.
Note: Mean waste generation in kilogram per capita per day projected to 2022.

Figure 3.19 Composition of municipal solid waste in the Middle East and North Africa



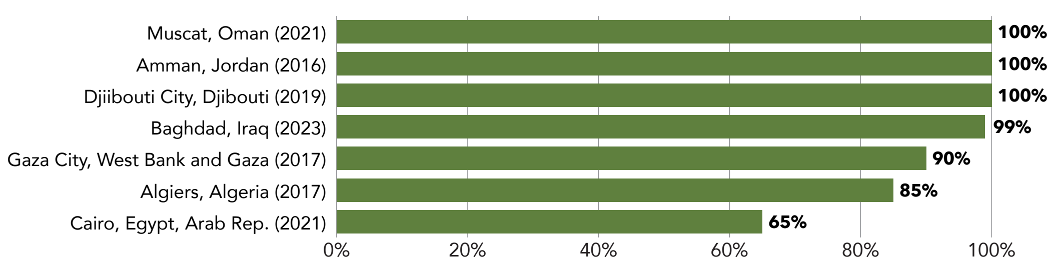
Source: Original figure for this report.
Note: Weighted mean based on 2022 waste generation.
WEEE = waste electrical and electronic equipment.

Figure 3.20 Waste collection coverage in countries from the Middle East and North Africa



Source: Original figure for this report.
Note: Country dataset. Central tendency and spread of waste collection coverage in weight percent. Each dot refers to waste collection coverage at national, national urban, and national rural levels, based on data from different and inconsistent years. The summary statistics presented are not weighted, meaning that each country is counted equally regardless of its population size. As a result, these collection rates are not directly comparable to the regional weighted collection rate. Outliers are defined as values lying more than 1.5 times the interquartile range beyond the upper or lower quartiles. IQR = interquartile range.

Figure 3.21 Municipal solid waste collection coverage for selected cities in the Middle East and North Africa



Source: Original figure for this report.
Note: City dataset. Bars refer to the proportion of waste collected by weight in cities. Bracketed years indicate the year that the measurement refers to.

The collection rate in cities varies—from 65 percent in Cairo, the Arab Republic of Egypt, to 100 percent in Muscat, Oman, and Amman, Jordan (figure 3.21). In most cases it is above 85 percent (figure 3.20), which reflects relatively strong municipal capacity, established service provision systems, and active municipal involvement in urban areas across the region. However, such high coverage may mask disparities in service quality and consistency, particularly in peri-urban or informal settlements.

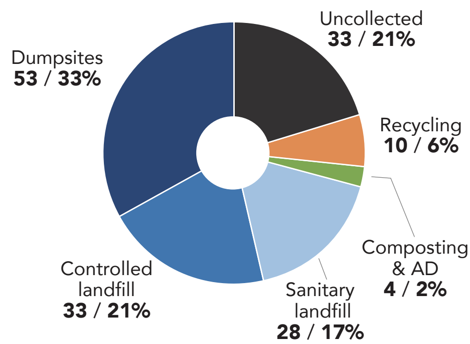
The informal waste sector is active in the Middle East and North Africa region, although data on the informal sector were only found for two out of 21 countries studied in this region—Jordan and the Republic of Yemen. Jordan, for example, reports 6,500 informal waste workers who salvage mainly recyclable or other valuable materials from final disposal sites (Taher, Abu Safe, and Patchett 2022).

The predominant method of collection varied between cities with no clear preferred method across the region. Sixteen of the 29 cities studied reported their primary waste collection methods. Three cities used curbside collections, another three used centralized drop-off points, while two others used door-to-door pickups. Eight cities used a mixture of methods.

3.4.4 Waste Treatment and Disposal

The majority of municipal solid waste generated—70 percent or 114 million tonnes—is disposed of in a land disposal site. Thirty-three percent or 53 million tonnes of all generated waste ends up at disposal sites that are not engineered landfills and effectively are operated as dumpsites (figure 3.22). Saudi Arabia treats about 88 percent of its waste in sanitary landfills, whereas Morocco and Oman are primarily reliant on controlled landfills to dispose their waste. However, 16 of the 21 countries continue to send most of their waste to unspecified landfills or dumpsites with limited or no controls.

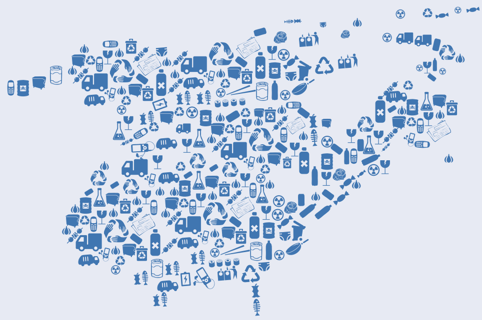
Figure 3.22 Waste treatment and disposal in the Middle East and North Africa



Source: Original figure for this report.
Note: Numbers refer to the amount of waste treated or uncollected in millions of tonnes per year. AD = anaerobic digestion.

Some level of recycling and composting occurs in the region, although it is relatively small scale; about 8 percent or 10 million tonnes of waste is recycled or composted amounting to four million tonnes. Of the 21 countries studied, 17 reported some amount of recycling activities ranging from 0.3 to 30 percent, whereas nine countries reported composting activity ranging from one to 20 percent.

Despite the relatively high regional waste collection coverage, roughly one-fifth of all waste generated remains uncollected. The highest percentage of uncollected waste is in the Republic of Yemen at 82 percent, although no data were found on what happens to this waste (UNEP 2019).



3.5
North America

KEY INSIGHTS

- The North America region generates the highest per capita municipal solid waste globally, at 2.25 kilograms per capita per day. In 2022, total waste generation reached 311 million tonnes annually.
- Organic waste—food, garden, and wood—accounts for less than 40 percent of the total and the lowest share among all regions, while engineered materials —plastics, paper, glass, and metals— make up nearly 47 percent, the highest proportion globally.
- Waste collection coverage in the region is reported to be the highest of all regions at 100 percent.
- Approximately 27 percent of waste is recycled, 15 percent is processed through composting or anaerobic digestion, and 12 percent is incinerated. Sanitary landfills receive 44 percent of waste and only 2 percent is disposed of in controlled landfills.
- Waste management is locally delivered in Canada and the United States, with regulatory oversight at the state or provincial level, whereas in Bermuda, services are centrally managed by the national government due to its small size and unified governance structure.

3.5.1 Background and Trends

The North America region comprises three countries: Bermuda, Canada, and the United States of America. In 2022, the region had a total population of 379 million. The United States accounted for the largest share with 341 million people, followed by Canada with 39 million, and Bermuda with approximately 65,000 (UNDESA 2024). All three countries in the region are high-income economies.

In Bermuda, waste management is overseen by the national government through a department within the Ministry of Public Works. Responsibilities include household waste and recycling collection, composting, waste treatment, and the handling of hazardous and special waste. This centralized approach reflects Bermuda's small size and unitary governance structure, with services managed at the national rather than local level.

In Canada and the United States, municipal solid waste collection is primarily managed at the local level. Services are either provided directly by public agencies or outsourced to private companies. Collection coverage is high in both countries, with most urban and suburban households receiving regular curbside pickup for waste, recyclables, and increasingly, organics. In rural and remote areas, service models vary; residents may rely on drop-off centers or subscription-based services, depending on local infrastructure and population density. Funding typically comes from a combination of user fees and property taxes. While approaches vary across states and provinces, both countries have been placing growing emphasis on diverting organic waste and implementing extended producer responsibility programs, particularly in Canada where most provinces have enacted extended producer responsibility legislation, compared to seven states[7] in the United States. Technology plays an important role, with many municipalities adopting route optimization and digital tracking systems to improve service efficiency.

In Canada, waste system modernization is notably driven by provincial leadership, with extended producer responsibility programs in place across most provinces for materials such as packaging, electronics, and hazardous products. Municipalities also advance organics diversion, with curbside collection of food and yard waste in many urban centers. These efforts, supported by federal initiatives like the Zero Plastic Waste Strategy (Canada MoECC n.d.), underscore Canada's multitiered approach to improving waste outcomes while reducing landfill reliance, methane emissions from the waste sector, and broader environmental impacts.

Single-stream recycling remains the dominant approach in many parts of the United States, primarily owing to the convenience it offers households by allowing all recyclables to be placed in a single bin. This system, widely adopted in the 2000s, helped increase participation rates and also introduced challenges related to contamination and higher processing costs at material recovery facilities. In recent years, some municipalities have begun re-evaluating their recycling strategies, with a few opting to revert to dual-stream systems to improve the quality of recovered materials (Ross and Law 2023). Unlike the United States, many Canadian municipalities have retained or reverted to dual-stream recycling, where paper products and containers—plastics, metals, glass—are sorted into separate bins or bags by residents. This approach, used to reduce cross-contamination and improve the quality and marketability of recovered materials, has been encouraged in a few jurisdictions, such as British Columbia.

Regional differences in landfill capacity and waste management practices are evident between the East and West coasts. On the East coast, limited landfill availability and land use constraints have led to a reliance on long-haul transportation for residual municipal solid waste. While the region maintains high recycling and incineration rates, significant volumes of residual waste remain. This waste is commonly compacted into sealed containers and transported by rail over very long distances, often exceeding 500 to 1,000 miles, to large regional landfills located in the Midwest and southern parts of the country. Known as mega landfills, they are designed to handle high quantities and accept waste from multiple states. By contrast, the West coast generally has more in-state landfill capacity and less reliance on long-distance transport. Waste is primarily hauled by trucks to regional landfills. States on the West coast also tend to implement more aggressive waste diversion policies, including mandatory organics diversion programs, reducing overall landfill dependence and promoting a more self-contained waste management system. In many parts of the U.S. Midwest, Mountain West, and Southeast, solid waste management remains limited to a low cost, disposal-only model centered on landfilling, with little progress toward more integrated or circular approaches. Landfill capacity in Canada is generally sufficient at the provincial level, reducing the need for long-haul waste transport seen in the United States. However, intermunicipal waste transfer and use of regional facilities is common, particularly in densely populated regions. Provinces like British Columbia and Quebec have also adopted ambitious diversion targets, including mandatory diversion of organics and certain recyclables from landfilling, supported by enforcement mechanisms and provincial targets.

At the institutional level, states in the United States and provinces and territories in Canada are responsible for the policy and regulatory frameworks that govern local governments in handling solid waste. They set environmental standards, issue permits, and oversee compliance for facilities including landfills, composting plants, and incineration facilities. In Canada, provinces also typically lead the design and implementation of extended producer responsibility systems and set provincewide diversion targets. In the United States, recycling is managed at state level, with no federal laws that mandate collection for recycling and no federally implemented recycling targets (Schultz and Hildreth 2020). That said, the United States Environmental Protection Agency (US EPA) oversees a national recycling strategy that encourages states to adopt circular economy principles, although no federal recycling mandate exists (US EPA 2024). Canada's federal government provides funding for pilot projects, community initiatives, and infrastructure aimed at reducing landfilling and improving resource efficiency. It also collaborates with provincial, territorial, municipal, and Indigenous partners to develop and implement standards on shared issues such as the management of plastics and mercury from used fluorescent lights (Canada MoECC 2024).

3.5.2 Waste Generation and Composition

The North America region generated 311 million tonnes of municipal solid waste in 2022, with an average of 2.25 kilograms per capita per day (figure 3.23). This represents the highest per capita waste generation of all regions globally, by a significant margin. The second highest, Europe and Central Asia, reported a per capita rate of 1.22 kilograms per day. Among the three countries in the region, Bermuda has the highest per capita waste generation rate of 3.15 kilograms per day.

Food waste accounts for 22 percent of municipal solid waste in North America; the lowest share among all regions globally. By contrast, garden waste at 11 percent and wood waste at over 6 percent represent the highest proportions among all regions (figure 3.24). Inert and rubble waste is relatively low, making up less than 1 percent, compared to over 3 percent reported in other regions.

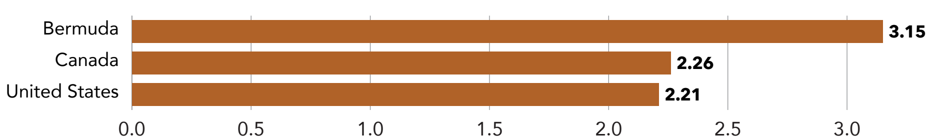
Among engineered materials,[8] paper, and cardboard represent a substantial share, accounting for 22 percent of the overall waste stream. In the United States, this share is 23 percent, although it was much higher in 2010 at 28 percent (US EPA 2020). The decline reflects reduced use of paper-based products, such as newspapers and office paper, due to the increasing shift toward digital communication and electronic media (US EPA 2025).

3.5.3 Waste Collection, Treatment, and Disposal

Waste collection coverage in the region is 100 percent. Of the 311 million tonnes of municipal solid waste per year generated in the region in 2022, 138 million tonnes were sent to sanitary landfill, 84 million tonnes were recycled, 46 million tonnes were composted or sent for anaerobic digestion, and 36 million tonnes were incinerated (figure 3.25). This region has the highest proportion of both recycling and composting and anaerobic digestion treatment routes of all regions.

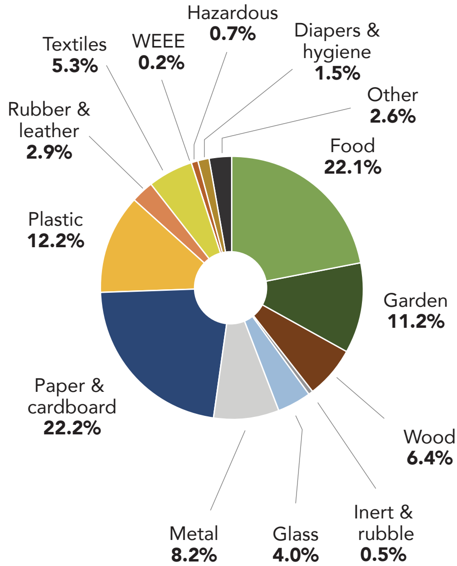
In Bermuda, nonrecyclable municipal solid waste is sent to a waste-to-energy facility on the island. Recyclable materials are transported to a material recovery facility, where they are sorted and then exported to the United States for processing, except for glass, which is used for drainage and backfill on the island. Special waste streams are also shipped to the United States for further treatment and disposal (Government of Bermuda 2025).

Figure 3.23 Municipal solid waste generation in North American countries



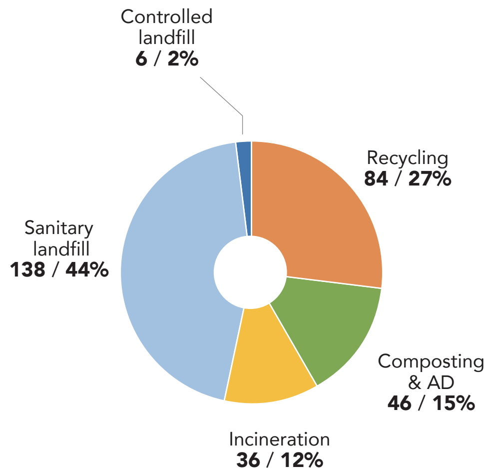
Source: Original figure for this report.
Note: Mean waste generation in kilogram per capita per day projected to 2022.

Figure 3.24 Composition of municipal solid waste in North America



Source: Original figure for this report.
Note: Weighted mean based on 2022 waste generation. WEEE = waste electrical and electronic equipment.

Figure 3.25 Waste treatment and disposal in North America



Source: Original figure for this report.
Note: Numbers refer to the amount of waste treated or uncollected in millions of tonnes per year. AD = anaerobic digestion.

3.6 South Asia

KEY INSIGHTS

- South Asia region generated 346 million tonnes of municipal solid waste in 2022, with an average generation rate of 0.49 kilogram per capita per day, lower than the global average of 0.88 kilogram per capita per day, and the lowest globally.
- Approximately 46 percent of waste in South Asia is organic—food, garden, and wood waste—whereas engineered materials of plastics, paper, glass, and metals make up 36 percent.
- An estimated 67 percent of waste, weighted mean, is collected, primarily through door-to-door systems. In urban areas, the medium waste collection coverage is 88 percent, compared to 54 percent in rural areas.
- Of the waste generated, 38 percent is disposed of in dumpsites, and 6 percent in controlled landfills. Composting and anaerobic digestion account for 11 percent of waste treatment, recycling accounts for another 11 percent, and 3 percent is incinerated.
- The uncollected waste, which represents one-third of the total generated in the region, is reported to be mainly openly burned.
- Informal waste collection is prevalent across South Asia, with informal workers playing a key role alongside formal employees in most countries.
- Countries in the region are gradually strengthening their regulatory and institutional structures, including implementing single-use plastic bans and localized waste management policies, although enforcement remains a challenge.
- India has embarked on the Swachh Bharat Mission, a large-scale national campaign to improve urban sanitation and solid waste management, with a focus on full door-to-door collection, source segregation, informal sector integration, and landfill remediation.

3.6.1 Background and Trends

South Asia comprises eight countries with a combined population of approximately 1.9 billion in 2022 (UNDESA 2024). India, with 1.4 billion people, accounts for 74 percent of the region's population and generates about 58 percent of its municipal solid waste. Most countries are classified as lower-middle-income, except Afghanistan as low-income and the Maldives as upper-middle-income. The region is the most densely populated globally, with 492 people per square kilometer as of 2022, and the least urbanized, with only 36 percent of its population living in urban areas as of 2022.[9]

Waste collection services in the region are concentrated in urban areas, while rural areas have limited or no formal coverage. In the absence of organized collection systems, waste is often dumped or openly burned as a common method to reduce waste quantity. In semi-urban and rural areas, the self-management of biodegradable waste is encouraged through methods such as aerobic composting or anaerobic digestion, with the latter also enabling methane production for cooking purposes. Bhutan and Sri Lanka have introduced some structured approaches to source segregation. Across the region, other countries' practices of separating recyclables for sale to itinerant waste buyers are common. Infrastructure to support source segregation—such as for storage, transport, and processing—remains limited while secondary manual sorting is common.

The informal sector plays a central role in waste collection and sorting. Informal workers extract valuable materials at various points along the waste management chain: (1) directly from households and commercial generators; (2) at communal disposal points and transfer stations; and (3) at dumpsites and landfills. Despite their contribution to the functioning of urban waste flows and materials recovery, informal waste workers are rarely recognized. They often work without legal status, face social stigma, and lack access to occupational protections or economic security. While informal recovery and recycling activities are extensive, municipal authorities have generally not established systematic mechanisms to engage with or integrate these actors. Exceptions exist, notably in India, where cooperatives and self-help groups could be an integral part of waste management systems mainly providing door-to-door collection. For example, in Pune, India, waste picker cooperatives are formally recognized and engaged by the municipality to provide door-to-door collection and recycling.

Disposal practices across the region are dominated by the use of unmanaged and, to a lesser extent, controlled sites. An estimated 38 percent of waste is disposed of in uncontrolled dumpsites with no environmental controls in place. Engineered sanitary landfills are uncommon, and where they do exist, operational performance remains below standards. The paucity of infrastructure also leads to waste being directly dumped into drains, gullies, and waterways. Open burning is widespread and significantly contributes to both local and regional air pollution. Several incidents of waste disposal sites' failures have been reported in recent years, resulting in fatalities and raising concerns about the safety and environmental risks associated with poorly managed disposal facilities.

Solid waste management responsibilities in South Asia are typically assigned to local governments. The capacity of local authorities to manage waste systems varies and is influenced by governance challenges in the sector. The challenges include gaps in regulatory oversight, planning, implementation, and financial resourcing, as well as levels of public compliance and participation. Initiatives targeting specific waste streams, such as bans on single-use plastic bags, although present in all countries in the region, encounter implementation challenges related to public awareness, enforcement capacity, and the availability of alternatives. Funding for the sector remains limited. Solid waste management fees are rarely collected across South Asia and in most areas, fees are set at levels insufficient to fully recover service costs.

India, Bangladesh and Pakistan together account for 97 percent of the municipal solid waste generated in the South Asia region.

Unlike most federal systems where waste management is primarily led by provincial or state authorities, India stands out for the strong involvement of its central government in shaping and advancing the sector. While urban local bodies are responsible for operational functions such as collection, segregation, transportation, and disposal as is standard practice globally, the central government in India goes beyond providing policy direction and financial support. It plays a key role in steering sectoral reforms and driving national level initiatives. Additionally, the federal level pollution control authority, the Central Pollution Control Board, exercises strong oversight, setting standards, monitoring compliance, and supporting state and local bodies, which reinforces regulatory enforcement and technical capacity across the country.

India has embarked on an ambitious national initiative to address urban sanitation and solid waste management challenges through the Swachh Bharat Mission, launched in 2014. Its second phase, launched in 2021, places greater emphasis on waste management and implementation of the Solid Waste Management Rules 2016 aiming at achieving service saturation with full door-to-door collection, source segregation, and processing of municipal solid waste. The mission encourages integration of informal waste workers and behavior change, incentivized by central financial assistance and a performance monitoring framework (box 3.2). Several initiatives such as the Waste-to-Energy Program, Gobardhan, and the Sustainable Alternative Towards Affordable Transportation promote the production of biogas from organic waste, including municipal solid waste. While primarily focused on clean energy, these initiatives contribute to improved waste processing.

India has launched large-scale dumpsite closure and reclamation programs to address legacy waste accumulated across thousands of dumpsites nationwide. According to the Central Pollution Control Board (2024), the quantity of legacy waste was 461 million tonnes in 2,244 dumpsites as of June 2023. National regulations mandate urban local bodies to remediate such sites, and many cities have undertaken projects to reclaim land and recover materials. This represents the largest dumpsite mining effort underway anywhere in the world. Internationally, while landfill mining is acknowledged as technically feasible, it has generally been undertaken in a limited number of cases, primarily where land values are high and where the cost and complexity of meeting environmental standards and preventing secondary contamination can be justified.

City-level progress under the mission is monitored through the annual Swachh Survekshan—cleanliness survey—which rates urban areas based on a range of sanitation and solid waste indicators. The survey is one of the world's largest cleanliness assessments, involving thousands of field staff, evaluators, and citizen feedback across hundreds of cities.

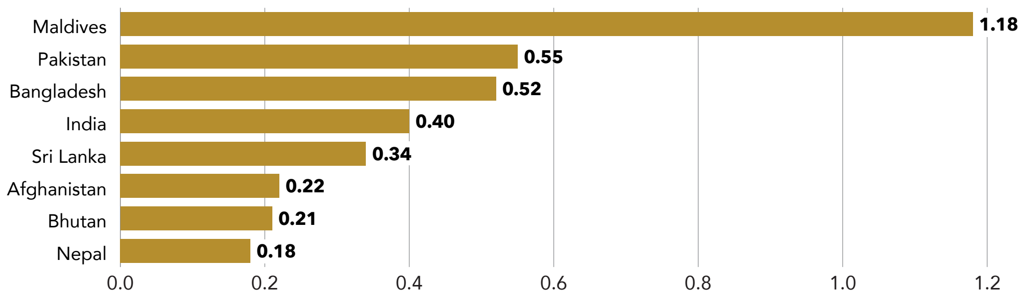
Alongside India, Bangladesh and Pakistan—the other two heavily populous countries in South Asia—are experiencing increasing pressure on their municipal solid waste management systems owing to population growth, urbanization, and economic development. In both countries, waste collection coverage is higher in major cities but remains limited in rural areas. Open dumping and burning are common practices, largely due to inadequate infrastructure for waste processing and modern disposal. Informal actors contribute to recycling and composting, with varying degrees of coordination with local authorities. In Bangladesh, recent efforts focused on developing long-term strategies, including the 2021 Solid Waste Management Rules, which introduced extended producer responsibility and the national 3R strategy[10] to improve service delivery and optimize waste collection and transportation. In Pakistan, waste management responsibilities are distributed across national, provincial, and local levels, with dedicated entities operating in provinces such as Khyber Pakhtunkhwa, Punjab, and Sindh. The Suthra Punjab Program, launched in 2024, is a phased initiative aimed at expanding collection coverage and implementing performance monitoring. Private sector participation is notable in the provinces of Punjab and Sindh, where a substantial share of waste collection and transportation services are handled by private operators. This involvement remains concentrated in front-end services, with no prevailing engagement in waste processing or treatment activities.

3.6.2 Waste Generation and Composition

The South Asia region generated an estimated 346 million tonnes of municipal solid waste in 2022 with a mean of 0.49 kilogram per capita per day (figure 3.26). This is close to half the global mean of waste generation per capita. All countries in this region except Maldives generate less than the global average of waste per capita. The Maldives is the only upper-middle-income country in the region that generates 1.18 kilograms per capita daily.

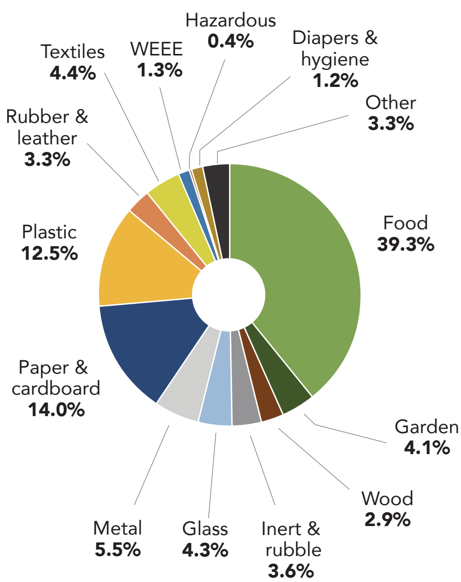
Just under 40 percent of municipal solid waste in this region is food waste, with another four percent being garden waste (figure 3.27). Approximately 36 percent of this waste is plastic, paper and cardboard, glass and metal. This region is dominated by the data from India,[11] being the most populous country in the world. As expected, the composition is roughly in line with the composition of lower-middle-income countries, which is how the majority of countries in this region are categorized.

Figure 3.26 Municipal solid waste generation in South Asian countries



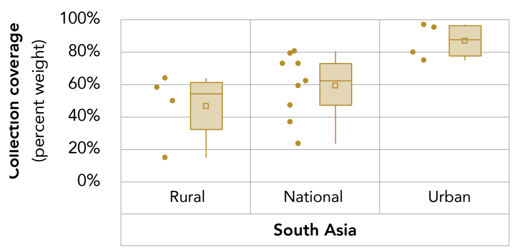
Source: Original figure for this report.
Note: Mean waste generation in kilogram per capita per day projected to 2022.

Figure 3.27 Composition of municipal solid waste in South Asia

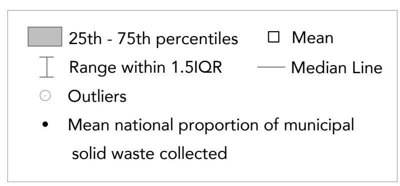


Source: Original figure for this report.
Note: Weighted mean based on 2022 waste generation. WEEE = waste electrical and electronic equipment.

Figure 3.28 Waste collection coverage in countries from South Asia



	Rural	National	Urban
Count	4	9	4
Median	54%	62%	88%



Source: Original figure for this report.
Note: Country dataset. Central tendency and spread of waste collection coverage in weight percent. Each dot refers to waste collection coverage at national, national urban, and national rural levels, based on data from different and inconsistent years. The summary statistics presented are not weighted, meaning that each country is counted equally regardless of its population size. As a result, these collection rates are not directly comparable to the regional weighted collection rate. IQR = interquartile range.

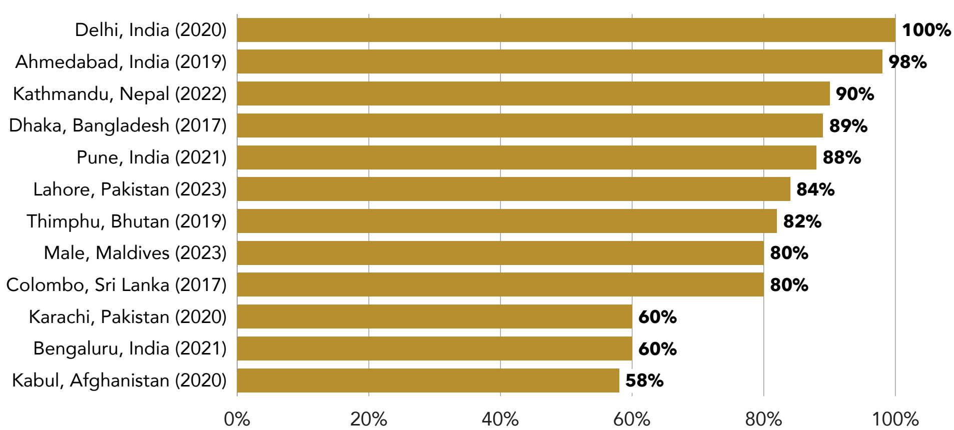
3.6.3 Waste Collection

The weighted mean national waste collection rate in the South Asia region is 67 percent (figure 2.11). As with other regions, collection rates are higher in urban areas than in rural ones, with median values of 88 percent and 54 percent, respectively (figure 3.28). Urban collection rates range from 75 to 97 percent. Data on rural areas are limited, with only four countries reporting in the region. Of those countries where rural collection rates were reported, the collection coverage range is 15 to 64 percent.

Informal waste collection is very common in South Asia; however, a limited amount of statistical data are available. All countries in South Asia have informal waste workers in addition to formal employees. Pakistan reports approximately 196,000 employed in water supply, sanitation, and waste management and remediation activities, of which approximately 3,100 are women (PBS 2021). A common municipal waste collection method in South Asian cities is door-to-door collection as in Indian cities, in the Maldives, Dhaka, Bangladesh, and Kabul, Afghanistan.

Collection rates can vary between cities in the same country. Ahmedabad in India reported a 98-percent collection rate in 2019 (Ahmedabad SWMD n.d.) similar to other high-performing cities such as Surat, Indore, and Chandigarh. Collection rates in India have been improving and are now reported at 95 percent in urban areas (CPCB 2021). Karachi, Pakistan reported lower collection rate of 60 percent similar to Kabul, Afghanistan (World Bank 2020; Ullah et al. 2023; see figure 3.29).

Figure 3.29 Municipal solid waste collection coverage for selected cities in South Asia

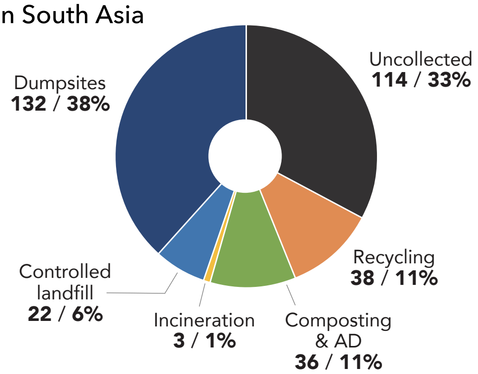


Source: Original figure for this report.
Note: City dataset. Bars refer to the proportion of waste collected by weight in cities. Bracketed years indicate year that the measurement refers to.

3.6.4 Waste Treatment and Disposal

In the South Asia region, a total of 71 percent of municipal solid waste is either uncollected or ends up on dumpsites (figure 3.30). The remainder of the waste is collected and treated in a more sustainable way, with 6 percent transported to controlled landfills, 1 percent incinerated, and the rest, 22 percent, recycled and composted. Afghanistan and Bhutan lead recycling efforts in the region, with Bhutan recycling just under a quarter of its municipal solid waste (Bhutan NSB 2019; 2021) and Afghanistan recycling just under 20 percent (Afghanistan NEPA 2019). Sri Lanka composts 14 percent of its waste and incinerates almost 9 percent in a facility in Colombo (Sri Lanka MoE 2021).

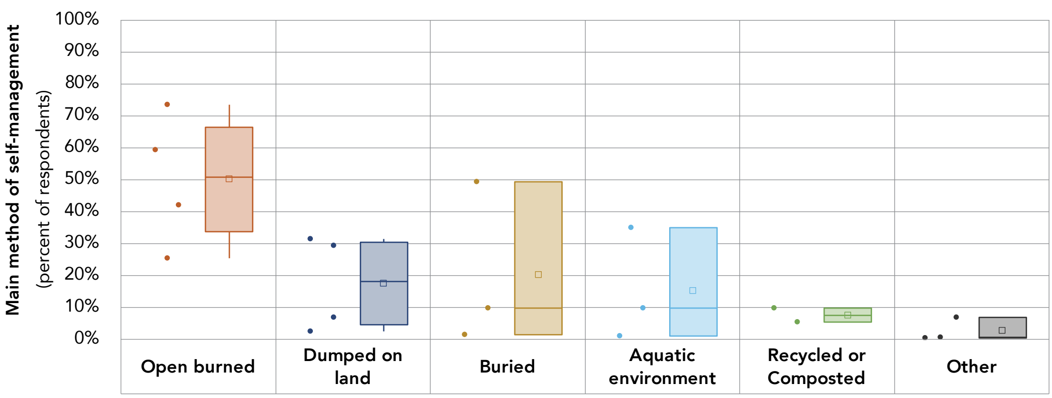
Figure 3.30 Waste treatment and disposal in South Asia



Source: Original figure for this report.
Note: Numbers refer to the amount of waste treated or uncollected in millions of tonnes per year. AD = anaerobic digestion.

Due to the large proportion of uncollected waste—a third of municipal solid waste generated—various forms of self-management occur in South Asia (figure 3.31). The most common form of self-management is open burning. Uncollected waste in Bhutan is reported to be commonly buried, whereas in the Maldives, waste is more often dumped in aquatic environments. Bhutan and Sri Lanka also compost or recycle some of their uncollected waste.

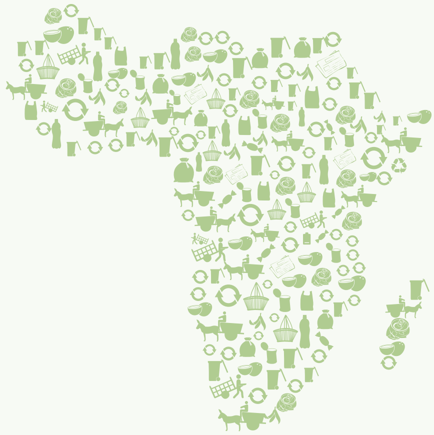
Figure 3.31 Self-management of uncollected municipal solid waste in South Asia



	Open burned	Dumped on land	Buried	Aquatic environment	Recycled or Composted	Other
Count	4	4	3	3	2	3
Median	51%	18%	10%	10%	8%	1%

25th - 75th percentiles | Range within 1.5IQR | Median Line | Mean
• Mean national proportion of municipal solid waste main method of self-management

Source: Original figure for this report.
Note: Country dataset. Dots refer to the mean main method of self-management as reported by respondents in national surveys and censuses. IQR = interquartile range.



3.7
Sub-Saharan Africa

KEY INSIGHTS

- Sub-Saharan Africa generated 231 million tonnes of municipal solid waste in 2022, representing 9 percent of global waste generation. With a mean per capita generation rate of 0.52 kilogram per capita per day, similar to that in South Asia, the region has one of the lowest rates globally.
- The proportion of organic waste—food, garden, wood—is 50 percent whereas engineered materials—plastic, paper and cardboard, glass and metal—make up 31 percent of the waste stream.
- Sub-Saharan Africa has the lowest overall waste collection rate of any region, with a weighted mean of 31 percent. While median collection coverage in urban areas is higher at 45 percent, it drops to just 6 percent in rural areas. As a result, more than two-thirds of the waste generated in the region remains uncollected and is disposed of mainly through open dumping and burning. Uncollected and scattered waste obstructs drainage systems and significantly exacerbates flooding, especially in areas with unplanned development and limited waste and stormwater management systems.
- Collected waste is primarily placed in open dumpsites, with only 5 percent of total waste managed in sanitary landfills. Recycling is low, with only 2 percent of generated waste recycled.
- Waste generation in Sub-Saharan Africa is projected to increase 2.24 times by 2050—the fastest rate globally—driven by rapid population growth, urbanization, and economic development, placing increasing pressure on already constrained waste management systems.
- Key barriers to improving waste management in Sub-Saharan Africa include low policy and planning priority, insufficient financing, limited institutional and technical capacity, weak governance, inadequate infrastructure and equipment, and limited public awareness and participation. Chief among these is lack of prioritization in development planning, and inadequate financial resources for operation and maintenance.

3.7.1 Background and Trends

Sub-Saharan Africa comprises 48 countries, 22 of which are classified as low income, the highest number of any region globally. The region also includes 19 lower-middle-income countries, six upper-middle-income countries, and one high-income country, Seychelles as of 2022. In 2024, 12 countries in the region were designated fragility and conflict-affected areas. The population in Sub-Saharan Africa was approximately 1.2 billion in 2022 (UNDESA 2024).

In 2022, Sub-Saharan Africa had one of the lowest per capita waste generation rates and accounted for less than a tenth of the global municipal solid waste.

Waste generation is positively correlated with population growth, economic development, and urbanization—all of which are undergoing rapid change in Sub-Saharan Africa. The region's population is projected to double by 2050, and urbanization is expected to increase significantly. Although Sub-Saharan Africa has one of the lowest urbanization rates globally, it has recorded the fastest pace of urban growth over the past six decades. By midcentury, more than 1.26 billion people are projected to reside in urban areas, over 2.5 times the urban population in 2023 (Combes et al. 2023). Consequently, solid waste generation is expected to increase by a factor of 2.24, the fastest growth among all regions.

Solid waste management in the region is typically the responsibility of local governments and is delivered either directly by municipal authorities or through private sector providers. These providers operate under service contracts with local authorities or franchise arrangements in which service zones are assigned to them and fees are collected directly from households. An unintended consequence of the franchise model is that, in the absence of strong municipal oversight, areas with lower ability to pay are left unserved or receive lower quality, less frequent waste collection services. In many cities, public and private operators function in parallel, with some municipalities deliberately maintaining both types of providers to mitigate the risk of service failure by a single provider. Commercial and business establishments are most often served by private providers. This, for example, is the case in Kampala, Uganda, where the municipality services households in lower-income areas, while private operators serve the rest of the city, including commercial customers.

The public waste management system in the region typically begins at the secondary, communal collection or transfer point, and extends through treatment and final disposal. Primary collection—from households to communal collection or transfer points—is handled by community-based enterprises, small and medium enterprises, or individual collectors. These providers usually charge service fees directly to households and retain the revenues. In certain cities, such as Maputo, Mozambique, the municipality has successfully integrated the informal sector. Under its system, community-based enterprises operate on municipal contracts, and the municipality is responsible for collecting service charges from households. Fees in the region charged by community-based enterprises and small and medium enterprises generally range from US$10 to US$50 per household per year. Such fees often remain below the affordability threshold of 1 to 1.5 percent of household disposable income, which is commonly used as a benchmark for assessing affordability of solid waste management services.

Integration of the informal sector into formal waste management systems remains limited across the region. In South Africa, where informal waste pickers—commonly referred to as reclaimers—play a critical role in municipal solid waste management, efforts have been made to register them as a first step toward further integration within the waste management system. The registered informal reclaimers support the implementation of extended producer responsibility framework in the country. They collect an estimated 80 to 90 percent of used packaging and paper that is recycled, contributing significantly to the country's overall recycling rate (Eunomia 2024). Such integration efforts are rare across the region.

In most cases, the municipal solid waste system is severely underfunded. The majority of available funding is mainly directed toward collection and transportation, with significantly less allocated to treatment and disposal. Newly constructed facilities and infrastructure deteriorate quickly due to insufficient funding for operations and maintenance. Financing arrangements vary; some local governments collect fees directly from residents; in others, charges are bundled with utility bills such as water or electricity; and in many poorer areas, no waste fee is collected at all. The system is generally financed through a mix of user charges, municipal revenues, and transfers from central government. User charges often represent the smallest share of total financing, although notable exceptions exist, such as metropolitan municipalities in South Africa, where user charges account for 70 to 80 percent of the cost of waste services.

Unmanaged or poorly managed municipal solid waste contributes to environmental, infrastructure, and public health challenges across the entire region. Uncollected and scattered waste obstructs drainage systems and intensify flooding, particularly in areas with high annual rainfall. With some countries in the region experiencing up to 5,000–6,000 millimeters of rainfall per year, the combination of unmanaged waste and heavy rainfall significantly exacerbates recurrent flooding, posing ongoing challenges for urban management and resilience.

Legacy pollution remains a significant challenge, with large, unmanaged dumpsites situated within densely populated urban areas including many of the capital cities. A notable example of progress in addressing this issue while attracting private sector investment is Abidjan, Côte d'Ivoire. The city entered into a concession agreement with a private operator to close a major dumpsite, develop new and expanded waste management infrastructure, and capture landfill gas for electricity generation.

Innovative infrastructure investments are also emerging elsewhere in the region. In Addis Ababa, Ethiopia, the first waste-to-energy incineration plant in Africa was inaugurated in 2018. With an installed capacity of 1,400 tonnes per day, the facility converts municipal solid waste into electricity, representing a significant advancement; reportedly, it is operated below capacity (GIZ 2023).

Private sector participation has also supported the development of alternative treatment technologies for organic waste. In South Africa, black soldier fly technology is being applied as a sustainable method for organic waste processing. Key factors constraining the scale-up of this approach include the availability of clean, consistent feedstock and the market competitiveness of resulting protein rich products in relation to lower-cost animal feed.

Capacity and governance limitations hinder the effective enforcement of solid waste management laws and regulations in Sub-Saharan Africa. Although many countries have adopted national strategies and regulatory frameworks, enforcement at the local level is consistently reported as a persistent challenge. Compliance is generally monitored through central government field visits, reviews of local government reports, and evaluations of relevant sites and documentation. However, weak institutional coordination, limited accountability mechanisms, and insufficient oversight constrain effective governance in the sector. With few exceptions, the solid waste management sector is not viewed as a priority by political leaders and central governments—a key barrier to advancing sectoral reforms and investment.

3.7.2 Waste Generation and Composition

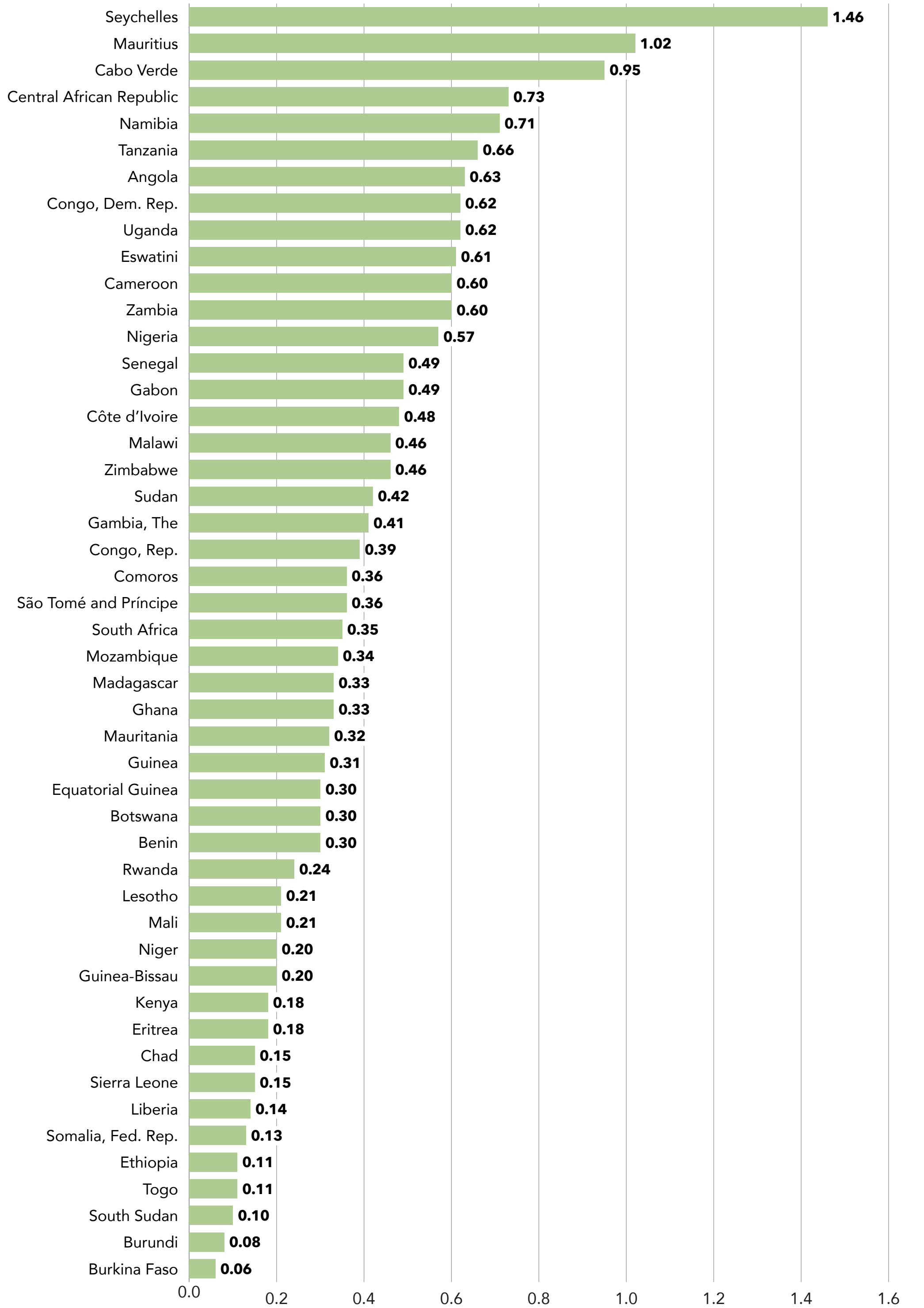
The Sub-Saharan Africa region generated 231 million tonnes of municipal solid waste in 2022, a mean of 0.52 kilogram per capita each day (figure 3.32). The region's per capita generation rate is one of the lowest globally, and similar to that of South Asia. Seychelles has the largest waste generation per capita, per day of all Sub-Saharan countries at 1.46 kilograms; it is the only high-income country in the region, with tourism one of its main sources of income. At the lower end of the spectrum, municipal solid waste generation rates in the region have been reported at approximately 100 grams per capita per day.

Food waste comprises 44 percent of municipal solid waste in the Sub-Saharan Africa region (figure 3.33). Among engineered materials,[12] plastics account for less than 10 percent, the lowest share across all regions. Paper and cardboard constitute 12 percent, a proportion comparable to most other regions, except North America and Europe and Central Asia, where levels are much higher. Although the overall share of engineered materials in the region is slightly below the global average of approximately 31 percent, rising consumption of packaged goods may contribute to an increase in these fractions over time.

3.7.3 Waste Collection

The weighted mean nationwide municipal solid waste collection coverage in Sub-Saharan Africa is 31 percent (figure 2.11), the lowest among all regions. While median collection coverage in urban areas is higher at 45 percent, it drops to just 6 percent in rural areas (figure 3.34). National collection coverage has a very large range across the region, from almost 100 percent for Mauritius (UNSD 2022) down to 3 percent for Malawi (Malawi NSO 2019).

Figure 3.32 Municipal solid waste generation in Sub-Saharan African countries



Source: Original figure for this report.
Note: Mean waste generation in kilogram per capita per day projected to 2022.

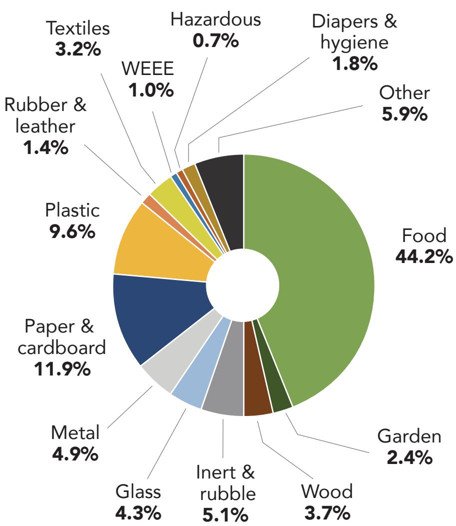
Of the cities selected in this study, those in South Africa have the highest collection rates—Cape Town and Johannesburg (figure 3.35). At the opposite end of the spectrum, are five cities with under 30 percent collection rates, three of which are capital cities.

As of 2024, Sub-Saharan Africa has 12 countries in fragile and conflict-affected areas. As with other services in fragile, conflict, and violence-affected contexts, municipal solid waste management is significantly impacted by broader systemic challenges, resulting in disruptions and limitations in service delivery.

3.7.4 Waste Treatment and Disposal

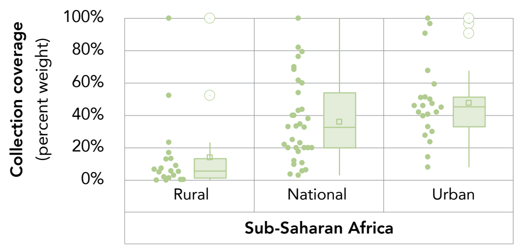
Of the 231 million tonnes of municipal solid waste per year generated in the Sub-Saharan Africa region in 2022, 160 million tonnes were uncollected, 54 million tonnes taken to dumpsites and the remaining 17 million tonnes either taken to controlled landfills or recycling (figure 3.36).

Figure 3.33 Composition of municipal solid waste in Sub-Saharan Africa

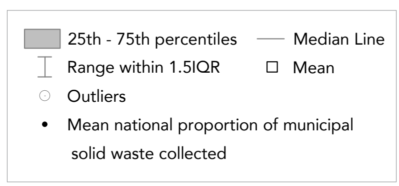


Source: Original figure for this report.
Note: Weighted mean based on 2022 waste generation. WEEE = waste electrical and electronic equipment.

Figure 3.34 Waste collection coverage in countries from the Sub-Saharan Africa region

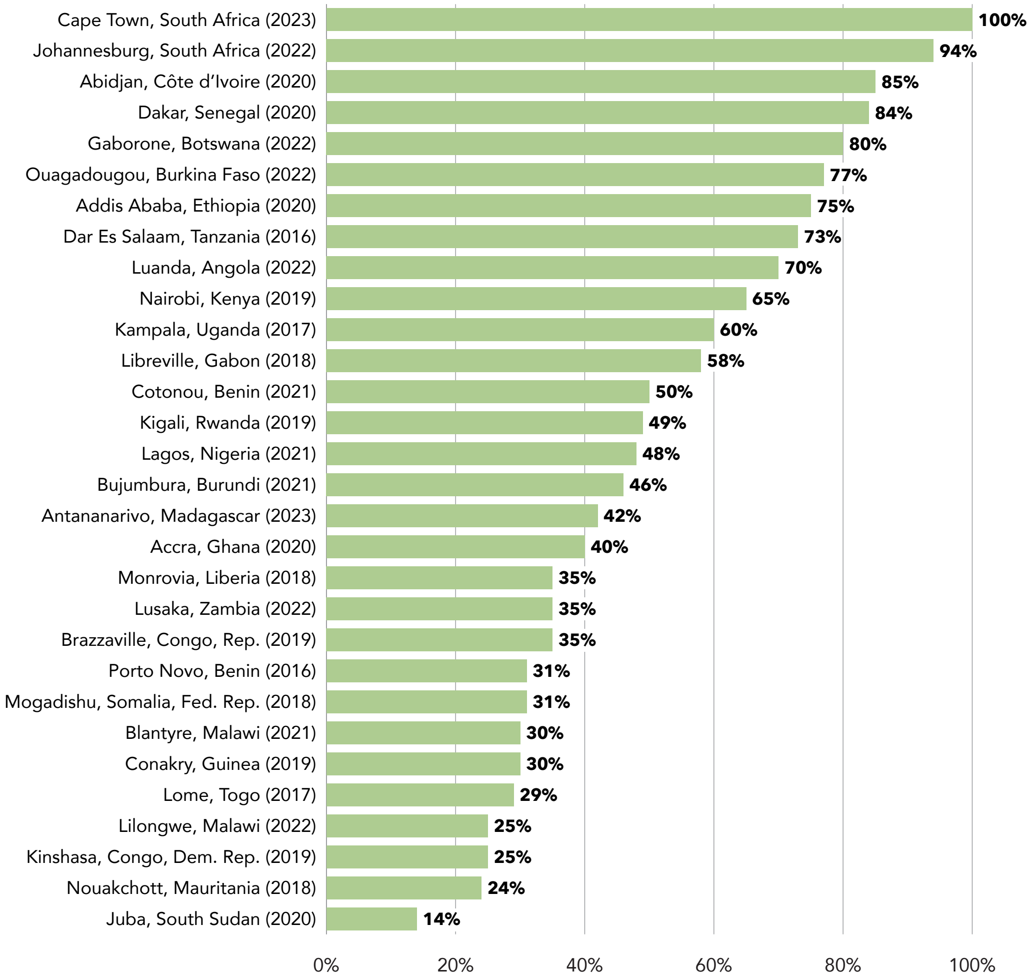


	Rural	National	Urban
Count	19	34	22
Median	6%	33%	45%



Source: Original figure for this report.
Note: Country dataset. Central tendency and spread of waste collection coverage in weight percent. Each dot refers to mean waste collection coverage at national, national urban, and national rural levels, based on data from different and inconsistent years. The summary statistics presented are not weighted, meaning that each country is counted equally regardless of its population size. As a result, these collection rates are not directly comparable to the regional weighted collection rate. Outliers are defined as values lying more than 1.5 times the interquartile range beyond the upper or lower quartiles. IQR = interquartile range.

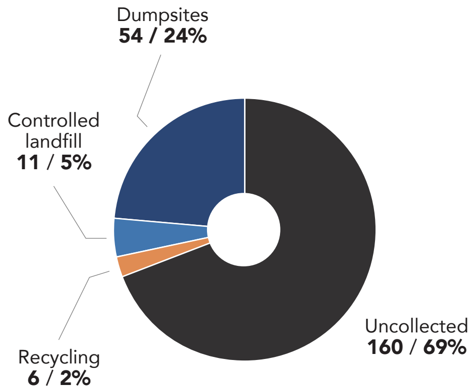
Figure 3.35 Municipal solid waste collection coverage for selected cities in Sub-Saharan Africa



Source: Original figure for this report.
Note: City dataset. Bars refer to the proportion of waste collected by weight in cities. Bracketed years indicate year that the measurement refers to.

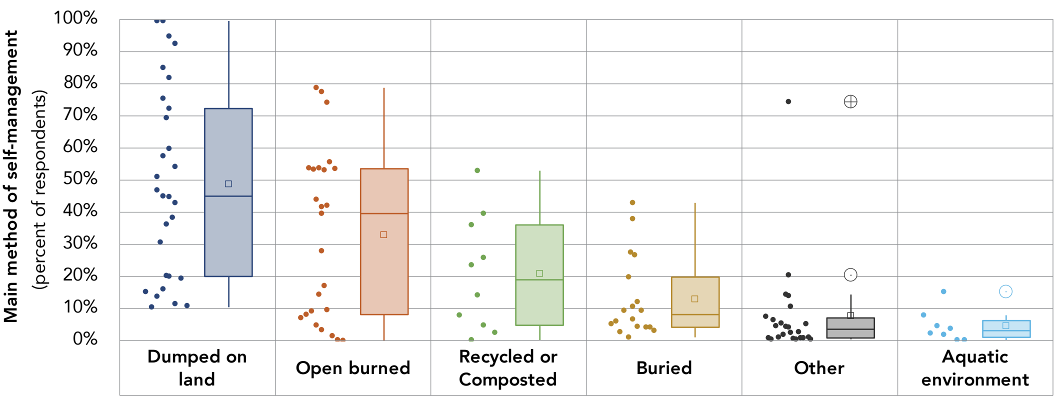
The proportion of uncollected waste is very high at almost 70 percent—the highest of all regions. Of the 160 million tonnes per year that were uncollected, the most common handling method is reported to be dumping on the land and open burning (figure 3.37). While some of the uncollected waste is composted or extracted for reuse and recycling, uncollected waste is also often buried or disposed of in water bodies.

Figure 3.36 Waste treatment and disposal in Sub-Saharan Africa



Source: Original figure for this report.
Note: Numbers refer to the amount of waste treated or uncollected in millions of tonnes per year.

Figure 3.37 Self-management of uncollected municipal solid waste in Sub-Saharan Africa



	Dumped on land	Open burned	Recycled or Composted	Buried	Other	Aquatic environment
Count	29	25	10	18	24	8
Median	45%	40%	19%	8%	4%	3%

25th - 75th percentiles | Range within 1.5IQR | Median Line
Mean | Outliers | Extreme values
• Mean national proportion of municipal solid waste main method of self-management

Source: Original figure for this report.
Note: Country dataset. Dots refer to the mean main method of self-management as reported by respondents in national surveys and censuses. Outliers are defined as values lying more than 1.5 times the interquartile range beyond the upper or lower quartiles. Extreme values are values lying more than 3 times the interquartile range beyond the upper or lower quartiles. IQR = interquartile range.

Box 3.2 Stakeholder Engagement and Behavior Change

Stakeholder engagement in solid waste management

The effectiveness of waste management is closely linked to the active involvement of stakeholders and the establishment of a mutual understanding, or social contract, across all segments of society. When the public is willing to follow established guidelines for waste handling and contribute financially to services, the overall performance of waste management operations can be significantly enhanced. Conversely, if waste generators or service providers are disengaged or resistant, the system's effectiveness is likely to decline.

A broad spectrum of stakeholders is involved in waste management. These include waste generators such as residents, institutions, businesses, and commercial enterprises; private service providers and investors; producer responsibility organizations; professional associations; community groups; informal waste collectors and waste picker associations; various levels of government administration; state-owned enterprises and utility companies involved in billing and fee collection; and financial institutions. These stakeholders play different roles, and each interacts with the waste management system in distinct ways, experiencing varied impacts from its design and implementation. While some are primarily interested in reliable waste collection in their communities, others depend on the sector for employment and income, and some view it as a field for investment and business opportunities. For certain groups, the system offers convenience and empowerment, whereas for others, it may result in exclusion or disadvantage.

It is important for local authorities to consider the diverse perspectives of all stakeholders when designing their waste management systems. Stakeholder input can encourage positive behaviors that support smooth system operation, contribute to building a more equitable, sustainable, and inclusive public service, and generate employment opportunities. Local authorities can foster a sense of shared ownership by ensuring that the needs of all groups are addressed, which in turn support positive social, environmental, and economic outcomes.

The successful transition of the sector toward circularity is also fundamentally reliant on the behaviors and actions of stakeholders. For instance, when waste generators fail to segregate waste at the source, the resulting waste stream becomes contaminated and mixed. This contamination significantly complicates subsequent recycling and composting processes, thereby constraining the potential for circularity and resource recovery within the sector. Ultimately, the effective implementation of policy objectives in this sector is only possible when robust support and a shared commitment, or a social contract, exist among waste generators and all relevant stakeholders. Without this collective engagement and buy-in, even the most well-designed policies are unlikely to achieve their intended outcomes in practice.

Sustained and effective communication and engagement by local authorities are therefore critical to ensure meaningful stakeholder involvement in achieving policy objectives. It is important that stakeholders not only receive information but also have opportunities to provide feedback and participate in decision making for engagement to have a lasting impact. This two-way communication builds trust and fosters a sense of community ownership over the waste management system and objectives. At a minimum, residents need to understand the impact of waste management practices on water pollution, air quality, flooding, and public health, and how these elements can affect their immediate environment and themselves. Beyond important considerations of health, environmental protection, and regulatory compliance, it is essential that waste generators and stakeholders collectively commit to moving up the Waste Hierarchy and actively support the sector's transition toward circularity.

Achieving such objectives depends significantly on the active participation of local communities. One such good example is observed in Japan, where neighborhood associations known as Jichikai are pivotal to the country's highly effective waste management system. These voluntary groups organize, monitor, and educate residents on proper waste separation and disposal, ensuring compliance with strict municipal guidelines and collection schedules (JICA 2022). Jichikai members take turns overseeing waste stations, reinforcing rules, and addressing issues such as illegal dumping, while also facilitating clean-up activities and community recycling activities (Japan MoE 2014). They help implement local waste management initiatives, distribute educational materials, and organize training sessions to promote effective sorting and recycling.

Many local governments have developed incentive schemes such as subsidies for neighborhood associations to set up group collection activities and to buy necessary equipment for collection and sorting (Akiko 2024). Social norms and a strong sense of collective responsibility further motivate residents to participate actively, resulting in impressive waste reduction and recycling rates. For example, Kitakyushu City reduced household waste by about 25 percent and increased recycling rates through active citizen engagement and neighborhood association involvement (World Bank 2018a; 2018b). Similarly, Osaki Town achieved Japan's highest recycling rate exceeding 80 percent for more than a decade by mandating community participation in waste separation, with neighborhood associations playing a central role in educating and mobilizing residents (CLAIR n.d.).

While Japan's experience highlights the impact of strong community engagement, in many lower-income countries, it is the informal sector that plays a critical role. Across the Global South, informal actors, such as waste collectors, small-scale recyclers, and aggregators, are key to service delivery. Informal workers are often responsible for a substantial share of material recovery, diverting significant quantities of recyclable materials from disposal sites. Their efforts help reduce environmental pollution, conserve resources, and support the development of circular practices. Their work is typically unregulated and characterized by low wages, hazardous conditions, and a lack of social protections. Many are exposed to unsafe environments, often without personal protective equipment or adequate access to healthcare, resulting in heightened health risks. Social stigma and marginalization further compound their vulnerability. Millions of people, especially those from marginalized communities, rely on informal waste work as their primary means of livelihood.

Owing to advocacy by organizations such as Women in Informal Employment: Globalizing and Organizing (WIEGO), the International Alliance of Waste Pickers, and others, the informal sector's vital role in solid waste management is increasingly recognized. This has led to a growing movement to integrate them into formal systems, with successful models emerging in various contexts. Examples include the establishment of cooperatives, microenterprises, and partnerships with local authorities. In several countries, policy reforms have created mechanisms to formally recognize and support informal workers, resulting in improved working conditions and livelihoods.

The informal sector is often the primary point of contact with waste generators, positioning these workers as key agents of change. Through daily interactions, informal waste workers are uniquely able to educate, influence, and encourage residents to adopt improved waste handling practices. Their direct engagement enables them to drive behavioral change and support the transition toward more sustainable solutions. The examples below illustrate how local government leadership, in partnership with stakeholders and through inclusive policies, can facilitate the integration of informal workers into formal waste management systems, leading to improved livelihoods, greater social inclusion, and more effective services.

In Pune, India, the SWaCH (Solid Waste Collection and Handling) cooperative, originating from the Kagad Kach Patra Kashtakari Panchayat (KKPKP) trade union, has partnered with the municipal government to provide door-to-door waste collection and recycling services. Through this collaboration, over 3,500 waste pickers have transitioned from informal waste pickers to recognized service providers, benefiting from improved working conditions, stable incomes, and access to health insurance (SWaCH 2020).

In Brazil, significant strides have been made toward recycling by actively integrating the informal sector into municipal waste management, underpinned by strong public leadership and progressive legal frameworks.[a] Federal law encourages municipalities to partner with waste picker cooperatives for source separation and recycling, making such collaboration a prerequisite for accessing federal resources.[b] Other regulations have streamlined procurement processes and established innovative certificate schemes that channel investments and payments derived from Brazil's extended responsibility scheme—locally known as reverse logistics—directly to waste picker associations for their environmental services.[c,d] These measures, alongside social recognition and dedicated programs, have improved working conditions, expanded selective collection,[e] and ensured that waste pickers are central agents in Brazil's evolving circular economy.[f,g] Academic research has documented the effectiveness of these policies, highlighting Brazil's role as a global reference for inclusive recycling practices (Lima and Mancini 2017; Rutkowski and Rutkowski 2015; Rutkowski et al. 2017).

In Maputo, Mozambique, the municipality helped organize informal waste collectors into microenterprises and established formal contracts with them. Forty-three microenterprises collect waste from households and small businesses, transporting it to designated transfer stations. This initiative has improved urban cleanliness, provided stable livelihoods for former informal collectors, and created a more structured and sustainable waste management system. Maputo's approach serves as a model for inclusive urban service delivery, showing how municipalities can partner with local entrepreneurs.

Behavior change in solid waste management

The transition to sustainable and circular solid waste management systems is fundamentally a challenge of behavior change. While infrastructure, policy, and financing are essential, the effectiveness of any waste management system ultimately depends on the daily decisions and actions of individuals, households, businesses, and institutions. Behavioral science offers a powerful lens to understand and influence these decisions, helping to bridge the gap between policy intent and real-world outcomes. The following paragraphs outline drivers of change, barriers, and recommended approaches (World Bank 2023).

In terms of behavior drivers, change is shaped by an interplay of economic, environmental, social, and psychological factors. The World Bank applies and adapts established behavioral science models, such as the Social Ecological Model (McLeroy et al. 1988), to highlight key contexts that influence waste-related behaviors in its solid waste management work. First, the economic context encompasses legal instruments such as bans, taxes, and incentives, which can encourage or discourage certain behaviors. However, economic tools alone are rarely sufficient for sustained change; and they must be complemented by other measures. Second, the urban environment, such as the physical design of waste infrastructure, the convenience of access to bins or recycling centers, and the visibility of waste services, shapes habits and routines. For example, if recycling bins are inconveniently located, even motivated individuals may not participate. Third, the interpersonal context includes social practices, shared values, social expectations, and norms. Social norms—such as what people perceive others are doing or expect them to do—are especially powerful in shaping waste behaviors, as are reminders, prompts, and feedback mechanisms. Finally, individual aspects of behavior—which include personal beliefs, experiences, cognitive biases, and emotional drivers—mediate daily behaviors in solid waste management.

A widely used diagnostic tool in behavioral science is the capability, opportunity, motivation–behavior model (COM-B model), which posits that for any behavior to occur, individuals must have the capability (knowledge and skills), the opportunity (physical and social context), and the motivation (conscious and unconscious drivers) to act (Michie, van Stralen, and West 2011). Effective interventions target one or more of these components.

In terms of identifying barriers and solutions, behavioral diagnostics is essential. Common barriers include: (1) lack of awareness or knowledge about the environmental and health impacts of poor waste management; (2) inconvenience or lack of access to proper disposal or recycling facilities; (3) social norms that tolerate littering, open dumping, or burning, and (4) entrenched routines that are hard to break. Perceived lack of accountability or belief that individual actions do not matter, as well as economic or time costs associated with sustainable behaviors, further impede change.

Previous World Bank work has shown that across different contexts, stakeholders often express strong environmental values. Yet good intentions do not always translate into sustainable behaviors. In many cases, non-desired practices remain the most feasible option. For instance, in Bangladesh, Ghana, and Nigeria, plastic sachets are often the only affordable way to access clean water (World Bank Group 2024a; 2024b). In Belize and Lao PDR, waste bins are costly, and collection services are limited (World Bank 2022). However, accessibility is not the only behavioral barrier. In Bangladesh, for example, social expectations among businesses shaped perceptions of what constitutes a quality product, influencing behavior in ways that are not directly tied to infrastructure (World Bank 2024b). Importantly, behavioral barriers vary across stakeholder groups. Vulnerable communities, in particular, often lack access to adequate infrastructure and resources, which pushes them to continue engaging in non-desired behaviors despite their environmental values.

To address these, behaviorally informed interventions can include awareness campaigns using simple, timely, and targeted messaging, often leveraging the fresh-start effect to motivate change. Nudges and prompts at the point of decision, such as clear signage at disposal points or color-coded bins, can make desired behaviors easier and more automatic. Social norm interventions that make positive behaviors visible and desirable, such as public recognition, community competitions, or peer comparisons, are effective in shifting collective attitudes. Feedback and reminders, whether through text messages or community meetings, reinforce correct behaviors and help correct errors. Reducing friction and increasing convenience by improving infrastructure is critical. Incentives and rewards for desired behaviors, or penalties for noncompliance, can be effective when appropriate and feasible.

Finally, in terms of recommended approaches, the incorporation of behavior change into solid waste management strategies and local action is essential. Change is iterative and context specific. No one-size-fits-all solution exists. Interventions should be piloted, evaluated, and adapted based on evidence and feedback. Impact evaluations are critical to understanding what works, for whom, and why. Behavioral interventions cannot substitute for basic service provision. If collection services are unreliable or recycling facilities are absent, even the most motivated individuals will struggle to comply. Sustained communication and feedback loops are key; one-off campaigns rarely lead to lasting change. Ongoing engagement, monitoring, and adaptation are needed to reinforce new behaviors and address emerging challenges.

Leveraging social norms and community leadership by making positive behaviors visible and celebrated can create a virtuous cycle of adoption. Community leaders, informal workers, and peer networks are powerful agents of change. Addressing barriers by combining economic incentives, regulatory measures, and infrastructure improvements with behavioral insights, maximizes impact. Building institutional capacity for behavioral approaches is also crucial; local authorities and service providers need training and resources to design, implement, and evaluate behaviorally informed interventions.

As cities and countries strive to move up the Waste Hierarchy and advance circularity, embedding behavior change into solid waste management strategies is not optional but essential. This requires systematic behavioral diagnostics at the outset of program design, integration of behavioral objectives and indicators into monitoring and evaluation frameworks, and partnerships with behavioral scientists, community organizations, and the private sector to create and scale solutions. Commitment to learning and adaptation is vital, recognizing that behavior change is a long-term process. Local authorities can enhance the effectiveness of solid waste management systems by combining robust stakeholder engagement with evidence-based behavioral interventions.

Notes

a. Brazil Federal Law No. 12,305/2010 – Brazil National Policy on Solid Waste Policy.

b. Decree No. 8,538/2015 – Regulating preferential, differentiated and simplified treatment for microenterprises and cooperative societies in public procurement, Brazil.

c. Decree No. 11,413/2023 – Establishing certificate schemes for reverse logistics and recycling, Brazil.

d. Law No. 14,119/2021 – National Payment Policy for Environmental Services, Brazil.

e. "Selective collection" is the local term used for source separation for recycling in Brazil.

f. Law No. 17,256/2020 (State of Ceará) – State program to reinforce income resulting from the provision of environmental services of waste pickers, Brazil.

g. Decree No. 11,414/2023 – Instituting the Diogo de Sant'Ana Pro-collectors' Program for Popular Recycling, Brazil.

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Notes

1. Comprises approximately 311 million tonnes of urban and 191 million tonnes of rural municipal solid waste (see appendix A).
2. Engineered materials refer specifically to plastic, paper and cardboard, metal, and glass.
3. Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives. https://environment.ec.europa.eu/topics/waste-and-recycling/waste-framework-directive_en.
4. Eurostat. 2024. *Municipal waste by waste management operations.* Data browser, dataset for Germany. https://ec.europa.eu/eurostat/databrowser/product/page/env_wasmun__custom_11476025?lang=en.
5. World Bank Open Data. https://data.worldbank.org/indicator/SP.URB.TOTL?end=2023&locations=Z7&start=2019.
6. GCC Statistical Centre. https://dp.marsa.gccstat.org/search/og_group_ref/342/type/dataset.
7. The US states include California, Colorado, Maine, Maryland, Minnesota, Oregon, and Washington (Washington State Department of Ecology 2025).
8. Specifically referring to plastic, paper and cardboard, metal, and glass.
9. World Bank Open Data. https://data.worldbank.org/indicator/EN.POP.DNST?locations=8S and https://data.worldbank.org/indicator/SP.URB.TOTL.IN.ZS?locations=8S.
10. Solid Waste Management Rules, 2021, Ministry of Environment, Forest, and Climate Change, Government of Bangladesh. https://wasteconcern.org/wp-content/uploads/2024/03/Solid-Waste-Management-Rules-2021.pdf.
11. Without India, the food waste composition of South Asia reduces to 34 percent while the plastic, paper, and cardboard, metal, and glass component increases to 40 percent.
12. Specifically referring to plastic, paper and cardboard, metal, and glass.

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©Alamy/Blossey. Abfall- und Energiezentrum Asdonkshof, Germany – an integrated waste management complex combining recycling and sorting, biowaste composting and anaerobic treatment, waste-to-energy incineration, slag processing, and landfill operations.

4.

Scenarios for Municipal Solid Waste Management and Circularity until 2050

KEY INSIGHTS

- This chapter presents projections for municipal solid waste management through 2050 under three scenarios: business as usual, which extends prevailing trends, and low- and high-ambition, which reflect progressively improved waste management futures. Designed to support long-term planning and policy development, the scenarios illustrate how varying levels of ambition and intervention could shape future waste generation, collection, treatment, and disposal. They reflect growing global commitment to waste minimization and prevention, while underscoring the urgency of addressing the global waste crises and the consequences of inaction. The scenarios inform greenhouse gas emissions estimates in chapter 5, financial cost analysis in chapter 7, and broader discussions on development trajectories.
- The business-as-usual scenario projects a rise in global waste from 2.56 billion tonnes in 2022 to 3.86 billion tonnes by 2050, a 50-percent increase. By contrast, the high-ambition scenario models waste reduction, capping global waste generation at prevailing levels despite population and economic growth. The low-ambition scenario assumes half the reduction achieved under the high-ambition scenario, that is 3.12 billion tonnes by 2050.
- Projected waste reduction is uneven across income groups. High-income countries, with the highest waste generation rates, are projected to reduce waste by 50 percent under the high-ambition scenario, followed by upper-middle-income and lower-middle-income countries at 39 percent and 22 percent, respectively. By contrast, low-income countries are expected to see an increase that reflects rising consumption from a low baseline from 0.43 to 0.52 kilogram per capita per day.

KEY INSIGHTS (CONTD.)

- Waste collection coverage improves across all scenarios and income groups, with the most substantial gains in low-income countries. In the high-ambition scenario, waste collection in low-income countries reaches full coverage by 2050 compared with 48 percent collection coverage projected under the business-as-usual scenario.
- Waste treatment and disposal practices improve significantly under the low- and high-ambition scenarios. Global recycling and composting reach 41 and 54 percent respectively, compared with 27 percent in business as usual. Uncollected waste and dumpsite disposal decline from 20 percent under the business-as-usual scenario to 11 percent in the low-ambition scenario and less than 1 percent in the high-ambition scenario.
- These achievements in treatment and disposal vary by income group: in high- and upper-middle-income countries, high-ambition outcomes are achieved by sharply increasing recycling and composting as proportion of waste treatment and diverting most land-disposed waste to incineration. Low- and lower-middle-income countries see dramatic improvements in treatment by eliminating open dumping and expanding recycling, composting, and sanitary landfilling.

4.1 Overview of Scenarios

This edition of *What a Waste* introduces scenario-based projections for municipal solid waste generation and management through 2050—a significant addition not included in *What a Waste 2.0.* The scenarios—developed to support long-term planning and policy formulation—explore how different levels of ambition and intervention could shape the trajectory of the waste sector over the coming decades. In addition to a business-as-usual scenario, two alternative futures are modeled: a low-ambition and a high-ambition scenario. Together, these scenarios reflect a range of modeled outcomes of waste generation, collection, recycling, treatment, and disposal. This framework can be used to inform strategic decision making by illustrating how different development pathways may affect the scale and complexity of waste management needs over time.

In each scenario, business-as-usual expectations will remain the same until 2030, after which two levels of ambition, low and high, are explored to envisage a world where waste is reduced, brought within human control, and where it is used as a resource to reduce burdens on the environment and human health (table 4.1).

Table 4.1 Overview of scenario projection targets for 2050 explored in this report

Scenario	Waste generation	Waste collection as proportion of waste generated (weight)	Recycling and composting as proportion of waste generated (weight)	Waste managed in controlled facilities (weight) – SDG 11.6.1 indicator
Business as usual	3.9 billion tonnes	89%	• Global 27% • High-income 44% • Upper-middle-income 22% • Lower-middle-income 23% • Low-income 5%	80%
Low ambition	3.2 billion tonnes	94%	• Global 41% • High-income 58% • Upper-middle-income 41% • Lower-middle-income 36% • Low-income 13%	89%
High ambition	2.6 billion tonnes	100%	• Global 54% • High-income 70% • Upper-middle-income 60% • Lower-middle-income 50% • Low-income 20%	100%

Source: Authors' presentation.
Note: The low-ambition scenario is approximately half the ambition of the high-ambition scenario. SDG = Sustainable Development Goal.

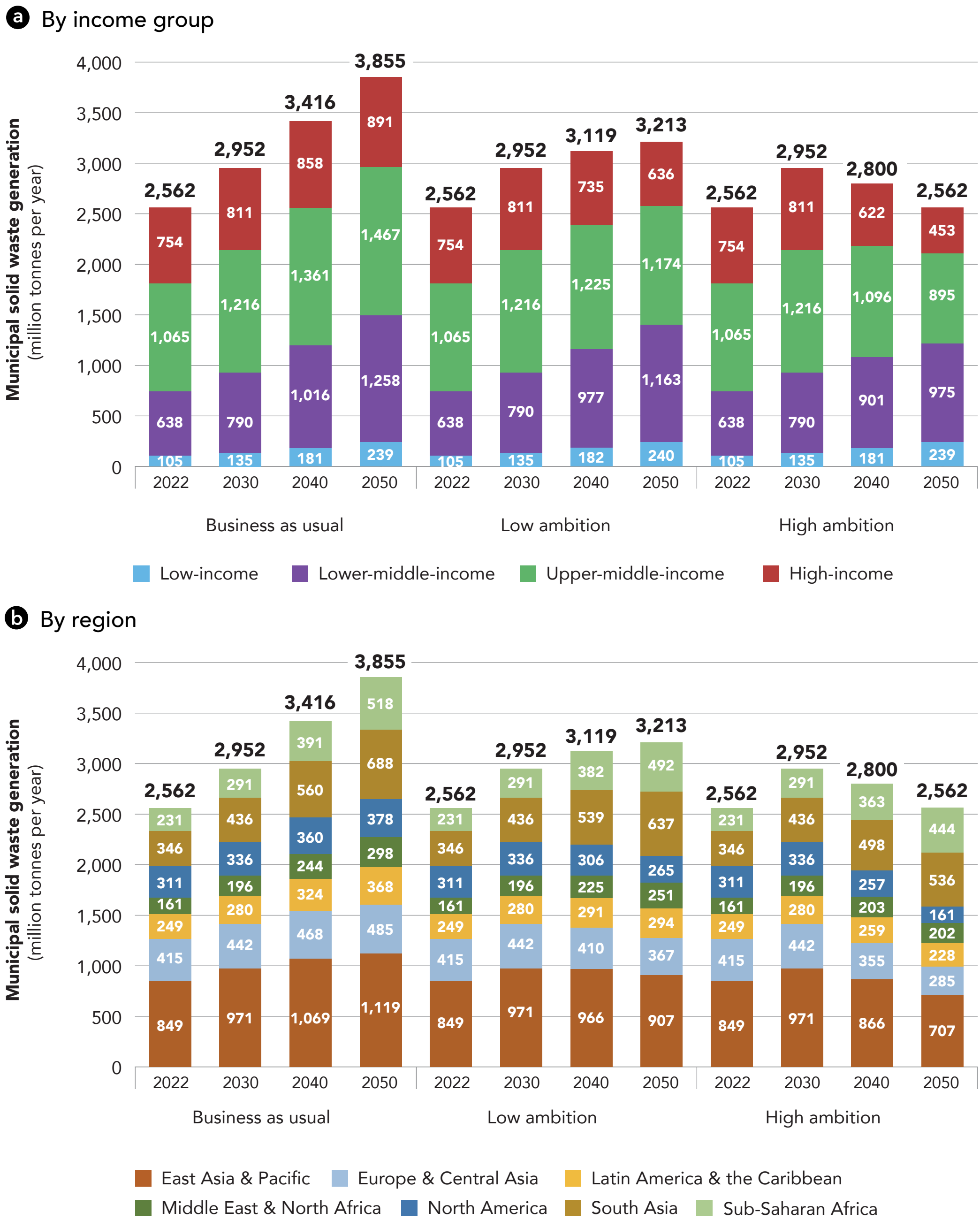
4.2 Scenarios for Waste Generation

Global waste generation is anticipated to reach 2.95 billion tonnes across all scenarios in 2030 (figure 4.1), and in the business-as-usual scenario it is projected to reach 3.86 billion tonnes by 2050, a 50- percent increase compared with 2022. The high-ambition scenario envisages a world where aggressive waste reduction policies are implemented, effectively returning the absolute weight to the 2.56 billion tonnes generated in 2022; a reduction of 1.30 billion tonnes compared to the baseline projection. In the low-ambition scenario, it is assumed that half of the waste reduction efforts of the high-ambition scenario will be achieved, meaning that global absolute waste generation will reach approximately 3.21 billion tonnes by 2050, a 25 percent increase compared with 2022.

In low-income countries and economies where waste generation is already comparatively low on both a per capita (figure 4.2a) and absolute basis (figure 4.1a), waste generation will stay the same in the projected scenarios (figure 4.2b and c). And while the scenario expects modest reductions in the per capita waste generation in lower-middle-income countries, as a result of waste prevention and minimization efforts, most of the reductions in low- and high-ambition scenarios are modeled to take place in upper-middle- and high-income countries where per capita rates are already high.

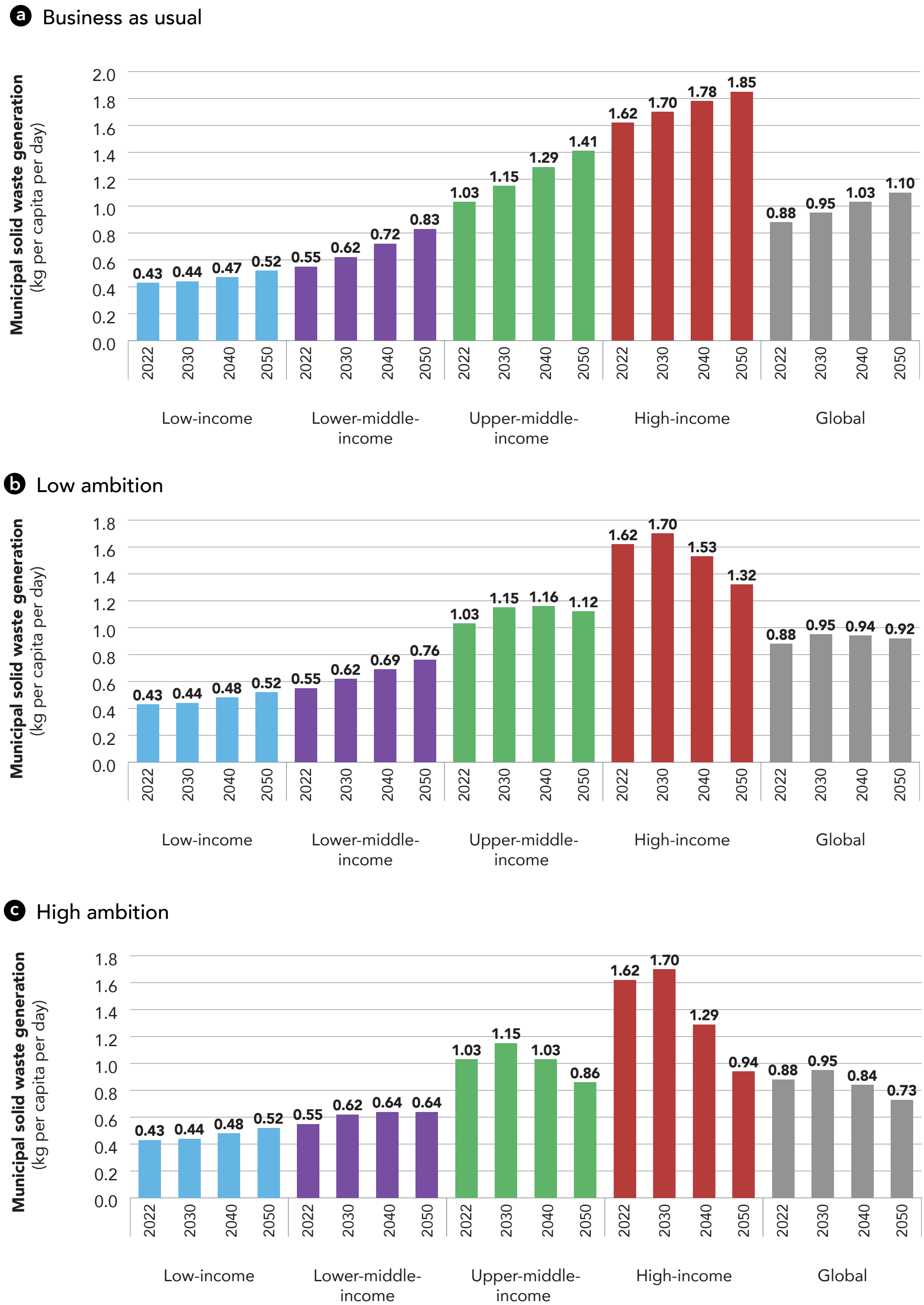
As the model presented here targets high-income countries for the most aggressive waste reduction over the coming decades, North America and Europe and Central Asia will have some of the largest reductions in waste generated on an absolute basis (figure 4.1b). East Asia and Pacific is also projected to have large reductions in waste generation, driven mainly by the presence of China, which dominates the waste

Figure 4.1 Total municipal solid waste generation projection scenarios



Source: Original figure for this report.

Figure 4.2 Per capita municipal solid waste generation by income group for each scenario



Source: Original figure for this report.

generation weight in that region.

North America is projected to have the largest reductions on a per capita basis in the high-ambition scenario where waste generation will be reduced to 1.03 kilograms per capita per day in 2050 compared with 2.43 kilograms per capita per day projected in the business-as-usual scenario (figure 4.3c). Despite these aggressive reductions, North America will still generate more waste per capita than the global mean which is anticipated to reduce to 0.73 kilogram per capita per day in the high-ambition case (figure 4.3c).

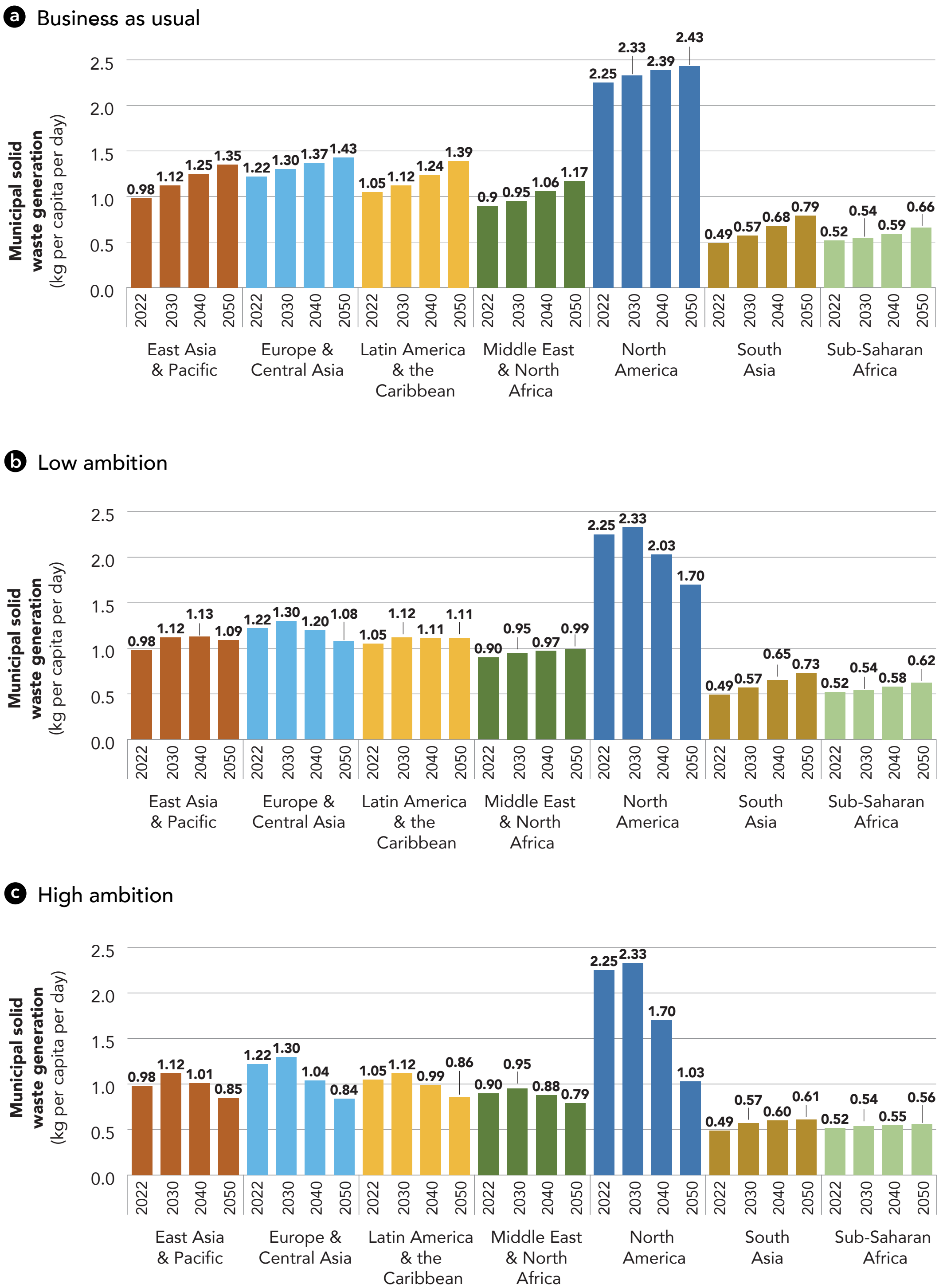
4.3
Scenarios for Municipal Solid Waste Collection Coverage

Without intervention, it is anticipated that waste collection coverage will gradually improve across all income levels by 2050, with a global mean of 89 percent compared with 83 percent in 2022 (figure 4.4a to 4.4e). The high-ambition scenario sets a global target of reaching 100 percent collection rate worldwide, whereas the low-ambition scenario achieves nearly full collection in upper-middle-income countries but more modest progress in lower-middle-income and low-income countries.

4.4
Scenarios for Municipal Solid Waste Recycling and Composting

Without intervention, the business-as-usual scenario indicates that compared with 2022 levels, the global combined recycling, composting, and anaerobic digestion rate will grow by six percentage points, reaching 27 percent by 2050 (figure 4.5). The high-ambition scenario aims for 54 percent global recycling rate, which is double that anticipated in the business-as-usual case.

Figure 4.3 Per capita municipal solid waste generation by region for each scenario

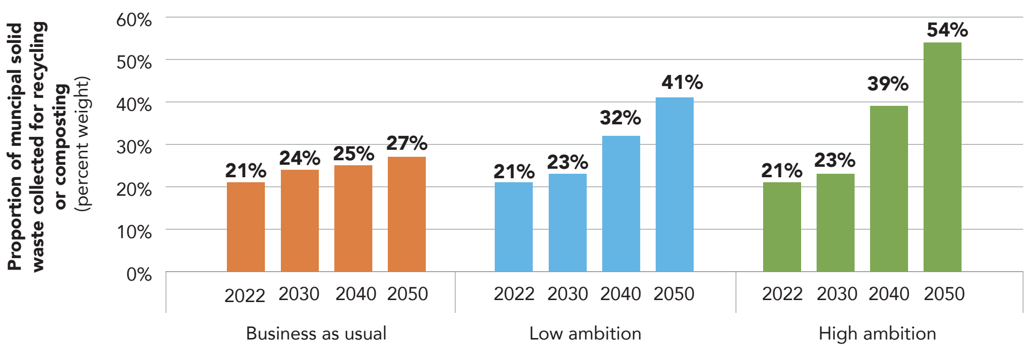


Source: Original figure for this report.

Figure 4.4 Scenarios for municipal solid waste collection coverage by income group

Source: Original figure for this report.
Note: Bars represent collected waste as a proportion of municipal solid waste generated

Figure 4.5 Waste collected for recycling or composting

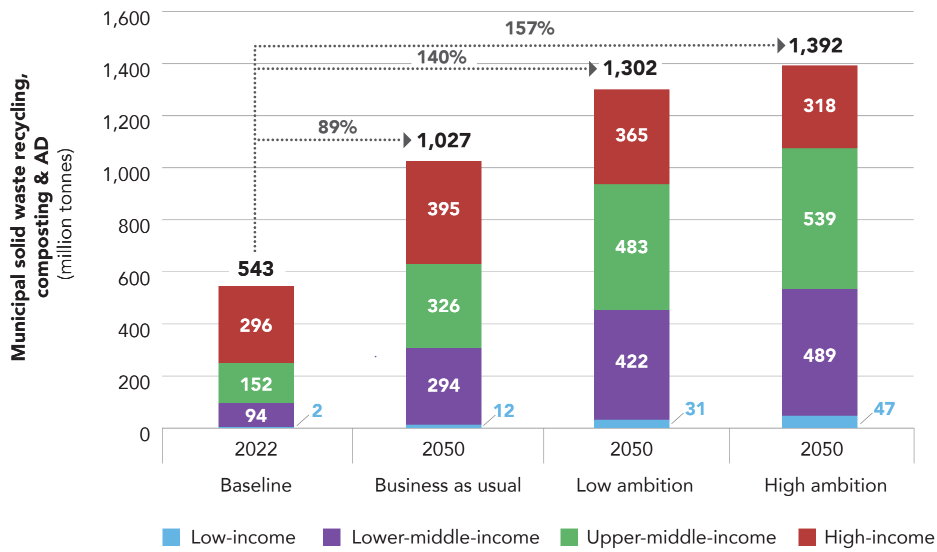


Source: Original figure for this report.
Note: 2030 recycling and composting are slightly higher in the baseline compared with the low- and high-ambition scenarios since in the scenarios, the two are constrained by the quantity of organic and engineered materials available in the system.

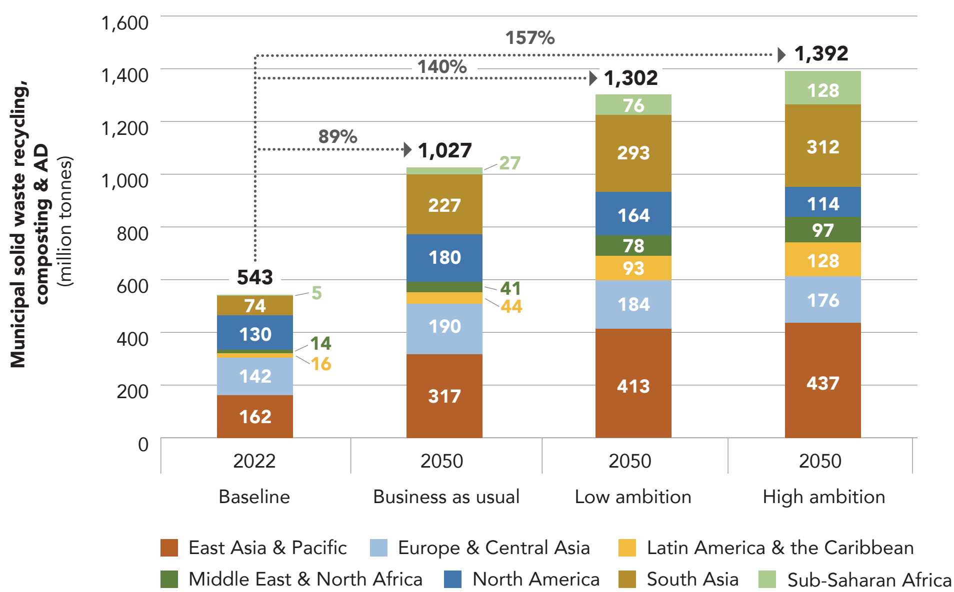
The amount of waste collected for recycling will not increase evenly across income groups or regions (figure 4.6). In high-income countries, the amount of municipal solid waste collected for recycling and composting will decrease while those countries focus their efforts on waste prevention and minimization. Most absolute increases in recycling and composting will take place in lower-middle-income countries.

Figure 4.6 Scenarios for municipal solid waste recycling, composting and anaerobic digestion

a By income group



b By region



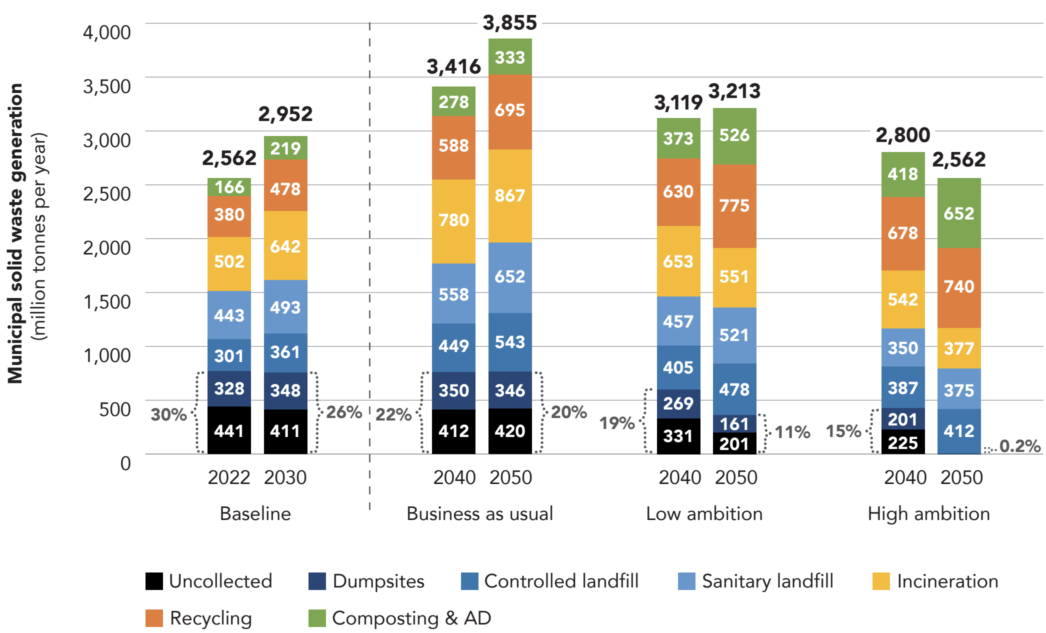
Source: Original figure for this report.
Note: AD = anaerobic digestion.

4.5
Scenarios for Municipal Solid Waste Treatment, Disposal, and Uncollected Waste

The ambition of 100-percent collection coverage and management in controlled facilities in the high-ambition scenario by 2050 will require substantial intervention across the waste system worldwide (figure 4.7). The eradication of dumpsites will require construction of alternative facilities and also an overall reduction in waste generation together with a considerable ramp-up of recycling and composting systems to maximize diversion from disposal.

In high- and upper-middle-income countries and economies, high-ambition scenario targets will be met by increasing recycling and composting and diverting the majority of waste disposed of on land to incineration (figure 4.8a and b). Although recycling and composting will need to be substantially increased, in lower-middle- and low-income countries, the focus will be on ensuring that 100 percent of waste is collected and then diverted from dumpsites to controlled landfills.

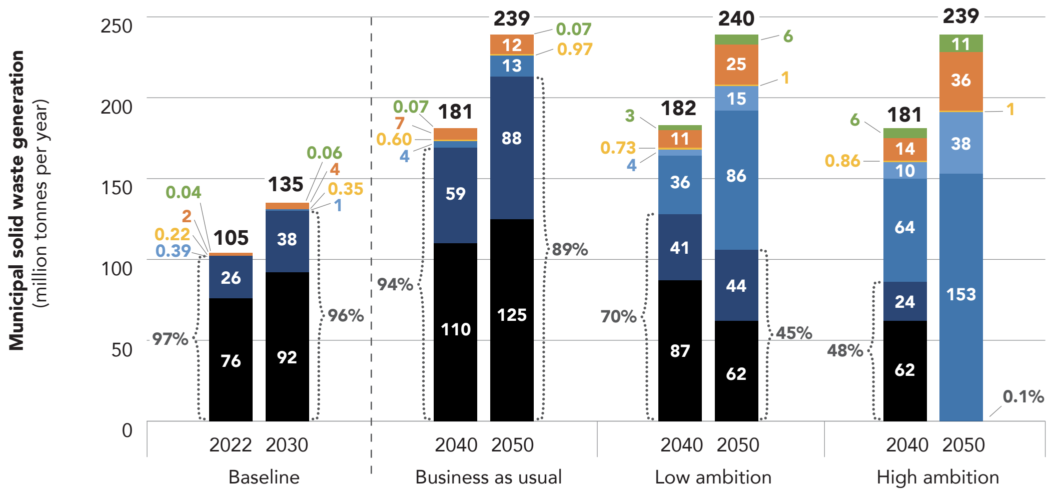
Figure 4.7 Scenarios for global municipal solid waste treatment, disposal, and uncollected waste



Source: Original figure for this report.
Note: Dashed brackets at base of columns indicate mismanaged waste, which is the sum of dumpsites (poorly managed) and uncollected (unmanaged) municipal solid waste. AD = anaerobic digestion.

Figure 4.8 Scenarios for municipal solid waste treatment, disposal, and uncollected waste by income group

a Low-income



b Lower-middle-income

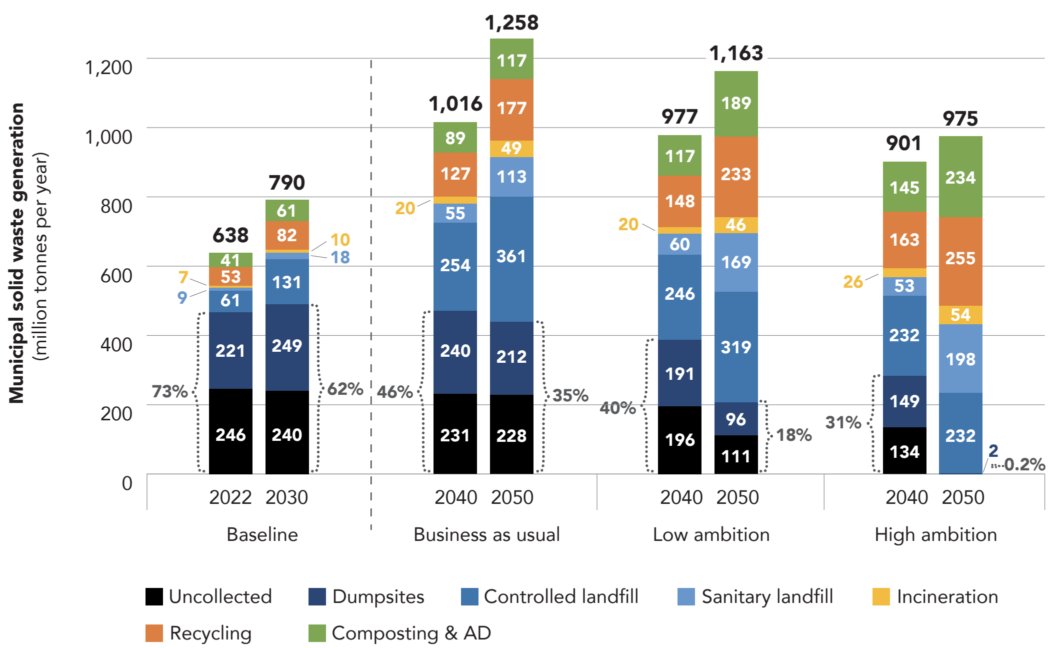
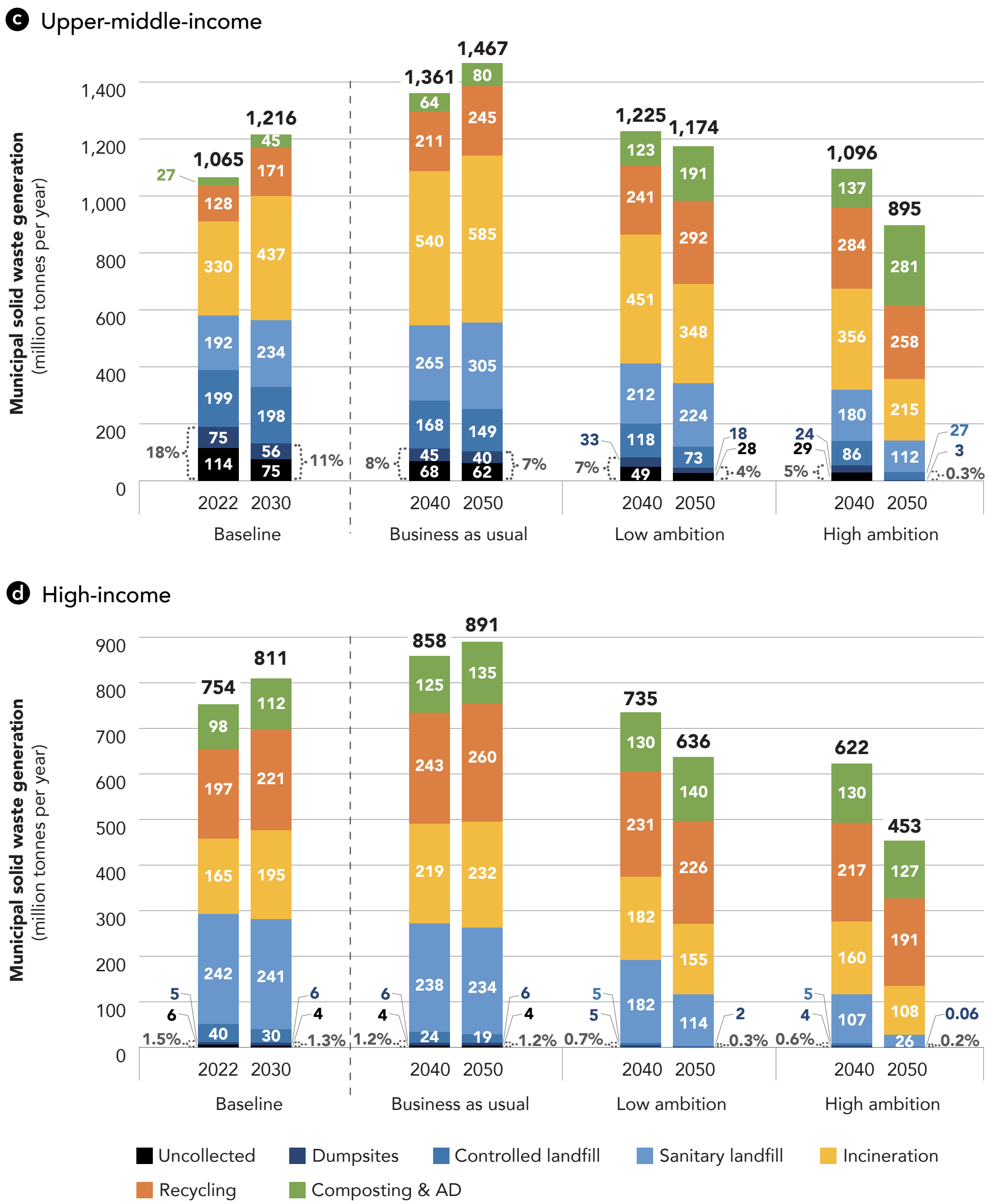


Figure 4.8 Scenarios for global municipal solid waste treatment, disposal and uncollected waste *(contd.)*



Source: Original figure for this report.
Note: Dashed brackets at base of columns indicate mismanaged waste, which is the sum of dumpsites (poorly managed) and uncollected (unmanaged) municipal solid waste. AD = anaerobic digestion.

Both the low- and high-ambition scenarios in this chapter assume that future waste generation will be effectively controlled and reduced, even as population and economic growth continue. Achieving significant waste reduction is essential for adequate waste management and for mitigating and eliminating its negative impacts, as it reduces pressure on collection systems, lowers treatment and disposal requirements, and helps limit environmental and public health risks (box 4.1).

Box 4.1 Waste Reduction

The critical need for bending the trend and reducing the flow of waste

With global population growth, rising incomes and rapid urbanization, waste quantities have increased substantially in recent decades and, without interventions, are projected to continue growing through 2050. This report demonstrates that prevailing actions to manage waste are falling behind. Increasing quantities of uncollected and poorly managed waste lead to worsening social and environmental impacts and adverse consequences for economic development. As the business-as-usual scenario demonstrates, managing waste with conventional approaches and without interventions to control waste generation will require high levels of investment and even more burdensome daily operating costs to keep systems running. The required cost levels will be particularly challenging for lower-income countries.

As the scenarios adopted for this report show, bending the trend of ever-increasing quantities of waste toward stabilization and reduction will be critical for achieving adequate waste management in the coming years, and for mitigating and eventually eliminating its negative impacts.

This text box presents some basic elements of waste reduction, including possible interventions, examples of country practices and what could be considered achievable targets, as well as explains how these align with the three scenarios—business as usual, low- and high-ambition scenarios—presented in this report.

Defining waste reduction – prevention and waste management solutions

A clear understanding of concepts and terminology is essential for designing effective policies and interventions. The Waste Hierarchy principle has been recognized globally and serves as a guiding principle for ranking waste management solutions from least to most preferred in preventing and dealing with waste. At the bottom of the preferred options are dumping and disposal. Moving upward is recovery, which includes processes that recover energy from waste, for example through incineration with energy recovery, or conversion of waste into fuel such as refuse-derived fuel. More preferable waste management options are recycling, composting and anaerobic digestion of organic waste. Toward the top of the waste pyramid are measures to reduce waste generation—such as preparing discarded products for repair and reuse—while prevention of waste from being generated in the first place sits at the top of the hierarchy.

Many terminologies are used for interventions to lower waste quantities, such as prevention, source reduction, minimization, diversion, and zero-waste approaches. The term waste prevention used in this report covers actions that reduce the flow of materials entering the waste stage and therefore directly reduce the need to manage the associated avoided waste streams and their environmental impacts. Waste prevention is defined in the EU Waste Framework Directive 2008/98/EC, Article 3(12), as: "Measures taken before a substance, material or product has become waste, that reduce: (a) the quantity of waste, including through the reuse of products or the extension of the life span of products; (b) the adverse impacts of the generated waste on the environment and human health; or (c) the content of harmful substances in materials and products"(EU 2008).

In practice, waste prevention focuses on:

- Avoiding the generation of waste altogether through changes in production and consumption patterns;
- Facilitating the reuse of products rather than discarding them; and
- Extending product lifespans through better design, repair, or shared use.

All measures in the Waste Hierarchy other than waste prevention that contribute to the reduction of waste quantities—up to, but not including energy conversion, which is a one-time process and does not support material circularity, or final disposal—are categorized as recycling.[a] Composting organic waste is considered as a form of recycling as it reprocesses material into a usable product (EU 2008).

In principle, recycling does not reduce the amount of waste generated; however, recycling schemes combined with segregated collection of recyclables are often organized alongside public waste service systems and thereby reduce the quantities of total waste that need to be managed by parties that collect and process mixed municipal waste.

A special case is reuse of waste. Reuse has been defined as "any operation by which products or components that are not waste are used again for the same purpose for which they were conceived" (EU 2008). Under this definition, reuse (or 'direct reuse') is not part of the Waste Hierarchy but rather a form of waste prevention. However, preparation for reuse of discarded products can be regarded as a waste management activity. Typical examples are centers for secondhand products and take-back schemes for reuse of discarded products under extended producer responsibility arrangements. Both direct reuse and preparation for reuse reduce the quantity of waste requiring collection and treatment and thus contributes directly to waste reduction efforts.

The term "waste diversion" refers to efforts to direct materials away from disposal and is sometimes also used for diversion of materials away from conversion solutions or waste-to-energy. It is therefore broader than recycling. Beyond recycling, these measures have no bearing on waste quantities that require waste management solutions. Waste diversion is therefore not discussed further as a waste reduction option.

Overall, waste that needs to be collected and managed by public service systems, can be reduced through waste prevention and waste reuse measures, as well as through recycling initiatives with collection and processing arrangements that operate parallel to public waste services.

Policy instruments and market mechanisms

A wide array of policy instruments and mechanisms to influence markets are available to support waste reduction. Options for policies and measures are well researched, applied, and documented. Upstream or pre-waste stage waste prevention and reuse include:

- Product design regulations: Mandate ecodesign for durability, reparability, and recyclability in products; minimizing use of new materials, minimum content standards for recycled materials in new products.
- Regulations to directly reduce waste generation: Restrict production and consumption of products such as single-use plastics (SUPs), for example plastic bags or cups, and discourage wasting food.
- Extended producer responsibility (EPR): Hold producers responsible for the end-of-life management of their products, incentivizing design for reuse or recycling.
- Economic instruments: Tax virgin materials or products such as packaging materials, pay-as-you-throw schemes, landfill or incineration taxes, and subsidies for repair or reuse activities.
- Public procurement policies: Favor recycled content, remanufactured goods, and minimal packaging.
- Awareness and education campaigns: Promote sustainable consumption, sharing, and the circular economy.
- Policies to introduce measures at all stages of the supply chain, from production to consumption, for instance, to reduce food waste (see box 5.1).

Applied at scale, such interventions can shift both production and consumption patterns, supporting a systemic move toward lower waste quantities.

Once products have entered the waste stage, policies can be put in place to maximize recycling and composting and reduce the flow of materials for disposal. Policy options and implementation approaches include:

- Separate collection systems: Implement well-organized and convenient systems for collecting recyclable materials, such as paper, plastics, glass, metals, and organics for composting. Public education and long-term community engagement are key factors in the design and successful implementation of separate waste collection systems.
- Recycling targets: Agree with stakeholders and subsequently impose achievable targets for different materials and waste streams, such as paper, plastics, and packaging.
- Policy measures: Build and sustain the enabling environment for improved sorting and reprocessing. These policies should focus on ensuring sufficient operational funding for advanced sorting technologies to improve the quality and efficiency of recycling processes, and the further processing of these recyclables for the market, including composting.
- Market-based recycling schemes: Introduce measures such as under extended producer responsibility and deposit return schemes for beverage containers.
- Waste-to-energy technologies: Explore and implement waste-to-energy technologies such as anaerobic digestion for food waste to recover energy from non-recyclable waste.
- Landfill bans and taxes: Ban or tax recyclable materials from landfills to encourage their recovery and recycling.

By implementing a combination of these measures, paired with regulations, data systems, monitoring and enforcement mechanisms, policy makers can create a more sustainable and circular approach to waste management, minimizing environmental impact and maximizing resource recovery.

Applied practices

Waste reduction ambitions are typically legally framed in the context of circular economy policies, general waste management sector regulations, or dedicated regulations for the management of municipal solid waste as the latter is normally considered a public sector mandate. Specific targets for recycling and diversion of municipal waste from disposal are common and typically included in national waste sector strategies. Such targets, for instance, are set in Indonesia at 38% (20% recycling, 18% material or energy recovery) by 2029 and 90% (35% recycling; 55% material or energy recovery) by 2045 (Republic of Indonesia 2025; Indonesia Bappenas 2025). These targets, primarily implemented by local governments, are to be applied directly to the volumes of waste generated or collected within their jurisdictions.

In many countries, including high-income countries, waste prevention targets have been formulated as ambitions, outlining directions for interventions with intended reduction levels and timelines, but they are generally not yet legally binding. For example, as part of the European Green Deal,[b] the EU has articulated a 2050 ambition to reduce material resource consumption and waste generation to levels within planetary boundaries, that is an ecologically sustainable footprint. This objective has not yet been translated into specified actions, which are expected to be defined with specific targets and made legally binding by 2030.

Waste reduction has already been very successful in many countries for specific waste streams. Construction and demolition waste is virtually fully recovered in many EU countries with an average for the 27 EU countries of 89% (Eurostat 2019). Countries like Japan and Republic of Korea achieve similar levels for construction waste reduction (Yonetani n.d; Kim 2021). Also, for other waste that can be managed well apart from municipal waste collection systems—such as end-of-life vehicles and electrical equipment or materials with a high intrinsic value such as scrap metals, wastepaper, and PET bottles—high recovery rates are being achieved.

In the context of circular economy and waste prevention, the broader category of municipal waste represents one of the most challenging waste streams to manage because of its heterogeneous and mixed composition.[c] This box presents examples of prevailing practices that involve waste prevention as well as reduction of waste through reuse or recycling in the European Union, Japan, and the Republic of Korea; countries among others that are considered front runners in waste reduction.

Achievements in municipal waste prevention and recycling in the EU

Targets for recycling and reducing disposed waste in the EU are defined for 2030, namely, to reduce residual municipal waste sent to disposal—landfill or incineration without energy recovery—with 50% compared with 2015 levels and to reuse or recycle at least 60% of generated waste (EEA 2024a; EU 2008). These targets have been key factors for boosting waste recycling efforts. Overall municipal waste recycling rates in the EU countries increased from 23% to 49% between 2004 and 2022 (EEA 2016; EEA 2024b). Germany, that reported 69%, leads a handful of countries that achieve recycling rates of more than 50%. Large variations exist with rates as low as 13% in Romania and limited reported progress reported among the lower performing countries. Such variations raise uncertainty about the prospect of achievement the overall EU target of 55% recycling of municipal waste by 2025. Though large variations also exist among landfilling rates, with an average of 23% in 2022 and eight EU countries reaching levels of 5% or less, the EU appears on track to achieve its landfill diversion target of 10% or less of waste going to landfills in 2035.[d]

The picture is more complex for achievements in waste prevention and reducing waste generation levels. In policies and legislation, the EU Single-Use Plastics Directive came into force in 2019 (EU 2019). The EU Waste Framework Directive, amended in 2018 as part of the EU Legislative Package on the Circular Economy, explicitly puts prevention as the preferred approach to manage waste and provides guidance on measures, monitoring, and the involvement of stakeholders and the public (EU 2018). The directive encourages member states to adopt policies to reduce waste generation. However, apart from objectives for food waste reduction, it does not yet set specific targets for overall reduction in municipal waste generation. The directive requires a 10% reduction in processing and manufacturing for food waste and 30% reduction in retail and consumption by 2030 (EC 2023; CEU 2025). The Circular Economy Action Plan (CEAP), a key part of the European Green Deal that seeks zero emission economies by 2050, aims to "transform consumption patterns so that no waste is produced in the first place" (EC 2020). The European Commission plans to propose waste reduction targets, enhance requirements of extended producer responsibility schemes and halve the amount of residual municipal waste, or waste quantities after recycling, by 2030.

Several countries and regions already adopted more concrete waste prevention targets. Catalonia in Spain sets targets in their General Waste and Resource Management Prevention Programme 2019–2025 at 15% waste reduction by weight by 2020, or a limit on the amount of residual waste generated per capita at 150 kg per year by 2025. Flanders in Belgium developed targets to reduce the total quantity of residual waste from households, companies and organizations. As a result, municipal waste generated in 2021 was 471 kg per capita, the lowest since 1994, including a decreased quantity of residual waste at 140 kg per capita. France adopted a Waste Reduction and Circular Economy Bill, with the goal to reduce municipal waste generation per capita by 15% and commercial waste generation by 5% by 2030.[e]

EU-wide municipal waste generation levels for the 27 EU member states (Eurostat 2024) fluctuated in the last 25 years between 513 kg per capita in 2000, 479 in 2014, to a peak of 532 in 2021. Data from 2023 show a 4% average reduction in waste generation since 2021, with some countries in western Europe, for instance, Germany, Belgium, and the Netherlands seeing decreases in waste generation of 7% to 9%.[f] Some of these variations are a result of revised waste classification and reporting requirements, and it is challenging to attribute these fluctuations to changes in policy. It is important to note that the EU applies a definition for municipal waste generation that includes all separately collected recyclables.[g] Consequently, these segregated materials are also included in generation statistics and therefore, do not contribute to the accounting of achievements in waste prevention and reductions of generated waste.

Achievements in municipal waste prevention and recycling in Japan

In the field of waste prevention, since the early 2000s, Japan has made steady progress in lowering its national municipal solid waste generation. In 2000, Japan produced approximately 52.4 million tonnes of municipal solid waste. This figure dropped to about 42.8 million tonnes by 2020—a reduction of nearly 18% or a reduction of 19% in waste generation on a per capita basis to 0.92 kg per day in 2020 (Japan MoE 2020). Japan's reduction in municipal solid waste generation has been driven by a comprehensive suite of policy measures spanning national legislation, local government regulations, and community-oriented initiatives.

The Containers and Packaging Recycling Law (1995) in Japan was a landmark regulation, requiring businesses to take responsibility for the recycling of containers and packaging materials they produce. This principle of extended producer responsibility was later expanded with the Home Appliance Recycling Law (2001) and the Food Recycling Law (2001), mandating that manufacturers and retailers recover, recycle, or reuse products at end-of-life, thereby reducing the overall waste stream. The Waste Management and Public Cleansing Law was revised in 2000 to prioritize waste reduction and recycling.

Local governments in Japan play a critical role in enforcing strict waste sorting and collection protocols. Municipalities provide residents with detailed sorting instructions and schedules, which often require separating waste into numerous categories. In some areas, residents must sort items into more than ten distinct groups, from burnable and nonburnable waste to glass, plastics, metals, and hazardous materials. Noncompliance can result in noncollection, creating a strong incentive for proper waste disposal and minimal contamination of recyclables.

The Government of Japan also supports community engagement and education campaigns, such as school programs and public outreach events, to promote the 3Rs (reduction, reuse, recycling) and foster a sense of environmental stewardship. Additionally, economic incentives like pay-as-you-throw (PAYT) programs encourage households to produce less waste by charging garbage disposal based on the volume or weight of waste offered for collection.

Achievements in waste prevention and recycling at city level

Examples of Kamikatsu, Ljubljana, San Francisco, Seoul, and Singapore demonstrate that meaningful reductions in municipal waste generation are also achievable at city level, often beyond national requirements, through a combination of policy innovation, public participation, technology, and sustained cultural shifts. Although the specific approaches of each city differ, common threads emerge—incentivizing waste reduction, facilitating recycling and composting, engaging communities, and fostering accountability among both producers and consumers.

Kamikatsu, Japan: This small town is renowned for its radical zero waste ambition. Since 2003, Kamikatsu has explored what is possible at community level. Residents separate their waste into 45 distinct categories at a central facility. Kamikatsu's emphasis on community involvement has fostered a culture of environmental stewardship, with residents actively engaged in reducing waste and advocating for sustainable practices. The town operates a "Kuru Kuru Shop" where usable items are donated and reused by other residents, further curbing waste generation. Kamikatsu now recycles or composts over 80% of its waste, thus sending a small fraction to incineration or landfill (Fagerholm et al. 2025).

Ljubljana, Slovenia: The capital of Slovenia has emerged as a leader in waste reduction in Eastern Europe. Ljubljana's commitment to zero waste principles has transformed its waste management landscape. The city introduced door-to-door collection of separated waste streams, drastically improving participation rates. Residents pay for waste services based on the amount of unsorted waste they produce, incentivizing better recycling and composting habits. Ljubljana invests heavily in educating citizens, especially schoolchildren to support public participation about the importance of reducing waste and recycling. Ljubljana boasts a recycling rate above 68%, one of the highest in the European Union, and the amount of residual waste sent to landfill has dropped by over 95% in the last decade (Zero Waste Europe n.d.)

San Francisco, United States, set an ambitious goal to achieve zero waste by 2020. Although this target was not fully realized, the city has nonetheless yielded remarkable results and established a robust framework for sustainable waste management, that comprises: (1)

legislation requiring all residents and businesses to separate recyclables, compostables, and landfill waste; (2) intensive public education campaigns; and (3) banning Styrofoam food containers and promoting reusable packaging. By 2020, the city had diverted approximately 80% of its waste from landfills, one of the highest rates in the United States (C40 Cities 2016; SF Environment 2018; 2019; 2020).

Seoul, Republic of South Korea: Seoul's volume-based waste fee system, introduced in 1995, revolutionized how waste is dealt with at the household level. It requires residents to purchase special bags for general waste, whereas recyclables are collected separately at no extra charge. This system motivates citizens to minimize nonrecyclable waste. The city has also tackled food waste aggressively by installing radio frequency identification (RFID)-enabled smart bins that track and charge households for the amount of food waste they produce. In support, neighborhood-level education and community recycling centers have helped change cultural norms around waste disposal. As a result, between 1995 and 2015, municipal waste generation per capita decreased by more than 40%, with recycling rates soaring above 60%.[h]

Singapore's integrated approach to waste management blends regulatory measures, technological innovation, and cultural transformation. Although the majority of Singapore's solid waste is incinerated with electricity generation, the city-state runs a comprehensive public education campaign and provides recycling bins to all households to reduce waste volumes. It adopted its zero waste masterplan; a roadmap to reduce waste generation per capita by 30% within a decade, focusing on food, packaging, and electronic waste. Singapore's waste generation per capita has decreased in recent years, and landfill reliance is among the lowest in the region (Singapore NEA n.d.; Singapore NEA 2025).

Setting and achieving waste reduction targets: What is possible?

The notion that waste prevention or otherwise its reuse or recycling must be prioritized over disposal solutions is universally adopted and recognized in most countries' development policies. The presented examples demonstrate that despite the special efforts that this requires—including additional costs and intensive public and stakeholder engagement—many countries and cities choose to invest extensively in waste reduction and seek the rewards from less to near-zero levels of waste to manage.

Waste recycling of up to 20% of generated waste is achievable without significant additional costs to what is required for basic collection and disposal services regardless of country income levels. For instance, this can be attained by involving communities for segregated collection of selected waste categories. High recycling levels—up to 65% at country level and even higher at city level—have been shown to be achievable. Such levels are mostly achieved in upper-middle-income countries and high-income countries, and many high-income countries have demonstrated that nearly 100% diversion from land disposal is possible.

Waste prevention is at the top of the Waste Hierarchy and therefore a priority in many national policies and waste strategies. However, it has proven to be challenging. As the city examples show, a growing group of high-income countries has managed to stabilize the increase of waste generation per capita at levels between 1.0 and 1.5 kg per capita per day, and several have even started to bend the curve downward, achieving modest to meaningful reduction in waste generation in recent years. It can be expected that in the coming years most high- and middle-income countries will manage to stabilize their waste generation levels. And in coming decades, the growing pressure to limit the exhaustion of natural resources will be translated into patterns of gradually decreasing waste volumes. The EU, for example, is expected by 2030 to have defined far-reaching targets for 2050.

Waste prevention requires comprehensive approaches to adapt manufacturing practices, product marketing, and change consumer behavior, which will require strong incentives and the buy-in and engagement of the public and many stakeholders. Prevailing practices show that initial steps have been taken and that waste prevention policies can bend the trend downward and result in significant reductions in waste generation.

Waste prevention is essential for reducing waste generation, conserving natural resources, lowering greenhouse gas emissions (GHG), and reducing both pollution and financial costs for the sector. Comprehensive approaches that involve stakeholders, including civil society, have shown that prevention efforts can deliver meaningful reductions in waste volumes. With sustained commitment and collaboration, further progress is attainable, as demonstrated by the stated experience in several countries.

Notes

a. Recycling of waste is defined in the EU Waste Framework Directive as any recovery operation by which waste materials are reprocessed into products, materials or substances whether for the original or other purposes.

b. European Commission. 2019. *The European Green Deal*. Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions, COM(2019) 640 final, December 11. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52019DC0640.

c EU Directive 2018/851, amending Directive 2008/98/EC on Waste. https://eur-lex.europa.eu/eli/dir/2018/851/oj/eng.

d. Based on Eurostat data: https://ec.europa.eu/eurostat/databrowser/view/env_wasmun/default/table?lang=en.

e. *Leading the Way Towards Waste Prevention - A Policy Brief from the Policy Learning Platform on Environment and Resource Efficiency*. Interreg Europe, European Union, European Regional Development Fund, April 2023.

f. Based on EUROSTAT data: https://ec.europa.eu/eurostat/databrowser/view/cei_pc031__custom_18260833/default/table.

g. Directive 851/2018 (amending the Waste Framework Directive (Directive 2008/98/EC). "Municipal waste" means: (1) mixed waste and separately collected waste from households, including paper and cardboard, glass, metals, plastics, bio-waste, wood, textiles, packaging, waste electrical and electronic equipment, waste batteries and accumulators, and bulky waste, including mattresses and furniture; and (2) mixed waste and separately collected waste from other sources, where such waste is similar in nature and composition to waste from households.

h. Seoul Metropolitan Government. *Seoul Statistics by Category*. https://english.seoul.go.kr/get-to-know-us/statistics-of-seoul/seoul-statistics-by-category/#none.

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©Alamy/Hossain. Access path alongside an open dump with uncontrolled waste combustion.

5.

Waste and Climate

KEY INSIGHTS

- Global greenhouse gas (GHG) emissions from solid waste management activities in 2022 are estimated at about 1.28 billion tonnes of carbon dioxide equivalent per year. The majority, at 89 percent of these emissions, are generated from waste disposal, whereas only a small fraction at 11 percent is generated from other solid waste management activities.
- The highest amount of emissions is associated with methane—1.15 billion tonnes of carbon dioxide equivalent annually, followed by carbon dioxide at 115 million tonnes of carbon dioxide equivalent annually.
- Upper-middle-income countries generate the highest total GHG emissions from solid waste management activities. High-income countries generate the highest emissions per capita exceeding 200 kilograms of carbon dioxide equivalent per capita annually.
- Under the business-as-usual scenario, projected GHG emissions from solid waste management are expected to rise from 1.28 billion tonnes of carbon dioxide equivalent in 2022 to 1.84 billion tonnes of carbon dioxide equivalent by 2050—a 43-percent increase. The most significant increase is in lower-middle-income countries where emissions are expected to more than double.
- Greenhouse gas emissions decline between 2030 and 2050 under both the low- and high- ambition scenarios, reaching 1.34 billion tonnes of carbon dioxide equivalent per year and 0.91 billion tonne of carbon dioxide equivalent per year, respectively, by 2050. In the low-ambition scenario, reductions stem mainly from smaller waste quantities compared with business as usual and a shift away from dumping, while emissions from disposal and incineration remain largely unchanged. In the high-ambition scenario, deeper reductions are achieved through both greater waste reduction and a significant decline in incineration-related emissions.

KEY INSIGHTS (CONTD.)

- Nationally Determined Contributions under the Paris Agreement on climate change from 156 countries include the waste sector in their mitigation strategies, with 95 explicitly prioritizing solid waste management; 48 set quantitative targets, 52 qualitative goals, and 22 include both.
- Although many countries aim to reduce emissions through recycling, composting, landfill methane capture, and recovery, implementation remains limited owing to financing and regulatory gaps, prompting 77 percent of Nationally Determined Contributions with waste references to include conditional targets tied to international support.

Solid waste management activities generate greenhouse gas (GHG) emissions. The amount of GHG emissions from the different waste activities depends on the amount of waste generated, along with various factors such as waste composition, local climate, and how the waste is managed.

The three main GHGs generated from various solid waste management activities are methane, carbon dioxide, and nitrous oxide. Methane is primarily generated from anaerobic decomposition of organic wastes in landfills and dumpsites, as well as from biological treatment of organic wastes, whereas the primary source of carbon dioxide is incineration of wastes containing fossil carbon such as plastics and synthetic textiles. Nitrous oxide emissions mainly result from the biological decomposition of nitrogen-rich organic waste, particularly during processes involving both aerobic and anaerobic conditions.

Prevailing GHG emissions from various solid waste management activities—as well as projections of GHG emissions under the business-as-usual, low-ambition and high-ambition scenarios—are calculated for global, country income, and regional groupings and are presented in the following sections. Greenhouse gas emissions are estimated for three types of solid waste management activities:

- Solid waste disposal, which includes disposal of waste in dumpsites, controlled landfills, and sanitary landfills, as well as uncollected waste;
- Biological treatment of waste, which includes waste composting and anaerobic digestion; and
- Waste incineration.

The methodology for estimating GHG emissions from these activities, along with the assumptions made for estimation, follows the latest Intergovernmental Panel on Climate Change (IPCC) guidelines—2006 IPCC guidelines for National Greenhouse Gas Inventories and 2019 refinement to the 2006 IPCC guidelines for National Greenhouse Gas Inventories (IPCC 2006 and 2019, respectively)—for estimating GHG emissions from various solid waste management practices, which are summarized in appendix C.

5.1

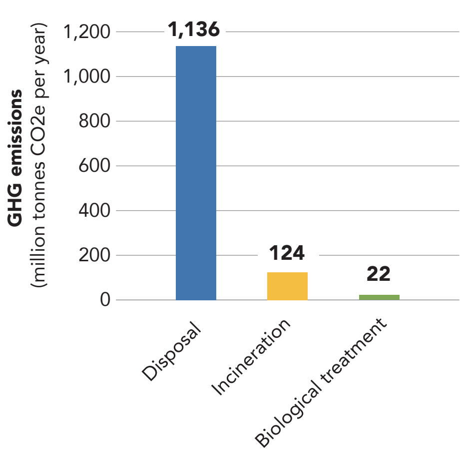
Greenhouse Gas Emissions from Solid Waste Management

Global GHG emissions from solid waste management activities in 2022 are estimated at 1.28 billion tonnes of carbon dioxide equivalent per year (figure 5.1). Eighty-nine percent of these emissions are generated from waste disposal, whereas only a small fraction is generated from other solid waste management activities at 11 percent.

The highest amount of emissions is associated with methane at 1.15 billion tonnes of carbon dioxide equivalent annually—applying a global warming potential (GWP) of methane of 27 from IPCC AR6[1]—followed by carbon dioxide at 115 million tonnes of carbon dioxide equivalent annually (figure 5.2). When comparing annual GHG emissions per capita, 144.6 kilograms of carbon dioxide equivalent of methane, 14.4 kilograms of carbon dioxide, and 2.0 kilograms of carbon dioxide equivalent of nitrous oxide are generated from various solid waste management activities globally.

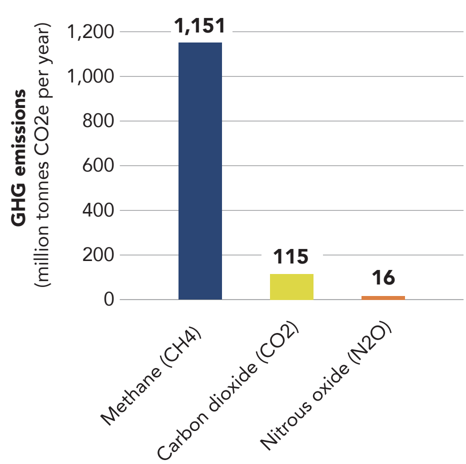
Upper-middle-income countries generate the highest total GHG emissions from solid waste management activities, followed by lower-middle-income countries (figure 5.3). However, with regard to per capita emissions, the situation changes with the highest per capita GHG emissions generated by high-income countries (figure 5.4) due to higher per capita waste generation. Both high-income and upper-middle-income countries generate higher per capita GHG emissions compared with the global per capita GHG emissions from solid waste management activities.

Figure 5.1 Global GHG emissions from solid waste management by activity type



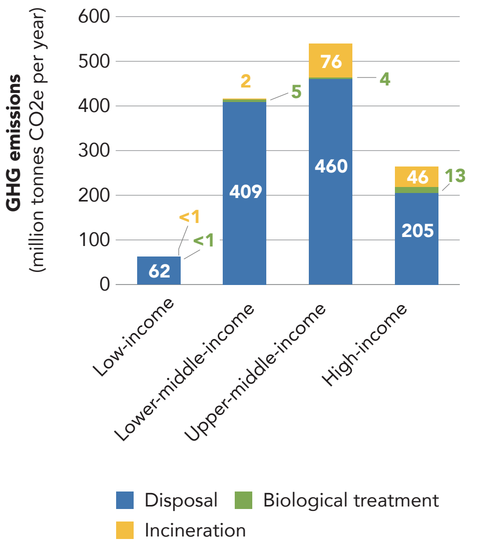
Source: Original figure for this report.
Note: Calculated for municipal solid waste generated and treated, projected to 2022.
CO2e = carbon dioxide equivalent, GHG = greenhouse gas.

Figure 5.2 Global GHG emissions from solid waste management by main greenhouse gas



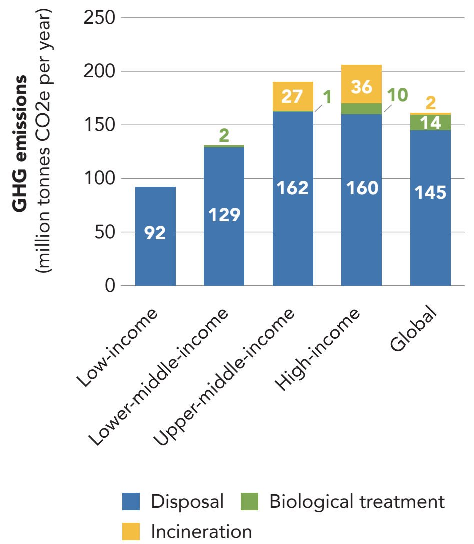
Source: Original figure for this report.
Note: Calculated for municipal solid waste generated and treated, projected to 2022.
CO2e = carbon dioxide equivalent, GHG = greenhouse gas.

Figure 5.3 Total GHG emissions from solid waste management activities by income group



Source: Original figure for this report.
Note: Calculated for municipal solid waste generated and treated, projected to 2022.
CO2e = carbon dioxide equivalent, GHG = greenhouse gas.

Figure 5.4 Per capita GHG emissions from solid waste management activities by income group



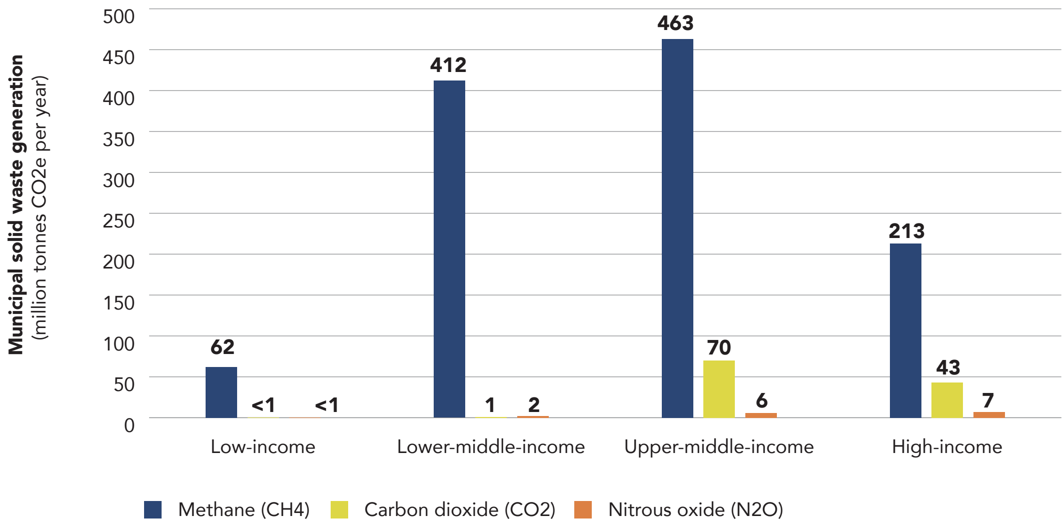
Source: Original figure for this report.
Note: Calculated for municipal solid waste generated and treated, projected to 2022.
CO2e = carbon dioxide equivalent, GHG = greenhouse gas.

Upper-middle-income countries generate the highest methane emissions, followed by lower-middle-income countries, due to a large amount of solid waste disposal activities there. Both high-income and upper-middle-income countries also create a large amount of carbon dioxide emissions due to a high amount of waste incineration occurring in these countries (figure 5.5). However, in per capita terms, the highest amount of methane emissions is generated by high-income countries, closely followed by upper-middle-income countries, both generating more than the average global per capita carbon dioxide equivalent from methane emissions from solid waste management activities.

The East Asia and Pacific region generates the highest total GHG emissions from solid waste management activities followed by the South Asia region (figure 5.6). In per capita terms, the North America region generates the highest GHG emissions per capita from solid waste management activities, closely followed by the Middle East and North Africa and Latin America and Caribbean regions (figure 5.7).

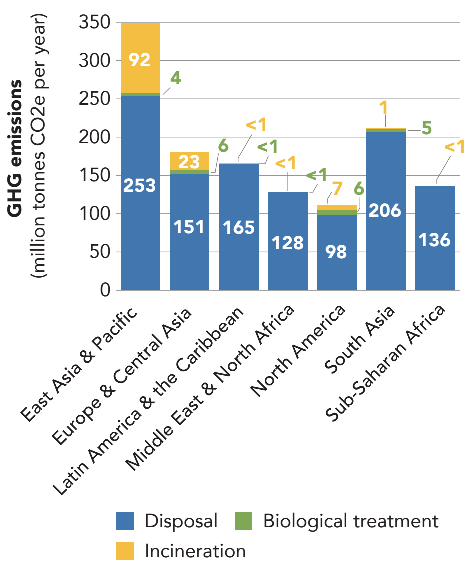
The East Asia and Pacific region generates the highest amount of methane emissions from solid waste management activities, followed by the South Asia region. East Asia and Pacific as well as Europe and Central Asia generate the most carbon dioxide emissions due to higher levels of incineration occurring in these regions (figure 5.8). In per capita terms, the highest three methane generating regions are North America, Middle East and North Africa, and Latin America and the Caribbean (figure 5.9).

Figure 5.5 Total GHG emissions from solid waste management by main greenhouse gas and income group



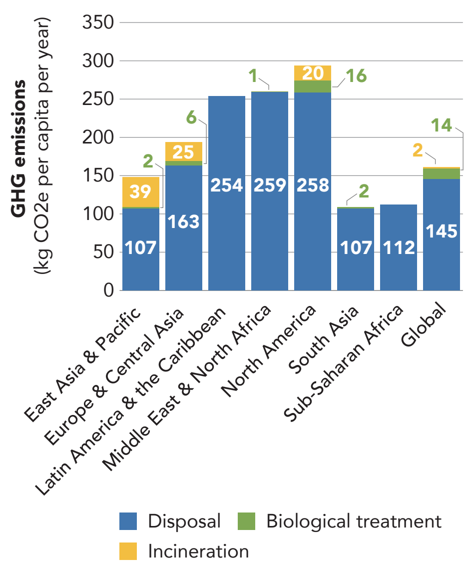
Source: Original figure for this report.
Note: Calculated for municipal solid waste generated and treated, projected to 2022.
CO2e = carbon dioxide equivalent, GHG = greenhouse gas.

Figure 5.6 Total GHG emissions from solid waste management activities by region



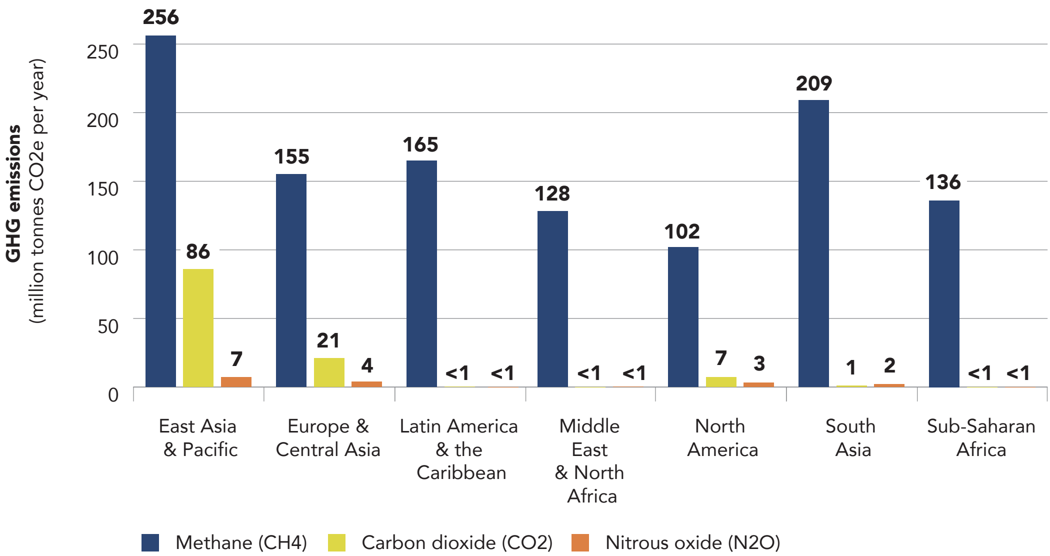
Source: Original figure for this report.
Note: Calculated for municipal solid waste generated and treated, projected to 2022.
CO2e = carbon dioxide equivalent, GHG = greenhouse gas.

Figure 5.7 Per capita GHG emissions from solid waste management activities by region



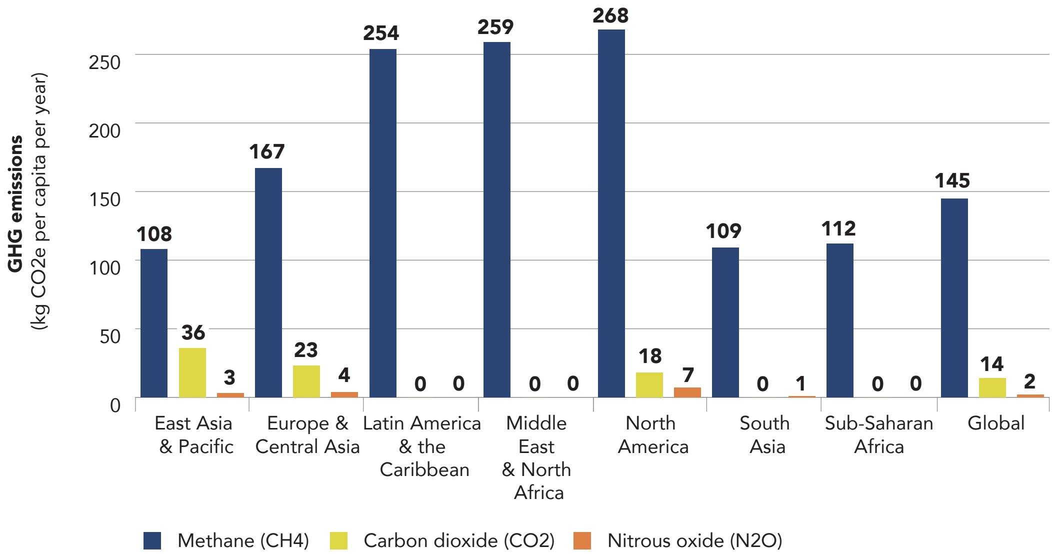
Source: Original figure for this report.
Note: Calculated for municipal solid waste generated and treated, projected to 2022.
CO2e = carbon dioxide equivalent, GHG = greenhouse gas.

Figure 5.8 Total emissions of different GHGs from solid waste management activities by region



Source: Original figure for this report.
Note: Calculated for municipal solid waste generated and treated, projected to 2022.
CO2e = carbon dioxide equivalent, GHG = greenhouse gas.

Figure 5.9 Per capita emissions of different GHGs from solid waste management activities by region



Source: Original figure for this report.
Note: Calculated for municipal solid waste generated and treated, projected to 2022.
CO2e = carbon dioxide equivalent, GHG = greenhouse gas.

5.2
Projected Greenhouse Gas Emissions

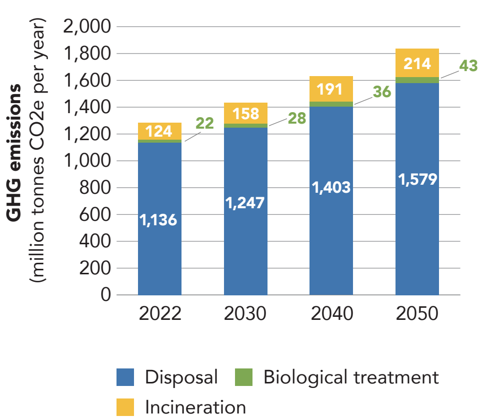
Using the scenarios outlined in chapter 4—business as usual, low ambition, and high ambition—the following subsections present projected GHG emissions from solid waste management under each pathway.

5.2.1 Business-as-usual Scenario

Under the business-as-usual scenario, projected GHG emissions from solid waste management activities are expected to grow from 2022 to 2050, in total and per capita terms (figures 5.10 and 5.11). This is mainly driven by the gradual increase in waste generation and collection services, followed by a reduction in open dumping leading to an overall increase in the volume of waste disposed of in controlled and sanitary landfills under the business-as-usual scenario (see chapter 4). It can also be observed that the total GHG emissions increase by over 43 percent from 2022 to 2050, whereas the increase in per capita GHG emissions is 19 percent over the same period.

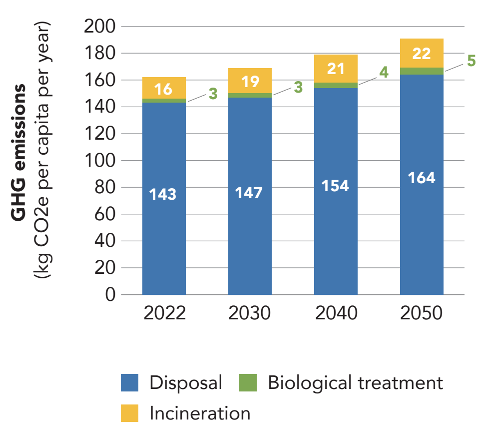
Significant differences emerge in GHG emissions trends from 2022 to 2050 between the different country income groups. Whereas GHG emissions are expected to increase—in total and per capita terms—for low-income and lower-middle-income countries, GHG emissions are expected to be roughly constant for high-income and upper-middle-income countries (figures 5.12 and 5.13).

Figure 5.10 Projected total GHG emissions by solid waste management activity in a business-as-usual scenario



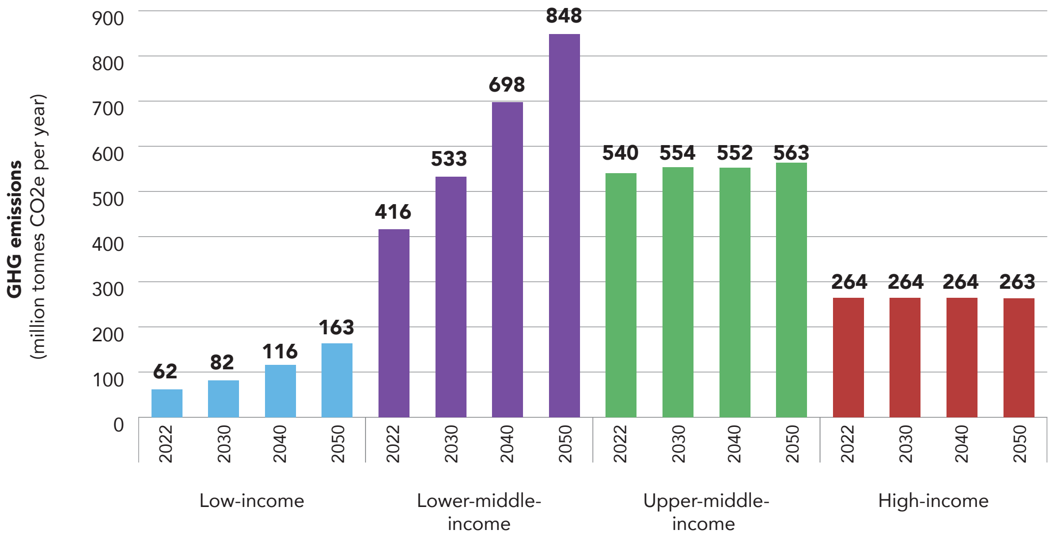
Source: Original figure for this report.
Note: CO2e = carbon dioxide equivalent, GHG = greenhouse gas.

Figure 5.11 Projected per capita GHG emissions by solid waste management activity in a business-as-usual scenario



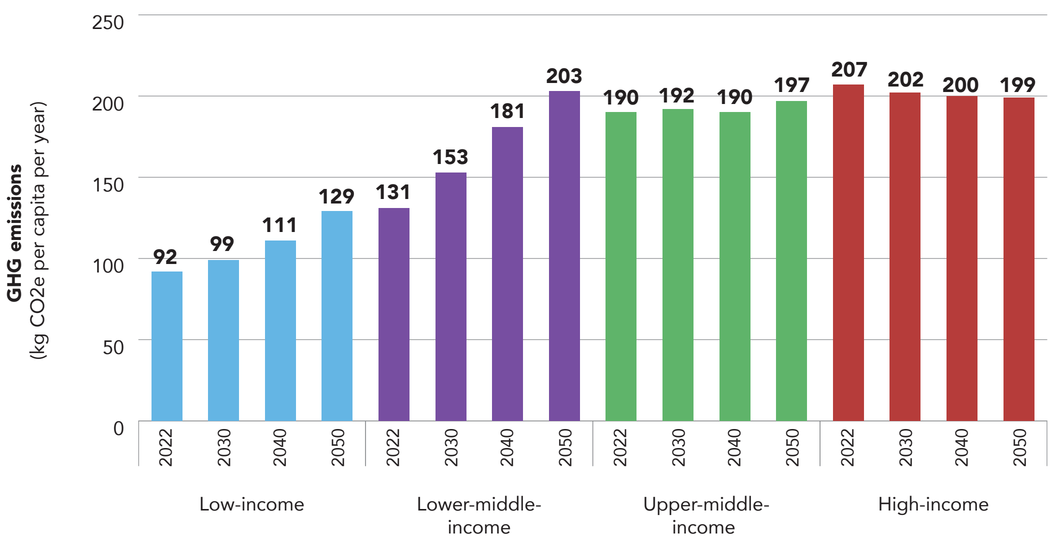
Source: Original figure for this report.
Note: CO2e = carbon dioxide equivalent, GHG = greenhouse gas.

Figure 5.12 Projected total GHG emissions from solid waste management activities by income group in a business-as-usual scenario



Source: Original figure for this report.
Note: CO2e = carbon dioxide equivalent, GHG = greenhouse gas.

Figure 5.13 Projected per capita GHG emissions from solid waste management activities by income group in a business-as-usual scenario

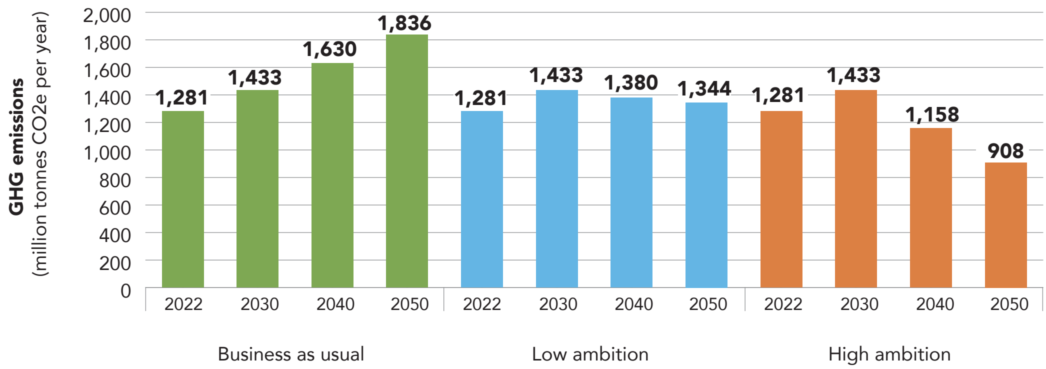


Source: Original figure for this report.
Note: CO2e = carbon dioxide equivalent; GHG = greenhouse gas.

5.2.2 High- and Low-ambition Scenarios

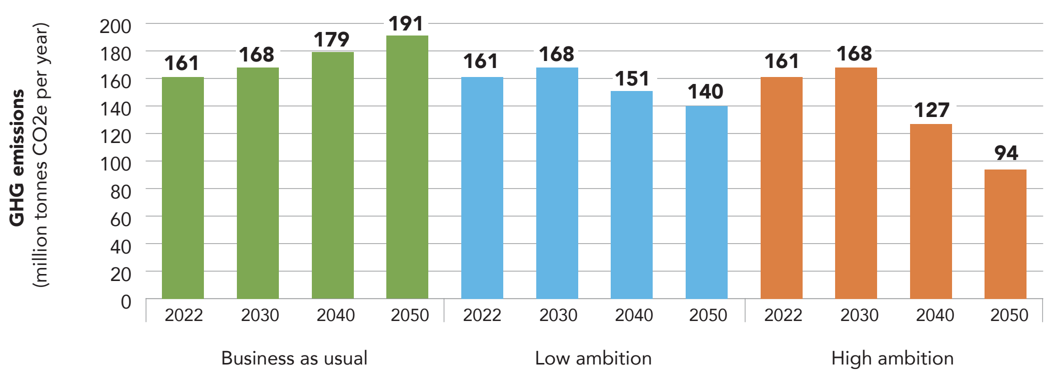
When comparing GHG emissions in the business-as-usual scenario with low-ambition and high-ambition scenarios, the latter display decreases in GHG emissions from 2030 to 2050 (figure 5.14). The decrease is mainly driven by the avoided GHG emissions from an increase in waste reduction at source followed by increase in recycling and composting as a proportion of waste collected (see chapter 4). The rate of decrease is higher in the high-ambition scenario, due to a higher diversion of waste from disposal to recycling. Similar trends are observed when comparing per capita GHG emissions between the scenarios (figure 5.15).

Figure 5.14 Projected total GHG emissions from solid waste management activities by scenario



Source: Original figure for this report.
Note: CO2e = carbon dioxide equivalent, GHG = greenhouse gas.

Figure 5.15 Projected per capita GHG emissions from solid waste management activities by scenario

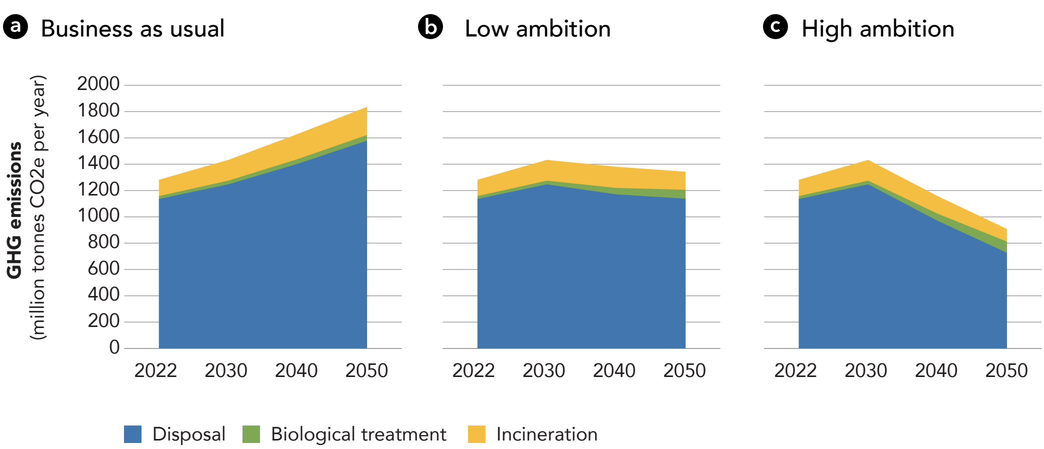


Source: Original figure for this report.
Note: CO2e = carbon dioxide equivalent, GHG = greenhouse gas.

When comparing GHG emissions from various solid waste management activities in the business-as-usual scenario with low-ambition and high-ambition scenarios, GHG emissions from disposal and incineration activities display reductions between 2030 and 2050, under low-ambition and high-ambition scenarios, whereas emissions from biological treatment display an increase (figure 5.16). The reductions in emissions from disposal and incineration activities are larger under the high-ambition scenario. Under the high-ambition scenario, emissions from disposal and incineration are significantly lower in 2050 compared with 2022 levels, whereas under the low-ambition scenario, they are very close to 2022 levels in 2050.

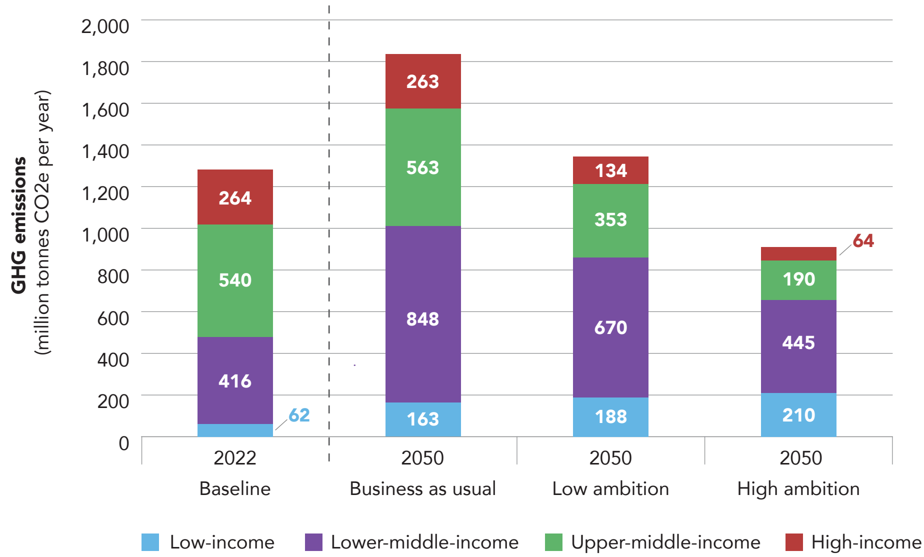
When comparing 2022 GHG emissions by income group with low-ambition and high-ambition scenarios, high-income and upper-middle-income countries display reductions in GHG emissions between 2022 and 2050, where a higher reduction in percentage terms is observed in high-income countries (figure 5.17). For high-income and upper-middle-income groups, higher reductions are observed in the high-ambition scenario. On the other hand, lower-middle-income and low-income countries display an increase in GHG emissions from 2022 to 2050 under low-ambition and high-ambition scenarios, with a higher increase, in percentage terms, observed in low-income countries. Greenhouse gas emissions are highest in the low-ambition scenario for lower-middle-income countries, whereas for low-income countries, the highest GHG emissions are observed in the high-ambition scenario. Under the high-ambition scenario, total GHG emissions in 2050 are reduced by 29 percent from 2022 levels.

Figure 5.16 Projected total GHG emissions by solid waste management activity and by scenario



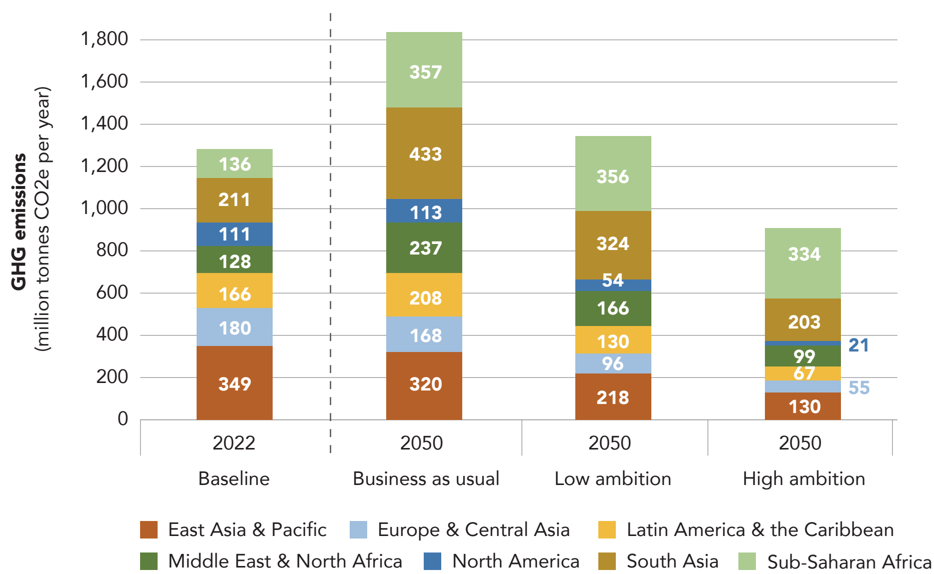
Source: Original figure for this report.
Note: CO2e = carbon dioxide equivalent, GHG = greenhouse gas.

Figure 5.17 Projected total GHG emissions from solid waste management activities by income group and by scenario



Source: Original figure for this report.
Note: CO2e = carbon dioxide equivalent, GHG = greenhouse gas.

Figure 5.18 Projected total GHG emissions from solid waste management activities by region and by scenario



Source: Original figure for this report.
Note: CO2e = carbon dioxide equivalent, GHG = greenhouse gas.

When comparing 2022 GHG emissions for the different regions with low- ambition and high-ambition scenarios, East Asia and Pacific, Europe and Central Asia, Latin America and the Caribbean, and North America displayed reductions in emissions from 2022 to 2050 under both low-ambition and high-ambition scenarios, with the highest reduction in percentage terms observed in North America, followed by Europe and Central Asia (figure 5.18). On the other hand, Sub-Saharan Africa region observed an increase in GHG emissions from 2022 to 2050 under low-ambition and high-ambition scenarios and the Middle East and North Africa and South Asia regions observed an increase under the low-ambition scenario.

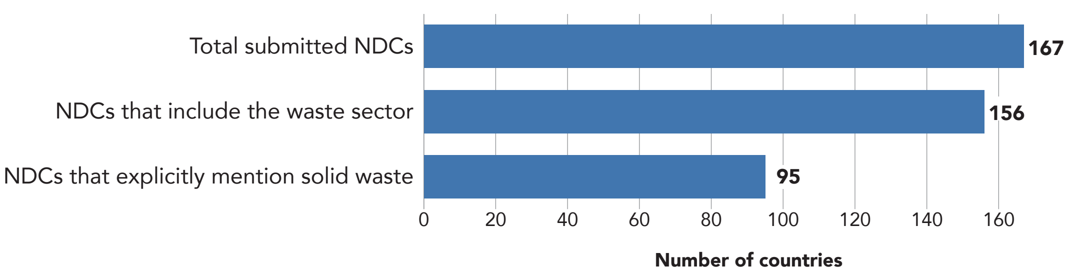
5.3
Solid Waste in Nationally Determined Contributions

Nationally Determined Contributions (NDCs) are country-led climate action plans under the Paris Agreement, reflecting national priorities and circumstances in reducing GHG emissions and adapting to climate change. Many Nationally Determined Contributions include specific commitments related to emissions from waste management and processing.

At the time of this report, 167 of the 195 countries, party to the Paris Agreement, have submitted their Nationally Determined Contributions, with 156 including the waste sector in their greenhouse gas mitigation strategies.[2] Among these, 95 explicitly identify solid waste management as a priority for emissions reductions (figure 5.19).[3]

Among the Nationally Determined Contributions that explicitly reference solid waste, 48 include quantitative targets to reduce emissions, 52 set qualitative objectives for waste management, and 22 incorporate quantitative and qualitative targets.

Figure 5.19 Inclusion of the waste sector in Nationally Determined Contributions



Source: Original figure for this report.
Note: Based on United Nations Framework Convention on Climate Change (UNFCCC), NDC Registry. NDC= Nationally Determined Contribution.

Strategies to improve waste management and reduce emissions include efforts to minimize waste streams and per capita generation, enhance recycling and composting programs (box 5.1), strengthen collection systems, implement waste-to-energy projects, and reduce landfill emissions through methane capture and destruction. A few Nationally Determined Contributions also refer to capacity building as part of their approach. These measures are often embedded within broader low-emission development strategies and circular economy frameworks. Several Nationally Determined Contributions highlight the cobenefits of solid waste management for climate adaptation. They include reducing flood risk by preventing drainage blockages from mismanaged waste, improving public health, or enhancing soil quality through composting—strategies that support both mitigation and adaptation objectives.

Despite the widespread availability and adoption of waste management technologies, many countries continue to face challenges in implementation. These challenges are primarily due to the absence of financial incentives and the lack of enforcement of existing regulations. Consequently, many countries expressed dependency on international cooperation to meet their waste sector emission reduction goals. In these cases, the ambition is marked as conditional targets in their Nationally Determined Contributions. Conditional targets in Nationally Determined Contributions outline the international support needed by developing countries to fully realize their climate ambitions. Conditional targets highlight the gap between what countries can achieve independently and what becomes feasible with access to climate finance, technology transfer, and capacity-building support.

Countries frequently emphasize the importance of technology transfer and capacity building, particularly for advanced waste treatment technologies and emissions monitoring systems. Of the 156 Nationally Determined Contributions that reference the waste sector, 120 or 77 percent include conditional and unconditional targets. In most cases, however, these targets apply to the entire Nationally Determined Contributions and are not broken down by sector.

Box 5.1 Food Wastage

Food loss and food waste

Every year, nearly one third of all food produced globally is lost or wasted (FAO 2011). Food loss[a] occurs throughout the supply chain from farms to markets, particularly in regions where inadequate infrastructure, limited cold storage, and inefficiencies in logistics, processing, and transport lead to substantial pre-consumer losses. Food waste,[b] on the other hand, occurs at the retail and consumer levels, where edible food is discarded or wasted due to spoilage, over purchasing, aesthetic standards, or expiry dates.

Addressing food loss and waste is critical for enhancing food security, building more resilient and sustainable food systems, protecting natural resources such as land, soil and water, and reducing GHG emissions (World Bank 2024). Globally, food loss and waste is estimated to contribute 8% to 10% of total GHG emissions (FAO 2024).

Efforts to reduce and manage food loss and waste effectively are essential to achieving several Sustainable Development Goals (SDGs), notably SDG 2 (zero hunger), SDG 12 (responsible consumption and production), and SDG 13 (climate action). Sustainable Development Goal target 12.3 specifically calls for halving per capita food waste at the retail and consumer levels, while also reducing food losses along production and supply chains, including postharvest losses, by 2030 (United Nations 2015).

Food waste alone poses a significant global challenge with far-reaching environmental, economic, and social impacts. This occurs even as an estimated 735 million people faced chronic hunger in 2022 (FAO et al. 2023). Food waste is a major driver of environmental degradation and public resource inefficiency. It represents a misuse of land, water, energy, and labor, and contributes to food insecurity and avoidable GHGs. When not properly managed, food waste generates methane and places significant strain on global public goods including climate, soil health, and water resources. It burdens municipal waste systems, which often lack the infrastructure or financing to handle large volumes of organic waste efficiently. Without intervention, food waste will continue to undermine food system resilience, waste natural resources, and burden waste systems. Yet, reducing food waste is one of the most complex issues facing the world today.

Reducing food waste

Food waste is the largest single category of municipal solid waste globally. This report estimates that food waste accounts for approximately 38% of global municipal solid waste, amounting to nearly a billion tonnes per year. In low-income countries, food waste accounts for nearly 50% of all waste, whereas it is 42–45% in middle-income countries and 23% in high-income countries. The United Nations Environment Programme (UNEP) estimates that, in 2022, 19% of food available to consumers—approximately 1 billion tonne—was wasted globally (UNEP 2024).

Reducing food waste is essential. Even modest reductions in daily food waste could make a meaningful difference in addressing food shortages and easing pressure on natural resources. It would also significantly reduce the burden on municipal waste management systems, where food waste represents the largest waste category by weight. Cutting down on food waste can help lower collection and disposal costs, reduce landfill use, and limit methane emissions from decomposing organic matter.

Reducing food waste at the retail and consumer levels requires a combination of prevention, redistribution, and behavioral change. Prevention efforts include clearer date labeling, improved portion sizing, better meal planning, and smarter inventory and purchasing practices by retailers and households. Retailers can also play a key role by adjusting promotions, donating surplus food, and reconsidering appearance-based criteria such as size, shape, or minor blemishes that often lead to the unnecessary rejection of edible food. Public awareness and education campaigns are critical to shifting mindsets and encouraging more sustainable consumption habits, especially among the young generation. Local authorities can support these efforts by introducing economic incentives, such as by funding local food recovery and redistribution initiatives, offering tax breaks or reduced waste collection fees for food donations, and investing in community composting or food sharing platforms, as well as educational campaigns targeting schools and youth.

Food waste management

Much of today's food waste ends up in landfills, dumpsites, or is being incinerated. Effective food waste management, however, requires targeted treatment solutions such as composting and anaerobic digestion. Such technologies are essential for diverting organic waste from landfills and dumpsites, minimizing environmental impacts and particularly reducing methane and CO2e emissions. In addition to mitigating climate effects, they can produce valuable outputs such as biogas for renewable energy and high-quality compost or soil enhancements for agricultural use.

Composting and anaerobic digestion remain challenging in most countries, as both rely on clean, source-separated organic waste to be effective. When composting is done with comingled municipal waste, the result is low quality compost with limited market value, even when distributed for free. Similarly, digesters operate far more efficiently with uncontaminated feedstock free from plastics, glass, and other materials. However, in many places, the policies, infrastructure, and incentives needed to support proper source separation are weak or underdeveloped. Although some local authorities have introduced ordinances mandating separation at source, implementation is often partial or ineffective, and organic waste continues to be mixed with packaging and other contaminants. Achieving clean feedstock remains challenging even in high-income countries. In the European Union, for example, many countries have only recently introduced at-scale separate organics collection for household waste, requiring scaled public sensitization, sustained outreach, and behavioral incentives to ensure compliance.

Although experience shows that progress is gradual and contamination often remains a challenge, source separation remains an essential foundation for effective organic waste treatment. Its adoption across all countries and income levels is critical for improving waste system performance and reducing environmental impacts. Separation at source significantly enhances the efficiency and effectiveness of downstream processes such as recycling, composting, and anaerobic digestion by enabling cleaner material streams and limiting contamination.

As a practical first step, introducing a basic two-stream system, separating waste into wet (organic) and dry (recyclable and residual) fractions, can yield immediate improvements in system performance. This approach increases recovery rates, enhances the quality of compost and recyclables, and reduces the volume of waste sent to landfills or incineration. Without separation at source, waste remains mixed and too contaminated to be processed efficiently, resulting in higher operational costs and greater environmental impacts. Institutionalizing source separation is, therefore, one of the most effective strategies available to local authorities seeking to improve waste system performance and advance circular economy goals.

A feasible starting point is targeting the commercial and hospitality sector. It can be pursued ahead of or in parallel with efforts to introduce source separation at the household level. Entities such as food markets, restaurants, and food processors generate large, relatively uniform organic waste streams that are typically less contaminated by packaging and other materials, making them well suited for composting and anaerobic digestion. These high-volume generators also tend to be easier to monitor and regulate and are often already subject to environmental oversight, allowing compliance measures to be integrated into existing frameworks. Implementing source separation in these sectors can demonstrate early success, build operational experience, and lay the groundwork for broader residential expansion.

Regulating food waste generated by commercial establishments

Globally, a range of policy instruments have been introduced to address organic waste, including financial incentives for diversion, landfill bans on organics, and support for the development of compost markets. Enabling conditions can also include requiring chemical fertilizer companies to blend or distribute compost alongside synthetic fertilizers and establishing organic agriculture certifications that accept certified compost as a soil enhancer, which would enable access to carbon credits for organic waste diversion.

The following sections summarize three different approaches for managing food waste from large generators. First, is Japan's approach to mandate recycling rates for commercial food waste generators and introduce a value chain certification scheme to promote targeted recycling operations and high value end use of recycled products. Second, is the approach by Massachusetts (United States) to ban commercial food waste for disposal in landfills and combustion facilities supported by systematic expansion of composting and anaerobic digestion capacity and market creation for recycled products. Third, is China's approach to mandate local authorities to monitor and enforce permitted food waste management practices and scale anaerobic digestion capacity. In all three examples, success of the programs has been attributed to robust regulatory frameworks, comprehensive monitoring and enforcement, and significant financial and technical assistance for the expansion of alternative treatment infrastructure.

Recycling and treatment of food resources in Japan: Japan passed the *Food Waste Recycling Law* in 2000 to establish a circular system by promoting the reduction and recycling of food waste generated by food-related businesses.[c] The law applies to food-related businesses such as food manufacturers, wholesalers, retailers, and restaurants. The production of animal feed from recycled food materials is preferred in support of national agricultural policies for feed self-sufficiency. The law also introduced a full value chain certification scheme to encourage collaboration between food waste generators, recycling operators, and agricultural producers, in support of market creation for recycled products and to help guide investments in recycling facilities toward areas with unmet supply and demand.

Legal framework. The *Food Waste Recycling Law* establishes recycling targets for food waste generated by manufacturers (95%), wholesalers (75%), retailers (65%), and restaurants (50%), while excluding household waste.[d] In 2021, 85% of food waste generated by food-related businesses was diverted from disposal, with 87% recycled, 3% utilized for heat recovery, and 11% reduced through dehydration and drying processes. The predominant recycling methods include feed production (76%), composting (16%), and anaerobic digestion (4%), collectively accounting for 96% of recycling activities (Japan MoAFF 2022).

The law mandates that food-related businesses prioritize reduction of food waste to the greatest extent possible and engage recyclers to treat any food waste that cannot be reduced. The law provides guidance for calculating the amount of food waste generated, volume reduced, recycled, recovered by heat, prevented, and the effective recycling rate.[e] Businesses must ensure that their annual recycling rates exceed their assigned baseline rates[f] to promote continuous improvement in food waste management.

Monitoring and reporting. A critical component of the law is the mandatory reporting system for large-scale food waste generators, defined as those producing over 100 tonnes annually.[g] This system enables systematic monitoring of food waste generation and recycling efforts across the industry and supports data-driven policy making. Approximately 2% of food-related businesses are subject to reporting requirements, yet they account for 87% of total food waste generated in Japan.[h] The reporting system enhances the monitoring of food waste management by ensuring that key stakeholders are involved and accountable. Reporting companies must submit data on company profiles including financial information, their waste generation, recycling activities, and reduction strategies, enabling the Ministry of Agriculture, Forestry and Fisheries and the Ministry of the Environment to monitor sector-specific performance benchmarks by comparing sales scale within the same industry. Businesses failing to meet their recycling targets are subject to administrative guidance, public disclosure, and formal orders, with fines of up to ¥500,000 (approximately US$3,500) for non-compliance.[i] Submission of false reports or failure to report can result in fines of up to ¥200,000 (US$1,390). Public disclosure serves as a reputational risk, encouraging accurate reporting and proactive recycling efforts.

Expansion of treatment capacity. The *Food Waste Recycling Law* prioritizes prevention, followed by recycling into feed or fertilizer, then heat recovery, and finally volume reduction for disposal. Standards guide businesses in executing these measures appropriately.[j] Among recycling methods, based on efficiency and sustainability, feed recycling is given the highest priority, followed by fertilizer production—including digestate from anaerobic digestion—as cultivation substrates, for example, mushroom bed materials, and methane fermentation for biogas production. Feed recycling is prioritized because food waste contains valuable nutrients and calories, making it highly suitable for livestock feed. This approach enhances resource efficiency and contributes to Japan's feed self-sufficiency, aligning with national agricultural policies.

The law also introduced a *Recycling Loop Certification Scheme*, which promotes collaboration between food waste generators, recycling operators, and agricultural producers.[k] Through this scheme, the recycled feed or fertilizer is used to produce agricultural products that re-enter the food supply chain, closing the resource loop. Food waste generators, recycling operators, and agricultural producers submit a recycling business plan together for certification by the relevant ministry. Certification provides regulatory incentives, such as exemptions from certain waste management licenses and enhanced credibility through national registration. As of March 2025, 54 recycling loops were certified: 21 focused on feed production, 32 on fertilizer production, and one combined both, thereby promoting local resource recycling and sustainable agricultural development.[l]

Diversion of food waste from disposal in Massachusetts: Massachusetts is a geographically small and densely populated coastal state in northeastern United States that has embarked on a mission to develop a *Pathway to Zero Waste*, in part due to decreasing availability of landfill space (MassDEP 2013). In 2014, Massachusetts was the second state in the US to enact a disposal ban on commercial food waste as one of its initiatives[m] for diverting at least 30% of all municipal solid waste from disposal statewide by 2030, aiming for 80% reduction by 2050 (MassDEP 2013). Food materials represent more than 25% of municipal solid waste in Massachusetts, and commercial businesses are responsible for 45% of all food waste generated.

Legal framework. In Massachusetts, environmental protection is comprehensively regulated by the Code of Massachusetts Regulation Title 310 (310 CMR), with all regulations pertaining to solid waste management codified in section 19,[n] with the aim of protecting public health, safety, and the environment from the storage, transfer, processing, treatment, disposal, use and reuse of solid waste. Title 310 CMR 19.000 has provisions for periodic review and amendment of the regulation following an approved process for amendment drafting and public review. In 1990, 310 CMR 19.000 was amended to introduce 310 CMR 19.017 *Waste Bans*, restricting waste haulers and waste treatment facilities—including transfer stations, landfills and combustion facilities—from accepting restricted materials.[o] In 2014, 310 CMR 19.000 was once again amended to include commercial organic material greater than 1 ton per week (0.9071 tonnes)[p] to the restricted materials list, which was subsequently reduced to half a ton per week (0.45359 tonne) in 2022 (MassDEP 2022). According to a regulatory impact study, businesses that generate more than 1 ton per week of food waste represent 46% of all commercial generators and 89% of all commercial food waste generated (MassDEP 2002). Reducing the threshold to half a ton per week covers 73% of all commercial food waste generators and 97% of all commercial food waste generated.

The regulatory authority, the Massachusetts Department of Environmental Protection (MassDEP), provides detailed *Guidance for Businesses, Institutions and Haulers* (MassDep 2023) that may be subject to the commercial organic materials ban including a comprehensive recycling assistance program, *RecyclingWorks Massachusetts*, offering site specific consultancies, a hotline and robust online catalog of resources.[q]

For facilities that meet the minimum threshold, the regulator, MassDEP, encourages a four-step process for compliance and provides detailed guidance for each step: First, the facility should reduce food waste generation through more efficient food service operations and systems to track food waste.[r] Second, the facility should donate servable food to shelters, food pantries, and food rescue operations.[s] Third, the facility should use an onsite system to process food waste.[t] Fourth and finally, the facility should work with a hauler to send separated food waste for animal feed, to digestion, or to a composting facility.[u] The MassDEP Guidance prioritizes source reduction as the most cost-effective approach, noting that some entities have been able to reduce their food waste by half through reduction efforts.

A clear penalty system is described,[v] with violations subject to criminal penalties (imprisonment for not more than two years) and civil penalties (fine not to exceed US$25,000 per day of violation) as well as civil administrative penalties (fine no less than US$100 and not to exceed US$25,000 per day of violation), to be determined by a judge.

Monitoring and reporting. According to 310 CMR 19:000: Solid Waste Facility Regulations, facility operators and waste haulers must be permitted. One condition for applying for and renewing a permit is the submission of a facility operational plan, which must also include a waste ban plan[w] detailing how the facility operator and waste hauler will ensure that no banned material is accepted, including operator guidelines for monitoring and record keeping, load inspection, procedures for rejection of failed or contaminated loads, communication, signage, training, and issuing an annual report to MassDEP as a condition to maintain compliance with permit requirements.

In addition to submission of the waste ban plan and annual reports, facility operators and haulers are subject to third-party inspections by MassDEP authorized inspectors, which verify facility and operational compliance with the MassDEP approved permit and waste ban plan.[x] The submission of annual reports to MassDEP must be accompanied by third-party inspection reports in accordance with the facility-specific approved inspection schedule included in the facility permit.

Expansion of treatment capacity. Since the inclusion of commercial organic materials in the state's waste bans, the government has provided numerous incentive programs[y] to encourage the expansion of composting and anaerobic digestion capacity across the state. Programs have included ongoing grants for municipalities,[z] to improve local programs and policies,[aa] technical assistance[ab] and state-backed low interest loans,[ac] and business development grants[ad] for the private sector, including dedicated funds to spur innovation,[ae] and direct support to local community-based groups and schools.[af]

In addition, the state has also supported market creation for recycled products[ag] to further strengthen affordability of services and viability of recycling facilities. Guidelines for compost,[ah] anaerobic digestion,[ai] and other recycling and reuse applications provide end-user assurance on the quality and approved end-use for recycled products. Clear provisions have been made for demonstration projects to test viability of new technologies and practices to continually drive optimization of operations and technologies for collection and treatment considering local market and waste stream characteristics.

The state coordinates its efforts and continually finetunes its approach based on lessons learned through periodic updates to the *Solid Waste Master Plan*[aj] and *Organics Action Plan*.[ak] These tools enable the state to define and communicate a coherent sector strategy to all value chain actors, highlighting priority programs and assistance available to achieve state-wide targets for commercial food waste reduction, reuse, recovery, and recycling.

Management of food waste from commercial establishments in China: The amount of restaurant and kitchen waste generated by cities in China has rapidly increased over the past decades owing to urbanization, improved living conditions, and a burgeoning catering sector. Historically, food waste from commercial kitchens was diverted from the public waste management system by unregulated, informal sector recyclers for animal feed and cooking oil reprocessing. Concerns related to hygiene and public safety instigated a series of comprehensive actions by the government, which, over the years, became interwoven with other national policy directives. A comprehensive system of legislative instruments have been developed, with a primary focus on the role of local authorities to regulate, monitor, and enforce standardized source separation and treatment of kitchen wastes and used cooking oil from commercial generators. In parallel, the central government prioritized the allocation of financial and technical assistance for the rapid expansion of anaerobic digestion capacity, as the preferred means of food waste recycling.

Legal framework. The legal framework governing the management of food waste by commercial establishments was initiated with the issuance of *Opinions on strengthening the improvement of gutter oil and kitchen waste management*.[al] It outlines a set of actions that local authorities must undertake to regulate commercial generators of kitchen waste and used cooking oil, including strict bans and enforcement against the use of recycled oil in food production; requirements for source separation and, where feasible, onsite pretreatment. The framework also contains a mandatory reporting system to monitor kitchen waste quantities and flows. Supervision and inspection are underscored as critical functions of local authorities and health departments. Penalties for violations may include revocation of business licenses, criminal sanctions, and public disclosure of noncompliance. Regional and central agencies are called upon to support the establishment of plans and resources for the expansion of recycling infrastructure, development of markets for recycled products, and support the development of new technologies and business models.

Following the 2010 *Opinions*, a series of supporting legal instruments and policy communications were introduced to systematically strengthen the regulation of restaurant and kitchen waste. A whole-of-government approach has since unfolded, involving shared mandates across multiple ministries, councils, and agencies. Some of the dedicated measures governed by legal instruments that have since emerged include: (1) a target set in 2013 that by 2015, 50% of large cities should implement segregated handling and recycling of restaurant kitchen waste, establish professional handling and recycling systems, and eliminate illicit collection and use of restaurant cooking oil;[am] (2) local authorities were made accountable for restaurant kitchen waste and oil noncompliance, incentives were provided to encourage investments in restaurant kitchen waste treatment and recycling enterprises;[an] (3) provincial-scale plans were released to encourage the management and financing of restaurant kitchen waste in an integrated way;[ao] (4) prohibition of animal farms using restaurant kitchen waste as animal feed was strengthened ;[ap] (5) guidance was provided for a tiered fee mechanism based on volumes and types of waste generated and rollout of a digital ledger and bill of lading system.[aq]

The *Law on Food Waste* was passed in 2021 with emphasis on food security and traditional national virtues and social values of frugality and resource conservation.[ar] Food waste reduction is prioritized, and commercial generators are charged to improve operational practices and to act as agents of social accountability with its customers. A number of supporting measures were also implemented, including the issuance of standard operating procedures[as] and technical codes[at] to bolster the food waste recycling sector.

Monitoring and reporting. Local authorities bear the main responsibility for monitoring and control and are held accountable for preventing illegal handling of commercial food waste. Development and Reform Commission coordinates cross-agency efforts to establish integrated systems, including waste tracking, scheduled collection, centralized treatment, recyclables assessment, and supervision. Local Environmental Sanitation Authorities design workflow, stakeholder responsibilities, enforcement, digital compliance monitoring, and engage qualified and licensed service providers through competitive selection. Local authorities establish restaurant and kitchen waste ledger systems, performance evaluation mechanisms, information management system platforms, and appeal and complaint redress mechanisms. Noncompliant entities may be subject to fines, corrective actions, or cancellation of business licenses. Generators must register with local authorities, report daily volumes and types of waste cooking oil, and maintain ledger records for the required period. Those without in-house treatment must engage approved providers under formal contracts—a key compliance metric used in regulatory monitoring.

Service providers must be registered with the relevant authorities and obtain a permit from the local Industry and Commerce Administration. Waste—including restaurant and kitchen waste—treatment entities must have the License of Municipal Solid Waste Commercial Treatment Service. Servicing without a permit or license is deemed illegal and will incur suspensions and fines. Treatment facilities shall ensure consistency of data in their ledger system and the bill of lading. They are not allowed to sell or pass untreated waste cooking oil or below-standard processed waste cooking oil for other purposes. Local Bureaus of Housing and Urban Rural Development and Bureaus of Urban Management responsible for administering municipal solid waste management organize annual performance evaluation of all service providers—collection, transfer, treatment—and disclose results to the public. Service providers failing in the evaluation for two consecutive years are disqualified from service in the third year. Service providers with excellent ratings for three consecutive years are given priority in contract renewal.

Expansion of treatment capacity. The central government has utilized multiple approaches to systematically expand food waste treatment capacity across the country, with a focus on the most populous urban centers. Sectorwide strategies[au] and master plans[av] established goals for the expansion of restaurant and kitchen waste recycling and local governments were encouraged[aw] and supported financially[ax] to invest in treatment facilities.[ay] Targets were established for the number of facilities and total treatment capacity to be realized in each province over three consecutive *Five-Year Plans (FYPs) for Urban MSW Treatment Facilities Development* spanning the 12th FYP of 2011–2015,[az] the 13th FYP of 2016–2020,[ba] and the 14th FYP of 2021–2025.[bb] The Five-Year Plans were informed by a *National Pilot Program in 100 Cities*[bc] to advance new technologies and approaches to: (1) onsite kitchen waste management systems including waste registration, scheduled collection, centralized treatment, recyclable evaluation, and monitoring systems, (2) expansion of treatment capacities including investments in hardware, technologies, and operations and maintenance, (3) incentive measures to encourage business participation, and (4) public outreach and education.

Notes

a. Food loss refers to a decrease in quantity or quality of food intended for human consumption and tend to occur upstream in the food value chain, and is mainly caused by inefficiencies in agricultural production, harvesting, post-harvest handling, transportation, and storage of crops (FAO 2013).

b. Food waste refers to the discarding of food appropriate for human consumption downstream in the value chain, particularly at the retail and consumer levels (FAO 2013).

c. Japan House of Representatives. *Act on the Promotion of Recycling of Food* Circular Resources No. 116 of 2000 (English translation). https://www.shugiin.go.jp/internet/itdb_housei.nsf/html/housei/h147116.htm.

d. Existing recycling targets to be achieved by 2029 according to the Japan Ministry of Agriculture, Forestry and Fisheries' *Targets of Recycling of Food Waste Recycling* (English translation). https://www.maff.go.jp/j/shokusan/recycle/syokuhin/s_info/saiseiriyo_mokuhyou.html.

e. Japan MoAFF (Ministry of Agriculture, Forestry and Fisheries). *Guidelines for Measuring the Amount of Food Waste Generated and Food Waste Recycling Rate*. Food Industrial Policy Office. https://www.maff.go.jp/e/policies/env/attach/pdf/frecycle-2.pdf.

f. The baseline rate is updated annually based on the previous year's performance. If the prior year's recycling rate is between 20% and less than 50%, the baseline must be increased by two percentage points. If the prior year's rate is between 50% and less than 80%, the baseline must be increased by one percentage point. Businesses achieving 80% or more are required to maintain or improve their recycling rate.

g. Japan MoAFF (Ministry of Agriculture, Forestry and Fisheries). *Promotion of Food Recycling* (English translation). https://www.maff.go.jp/j/shokusan/recycle/syoku_loss/161227_7.html.

h. Japan MoE (Ministry of the Environment). *About the Food Recycling Loop System* (English translation). https://www.maff.go.jp/kanto/kikaku/midori_syokuryou/attach/pdf/setsumeikai_annai-20_1.pdf.

i. Utilizing an exchange rate of ¥1 to US$0.007.

j. Japan MoE (Ministry of the Environment). *Food Recycling. Environmental Regeneration and Resource Recycling* (English translation). https://www.env.go.jp/recycle/food/index.html.

k. Japan MoAFF (Ministry of Agriculture, Forestry and Fisheries). *Recycling Business Plan Certification System (Food Recycling Loop)* (English translation). https://www.maff.go.jp/j/shokusan/recycle/syokuhin/s_hourei/keikaku.html.

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Notes

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©iStock/Horoshevych. Recycling park area, aerial view.

6.

Waste Administration, Operations, and Jobs

KEY INSIGHTS

- In most countries, solid waste management is a local responsibility. Direct involvement by central governments in the provision of waste services is rare and typically limited to small countries or small island states.
- Waste services are primarily administered at the municipal or metropolitan level. Intermunicipal cooperation remains limited, despite its potential to deliver economies of scale and operational efficiencies.
- Ninety-five percent of countries have legislation governing solid waste management. In 70 percent of countries, local governments develop regulations and local ordinances that expand on national laws, often introducing stricter measures such as single-use plastic bans or mandatory source segregation.
- About 88 percent of countries and economies have a national legislative or regulatory instrument targeting plastics. Upstream measures are most widespread, identified in 158 countries, which aim to address imports and production, such as taxes, bans and fees. Extended producer responsibility, at 48 percent, is commonly applied as a midstream measure to address design, manufacturing, retail, and use. Downstream measures to improve end-of-life management, such as deposit return schemes for beverage containers, are the least common at 32 percent, strongly driven by trends in the European Union, which represent nearly half of all deposit return schemes identified.
- Approximately half of waste services—from collection to final disposal—are publicly operated. The remaining half

KEY INSIGHTS (CONTD.)

is fairly evenly split between private and mixed public–private management, except in treatment and disposal, where private operators are responsible for 34 percent of cases. Concession contracts are the predominant form of private sector engagement, followed by service and franchise contracts.

- Local governments are the primary source of investment financing for solid waste management. National and private sector financing play a more significant role in funding treatment and disposal infrastructure.
- Dedicated institutions responsible for overseeing solid waste management exist in nearly all countries. At the city level, 201 of 262 cities report having a solid waste management department responsible for planning, contract management, public engagement, and the delivery of waste services.
- Waste and recycling activities generate substantial direct and indirect employment. This report estimates that globally, approximately 18 million urban waste workers are directly engaged in the sector, representing about 0.3 percent of the global urban population. In lower-income settings most employment remains directly tied to waste collection, sorting, and recycling activities. In upper-middle- and high-income countries, a growing share of employment is generated indirectly through industries that supply goods and services to, or benefit from, the waste sector. Indirect job creation remains outside the scope of this report.
- The informal sector plays a critical role in delivering solid waste management services, particularly in lower-income settings, but often operates under precarious conditions, facing social stigma, limited protections, and significant health risks.
- Systematic public reporting on waste policies and data remains largely confined to high-income and some middle-income countries, and data reliability continues to be a concern.

6.1 Solid Waste Management Laws and Regulations

Solid waste management laws and regulations provide a legal foundation for organizing, delivering, and enforcing waste-related activities. They define the roles and responsibilities of institutions, waste generators, service providers, and facility operators, ensuring alignment with national goals for public health, environmental protection, and resource efficiency.

Legal frameworks typically cover the classification of waste types; requirements for prevention, collection, recycling, recovery, and disposal; and restrictions such as bans on uncontrolled dumping and unauthorized transboundary movement. They establish targets, mandate planning processes, and define procedures for permitting, reporting, and documentation. They also regulate financial responsibilities, institutional mandates, and the operation of waste treatment and disposal facilities. This regulatory framework is often supported by related legislation in areas such as environmental protection, public health, chemical safety, and urban development.

The waste sector uses various types of legal instruments. A legislative framework sets out core principles and sectorwide requirements and is typically adopted at the highest legislative level in a country. These are supported by more detailed regulations, including decrees, technical guidelines, and standards, often issued by line ministries or specialized agencies. Some instruments target specific waste streams, such as packaging, electronic waste, or construction and demolition debris, while others define the rules for infrastructure siting, facility operations, and data reporting.

At the national level, legislation defines the operational and environmental standards that subnational authorities must observe in delivering services and enforcing regulations. These legal instruments typically include definitions and classifications of waste, clearly distinguishing between hazardous and nonhazardous types. They establish obligations for safe handling, treatment, and disposal, while prohibiting practices such the mixing of incompatible waste streams. Standards are also set for the planning, construction, operation, and closure of waste facilities. In addition, national laws regulate crossborder waste movements, requiring proper documentation, and the designation of competent authorities.

In this report, 95 percent of countries and economies are identified as having national laws governing solid waste management (table 6.1). More than 90 percent of countries across all regions have dedicated legislation on waste management with the exception of Sub-Saharan Africa at 88 percent.

In addition to legislation on municipal solid waste, specialized laws are often developed to regulate specific waste streams such as plastic waste, medical waste, hazardous waste, and waste electrical and electronic equipment. The management frameworks and scope of stakeholders engaged in the management of these streams differ from that of municipal solid waste.

This report identifies 190 countries with legislative instruments and regulations targeting plastics (table 6.2). Legal and regulatory instruments[1] are categorized based on the point in the value chain that the instrument targeted. Upstream measures—aimed at reducing the amount of plastics placed on the market through various approaches including taxes, bans and fees charged at point of sale, such as plastic carrier bag fee—are the most commonly identified in 158 countries. Midstream instruments exclusively include extended producer responsibility schemes that specifically target packaging, other plastic products or both, were identified in 88 countries. Downstream instruments exclusively include deposit return schemes for beverage containers identified in 69 countries. In this report, 40 countries are identified with legal and regulatory instruments targeting the full value chain, strongly influenced by Europe and Central Asia, which account for 68 percent of all cases identified.

Table 6.1 Existence of national law governing solid waste management

	Total number of countries and economies	Number of countries and economies with national law governing solid waste management		Share of countries and economies with national law governing solid waste management
		Yes	No information found	
Income group				
Low-income	24	22	2	92%
Lower-middle-income	55	52	3	95%
Upper-middle-income	57	53	4	93%
High-income	81	80	1	99%
All	**217**	**207**	**10**	**95%**
Region				
East Asia & Pacific	37	36	1	97%
Europe & Central Asia	58	58	0	100%
Latin America & the Caribbean	42	39	3	93%
Middle East & North Africa	21	21	0	100%
North America	3	3	0	100%
South Asia	8	8	0	100%
Sub-Saharan Africa	48	42	6	88%
All	**217**	**207**	**10**	**95%**

Source: Original table for this report.

Despite the presence of legislation governing solid waste management, enforcement remains inconsistent across countries. Effective implementation is often hindered by gaps in institutional capacity, financial resources, and technical capabilities. Some countries report difficulties in compliance with environmental standards laid out by legislation due to limited technical capacity or misalignment with operating agencies. High solid waste management costs, combined with limited cost recovery and financing options, are also present challenges to the enforcement of waste management rules and regulations.

6.1.1 Extended Producer Responsibility

The extended producer responsibility policy approach is a group of economic instruments that raise revenues and set incentives for the collection and recovery of material at the postconsumer stage of the product lifecycle, with producers[2] playing an integral role in the implementation of the policy (OECD 2024). National governments enact instruments on extended producer responsibility policy to institute a mechanism for producers and importers of products to take responsibility for managing waste or pollution produced across their products' entire lifecycle (OECD 2024). Fundamentally, the core concept of extended producer responsibility policy is to implement the polluter-pays principle and to shift the responsibility for the management of products at their end-of-life from local governments to the producer (box 6.1).

Table 6.2 Existence of legislation and regulation targeting plastics

	Total number of countries and economies	Number of countries and economies with legislation or regulations on plastics					Share of countries and economies with legislation or regulations on plastics
		Up-stream	Mid-stream	Down-stream	Full value chain	No information found	
Income group							
Low-income	24	19	4	1	0	4	83%
Lower-middle-income	55	34	21	11	3	10	82%
Upper-middle-income	57	37	32	15	8	9	84%
High-income	81	67	48	42	29	4	95%
All	**217**	**157**	**105**	**69**	**40**	**27**	**88%**
Region							
East Asia & Pacific	37	28	15	16	6	2	95%
Europe & Central Asia	58	48	46	32	27	3	95%
Latin America & the Caribbean	42	26	16	8	2	9	79%
Middle East & North Africa	21	14	9	4	2	5	76%
North America	3	3	2	2	2	0	100%
South Asia	8	5	2	4	1	0	100%
Sub-Saharan Africa	48	33	15	3	0	8	83%
All	**217**	**158**	**105**	**69**	**40**	**27**	**88%**

Source: Original figure for this report.

Box 6.1 Extended Producer Responsibility

Extended producer responsibility is a policy instrument that transfers responsibility for the end-of-life management of products and their packaging on to producers. It also provides incentives to prevent waste at source and promotes product design for the environment. The extended producer responsibility policy initially focused on packaging and packaging waste and few other product categories like electrical and electronic appliances, batteries, automotive tires, motor oils and vehicles, and more recently extended to other goods like textiles, diapers, and tobacco products. Over the past thirty years, extended producer responsibility has grown from a novel concept to a widely adopted policy approach across most regions and country income groups. Interest in extended producer responsibility has been growing rapidly in part because of the track record of success in delivering on policy objectives of increasing access to and financing for waste collection, recovery, and recycling infrastructure (OECD 2016).

The success of extended producer responsibility in a given national context is influenced by the appropriateness of the scheme design based on national characteristics—legal, sectorial, and cultural. Effective adaptation and national policy design should carefully respond to common implementation challenges including: (1) complex monitoring and reporting mechanisms; (2) the need for robust digital infrastructure and tracking; (3) phased implementation to overcome infrastructure gaps; and (4) coordination of roles and responsibilities across stakeholder groups, including waste pickers. Extended producer responsibility is a complex and dynamic tool that can shape and adapt to changing market conditions and, therefore, requires constant management and oversight. The exact scope of extended producer responsibility is detailed in legislation and varies across jurisdictions. It could be limited to financial responsibility but often includes physical or operational responsibility for the attainment of defined waste management objectives.

Financial responsibility: This is typically implemented through fees paid by the obliged producers to an authorized collective compliance scheme, aiming to generate sufficient amount of revenues to cover full or incremental costs for separate collection, preparing for reuse, sorting, treatment, recycling, recovery, and disposal of the respective waste stream, taking into account the potential revenues from the sales of recyclable waste commodities.

Operational responsibility: Within it, the obligations to organize waste management services for set products and packaging are shifted from the public authorities like municipalities to the obliged producers and implemented through one or several collective compliance schemes like producer responsibility organizations. Operational responsibility could include contracting of the respective waste management services and overseeing implementation. It could also include obligations for the provision of collection infrastructure, equipment and treatment facilities. Often, a combined approach is used whereby extended producer responsibility schemes are developed alongside and in collaboration with municipal services. They are underpinned by contractual agreements defining the roles and responsibilities of obligated producers, local government, and private sector waste operators to expand and finance waste recovery services.

In recent years, the concept of extended producer responsibility has evolved from a downstream tool (Compagnoni 2022; Ashworth 2022), such as end-of-life management to a more circular approach incorporating upstream objectives,[a] such as incentivization of more sustainable design and material choices through ecomodulation[b] and achievement of recycled content targets in new products. A trend is emerging to leverage the compliance and verification infrastructure established under extended producer responsibility to facilitate compliance with additional policy measures, such a single-use plastic bans across the European Union following the adoption of the Single-Use Plastics Directive (2019). Once an effective governance system is established, such as a legally recognized and registered producer responsibility organization, this body can evolve and expand its mandate relatively efficiently, incorporating new targets and programs.

Target setting: This is a compliance and verification mechanism whereby EPR legislation has established measurable objectives for system functions—such as collection, source separation, recycling, reuse, or reduction—for the entire product category or waste stream, and sometimes for specific materials. Such targets could be: (1) minimum collection percentages to be achieved; (2) minimum recycling percentages with product quantities placed on market, or waste collected; (3) minimum recycling efficiency measured toward quantities of input waste entering the recycling process; or (4) minimum recycled content in products or packaging. The achievement of targets is overseen by a designated public authority, typically the ministry of environment. Obliged producers are at liberty to develop and finance a collection and recovery system of their own design. Compliance may be achieved individually by each producer or collectively whereby a producer responsibility organization takes on legal responsibility on behalf of its members. Collective schemes can be more efficient, particularly for regulatory authorities who must ensure compliance, and for provision of waste management services based on zones under the principal of economies of scale. Competitive systems may be more effective at driving down costs and spurring innovation. The approach best suited for any given market is most influenced by the existing legal framework, the type and size of collection and recycling targets and other waste management objectives, the level of development of waste management services, local market conditions, and other factors.

Fee setting: A central concept to extended producer responsibility is fee setting. Under a collective scheme, the producer responsibility organization will set fees based on quantities of products and packaging placed on market, often taking into account the product type, purpose, and materials. Some collective schemes have fees per unit and types of products and packaging placed on the market aiming to address its reusability, recyclability, and recycled content, that is, ecomodulation.

Registration and reporting: The obliged producers are usually required to register and report to competent authorities. The producer responsibility organization will maintain responsibility to report on behalf of its members, normally anonymized data on product volumes and types placed on the market, collection, recovery and recycling rates, fees collected, and financing issued for waste management operations. This is done either directly under an operational scheme to local governments or private waste operators under financial or combined schemes.

Compliance: Compliance is often determined through authorization or licensing of producer responsibility organizations or producers implementing their obligation individually. Compliance is based on approved plan of operations and verified annual performance reports that demonstrates the achievement of legally defined targets, and often incremental system improvements such as collection coverage, capacities installed, facilities, public awareness measures, and implementation costs. These plans can also generate significant data that can be transformative to municipal solid waste planning and financing. Digital infrastructure is required to collate and share these data in a manner that protects privacy, anonymity, builds trust, and supports research and planning.

Key challenges that policy makers may face in successfully implementing extended producer responsibility include the following:

Lengthy development process: The full policy lifecycle from initial exploration through to implementation can be lengthy and requires political and administrative stamina that outlasts traditional political cycles. Practitioners should be prepared to manage expectations of all parties and maintain open and regular communication on the process and any changes and delays to build trust and cooperation, which is key for effective systems.

Stakeholder coordination: Effective design and implementation of extended producer responsibility require close, ongoing collaboration with a large group of stakeholders who may not have prior experience working together including manufacturers, brands, retailers, waste management providers, informal sector waste pickers, local governments and national governments, among others. One of several primary functions of central governments implementing extended producer responsibility schemes is to establish effective coordination modalities, which should be based on clear roles and responsibilities.

Role of local government: In most countries, the responsibility of municipal solid waste management is legally mandated to local governments, that is municipalities. When introducing a new system to increase collection and recovery rates, great care is needed to develop an institutional structure that maximizes the core competencies of all key actors and mitigates duplication or ambiguity of roles. This is particularly important in settings where primary waste collection capacity is not available for all residents. Priority should be to leverage additional capacity—both financial and operational—provided by extended producer responsibility to extend services to all residents, maximizing efficiencies. Local governments are almost always a key actor that must be central in the development of extended producer responsibility legislation and implementation.

Informal sector: Waste pickers perform a critical function in many cities that lack robust, formal recycling systems, recovering valuable materials, thereby extending disposal capacity, creating economic activity, bolstering waste collection, and generally contributing to cleanliness and environmental protection. When introducing extended producer responsibility with the expectation to rapidly scale the recycling system, it is critical to include existing actors such as waste pickers, middlemen, and microenterprises active in recycling and trading. Effective and equitable inclusion has proven to be difficult owing to differences in communication preferences, decision making, and capacity.

Regulatory requirements: Monitoring, enforcement, and compliance of extended producer responsibility schemes are resource intensive and often underestimated in initial scheme design, resulting in inefficient systems and noncompliance. For example, significant market shares of target product categories are often held by a minority of companies. Compliance can be streamlined through careful market analysis and legislative design to obligate the least number of companies necessary to achieve a significant shift in waste collection, recovery, and recycling.

Effectiveness monitoring: Extended producer responsibility requires continuous monitoring and evaluation of effectiveness. These attributes should spur continual and incremental reconfiguration of the scheme to respond to design failures and unique characteristics of the local market. Extended producer responsibility legislation should be drafted in a manner that creates flexibility for ongoing innovation without requiring lengthy and burdensome legal reforms. One approach is to mandate review periods and clarify those elements that can be subject to change—such as targets, reporting mechanisms, registration, fee setting, legal authorization of producer responsibility organizations, and stakeholder agreements—and the modalities for approval for instance, authorize a for-purpose council or a minister approves changes considering stakeholder review and feedback.

Start-up costs: It is often a hope that extended producer responsibility can finance the entire deficit, particularly in settings that are still working to achieve comprehensive waste collection and management for all residents. This aspiration can create tension as municipal solid waste plastic packaging—which is typically the focus of extended producer responsibility—accounts for roughly 8% of the entire municipal solid waste generation.[c] Producers may resist the introduction of extended producer responsibility legislation if it is expected that the system finance primary collection where it does not exist. Producers advocate that extended producer responsibility is intended to boost recycling, not finance basic urban services that are defined by law as a municipal mandate.

Notes

a. Effective delivery of upstream objectives requires that extended producer responsibility policies, which have demonstrated the greatest impact on downstream performance, be accompanied with targeted upstream measures, such as bans, reuse targets, and investments into alternatives.

b. Ecomodulation applies a prorated fee structure whereby fees paid by producers are adjusted based on design or performance criteria (for example, recyclability, cost to collect, monomaterial) to encourage improved environmental outcomes, whereby products that are rated more "eco" according to the rating criteria are charged less per unit and products with a less preferable "eco" rating are charged more per unit.

c. According to the data compiled for this edition of *What a Waste*, plastics account for 13% of all municipal solid waste and single-use plastics (most of which are packaging) accounting for 65% of all municipal solid waste plastics.

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The extended producer responsibility policy approach was first introduced in the 1990s to address growing volumes and complexities of waste streams. Today, extended producer responsibility policy has been widely adopted across high-income and upper-middle-income countries (figure 6.2) for a variety of product groups such as packaging, waste electrical and electronic equipment, batteries, and end-of-life-vehicles among others (figure 6.4) due to the relatively successful experience of some countries to improve the separate collection and recycling of priority product groups. Interest in extended producer responsibility policy continues to grow in all regions and economic groups (map 6.1) with emerging experience in lower-middle-income and low-income countries (figure 6.2) still to be assessed.

This report takes global stock of publicly available information on extended producer responsibility policy implementation and finds that 67 percent, or 145 countries, of all governments are somewhere along the continuum of extended producer responsibility policy development and implementation (map 6.1). This analysis focuses exclusively on mandatory schemes, initiated by the public sector, spanning legally binding regulations—representing the most advanced and robust instruments—to policies and strategic action plans that introduce government's intention to establish a legally binding system in the near future, as the legislative starting point. Identified policies are categorized as follows:

- Legally binding regulations or rules provide detailed guidance on the implementation of a law, that is, specified proper course of conduct for all involved stakeholders.
- Laws are made by legislatures, such as a parliament. While laws are legally binding, oftentimes, they must be supported by rules or regulations to further specify enforcement mechanisms to enable compliance. Laws in absence of rules may not be enforceable.

- Policies, or action plans, are not legally binding, and they are generally passed by ministries or agencies of the civil service. Policies provide guidance on the emerging priorities of the government and create some precedent for the interpretation of other laws and rules.
- Draft policies or strategies or action plans officially communicated by the government signal the intention to initiate policy development in the near future.

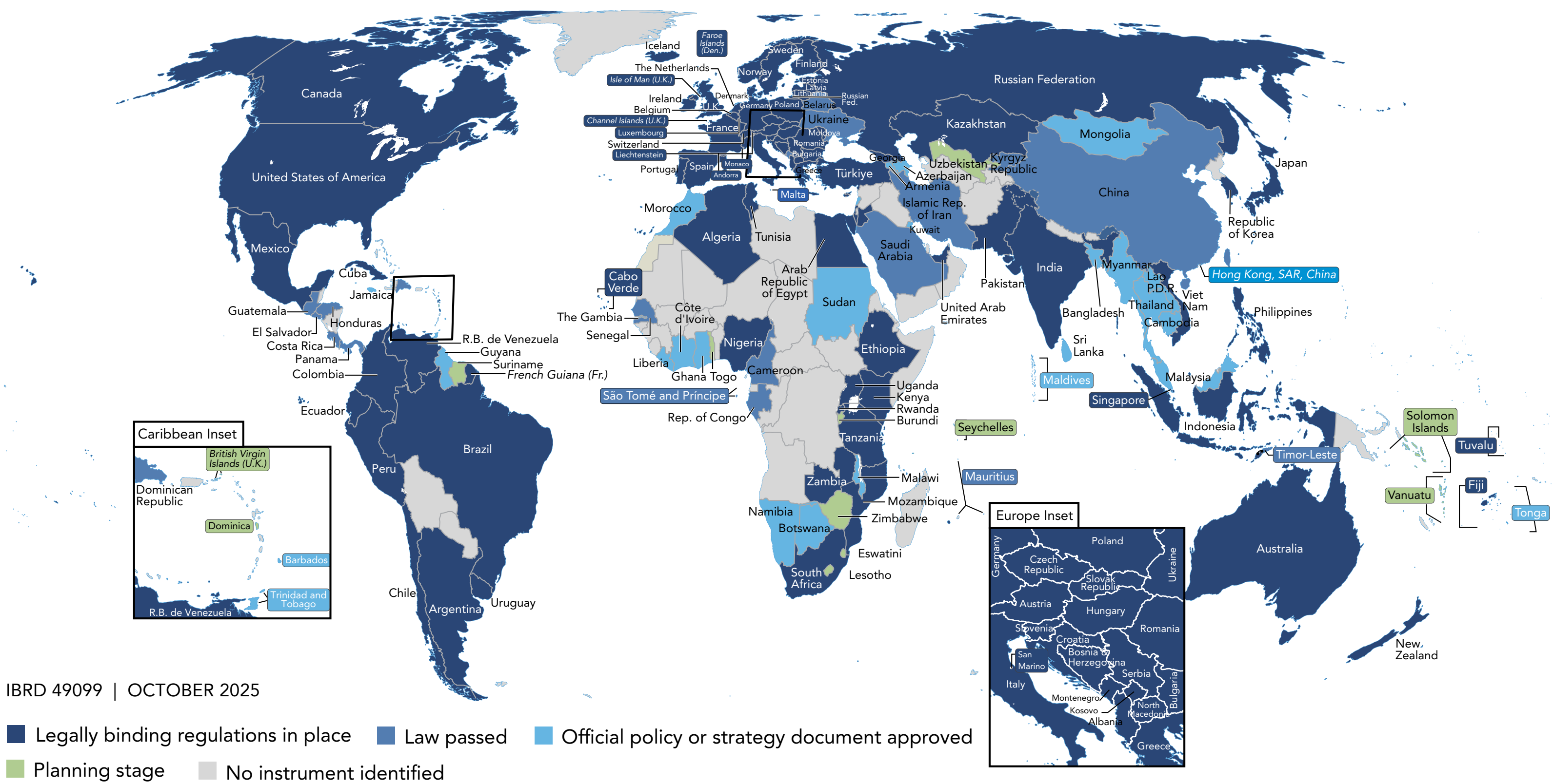
This report does not assess the effectiveness of any existing policies. A considerable number of countries adopted legally binding regulations on extended producer responsibility policy—some for many years—with limited evidence of compliance or changes to the waste management system. This report, nevertheless, includes these findings and researchers are encouraged to consult the available information in the codebook for further details. Several studies are available offering more critical analysis on drivers of performance (OECD 2024; World Bank 2022; GIZ 2022).

Europe and Central Asia represent 50 percent of all countries with legally binding regulations in place, strongly influenced by: (1) the European Commission's Waste Framework Directive,[3] which officially introduced extended producer responsibility policy as a Europe-wide strategy , and (2) EU Directive amending directive on packaging and packaging waste,[4] which introduced a compliance date of 31 December of 2024 for all EU Member States to establish extended producer responsibility policy for all packaging.[5] This instrument is further supported by the Single-Use Plastics Directive[6] that established extended producer responsibility policy for additional product groups such as fishing gear, tobacco products, balloons, and wet wipes or personal hygiene.

Proportionally, Europe and Central Asia have the broadest adoption of extended producer responsibility policy with 84 percent of countries having applied the instrument. Sixty-seven percent of the countries in North America, 68 percent in East Asia and Pacific, and 63 percent of the countries in South Asia have adopted extended producer responsibility policy. Sub-Saharan Africa at 60 percent, the Middle East and North Africa at 57 percent, and Latin America and the Caribbean at 55 percent have a majority of countries that have adopted extended producer responsibility policy instruments across the four phases of policy development (figure 6.1).

A linear trend is evident between income status and the number of countries with extended producer responsibility policy in place, with the highest absolute concentration in high-income economies, heavily influenced by Europe and Central Asia, and the lowest absolute concentration in low-income economies (figure 6.2).

Map 6.1 Countries with extended producer responsibility by phase of the policy development lifecycle

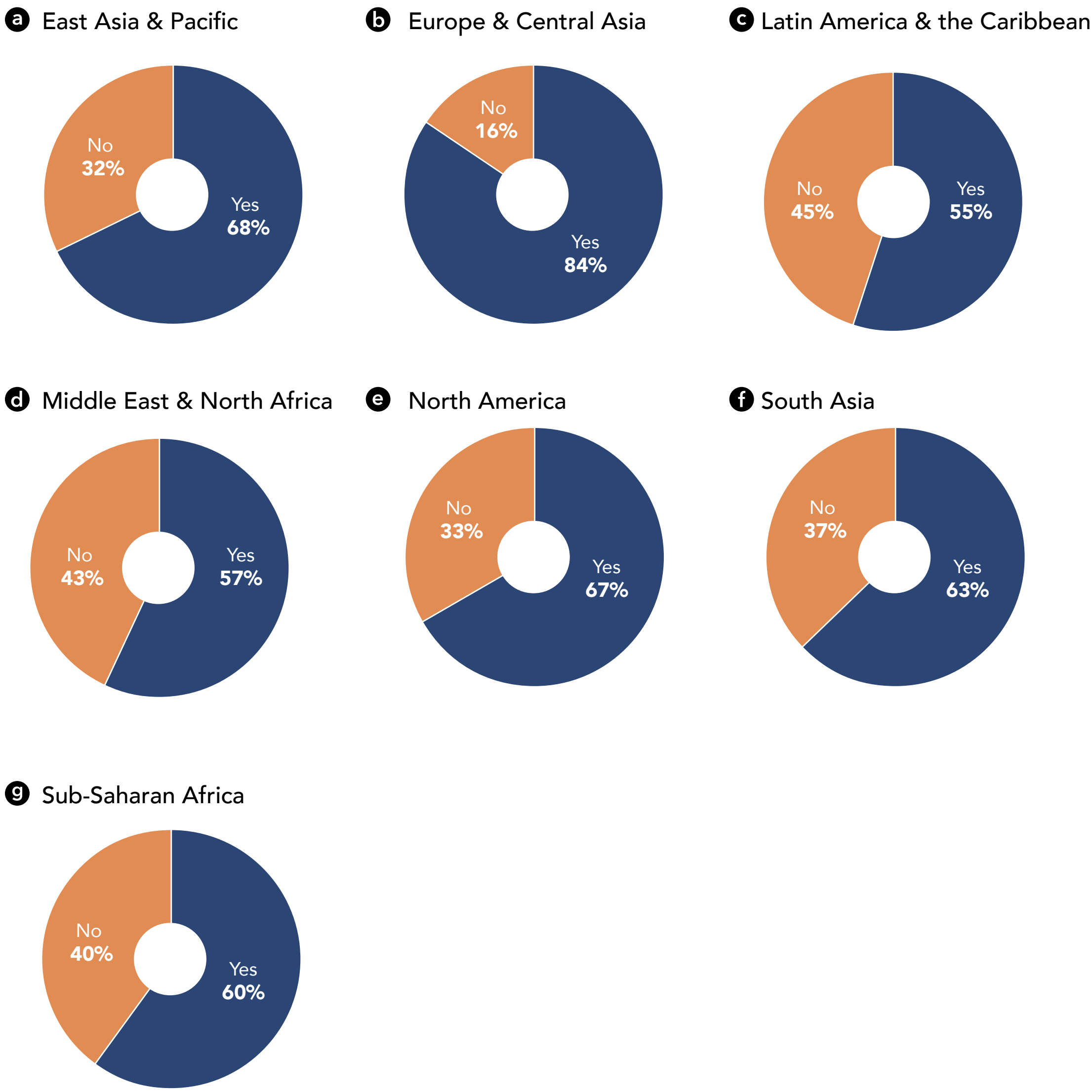


Source: Original map for this report.

Note: Policy instruments are categorized across four phases of policy development and implementation: legally binding regulations (dark blue) specify compliance mechanism and penalty system; law passed (medium blue) such as an act, bill, decree or similar instrument passed through relevant governance bodies, such as parliament or the presidency; official policy or strategy adopted (light blue) communicating the government's intention to develop an extended producer responsibility instrument; and draft policy (green) include official communication from a ministry or regulatory agency disclosing early efforts to explore extended producer responsibility, often published on the ministry's website, in workshop proceedings and in the media, or no instruments identified (gray).

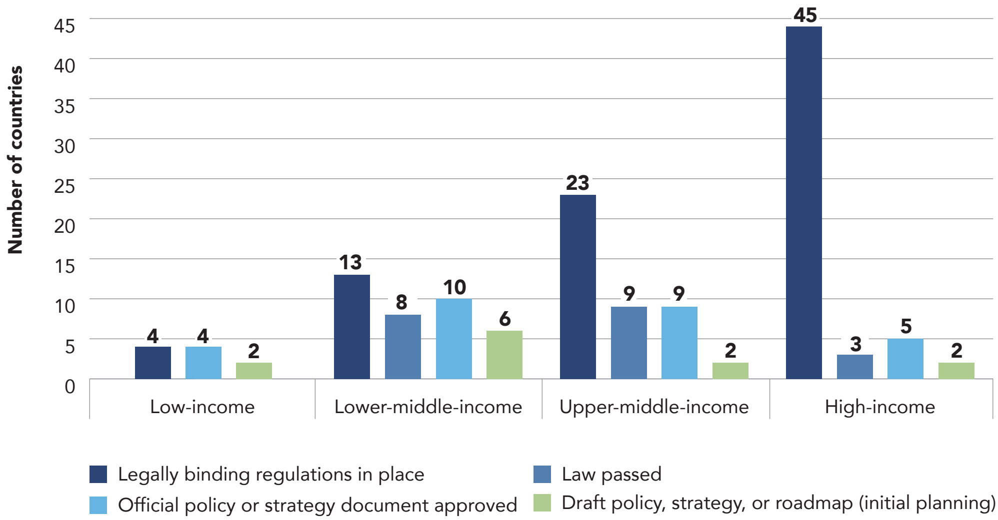
Australia, Canada, and the United States have implemented policy instruments at the state or provincial level. Ranking provided indicates the highest level of policy adoption in any jurisdiction and does not imply that the ranking is applicable to the entire country. The color-coding on this map for Taiwan, China represents the data value for China, which is "law passed". The data value for Taiwan, China is "legally-binding regulations in place".

Figure 6.1 Proportion of countries that have adopted or are exploring extended producer responsibility instruments by region



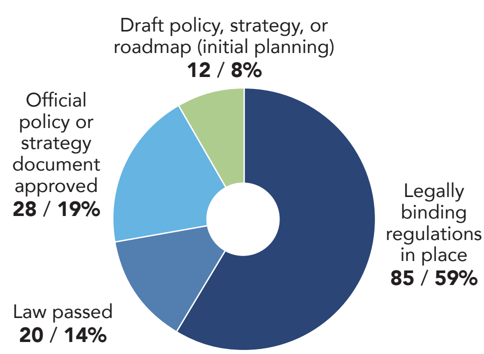
Source: Original figures for this report.
Note: Yes = extended producer responsibility instrument present in country, no = no extended producer responsibility instrument present.

Figure 6.2 Countries with extended producer responsibility schemes by policy status and income group



Source: Original figure for this report.

Figure 6.3 Number and proportion of countries with extended producer responsibility schemes by policy status



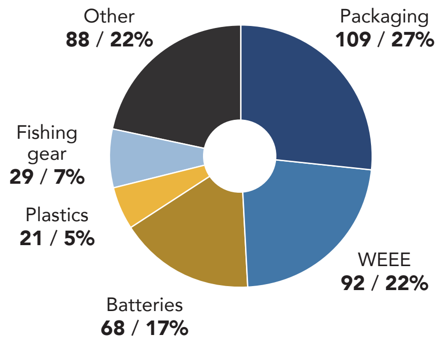
Source: Original figure for this report.
Note: Value refers to number of countries with extended producer responsibility schemes by policy status.

Of the 145 countries identified with extended producer responsibility policy instruments in place, 59 percent adopted at least one legally binding regulation (figure 6.3). Fourteen percent of countries passed a law introducing extended producer responsibility policy but have not yet adopted legally binding regulations with clear penalty mechanisms for compliance. Nineteen percent of countries with identified instruments have adopted an official policy, strategy, roadmap, or action plan that specifies extended producer responsibility policy as a priority action. Policies are differentiated from laws as they are not often legally binding and are commonly developed and adopted by a line ministry or agency in absence of a voting mechanism through an elected body, such as parliament.

Of the 85 countries with legally binding regulations that clearly specified implementation roles, 72 percent, or 61 countries, opted for operational schemes, 11 percent or 9 countries, opted for financial schemes, and 2 percent, Republic of Korea and Viet Nam, used a combined approach providing flexibility to producers to choose compliance through either the public scheme or available private schemes.[7]

This report identifies more than 400 existing extended producer responsibility policy instruments, covering various types of materials and representing all stages of policy development and implementation. Packaging is the most common material type targeted by extended producer responsibility policy with 108 instruments, representing 27 percent of all instruments identified, followed by waste electrical and electronic equipment with 91 instruments, representing 22 percent, and other with 88 instruments, capturing a variety of material types, such as lighting, used oil, construction and demolition wastes, and broad policy frameworks introducing extended producer responsibility policy as a concept without specifying targeted materials.

Figure 6.4 Number and proportion of extended producer responsibility schemes by product group



Source: Original figure for this report.
Note: Value refers to number of extended producer responsibility schemes per product group. Other includes tires, end-of-life vehicles, pesticides packaging, oils, fertilizers, lamps/lightbulbs, medicines, textiles, among other product groups.
WEEE = waste electrical and electronic equipment.

An interesting observation is the emergence of extended producer responsibility for nonpackaging waste plastics with 21 instruments, representing 5 percent of all instruments identified (figure 6.4). Some of these instruments refer to plastics broadly, establishing a legal pathway for any future product category, other instruments specifically list out new product categories, such as cigarette filters, textiles, diapers, feminine hygiene products, and artificial hair.

6.1.2 Deposit Return Schemes

Deposit return schemes are a specific application of extended producer responsibility policy, but are often distinguished by several notable features (OECD 2024; Laubinger et al. 2022). Most importantly, a deposit is charged at the point of sale for specified product groups, coupled with a clear mechanism for consumers to return used containers to recoup full deposit, often at retailers or dedicated depots. Deposit return schemes may be applied for recycling or for reuse and refill, resulting in unique requirements for system actors and potential environmental outcomes (Laubinger et al. 2022). Handling fees must be established to compensate retailers and depot operators for collection services and for managing the important function of data on purchases and returns and waste operators, occasionally including waste pickers, for transportation and sortation services required by recyclers.

Similar to extended producer responsibility policy, effective stakeholder engagement through the establishment of clear roles and responsibilities across the value chain is critical for efficiency, and ongoing system improvements. Data management is key for both extended producer responsibility policy and deposit return schemes but is unique in deposit return schemes applications because retail is often the point of data collection, for verification of units placed on the market and units recovered.

This report finds that 54 countries (25 percent) have adopted deposit return scheme instruments at various stages of policy implementation across the four defined phases.[8]

Deposit return schemes are present in all regions, with a strong concentration in Europe and Central Asia at 57 percent, representing 30 countries. The next concentration is in East Asia and the Pacific, with 10 countries adopting deposit return schemes (map 6.2).

Similar to the findings from extended producer responsibility policy dataset, several countries have published legally binding regulations, but implementation has been delayed. The Sub-Saharan Africa and South Asia regions are beginning to explore deposit return schemes, with one country in each region identified, followed by two countries in each region for the Middle East and North Africa and North America. It must be noted that deposit return schemes in Australia, Canada, China, India and the United States are implemented at the state or provincial level.[9]

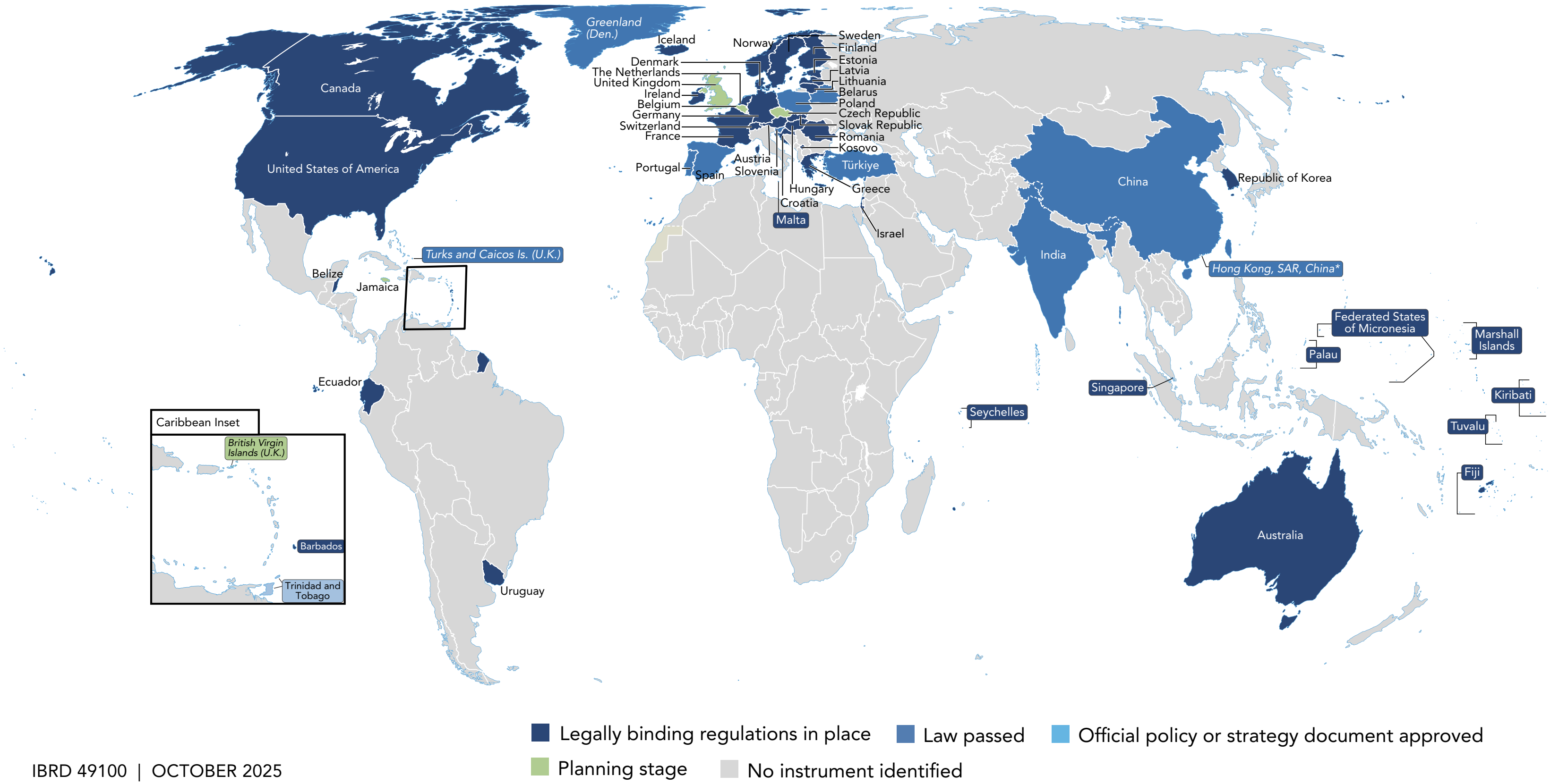
Similar to the findings from extended producer responsibility policy, legally binding deposit return schemes are highly concentrated in high-income countries at 76 percent, representing 29 of 38 countries that have legally binding regulations institutionalizing deposit return. Across all phases of policy implementation, 41 high-income countries were identified with deposit return instruments, more than four times greater than then next leading income group, the upper-middle-income, with ten deposit return instruments identified, collectively representing 94 percent of all countries with identified instruments (figure 6.5).

Notably, no legally binding deposit return instruments were identified in any of the policy phases in low-income countries. This may be due to generally smaller recycling industries dominated by micro and informal enterprises, or the informal nature of retail with much commerce moving through traditional markets. Mandatory deposit return schemes have been designed around semicomplex digital monitoring of sales and returns of individual units at retail, which may be a deterrent of greater adoption in low-income countries. However, voluntary deposit return schemes, particularly for refillable beer and soda, is still commonplace in many low-income countries demonstrating a need to continue exploring appropriately adapted legislative frameworks to respond to local market conditions, including consumption patterns and cultural norms.

Extended producer responsibility and deposit return schemes have been successful in improving collection and recycling infrastructure. However, supporting measures are required to further drive reduced demand and improved product design that make products more recyclable and increase circularity. These aspects will need to be addressed with additional complementary policy and regulatory instruments.

Both extended producer responsibility policies and deposit return schemes aim to

Map 6.2 Countries with deposit return schemes by phase of the policy development lifecycle



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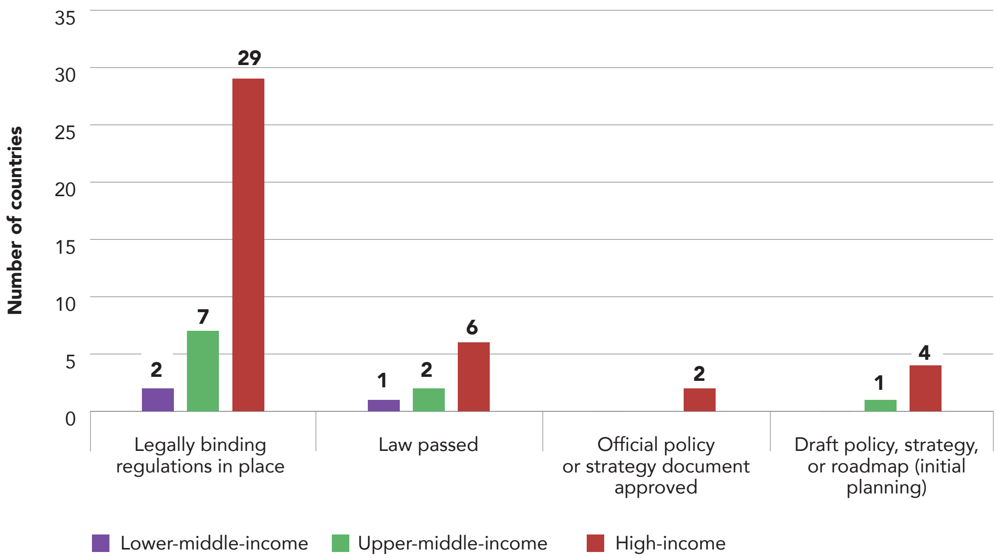
Source: Original map for this report.
Note: Australia, Canada, India, and the United States have implemented policy instruments at the state or provincial level. The implementation status indicates the highest level of policy adoption in any jurisdiction and does not imply that the ranking is applicable to the entire country. The color-coding on this map for China; Macao SAR, China; and Taiwan, China represents the data value for Hong Kong SAR, China, which is "official policy or strategy document approved"; however, there is no information available on deposit return instruments for China; Macao SAR, China; and Taiwan, China.

Figure 6.5 Number of countries adopting deposit return instruments by policy status and income group



Source: Original figure for this report.
Note: No low-income countries are reported to currently have deposit return instruments.

bring the producer as a central actor and collaborator in plastic pollution policy implementation based on the idea of extended liability or the polluter-pays principle. However, three decades of implementing extended producer responsibility policy for packaging wastes in economies around the world has demonstrated that extended producer responsibility policy alone does not drive down plastic production, consumption, eliminate leakage, or improve packaging design (Mallick et al. 2024; OECD 2024). Voluntary corporate commitments have emerged to address these gaps, spearheaded by international organizations and advocacy groups.[10–13] Despite these commitments and much enthusiasm, progress has been nominal,[14] and much prioritization continues to be placed on expansion of recycling infrastructure as the primary objective of sustainable packaging strategies.[15]

6.1.3 Local Waste Regulations

Local governments adapt national laws to design waste management services suited to their specific waste generation profiles and institutional capacities. Local rules may cover aspects such as collection methods, service frequency, designated disposal sites, and the responsibilities of households and institutions. Local regulations may mandate source separation of waste fractions, define service fees or local taxes, and impose penalties for noncompliance. In many cases, local governments also go beyond national requirements by introducing more ambitious standards or bans, such as restrictions on single-use plastics. Importantly, local regulations often provide mechanisms for residents and other users to submit complaints regarding service quality and reinforcing accountability at the point-of-service delivery.

This report reveals the presence of solid waste management rules and regulations in 70 percent of the cities studied, that is, 184 of 262 cities (table 6.3). Thirty percent of the cities either do not report having such regulations or no information could be found. Only 46 percent of cities in low-income countries have solid waste management regulations in place, compared with 87 percent of cities in high-income countries.

Table 6.3 Existence of city waste management regulations

	Number of cities in dataset	Number of cities with solid waste management rules and regulations		Share of cities with solid waste management rules and regulations
		Yes	No information found	
Income group				
Low-income	24	11	13	46%
Lower-middle-income	80	48	32	60%
Upper-middle-income	81	58	23	72%
High-income	77	67	10	87%
All	**262**	**184**	**78**	**70%**
Region				
East Asia & Pacific	38	30	8	79%
Europe & Central Asia	90	67	23	74%
Latin America & the Caribbean	42	34	8	81%
Middle East & North Africa	26	11	15	42%
North America	6	6	0	100%
South Asia	14	9	5	64%
Sub-Saharan Africa	46	27	19	59%
All	**262**	**184**	**78**	**70%**

Source: Original table for this report.
Note: City dataset.

6.2
Planning for Solid Waste Management

Laws and regulations establish formal solid waste management systems at national, regional, and subnational levels. Implementing these systems requires strategic planning, often outlined in waste management strategy documents and solid waste management plans, including master plans.

National waste management strategies serve to provide guidance in the long-term development of the sector. They provide a planning framework and offer guidance to regional and local authorities on how to design, finance, and coordinate systems within their jurisdictions. In some countries, these strategies offer a broad policy overview and leave implementation details to subnational governments; in others, they are more prescriptive, specifying infrastructure investments, cooperation models, and service standards.

The development of waste management strategies and plans reflects the specific context of the country or region, including the division of responsibilities across government tiers. Regional and local waste management plans are generally developed in alignment with national waste strategies. These subnational plans are intended not only to adapt national guidance to local conditions but also to demonstrate how local objectives and implementation actions contribute to broader national goals. National authorities often provide technical guidance and establish monitoring and coordination mechanisms for local planning processes to promote consistency and complementarity.

Strategic planning is also essential for ensuring alignment across jurisdictions and sectors and to secure investments required to develop and maintain infrastructure. Plans should be based on realistic assessments of baseline conditions and supported by data on waste generation, collection, and treatment. They should consider institutional and financial capacities, as well as the potential for community engagement and behavioral change. Coordination across administrative levels ensures that planning contributes to national policy objectives while responding to local needs and capacities.

In this report, 152 countries and economies are stated to have a national solid waste management strategy. Although no information could be found for the remaining countries, some countries are noted to be in the process of developing such strategies (table 6.4). In some cases, national strategies provide consolidated overviews for specific waste streams, such as plastics, hazardous waste, or agricultural waste.

Table 6.4 Existence of national strategy for solid waste management

	Total number of countries and economies	Number of countries and economies with national solid waste management strategy		Share of countries and economies with national solid waste management strategy
		Yes	No information found	
Income group				
Low-income	24	15	9	63%
Lower-middle-income	55	36	19	65%
Upper-middle-income	57	43	14	75%
High-income	81	58	23	72%
All	**217**	**152**	**65**	**70%**
Region				
East Asia & Pacific	37	33	4	89%
Europe & Central Asia	58	55	3	95%
Latin America & the Caribbean	42	19	23	45%
Middle East & North Africa	21	6	15	29%
North America	3	2	1	67%
South Asia	8	5	3	63%
Sub-Saharan Africa	48	32	16	67%
All	**217**	**152**	**65**	**70%**

Source: Original table for this report.

Localized planning is prevalent because solid waste management is a local service. Cities are often required by legislation to develop local solid waste management plans, which describe the overall modalities of extending waste management services to the public, including households and commercial and institutional entities. Such plans may include operational guidelines for waste collection, transport, treatment and disposal, as well as plans for infrastructure investments, community engagement, and social and environmental compliance.

Local plans are typically expected to include an assessment of prevailing waste generation and management practices, objectives for improvement, options analysis for system design, and an implementation schedule. They may also contain detailed measures related to infrastructure, service delivery, and operational practices. The planning process often involves consultation with national authorities and may require formal approval at higher administrative levels. In several countries, the existence of a local or regional waste management plan is a prerequisite for accessing national funding support. This financial linkage further reinforces the importance of integrated planning at all administrative levels.

This report documents 135 of 262 cities having a solid waste management plan (table 6.5). Approximately 50 to 60 percent of upper-middle-income and high-income cities report having such plans. The share of lower-middle-income and low-income cities with solid waste management plans is under 50 percent.

Table 6.5 Existence of local solid waste management plans

	Number of cities in dataset	Number of cities with long-term integrated solid waste management plan		Share of cities with long-term integrated solid waste management plan
		Yes	No information found	
Income group				
Low-income	24	7	17	29%
Lower-middle-income	80	36	44	45%
Upper-middle-income	81	43	38	53%
High-income	77	49	28	64%
All	**262**	**135**	**127**	**52%**
Region				
East Asia & Pacific	38	29	9	76%
Europe & Central Asia	90	47	43	52%
Latin America & the Caribbean	42	23	19	55%
Middle East & North Africa	26	7	19	27%
North America	6	6	0	100%
South Asia	14	9	5	64%
Sub-Saharan Africa	46	14	32	30%
All	**262**	**135**	**127**	**52%**

Source: Original table for this report.
Note: City dataset.

6.2.1 Institutions and Coordination

Institutional structures for solid waste management vary across countries. They may include a national-level body—generally, a department or agency at the national level—and dedicated departments at provincial or local levels or at both. National departments or agencies responsible for solid waste management may guide planning, enable coordination among stakeholders, promote collaborations, and act as a bridge between national targets and local capacities and expectations. These departments or agencies may also develop or support programs and initiatives on themes relating to recycling, behavior change, greenhouse gas emissions, and more depending on their mandate to oversee or administer solid waste management services. They also often directly support national governments in meeting guidelines as prescribed under international conventions and treaties. They are typically housed within ministries or national institutions with broader mandates.

Results from this report indicate that 94 percent of countries, or 203 of 217, have either a national agency or department mandated to oversee solid waste management and the enforcement of related laws and regulations (table 6.6). As for the remaining 6 percent of countries, either such agencies or departments were not confirmed to be present, or no information was found.

Table 6.6 Oversight of solid waste management

	Total number of countries and economies	Number of countries and economies with national agency or department to oversee solid waste laws and regulations		Share of countries and economies with national agency or department to oversee solid waste laws and regulations
		Yes	No information found	
Income group				
Low-income	24	22	2	92%
Lower-middle-income	55	50	5	91%
Upper-middle-income	57	54	3	95%
High-income	81	77	4	95%
All	**217**	**203**	**14**	**94%**
Region				
East Asia & Pacific	37	35	2	95%
Europe & Central Asia	58	58	0	100%
Latin America & the Caribbean	42	37	5	88%
Middle East & North Africa	21	19	2	90%
North America	3	3	0	100%
South Asia	8	8	0	100%
Sub-Saharan Africa	48	43	5	90%
All	**217**	**203**	**14**	**94%**

Source: Original table for this report.

Institutional bodies also take up responsibility for reporting data related to solid waste management operations. Data reporting provides crucial details on the status of waste collection, treatment, and disposal as well as other indicators such as separation of waste by household. Data aid planning and incorporate transparency in public services. This report finds that 48 percent, or 105 of 217 countries, have information systems for reporting on solid waste management. The majority of high-income countries report having such systems, whereas, in stark contrast, only one low-income country, Tajikistan,[16] is chronicled to have a reporting system. Forty-three percent of all countries also make key solid waste management data publicly available, which is expected to enable higher public participation and people awareness.

Institutional frameworks for solid waste management vary across countries, although dedicated departments, agencies, or enforcement units for solid waste management rules and regulations are commonly present in cities that bear the primary responsibility for service provision. At the local level, specialized departments, agencies, or units undertake responsibility to implement and monitor solid waste management services, in compliance with legislation and with guidance from master plans.

This report states the existence of a department responsible for solid waste management in 201 of the 262 cities studied, whereas 61 cities either do not report to have such a department or evidence of data. Having a dedicated solid waste management department is critical for effective planning, contract management, public engagement, and the delivery of waste services, whether directly or through outsourced arrangements.

6.3 Waste Management Operations

Cities adopt a range of administrative models and contractual arrangements to deliver waste management services, including cleaning, collection, treatment, and disposal. The choice of administrative arrangements and delivery models depend on contextual needs, local capacities, legislative frameworks, available financing, and other factors.

In most countries around the world, solid waste management is a functional responsibility of local governments. In more than three-quarters of cities included in this report, solid waste management operations are administered or overseen by either municipal or metropolitan bodies, or through intermunicipal arrangements (table 6.7). The intermunicipal model of administration is present in less than a tenth of cities for which data are available. Regional or provincial governments administer waste services in another tenth of cities with available data. Only in a handful of cases, national authorities are responsible for administering municipal waste services.

Cities often engage the private sector for provision of waste management services across functions like city cleaning, primary and secondary collection, transport, treatment, and disposal. Local administrations leverage the technical expertise and financial capacity of the private sector to access technologies, enhance know-how, and improve the efficiency of solid waste management service delivery (box 6.3).

Private operators, including public–private partnerships, are reported to be engaged in nearly half of the cities for the provision of collection, transport, treatment, and disposal services (table 6.8). In contractual arrangements with the private sector, concession contracts are reported in approximately a third of cities, followed by service contracts in a quarter of cases, and franchise arrangements ranging from 10 to 33 percent of cases.

Investments in solid waste management are financed primarily by local governments in about 50 percent of cities, followed by national governments (table 6.9). The role of the private sector in providing investment financing for solid waste management services is reported to be low, and cases of private financing are mostly observed in disposal and treatment operations from 12 percent of cities for which data are available.

The 34 largest cities in the 262-city database—those with populations of 5 million or more[17]—account for 60 percent of total waste while representing only 13 percent of the sample. Data from these cities were analyzed separately to identify whether distinctive patterns emerge. The results show that the largest cities do not differ significantly in per capita waste generation or collection rates compared with the broader sample. The largest cities, however, are more likely to have integrated waste management master plans and to finance their own waste investments. More than 60 percent of cities with populations above five million have a master plan, compared with 52 percent globally. Administration is primarily handled by the municipal or metropolitan governments. Private entities are involved in waste management in about 61 percent of the largest cities—22 percent through direct contracts and 39 percent through mixed public–private arrangements. Globally, participation is lower at 50 percent, with 28 percent under direct arrangements and 23 percent through mixed models.

6.4 Jobs

Waste collection, sorting, and recycling are labor-intensive activities that generate direct employment while simultaneously bolstering secondary industries, such as manufacturing and construction, by supplying valuable recovered materials as inputs. As cities transition toward circular economies, where waste-derived products and materials are reintegrated into economic cycles, waste management is increasingly positioned to become an important driver of secondary job creation. In high-income countries, a considerable portion of the economic impact, such as employment, wages, and tax contributions, already occurs indirectly rather than as a direct result of waste and recycling activities (US EPA 2020). Supply chain purchases linked to research and development for recyclability as well as the redesign, repurposing, and remanufacturing of products and materials—procured from industries beyond the traditional waste management sector—contribute significantly to the economy. Although beyond the scope of this report, this underscores the importance of accounting for upstream impacts when assessing the full benefits of effective waste management, recycling, and resource utilization.

In this report, employment estimates refer to direct jobs in the waste and resource recovery sector, up to the point of material recovery facilities, where waste-derived materials are sorted and baled, becoming economic commodities for further processing. Based on reported data from 63 cities, the analysis yields an average of 312 waste workers per 100,000 urban residents. Extrapolating these figures to the global level provides an indicative estimate of about 18 million urban waste workers worldwide—approximately 0.3 percent of the global urban population.

Table 6.7 Waste management administration, operation, and financing models – Administrative model

Administrative Model Entity or entities having a legally assigned mandate to administer solid waste management services										
	City cleaning		Primary collection		Secondary collection		Transfer station or intermediate collection point		Disposal and treatment	
	No. of cities	% of cities (of the total reporting)	No. of cities	% of cities (of the total reporting)	No. of cities	% of cities (of the total reporting)	No. of cities	% of cities (of the total reporting)	No. of cities	% of cities (of the total reporting
Municipal	66	65%	116	68%	46	56%	37	53%	88	56%
Metropolitan	14	14%	17	10%	9	11%	10	14%	23	15%
Intermunicipal	3	3%	7	4%	6	7%	6	9%	11	7%
Regional/ provincial	8	8%	15	9%	9	11%	7	10%	17	11%
National/state-owned enterprise	5	5%	10	6%	6	7%	6	9%	8	5%
Other	5	5%	7	4%	6	7%	4	6%	11	7%
Total	**101**		**171**		**82**		**70**		**158**	

Source: Original table for this report.
Note: City dataset. Total number of cities covered in the report: 262. Total row in the table indicates the number of cities reporting data under the respective category. Percentages may not total 100% due to rounding errors.

Table 6.8 Waste management administration, operation, and financing models – Operator

Operator: Entity or entities providing solid waste management services	City cleaning		Primary collection		Secondary collection		Transfer station or inter-mediate collection point		Disposal and treatment	
	No. of cities	% of cities (of the total reporting)	No. of cities	% of cities (of the total reporting)	No. of cities	% of cities (of the total reporting)	No. of cities	% of cities (of the total reporting)	No. of cities	% of cities (of the total reporting)
Municipal	48	45%	63	29%	21	23%	24	29%	44	27%
Metropolitan	9	8%	8	4%	6	7%	5	6%	6	4%
Intermunicipal	0	0%	1	0%	2	2%	1	1%	4	2%
Regional/provincial	3	3%	7	3%	6	7%	6	7%	9	5%
National/state-owned enterprise	7	7%	21	10%	7	8%	7	9%	17	10%
Private	20	19%	58	27%	25	27%	21	26%	57	34%
Mixed public-private	19	18%	55	25%	24	26%	18	22%	28	17%
Decentralized/community	1	1%	4	2%	0	0%	0	0%	1	1%
Total	**107**		**217**		**92**		**82**		**168**	

Source: Original table for this report.
Note: City dataset. Total number of cities covered in the report: 262. Total row in the table indicates the number of cities reporting data under the respective category. Percentages may not total 100% due to rounding errors.

Table 6.9 Waste management administration, operation, and financing models – Investment Financing Agent

Investment Financing Agent Entity or entities financing infrastructure investments										
	City cleaning		Primary collection		Secondary collection		Transfer station or intermediate collection point		Disposal and treatment	
	No. of cities	% of cities (of the total reporting)	No. of cities	% of cities (of the total reporting)	No. of cities	% of cities (of the total reporting)	No. of cities	% of cities (of the total reporting)	No. of cities	% of cities (of the total reporting
Local government	32	71%	59	60%	18	47%	15	48%	29	40%
National government	4	9%	13	13%	6	16%	3	10%	10	14%
Private sector	0	0%	8	8%	3	8%	1	3%	9	12%
Other	9	20%	18	18%	11	29%	12	39%	25	34%
Total	**45**		**98**		**38**		**31**		**73**	

Source: Original table for this report.
Note: City dataset. Total number of cities covered in the report: 262. Total row in the table indicates the number of cities reporting data under the respective category. Percentages may not total 100% due to rounding errors.

These estimates draw on reported data for formal employment in high-income countries, both formal and informal workers in upper-middle-income countries and lower-middle-income countries, and predominantly informal workers in low-income countries. Although these findings align with previous studies that estimate informal waste workers comprise 0.1 percent to 0.5 percent of the global urban population—with a median of 0.2 percent—they exceed the figures reported in national labor force surveys by the International Labour Organization (ILO), which account for both formal and informal waste workers (box 6.2).

Box 6.2 Employment in the Waste Sector – Insights from External Sources

A large-scale review and quantitative analysis of the informal recycling sector estimates that between 0.1% and 0.5% of the global urban population is engaged in informal recycling activities (Cook, Souza Lima Cano, and Velis 2024). This corresponds to approximately 4.4 to 22 million workers worldwide. To assess the prevalence and productivity of informal recycling, the report reviewed literature published between 2000 and 2020, analyzing 133 datasets from 71 studies across 32 countries, offering a comprehensive quantitative assessment of the sector to date.

The highest prevalence of informal recycling workers is found in Eastern Asia (median: 0.8%, interquartile range or IQR: 0.4–0.9%), particularly in China, followed by Southern Asia (0.5%, IQR: 0.2–0.7%) and Latin America (0.17%, IQR: 0.1–0.2%). Sub-Saharan Africa shows the lowest prevalence, with a median of just 0.03% of the population engaged in waste picking. In productivity, informal waste pickers are estimated to collect between 20 and 80 kilograms of recyclables per day, with plastics accounting for approximately 30% of the total materials recovered. Consistent with findings from national labor force surveys, the sector is predominantly male, with men comprising 70–80% of the workforce, though regional variations exist.

Data from the ILO presents a more conservative estimate, indicating that approximately 6.9 million people are employed in the global waste management and recycling sector—equivalent to about 0.2% of total global employment.[a] These figures are derived from national-level employment data based on 189 household surveys, primarily labor force surveys. The lowest employment rates are observed in low-income countries at 0.1%, while upper-middle-income countries report the highest at 0.3%. Regionally, employment is highest in the Europe and Central Asia region, with 174 workers per 100,000 people, and lowest in Africa, with fewer than 30 workers per 100,000. These employment figures include individuals whose primary job is in waste management and recycling. They exclude those engaged in secondary employment, migrants, or individuals without a permanent address, such as waste pickers residing at disposal sites or in informal settlements.

Reflecting the global increase in recycling rates over the past decade, the ILO reports a rise in employment in the waste and recycling sector in 55 of 77 countries with available data between 2014 and 2023. The sector remains predominantly male, with women making up approximately 23% of the workforce, except in Africa, where women account for nearly 30%. Workers in this industry tend to work longer hours than those in other sectors. Average weekly working hours range from 23 to 57 across countries, often exceeding the 50-hour maximum observed in other industries. Educational attainment is also generally lower in this sector. In 65 of 66 countries with data, the share of workers with advanced education is significantly lower in the waste and recycling sector, averaging 9.5%, compared with 24.8% across all economic activities.

Challenges with data gaps and significant uncertainties in data collection are emphasized, as well as the limitation stemming from many estimates relying on expert judgment rather than systematic enumeration or standardized methodologies. This reliance on nonuniform approaches can lead to inconsistencies and hinder comparability across countries and regions.

Notes

a. International Labour Organization. Labour force statistics database, ILOSTAT. https://ilostat.ilo.org/data/.

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Cook E., N. Silva de Souza Lima Cano, and C.A. Velis. 2024. "Informal recycling sector contribution to plastic pollution mitigation: A systematic scoping review and quantitative analysis of prevalence and productivity." *Resources, Conservation and Recycling*, Vol. 206. https://www.sciencedirect.com/science/article/pii/S0921344924001824.

Informality in the sector remains high. According to data reported in this report, 90 percent of waste workers in low- and middle-income countries are informal, compared with 26 percent in upper-middle-income countries. Their contributions are particularly significant in low- and middle-income countries, where, in the absence of formal systems, they often form the backbone of waste collection and recycling. Similarly, estimates from other studies indicate that approximately 40 percent of waste sector workers globally operate outside formal employment systems with higher concentrations in low-income settings (ILO 2023); and that they play a critical role in the overall performance of the sector, handling 10 to 30 percent of total municipal solid waste and helping to alleviate pressure on public services (UNEP and ISWA 2015).

It should be noted that significant uncertainties remain regarding data reliability, and the absence of a standardized methodology for capturing and reporting employment in the sector, and informal workers especially, should be considered when interpreting these results.

Informal waste workers frequently face serious challenges, including exposure to health and safety risks, unstable incomes, lack of financial security and social protection, and social stigma and marginalization. Addressing these challenges through inclusive policies that integrate informal workers into formal waste systems–alongside improvements in working conditions and access to social protection–would contribute to more inclusive communities and improved sector performance. Opportunities also exist for direct collaboration between manufacturers, producers, and importers, particularly those with obligations under extended producer responsibility policy schemes, and the informal recycling sector, which can play a key role in collecting waste products and packaging for recycling (Whiteman, Webster, and Wilson 2021).

Over time, investments in waste systems have the potential to catalyze broader economic transformation by creating new value chains and higher-quality employment. These value chains span sectors such as recycling, manufacturing, construction, and clean energy, multiplying employment opportunities across the economy. Beyond job creation, improved waste management enhances living and working conditions, supporting human capital development through better health, productivity, and quality of life. Cleaner cities also boost local economic development by increasing competitiveness and attractiveness for investment.

Box 6.3 Waste Management Operations and Technologies

Waste management technology choices reflect national policy objectives and operational priorities. Their feasibility typically depends on sector maturity and institutional capacity, waste characteristics, and lifecycle costs, including financing and tariff structures. Community participation—especially in source segregation—can shape the applicability of specific options. Each technology entails distinct capital and operating costs, technical and supply-chain requirements, and performance profiles. Consequently, environmental outcomes and unit costs vary according to the technical configurations and organizational arrangements adopted.

Waste Hierarchy serves as the guiding principle, namely that when waste cannot be prevented or prepared for reuse, it is managed first through material recycling and biological treatment, such as composting or anaerobic digestion, followed by energy recovery, and then sanitary landfilling. Although sanitary landfilling is the least preferred waste management option, it is environmentally acceptable and a typically cost-effective component of an integrated system to avoid waste dumping practices.

Commonly, national and subnational systems apply a mix of technologies. The treatment mix varies within and across countries depending on population density, waste volumes and composition, climate, affordability, market conditions for recovered products, and others. This text box outlines the principal technology options and key operational considerations.

Segregated collection and sorting of municipal waste

This is a critical step to increase recycling rates as material quality largely determines market demand and value. High-quality feedstock is needed for both dry recyclables, such as paper, cardboard, plastics, metals, and glass, and to produce compost that can be used in agriculture or for soil enrichment. Commingling—as happens with mixed waste collection—leads to contamination, which limits the potential for recycling into materials of equal or higher value.

Collection systems differ for households and commercial sources, reflecting the distinct waste profiles they generate. Businesses often produce large volumes of recyclable packaging material and generally require systems suited to higher volumes, with onsite storage, compaction facilities, and trained staff to maintain quality. Households typically rely on door-to-door, that is curbside, collection, or bring systems. The choice between them depends on desired capture rates as well as residual waste arrangements, tariff structures, public behavior, informal sector roles, and other local factors. Container size and type also influence the quantity, composition, and quality of collected material.

Different collection methods vary in recovery rates, material quality, and cost. Higher capture rates often come with higher operational costs, requiring municipalities to balance performance objectives with budget limits, vehicle availability, and container compatibility. Household participation generally improves gradually as residents transition from mixed disposal to consistent source separation, with communication campaigns, awareness programs, and incentives playing an important role.

Cities worldwide continue to pilot, learn from, and adapt their waste collection systems in search of an optimal balance between operational efficiency, cost, material quality, and resident convenience as well as practicality in what waste generators are realistically willing to do. Where statutory recycling targets exist, achieving high capture rates of source segregated materials tends to drive system design. In some high income countries, prevailing models combine curbside collection of mixed waste and dry recyclables with complementary bring systems for specific fractions such as glass, plastics, paper, textiles, and garden waste. In some cities, multiple curbside waste collection streams have been replaced by simpler two stream systems after finding high levels of contamination in mixed recyclables and increased logistics costs. Many municipalities continue to trial alternatives such as underground communal containers in dense districts in central business districts, and tailor the segregation schemes to both achieve local objectives, optimize costs, and align with behavioral patterns.

Separate collection and sorting usually operate at a net cost, as revenues from recyclables rarely cover collection and sorting expenses. Sustainable systems therefore depend on complementary financing mechanisms such as waste management tariffs or extended producer responsibility schemes. Unit costs per tonne vary by material and are influenced by participation levels, capture rates, and informal sector activities, which can affect both the quantity and quality of recovered materials.

Once collected, recyclables require further sorting and processing in dedicated materials recovery facilities designed to meet recycling plant specifications. Material recovery facilities come in a wide variety, with differing levels of automation, performance, and costs. Smaller facilities may rely mainly on manual sorting and baling, while larger material recovery facilities often operate specialized lines for paper, plastics, or glass, supported by mechanized feeding systems and automated presses. In recent decades, a marked shift favors more specialized equipment, optical sorting, and higher levels of automation, particularly for plastics. The fractions targeted and the level of sorting detail depend on prevailing market demand, quality standards, and commodity prices, which fluctuate significantly and require adaptable strategies.

Collection, transfer, and sorting of residual or mixed waste: In high-income countries, residual waste collection in urban areas is almost exclusively containerized, which is considered best practice. In many low- and middle-income countries, however, containers may be unavailable due to financial constraints, limited space availability, low public acceptance, or policy choices. Waste is then handed directly to collection trucks through door-to-door or bring point collection or left in uncontained piles for bulk collection. Noncontainment may lead to scattering by wind, rain, and animals, and increased waste weight through water infiltration, and poses health and safety risks for workers and the public. It may also reduce loading efficiency, as waste must be lifted manually or mechanically from the ground on to trucks.

Transfer stations are used when the cost of direct transport from the point of generation to the disposal or treatment site exceeds the cost of first moving waste to a transfer facility, then transporting it in larger vehicles or containers to the final site. Their viability depends on distance, waste volumes, road and topographic conditions, population density, and transfer technology. Broadly, transfer stations either use compaction systems or rely on containers or semitrailers without compaction. They may allow direct unloading on to hoppers or containers, or provide interim storage to buffer peak inflows. Roofed or enclosed facilities improve working conditions and can be fitted with ventilation and odor control. Compaction tends to be cost effective for longer hauls, while simpler noncompaction stations are often sufficient for shorter distances, reflecting a trade-off between investment and operating costs.

Sorting of residual or mixed municipal waste typically involves mechanical treatment methods such as shredding, screening, and automated or manual sorting to recover recyclable fractions and produce refuse-derived fuel. Material recovery facilities that process mixed waste are often referred to as "dirty" material recovery facilities, while those handling presorted recyclables are known as "clean" material recovery facilities. Recyclables recovered from mixed waste are generally of lower quality due to higher levels of contamination, so "dirty" material recovery facilities are sometimes used only as a transitional measure until separate collection systems are established. Common preparation and sorting techniques include bag splitting, sieving, air classification, ballistic separation, magnetic separation, and optical sorting. The design and cost of sorting facilities are influenced by operating days, number of shifts, processing lines, screen fractions, sorting technologies used, and the required quality of both recovered recyclables and refuse-derived fuel.

Composting

Because in lower-income countries organic waste accounts for roughly half of municipal solid waste by composition, composting in situ and the separate collection of biowaste are key measures to substantially reduce the amount of waste sent to landfill and to increase recycling rates. The biological process of composting involves the breakdown of organic material by microorganisms in an oxygen-rich or aerobic environment. Through this process, waste is converted into carbon dioxide, water, nitrates, and sulfates, with plant materials such as grass clippings, leaves, and branches transformed into an organic soil improver.

A wide range of organic wastes can be composted, including green waste from public spaces and private gardens, fruit and vegetable residues from markets, and organic waste from agriculture and food processing. Food waste from households and establishments such as restaurants and canteens can also be composted, although not all is suitable. Sludge from municipal wastewater treatment plants may be used if it complies with regulatory limits for heavy metals and other contaminants.

Different composting technologies are applied depending on the context. Static piles consist of unturned compost heaps constructed directly on the ground. Open windrows form long piles, triangular or trapezoid in cross-section, which are turned regularly to ensure aeration. Aerated static piles use blowers or suction systems connected to aeration pipes beneath the piles. In-vessel systems include tunnels, containers, rotating drums, or other enclosed designs that allow for more controlled decomposition.

In addition to centralized facilities, home composting is commonly practiced at the household or community level. The process is aided by shredding plant materials and regularly turning the pile to improve aeration. While kitchen waste may be included, products such as meat and dairy should be avoided, as they attract pests. Home composting can be carried out in simple wooden or plastic units, or in specialized devices, and the resulting compost is typically used for personal gardening and landscaping. For larger-scale systems, municipalities often support collection of green waste through drop-off sites, curbside collection, or dedicated bins. Transport costs can be reduced by mobile shredders or chippers, which increase the density of material before transfer.

Compost should undergo laboratory testing for safe and effective use to determine levels of heavy metals, pathogens, and other potential contaminants. Compost should be assigned quality grades based on these results, which define the permitted uses and placement options. High-grade compost may be applied as a soil improver in agriculture or landscaping, while lower grades may be restricted to uses such as brownfield restoration, landfill cover, or other applications with limited exposure risks. Establishing clear standards, quality control, and certification systems is critical to protect public health, build market confidence, and maximize the environmental benefits of composting.

Anaerobic digestion[a]

Anaerobic digestion is a technology for controlled anaerobic treatment of biodegradable waste used to transform the organic matter contained in the waste into biogas and digestate, which is valuable as an organic fertilizer or soil improver (Pinasseau et al. 2018). In municipal waste management, anaerobic digestion is mainly used for recovery of value from separately collected biowaste. It is also used by industries to handle wastes very high in chemical oxygen demand, and as a treatment process for sewage sludge after aerobic wastewater treatment. The production of biogas from controlled anaerobic digestion is one of the principal advantages of the process; it is a renewable energy source which can be used for the production of electricity, heat, and fuel, either gaseous or liquefied.

The characteristics of the feedstock have very important impact on the anaerobic digestion process and, therefore, on the biogas yield and digestate quality. For instance, high metal concentrations in feedstock can be toxic to methanogenic archaea. The volatile solids content will affect the extent to which the process needs to be monitored to avoid the damaging effect of overloading. One of the main limits of anaerobic digestion is its inability to degrade lignin, a major component of wood; that is, lignin is only partially or slowly transformed and contributes little to the methane yield. This contrasts with the process of aerobic treatment or composting.

Three digestion technologies are most commonly used: wet digestion, dry continuous digestion, and dry batch digestion. These main types of digesters differ according to the process configuration and degree of mixing. Vertical digesters with an agitator are typically used in wet digestion facilities to ensure thorough mixing of the diluted feedstock. In dry digestion, horizontal digesters with a slow transport agitator operate on plug-flow technology, while vertical digesters without mixing also apply plug-flow principles but rely on gravity and limited movement of the substrate. Box or percolation digesters are used for dry batch digestion, where leachate is recirculated to enhance contact between organic acids and methane-forming bacteria. Each configuration has specific operational advantages and limitations depending on feedstock properties, dry matter content, and site conditions.

A clean biodegradable feedstock will increase the quality of the digestate, which later can be used as an organic fertilizer or soil improver in agriculture, either in a liquid form (about 5–15% dry matter) like manure, or in a semisolid form (10–30%) like peat, or it can be further upgraded for example, by composting, drying or pelletizing in landscaping and horticulture as well as in private gardens. The common practice for digestate produced from anaerobic digestion treatment of separately collected biowaste is postcomposting.

Depending on the composition of input biowaste, the energy recovered could result in production of 0.4–0.9 megajoules electricity per tonne of waste treated. In addition, combined heat and power plants may generate a similar quantity of heat. Total residual waste from composting varies between 0.3-0.6 tonnes per tonne of input, depending on waste composition and composting process.

Biogas generation can vary significantly; for example, in one plant volumes ranged from 80 normal cubic meter (Nm^3) to 120 Nm^3 per tonne of throughput depending on feedstock composition. End uses for biogas include burning in a simple boiler to generate heat or use in an engine with a generator to produce power (Pinasseau et al. 2018).

Mechanical biological treatment of residual waste, including refuse-derived fuel production

Mechanical biological treatment refers to facilities where residual waste undergoes a combination of mechanical and biological processes. Mechanical biological treatment applies biological treatment—aerobic or anaerobic processes—together with further mechanical separation. Configurations vary and can be designed with or without integrated sorting plants for recyclables further outlined below.

Mechanical biological treatment producing refuse-derived fuel and a biotreated fraction: These facilities generate a high-calorific refuse-derived fuel stream and a biologically treated fraction, often referred to as compost-like output. The biological treatment process is similar to composting and typically takes place in enclosed conditions to limit odors and contamination risks. Refuse-derived fuel is used mainly in cement kilns, industrial boilers, for co-firing in coal power stations, as well as in combined heat and power plants. Compost-like output, also referred to as stabilized biowaste, results from aerobic processes such as in-vessel composting. Unlike source-separated compost, it is of lower quality and limited to uses such as brownfield restoration, landfill capping, or direct landfilling. Compost-like output rarely has a marketable sales value; its role is in stabilizing waste to reduce methane and leachate generation, compaction needs, and settlement when landfilled.

Mechanical biological treatment maximizing refuse-derived fuel production with minimal landfill residues: These facilities process organic waste for the production of refuse-derived fuel and usually employ biodrying, where biological processes reduce the moisture content of waste rather than producing compost-like output. The dried combustible fraction is then separated as refuse-derived fuel, while mineral residues are directed to landfill. The system is designed to maximize refuse-derived fuel output.

Biological pretreatment before landfilling (biological stabilization): The purpose of this approach is to reduce the quantity of waste designated for landfilling and, more importantly, to lower landfill gas generation and leachate contamination. Reductions are achieved through biodegradation losses, as part of the organic fraction is converted into carbon dioxide and water. Since neither compost-like output nor refuse-derived fuel is produced, the overall decrease in landfilled waste is considerably lower than in other mechanical biological treatment configurations, but the environmental impacts of landfilling are reduced.

Pretreatment before incineration: In this configuration, the mechanical biological treatment serves as a front-end process to improve the performance of waste-to-energy plants. Mechanical sorting removes inert materials and recovers recyclables, while biological treatment stabilizes or dries the waste to improve its calorific value. This enhances combustion efficiency, reduces emissions, and lowers the volume of residues requiring disposal.

Municipal waste incineration with energy recovery

Thermal treatment is another alternative to reduce waste destined for landfill. The incineration sector has undergone rapid technological development over the past 25 years, largely driven by stricter legislation. These regulatory requirements have significantly reduced emissions to air and water. Process development continues, with the sector also focusing on controlling costs while maintaining or improving environmental performance (Neuwahl et al. 2019).

The primary objective of waste incineration is to reduce the volume, mass, and hazardousness of waste, while capturing or destroying potentially harmful substances that may otherwise be released. Energy recovery is a byproduct of the process. Municipal solid waste can be incinerated in traveling grates, rotary kilns, or fluidized beds. Grate incinerators remain the most widely applied technology for mixed municipal waste, accounting for about 90% of European installations and has also become the technology of choice for mixed waste incinerators in Asia. Fluidized bed technology, by contrast, requires waste to be of a specific particle size and composition, which typically necessitates pretreatment.

Modern incineration plants include a series of operations: waste reception, storage, and pretreatment, if required; feeding into the furnace; thermal treatment; energy recovery through boilers and turbines; flue-gas cleaning; flue-gas residue treatment and discharge; continuous emissions monitoring; wastewater treatment; and ash management. Incineration can reduce the volume of combustibles by 80–95%, significantly decreasing the need for landfill space. Bottom ash, which typically represents 20–30% of the input waste by weight, can often be used as aggregate in construction, provided environmental standards are met. Fly ash, though produced in smaller quantities, contains higher concentrations of pollutants and requires careful management. Incineration contributes to climate mitigation goals by avoiding methane emissions from landfilled waste and by substituting for fossil fuels in energy systems.

Gasification and pyrolysis are often presented as advanced alternatives to conventional incineration. In principle, these technologies can produce syngas, oils, or char that may be further processed into energy or materials. However, although a few plants have been built with these technologies, they have not yet been proven at commercial scale for the treatment of mixed municipal solid waste to be technically and financially competitive. Existing plants generally operate at small scale and rely on more homogeneous, high-calorific feedstocks such as plastics, wood waste, or refuse-derived fuel. For heterogeneous municipal solid waste, challenges remain with feedstock preparation, process stability, syngas cleaning, and residue management. Although research and pilot projects continue, these technologies are not yet viable mainstream options for large-scale municipal waste treatment.

An incineration plant involves high capital investment and significant operating costs, and it requires skilled personnel for safe and efficient operation. The suitability of incineration is strongly influenced by waste composition, and in many developing countries the high organic and moisture content of municipal solid waste reduces its potential for self-sustained combustion. In addition, residues from flue-gas cleaning must be carefully managed, typically in dedicated landfills, to avoid contamination of soil and water. These factors underline the importance of sound regulatory oversight and robust environmental safeguards in the operation of incineration facilities.

Sanitary landfilling

This sits at the bottom of Waste Hierarchy, but it is a necessary part of modern solid waste management systems. Even with implementation of recycling, composting, and energy recovery initiatives, a landfill is, in practice, needed as part of the system for safe disposal of residuals, rejects from treatment, maintenance downtime at other facilities, for emergency situations, and as a contingency.

A modern sanitary landfill is a regulated, engineered facility designed to protect human health and the environment throughout its operation or lifespan, and after full closure. Key features of a sanitary landfill include an impermeable base which is usually established through excavation, leveling, and compaction of the base soil and installation of low-permeability bottom liner—typically layers of compacted clay, geomembrane, or both—and leachate collection system to prevent contamination of underlaying soil and groundwater. Waste is placed in cells with leachate drainage system that conveys the collected leachate to leachate treatment facility. Landfill gas is also captured within the disposal cell and managed through controlled flaring or energy recovery systems. Surface water is properly managed to keep the clean stormwater separate from contaminated areas. Supporting infrastructure commonly includes access control and fencing, internal roads, administrative and maintenance buildings, a weighbridge and scale house, and specialized heavy equipment for distribution and compaction of waste, as well as application of daily or intermediate cover. Anaerobic decomposition of organic wastes results in generation of landfill gas including methane, carbon dioxide, as well as trace compounds such as volatile organic compounds (VOCs) and hazardous air pollutants (HAPs). Therefore, proper and effective management of landfill gas is critical to minimize emissions from the facility, reduce explosion risk, avoid odor issues, and to protect human health and the environment.

Site selection for a sanitary landfill follows a risk based approach that prioritizes avoidance and then minimization of impacts. Locations should be compatible with surrounding land uses, with adequate buffer zones from communities, water bodies, and other sensitive receptors. Proximity to airports can increase hazardous bird activity and is generally avoided. Separation from drinking water sources, surface waters, and groundwater recharge areas—coupled with low permeability soils and hydrogeologic conditions that naturally limit leachate migration—improves environmental protection. Gently sloped terrain aides effective leachate drainage, with bases situated well above the seasonal high groundwater. Flood prone settings, unstable or highly fractured geology, karst formations, and active fault zones present elevated risk. Access to suitable daily and intermediate cover soils facilitates landfill operations. Larger landfills, planned for decades of future operation, typically achieve lower unit costs and are preferred.

Landfill development can affect nearby residents through odors, noise, dust, traffic, and other nuisances. Upgrading existing landfills may also disrupt informal waste-based livelihoods. It is essential to establish robust environmental control systems that minimize negative impacts to address these concerns, maintain adequate buffer zones between disposal areas and surrounding communities, and provide accessible grievance mechanisms. Good practice also includes continuous engagement with affected communities. When waste pickers are impacted, it is important to support their livelihoods by creating pathways into formal roles, offering skills training, and providing safer opportunities for sorting and recovery activities.

After closure, landfills are capped in accordance with regulatory standards and placed under long-term postclosure monitoring, which typically includes groundwater, surface water, air quality, leachate, and landfill gas. Over subsequent decades, differential settlement of the landfill surface is expected, and structural stability remains uncertain. Additionally, the ongoing decomposition of organic waste continues to generate methane, creating risks of gas accumulation within onsite structures and the potential for explosion. For these reasons, the construction of buildings or enclosed structures on closed landfills is strongly discouraged. Postclosure land use should therefore be limited to low-impact applications such as parks, parking areas, golf courses, solar farms, trails, or ecological restoration. Public access to these areas may be permitted, but only after careful evaluation of postclosure monitoring data and site conditions. More intensive uses can be considered only following a comprehensive geotechnical assessment and once the contaminating lifespan of the landfill has been exceeded.

Notes

a. The entire subsection on anaerobic digestion is based on or adapted from the work of Pinasseau et al. 2018.

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Notes

1. This report's dataset lists legislation and regulations that have been officially passed. Policies, action plans, strategies, and other non-legally binding instruments have not been included.
2. The term 'producer' needs to be defined in law based on local market characteristics but usually includes domestic manufacturers as well as importers or the actor that places a product, packaging, or resin first on the market.
3. Directive 2008/98/EC. Article 8. https://eur-lex.europa.eu/eli/dir/2008/98/oj/eng.
4. Directive (EU) 2018/852 amending Directive 94/62/EC on packaging and packaging waste. Article 7. https://eur-lex.europa.eu/eli/dir/2018/852/oj/eng.
5. Directive 94/62/EC on packaging and packaging waste. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=LEGISSUM:l21207.
6. European Parliament Directive (EU) 2019/904 of the European Parliament and of the Council of 5 June 2019 on the reduction of the impact of certain plastic products on the environment. https://eur-lex.europa.eu/eli/dir/2019/904/oj/eng.
7. In an operational scheme, producers are responsible for both implementation and financing operations for the collection and recovery of waste. In a financial scheme, producers are responsible for financing operations for collection and recovery, which is implemented by municipal governments. In a combined scheme, producers are offered the choice of entering an industry implemented scheme or a government implemented scheme, which operates simultaneously.
8. This report classifies policy instruments across four phases of policy development and implementation: (1) draft policy or initial planning, (2) official adoption of a policy or strategy, (3) passage of legislation, and (4) publication of legally binding regulations.
9. Deposit return schemes in Canada and the United States are reported to reach nearly 130 million residents across both jurisdictions (Reloop 2024).
10. UN Environment Programme. *The New Plastics Economy Global Commitment*. https://www.unep.org/new-plastics-economy-global-commitment.
11. Business Coalition for a Global Plastics Treaty. https://www.businessforplasticstreaty.org/.
12. Sustainable Packaging Coalition. https://sustainablepackaging.org/.
13. WRAP (Waste and Resources Action Programme). *The Plastic Pact Network*. https://www.wrap.ngo/taking-action/plastic-packaging/initiatives/plastic-pact-network.

14. Ellen MacArthur Foundation. *The Global Commitment Five Years*. In: Learning to accelerate towards a future without plastic waste or pollution. https://www.ellenmacarthurfoundation.org/global-commitment/overview.
15. Consumer Brands Association. Recycling Leadership Council. https://consumerbrandsassociation.org/sustainability/recycling-leadership-council/.
16. Statistical Agency under the President of the Republic of Tajikstan. "System of the Statistical Agency near the President of the Republic of Tajikistan" (English translation).
17. The population of cities in the database was categorized using classification from *UN World Urbanization Prospects 2018* (UNDESA 2019). Based on the classification, 34 cities with population more than (or equal to) 5 million were selected for analysis and included: Abidjan, Ahmedabad, Baghdad, Bangkok, Beijing, Bengaluru, Bogota, Cairo, Dhaka, Delhi, Hanoi, Ho Chi Min City, Istanbul, Jakarta, Johannesburg, Kabul, Kano, Karachi, Kinshasa, Lagos, Lahore. London, Luanda, Mexico City, Moscow, Mumbai, Rio de Janeiro, Riyadh, Sao Paolo, Seoul, Shanghai, Tehran, Tokyo, and Yangon.

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©Alamy/Stephan Schulz. Solar photovoltaic park constructed on a closed landfill site.

7.

Costs and Financing of Solid Waste Management

KEY INSIGHTS

- Municipal waste management costs vary widely across countries, influenced by factors such as collection methods, treatment technologies and level of automation, installed capacity, level of community engagement in waste collection and sorting, local costs of commodities, labor and fuel, and tax policies.
- This report estimates that in 2022, global costs for municipal waste management exceeded US$250 billion annually and will increase to US$426 billion annually by 2050 under the business-as-usual scenario—a 68-percent increase. The estimates cover only the direct financial costs of service provision and exclude the economic costs of inadequate municipal waste management, including impacts on health, ecosystems, productivity, and tourism. Investment in municipal waste systems—advancing waste prevention and minimization, expanding collection coverage, increasing reuse and recycling, and improving treatment—will prevent escalating economic costs that would otherwise exceed required financial expenditures.
- Basic municipal solid waste systems, including collection, transport and disposal, in low-income countries tend to cost at least US$40 to US$45 per tonne, depending on local conditions. In middle-income countries, basic systems cost approximately US$70 to US$80 per tonne, while more advanced systems with higher rate of recycling and landfill diversion could approach US$120 per tonne. In high-income countries, waste management costs may exceed US$200 per tonne. At these cost levels, low-income countries would need about 0.78 percent of their combined 2022 GDP to achieve universal waste management coverage in the same year; middle-income countries would require 0.31–0.46 percent of GDP; and high-income countries would need at least one-third of a percent. By comparison, reported public expenditure on solid waste management is less than 0.15 percent of GDP in about three-quarters of low- and middle-income countries and about 0.31 percent in high-income countries. While reported public spending in low- and

KEY INSIGHTS (CONTD.)

middle-income countries falls well below estimated financing needs, actual outlays are likely higher, as budget data often exclude expenditures by private providers and state-owned enterprises outside formal public systems.

- Estimating the total economic loss from inadequate waste management is difficult, as many impacts are not systematically quantified. Available assessments vary considerably, suggesting losses of about 0.10 percent to 0.60 percent of GDP and in some cases up to 1.5 percent, arising from health impacts, reduced land values around disposal sites, and the forgone value of unrecovered materials and energy. These figures are conservative, as they exclude negative impacts on development of economic sectors such as tourism, agriculture and fisheries, and other hard-to-measure externalities and broader development benefits such as climate mitigation, reduced marine pollution, and the gains from waste prevention. A more comprehensive assessment of the average economic loss from uncollected waste places the cost at about US$375 per tonne for middle-income countries in Southeast Asia, significantly above the estimated costs these countries would need to collect and manage such waste properly. Applied across all middle-income countries and quantifying the economic impact of uncollected waste there, corresponds to approximately 0.43 percent of their combined GDP in 2022.
- As waste volumes continue to grow—especially in low- and lower-middle-income countries where prevailing service coverage and infrastructure remain below adequate levels—the challenge is to both meet future demand and address existing shortfalls. Without accelerating investments, existing service gaps will widen, leaving countries further behind and locking in higher environmental, health, and economic costs. The urgency is therefore twofold: to expand systems fast enough to keep pace with rising waste volumes, and to raise performance well above current baselines to avoid compounding the broader economic costs of inaction and damages from unmanaged waste.
- In a business-as-usual scenario, low- and lower-middle-income countries face substantial investment needs in solid waste management, estimated at US$556 billion between 2022 and 2050. Relative to business as usual, the low- and high-ambition scenarios developed in this report would reduce global investment and annual costs, primarily due to lowering waste generation in high-income countries and upper-middle-income countries. Costs in low- and lower-middle-income countries, however, increase under all scenarios owing to the low baseline service levels, widespread uncollected waste, and prevalent open dumping.
- Mobilizing investments at this scale is likely to require a mix of domestic fiscal resources, development assistance, and private capital. Between 2003 and 2021, official development finance commitments to the sector totaled only US$14.5 billion, including US$1 billion for low-income countries and US$5.9 billion for lower-middle-income countries. While the public sector remains central to planning, regulation, and core service provision, additional financing from private sources will play an increasingly important role, particularly for advanced treatment and recovery facilities. Private sector participation in waste management depends on predictable revenue streams, underpinned by tariff policies, fee collection systems, and policy and regulatory frameworks that create conditions attractive to private operators. Reliable sector financing is essential to provide the foundation for private participation and to ensure continuous, high-quality service delivery.

KEY INSIGHTS (CONTD.)

- Globally, the recurrent costs of solid waste management are typically financed through a mix of user fees, municipal or central government revenues, and, to a lesser extent, from sales of recyclables and generated energy. As presented in this report, user fees range from as little as US$10 per household per year in low-income countries to more than US$500 in high-income countries, with averages of about US$30 and US$260, respectively. Full cost recovery through user fees remains largely limited to high-income settings. On average, solid waste management accounts for 6 percent of municipal budgets. Cities in lower-income countries tend to spend a higher than average share.
- The waste sector has successfully participated in carbon markets, particularly under the Clean Development Mechanism, and new opportunities are expected to emerge under Article 6 of the Paris Agreement. Participation in these markets enables operators to mobilize capital for advanced waste treatment technologies, reducing emissions while tackling critical waste management challenges.

7.1 Waste Management Costs

The provision of waste management services incurs significant financial costs, comprising two main types: capital expenditures for purchasing equipment and infrastructure investments, and operating expenditures for service provision and equipment maintenance. Although the largest single expenditure is typically for equipment and infrastructure investments, annual operational costs, excluding depreciation, are often higher than the annualized capital costs, accounting for 70 percent or more of total annual budgetary requirements.

Local factors such as limited market competition, procurement and contracting practices, inadequate risk allocation, planning and implementation challenges can significantly increase costs. Opting for low-cost investments at the procurement stage does not necessarily result in lower operating costs. While cheaper solutions may appear cost effective at first, they can sometimes lead to higher long-term expenses because of inefficiencies, increased maintenance needs, or system failures. In many cases, focusing solely on minimizing upfront costs may overlook the full lifecycle expenses, making these choices less optimal. Inefficient planning and implementation can further increase costs. In-country analyses reveal that collection and transport expenditures are often higher than necessary, indicating substantial potential for efficiency gains. At the same time, treatment and disposal expenditures are often lower than the full cost of adequate operations and maintenance.

Collection costs: Technical setups determine costs. The type of collection system, characteristics of containers and vehicles, collection frequency, working shifts, and transportation distances all impact waste collection costs. In middle- and high-income countries, large collection trucks with compaction are commonly used, while low-income countries often rely on secondhand equipment or low-cost solutions such as buggies, handcarts, and even donkeys. In high-income countries, waste collection is almost exclusively carried out using containers or specially designated bags. However, in many locations in low- and middle-income countries, containers are not available. Instead, waste is either taken directly to the collection truck by generators or accumulated in uncontained piles awaiting bulk collection. Noncontainment systems have several performance implications, including waste scattering caused by wind, rain, animals, and rain infiltration, which can increase the weight of waste. These systems also pose health and safety risks to workers and the public and can reduce loading efficiency owing to the time required to load waste manually or mechanically from the ground on to trucks.

The rollout of an integrated dual or multistream source-segregated waste system for household waste—that is, separate collection and sorting of household recyclable waste—typically results in a net cost, as revenues from the sale of recyclables are often lower than the combined costs of collection and sorting. The costs of collecting recyclable waste per tonne are generally higher than those for residual waste. These costs vary significantly by material type, the volume collected, resident participation, and the achieved capture rate. Separate collection from households as well as commercial, institutional, and administrative establishments requires distinct technical solutions and cost structures. In large urban areas, if properly organized, the collection of commercial recyclable waste, particularly cardboard and plastic foils, can be financially viable because of the generation of high-quality materials in large quantities. By contrast, organized separate collection from households is significantly more costly, especially in nonurban areas. The availability of recycling facilities within the country or region strongly influences the revenues and, respectively, the net costs. In countries where informal collection of recyclable waste is common, separate collection and sorting do not incur municipal expenses but carry the risk that collection of lower value recycling materials can drop when market prices are under pressure.

Waste treatment and disposal costs: Composting is a common practice to divert waste from landfills. The choice of composting technology depends on the type and quantity of input waste, product quality requirements, climate conditions, and site characteristics. While open windrow composting and aerated piles are well-established for green and market waste, the inclusion of food waste typically requires closed composting systems to effectively manage emissions and odors. Composting installations can vary widely in size and capacity, with different technologies suited to specific types of biowaste. Windrow composting, in particular, benefits from economies of scale, as larger facilities processing thousands of tonnes per year tend to have lower unit costs. Revenue from compost sales depends on quality, demand, and available outlets. In cases where compost quality is certified, revenues can be substantial. However, in many instances, markets for compost are limited, resulting in little or no revenue.

Applying more advanced treatment options for residual waste, such as mechanical biological treatment or incineration,[1] requires considerably higher initial investments. More advanced treatment options and technical solutions typically result in higher waste management costs as well. Additionally, it must be acknowledged that systems such as mechanical biological treatment and energy from waste are never standalone solutions. They still require arrangements for treatment residues or rejects, as well as arrangements to use outputs including heat, electricity, recyclables, and refuse-derived fuel (see also box 6.3 on waste management operations and technologies).

Policies seeking to increase the amount of municipal waste recycled and to establish more advanced treatment technologies are often based on assumptions about the municipal revenue to be generated from the production and sale of recovered materials and energy. Although these revenues rarely cover implementation costs, they can be significant when the quality of feedstock material is high, among other factors. The quality of feedstock material depends largely on whether waste is segregated at source; mixed waste separated at a later stage typically remains far more contaminated than source-segregated feedstock. Transitioning from mixed waste collection to source segregation is a gradual process that takes households a considerable amount of time to learn and adapt.

Landfilling remains the most common and cost-effective disposal method especially in lower-cost settings, but limited land availability and proximity are increasingly constraining its use. Significant economies of scale can be achieved by increasing landfill capacity, while smaller landfills tend to have higher unit costs and should generally be avoided. Leachate treatment can represent a substantial portion of overall landfill investment and operating costs. The establishment of auxiliary infrastructure, such as access roads, electricity supply, and wastewater discharge, can significantly increase the overall investment. Investing in effective landfill gas management is crucial to reducing methane emissions. In large capacity sites, it can generate additional revenue through the production of heat, electricity, or gas fuels. Significant costs continue to accumulate throughout the landfill's lifetime following the initial investment, including the construction of new cells, landfill gas collection, treatment or utilization, treatment to manage increased leachate quantities, interim closure and aftercare of old landfill cells, and equipment replacement.

In low- and lower-middle-income countries, a significant portion of waste is still disposed of at dumpsites or nonsanitary controlled landfills. The cost of open dumping is challenging to quantify, as it typically lacks construction, and tipping fees do not apply. However, dumping incurs substantial costs related to lost land value, environmental contamination, and poses a high risk of disaster-related expenses, particularly in areas with dense or nearby populations. Shallow dumps are more aerated, while deep dumps in anaerobic conditions generate large amounts of methane, which is highly problematic. Open burning of waste is also widespread and causes severe air pollution, public health impacts, and greenhouse gas (GHG) emissions. The closure of dumpsites and the remediation of legacy pollution can result in significant financial burdens.

Typical costs for various waste management operations are presented in this section's tables.[2]

Table 7.1 shows that the costs for similar activities vary significantly between countries. These differences may be attributed to several factors, including the type of waste collection or treatment method used, the technologies applied, the capacity of installations, and local variations in labor, fuel, consumables, construction costs, tax policies, and other context specific factors. It is important to note that the unit costs presented in the table reflect absolute costs by function and should not be summed to calculate a total system cost. The total costs of a municipal solid waste system depend on the amount of waste routed through each activity, with overall expenditures driven by the mix and volumes handled. Simple systems that collect mixed solid waste and dispose of it in sanitary landfills are estimated to cost about US$40 to US$60 per tonne. By contrast, systems involving source segregation and treatment of separate waste streams can vary significantly in cost and may reach several hundred US dollars per tonne, depending on the technologies used and other contextual factors.

Table 7.1 Typical costs by waste management operation type (US$ per tonne of waste)

	Low-income countries	Lower-middle-income countries	Upper-middle-income countries	High-income countries
Collection and transfer	20 - 50	30 - 75	40 - 100	60 - 200
Controlled landfill to sanitary landfill[a]	10 - 25	15 - 40	20 - 65	40 - 100
Open dumping	2 - 8	3 - 10	–	–
Separate collection of recyclable waste[b]	–	50 - 300	50 - 300	90 - 500
Sorting of separately collected waste (clean material recovery facility)[c]	–	30 - 120	40 - 200	70 - 300
Material recovery facility for residual (mixed) municipal waste	–	20 - 50	20 - 50	30 - 100
Mechanical biological treatment	–	20 - 50	30 - 80	40 - 120
Composting	5 - 30	10 - 60	20 - 75	35 - 100

Source: World Bank Group Solid Waste Management Community of Practice.
Note: Empty cells with "–" = not available.

a. Properly accounting for future liabilities is essential when calculating the total costs of landfill. These liabilities include cell replacement, landfill closure, and long-term monitoring. Incorporating depreciation and liabilities into the tariff requires setting aside equivalent funds in reserve accounts to be used when needed, particularly for end-of-life landfill closure, remediation, and ongoing monitoring.

b. The stated cost ranges refer to separate collection of recyclables from household waste. Significant variations are observed per material type (paper and cardboard, plastics, glass and metals, comingled collection of light packaging waste). The separate collection costs for recyclables are higher than costs for collecting residual or mixed waste due to the smaller quantities, different material densities of waste streams, and the applied collection frequencies.

c. Significant cost variations are driven by facility size, with larger-capacity facilities processing presorted waste typically achieving much lower per-tonne costs—often below US$100 per tonne.

Costs for waste-to-energy installations (table 7.2) and anaerobic digestion facilities (table 7.3) also differ significantly between regions owing to differences in technologies applied and the related investment and operating costs, waste composition characteristics, and green electricity tariff regulation and pricing.

Table 7.2 Capital and operating costs of municipal waste incineration

Region	Capital expenditures[a] (US$ per annual tonne capacity)	Operating costs (US$ per tonne processed)	Gate fee (US$ per tonne processed)	Electricity feed-in tariff	
				(US¢/kWh)	(US$/per tonne processed)[b, c]
Europe and North America	850 – 1,600	45 – 115	70 – 150	5 –12	33 – 78
China	200 – 300	15 – 30	8 – 16	~10	31
Asia (excluding India and Singapore)	385 – 435	15 – 32	12 – 24	10 – 14	40 – 56

Source: World Bank Group Solid Waste Management Community of Practice.
Note: Although other revenues are possible, such as waste heat for district heating and extraction of metals, waste incineration facilities primarily recoup their integrated costs from gate fees and feed-in tariffs for electricity generation. Gate fees—and sometimes other user contributions—need to cover the difference between feed-in-tariff revenues and total costs. The electricity feed-in-tariff is an important source of income; however, revenues can vary significantly depending on the calorific value and moisture contents of the feedstock. Revenues must cover not only the daily operating and maintenance costs presented in this table, but also depreciation of investments, financing charges, and other costs, such as management costs and insurance. Total integrated costs per tonne of waste are typically between US$75 and US$200.
a. In Europe and the United States, predominantly mass-burn or moving-grate technology is used for waste incinerators with energy recovery (waste-to-energy incineration) and have, in recent years, also become the mostly applied technology in other regions.
b. Mixed waste in the United States and Europe is relatively low in organics and water content and, hence, high in calorific value.
c. Indicative revenue per tonne of waste incinerated from electricity feed-in tariffs based on the following estimations: Europe 650 kWh_e(net)/tonne, Asia 400 kWh_e (net)/tonne, and China 310 kWh_e (net)/tonne.

Table 7.3 Capital and operating costs of anaerobic digestion facilities

Region - Anaerobic digestion - electricity and biomethanization[a]	Capital expenditures (US$ per annual tonne capacity)	Operating costs (US$ per tonne processed)
Europe and North America	350 – 500	50 – 90
China	100 – 350	35 – 50
Asia (excluding Singapore)	110 – 535	20 – 40

Source: World Bank Group Solid Waste Management Community of Practice.
Note:
a. Facilities treating agricultural waste tend to have lower capital expenditure and operating costs per tonne than facilities treating organic fraction of MSW (less pre-treatment, fewer rejects, lower maintenance costs). Anaerobic digestion plants producing bioCNG (RNG) have higher capital expenditure and operating costs than those producing renewable electricity. Figures exclude simpler, small farm type of projects.
RNG = renewable natural gas.

The decomposition of biodegradable municipal waste in landfills results in the generation of methane. To reduce the direct release of methane into the atmosphere, landfills must be equipped with gas collection systems and at least a basic flaring installation. At landfill sites where sufficient quantities of landfill gas are generated or where favorable conditions exist, it may be economically viable to recover energy in the form of heat, electricity, or both. Viability depends not only on gas volume but also on enabling factors such as a workable revenue model—for example, preferential feed-in tariffs or high grid prices—access to GHG reduction credits, secure offtake agreements, and affordable grid connection. Direct use of landfill gas can be even more cost effective when an end user is located nearby. In some countries, landfill gas is recognized as a renewable energy source, and preferential tariffs are offered for the electricity or heat produced. Indicative costs for energy recovery from landfill gas are shown in tables 7.4 and 7.5.

Table 7.4 Capital and operating costs for energy recovery from landfill gas[a]

Region	**Capital expenditures**[b] (US$/$kW_e$ installed capacity)	**Operating costs**[b] (US$/$kWh_e$)
North America and Europe	1,500 – 3,000	0.030 – 0.055
China	1,000 – 2,000	0.030 – 0.045
Latin America	1,500 – 2,000	0.030 – 0.055

Source: World Bank Group Solid Waste Management Community of Practice.
Note:
a. Refers to projects using LFG in reciprocating engines, with total installed capacity typically greater than 1 megawatt.
b. LFG collection system costs are included.
LFG = landfill gas, kW_e = kilowatt electrical, kWh_e = kilowatt hour electrical energy.

Table 7.5 Capital and operating costs for landfill gas to renewable natural gas

Region	**Capital expenditures** (US$/$Nm^3$ LFG annual capacity)[a]	**Annual operating costs** (US$/$Nm^3$ LFG annual capacity)[b]
North America and Europe Projects ranging 1,000 - 4,000 Nm^3/hr LFG flow rate[a]	0.50 - 1.00	0.16 - 0.20
Latin America Projects ranging 1,500 - 4,000 Nm^3/hr LFG flow rate[b]	1.10 - 2.40	0.24 - 0.44

Source: World Bank Group Solid Waste Management Community of Practice.
Note: The table refers to LFG-to-RNG projects. Projects upgrading/purifying LFG to renewable natural gas (RNG) or compressed RNG (C-RNG) for direct injection into the gas pipeline or compression and offtake to final consumption facilities or distribution points by truck.
a. LFG collection system costs are included.
b. Nm^3 of LFG input into biogas upgrading plant.
LFG = landfill gas, Nm^3/hr = cubic nanometer per hour.

Investment costs for establishing a waste treatment facility can vary significantly depending on the selected technology, the desired flexibility of the plant to adapt to changes in waste composition and quantity, labor safety standards, fire protection measures, and requirements for output quality and emissions control. The level of automation in the chosen technology also has a major influence on both investment and operating costs.

The costs of individual waste management operations tend to increase with a country's income level. Although higher wages and local costs partly explain these differences, they do not fully account for the disparity. In lower-income settings, cost reductions are often achieved through simplified treatment concepts, such as omitting process equipment, relying on locally available low-cost technologies, or applying lower standards for emissions, construction, and labor safety, which can reduce capital expenditures but may increase long-term operating costs as the asset ages. Although these measures reduce costs, they also have drawbacks compared with standard design facilities, including lower operational efficiency, limited flexibility to handle variations in waste input, reduced quality of output products, and potential health and environmental risks.

Major price differences are also observed between different manufacturers of equipment and vehicles, and costs for machinery with comparable technical characteristics can vary significantly. Local legal requirements, norms for emissions discharged into the environment, specific design and construction requirements, labor safety, and fire protection standards could also have a significant impact on the applied technical solutions and the related construction and equipment costs.

Costs can also vary significantly within a country, even when services are similar and provided under comparable conditions. Differences in service delivery efficiency between operators and local authorities often stem from factors such as varying levels of equipment utilization, underuse of installed capacity, and inadequate planning. For many waste management operations, such as landfilling or material recovery, significant economies of scale can be achieved with larger facilities. In such cases, shared treatment and disposal infrastructure serving multiple neighboring municipalities can offer a financially viable solution.

7.2 Current and Future Cost Estimates

Global waste management costs are already significant and are expected to rise further in the coming years.[3]

This chapter presents cost estimates to understand the cost implications of different development pathways associated with the scenarios outlined in chapter 4. These estimates are directly linked to the projected volumes of waste and are shaped by the technical and organizational solutions assumed within each scenario. In general, lower waste volumes lead to lower overall investment and operating costs. As the treatment mix becomes more technologically advanced—for example, through separate collection, diversion from landfilling, and additional processing or treatment—the costs of waste management tend to rise. Costs also increase as collection rates improve and more waste that would otherwise be dumped is instead collected, transported, and processed or disposed of. This transition toward more comprehensive and environmentally sound waste management drives the financial implications of each scenario. A summary of the scenarios presented in chapter 4 follows for ease of reference.

- Under the business-as-usual scenario, global waste generation is projected to rise from 2.56 billion tonnes in 2022 to 3.86 billion tonnes by 2050—a 50 percent increase. Over this period, the global collection rate is expected to increase moderately from 83 percent to 89 percent. About 27 percent of waste will be recycled or composted—up from 21 percent in 2022—with 22 percent incinerated and 31 percent landfilled. Approximately 20 percent of global waste is expected to remain uncollected or openly dumped.

  Within this global outlook, significant differences exist across income groups. High-income and upper-middle-income countries are expected to achieve near-universal waste collection by 2050, with most of their waste recycled, composted, or incinerated with energy recovery. In upper-middle-income countries, 7 percent of the waste will remain uncollected or dumped. By contrast, low-income and lower-middle-income countries are likely to face continued challenges: collection coverage is projected to reach only 48 percent in low-income countries and 82 percent in lower-income countries. Eighty-nine percent and 35 percent respectively of the waste in low-income and lower-middle-income countries is expected to remain uncollected or openly dumped.

- In the high-ambition scenario, global waste generation remains at 2022 levels, with universal collection, 54 percent of all waste being recycled or composted, 15 percent incinerated with energy recovery, and the remaining waste landfilled.

  The distribution of waste reduction is not evenly spread across income groups. Since high-income countries have the highest generation rates, they are assumed to account for the largest share of the reduction at 50 percent—followed by upper-middle-income and lower-middle-income countries—39 percent and 23 percent, respectively. Low-income countries, on the other hand, are expected to continue increasing their waste generation—from a low baseline of 0.43 kilogram per capita per day to 0.52 kilogram per capita per day by 2050—under all three scenarios.

  In the treatment mix, high-income countries and lower-middle-income countries reach 70 percent and 60 percent recycling and composting, respectively, along with another 24 percent incinerated with energy recovery. In lower-middle-income countries, 50 percent of waste is recycled or composted, and the rest is mainly landfilled. Low-income countries recycle or compost 20 percent of their waste and landfill the rest.

- The low-ambition scenario is approximately half the ambition of high-ambition scenario. Global waste generation is projected to rise from 2.56 billion tonnes in 2022 to 3.21 billion tonnes by 2050. Over this period, the global collection rate is expected to increase from 83 percent to 94 percent. About 41 percent of waste will be recycled or composted—up from 21 percent today—with 17 percent incinerated and 31 percent landfilled. Approximately 11 percent of global waste is expected to remain uncollected or openly dumped.

Within this scenario, high-income and upper-middle-income countries are expected to achieve near-universal waste collection by 2050, effectively nearly eliminating uncontrolled dumping, with most of their waste recycled, composted, or incinerated with energy recovery. By contrast, low-income and lower-middle-income countries are likely to face continued challenges: collection coverage is projected to reach 74 percent in low-income countries and 90 percent in lower-middle-income countries. Forty-five percent and 18 percent respectively of the waste in low-income and lower-middle-income countries is expected to remain uncollected or openly dumped.

In the treatment mix, high-income countries and lower-middle-income countries reach 58 percent and 41 percent recycling and composting respectively, along with another 24 percent incinerated with energy recovery. In lower-middle-income countries, 36 percent of waste is recycled or composted, 4 percent is incinerated with energy recovery, 42 percent is landfilled, and the remaining 18 percent is uncollected or dumped. Low-income countries recycle or compost 13 percent of their waste, landfill 42 percent of the waste, and 45 percent remain uncollected or dumped.

Sections 7.2.1 to 7.2.3 present the financial costs for the three scenarios.[4] Section 7.2.4 outlines potential revenues from the sale of waste-derived products and materials. Section 7.2.5 discusses economic costs and consequences.

Financial cost estimates are calculated separately for investment, operating, and depreciation costs, disaggregated by country income group and geographic region. Annual costs include operating costs and depreciation for each respective year. Cost figures per tonne of waste generated and per capita are also selectively provided. These estimates should be viewed as minimum values, which could rise substantially if projected economies of scale in waste recovery and disposal infrastructure, or optimal system performance, are not realized.

Since the estimates are prepared from a financial perspective, they do not include monetized impacts or benefits associated with the different scenarios. Therefore, nonfinancial outcomes, such as environmental externalities, social cobenefits, resilience gains, and long-term development impacts, are not reflected in the figures. Consequently, the comparison across scenarios focuses on direct financial implications rather than broader economic welfare.

The estimated costs also do not include upstream costs related to waste prevention, reuse, product design, manufacturing, the provision of more sustainable services, or consumption reduction. These additional costs not covered by public waste services are expected to be significant. Achieving substantial reductions in waste generation under the high-ambition scenario will require additional regulatory measures across the entire manufacturing and supply chain. These measures will influence how products and packaging are designed, produced, and placed on the market. Regulatory interventions may include product bans, restrictions on hazardous substances, and requirements to reduce materials of concern. Such changes will have direct cost implications for affected economic sectors and indirect impacts on their upstream suppliers. For example, if specific categories of products are phased out, suppliers of associated energy inputs, raw materials, semifinished goods, or services may lose access to key markets (Cordier et al. 2024). In parallel, advancing ecodesign—for instance, through products that are reusable, easy to repair, recyclable, or made with high recycled content—will require substantial investment and introduce new compliance costs for manufacturers and service providers. Although these upfront costs may be partly offset by gains in resource and energy efficiency at the enterprise level, they are likely to be significant.

Reduction in waste generation will also depend on significant efforts to influence consumer behavior. A combination of public awareness campaigns, product labeling, education in schools, social norm strategies, and behavioral nudges to promote reuse will be essential to encourage waste prevention, reuse, and proper sorting. Without corresponding shifts in household and business practices, the effectiveness of upstream regulatory and design interventions may remain limited.

The cost estimates associated with the three scenarios and presented in the following sections reveal that total global investment and operating costs are lowest under the high-ambition scenario, followed by the low-ambition scenario, and highest under business as usual. However, this global trend masks important differences across income groups.

In low-income countries, both investment and annual operating costs increase significantly under all scenarios due to low baseline conditions, including widespread uncollected waste and dumping. Although financial costs are substantial, economywide losses from unmanaged waste are significant. Effective waste management yields net economic gains through avoided health damages, environmental degradation, disaster risks, and lost productivity (see section 7.2.5).

In lower-middle-income countries, the high-ambition scenario results in only slightly higher financial costs than business as usual, reflecting reductions in waste generation and continued expansion of collection and treatment systems. Although investment and operating costs are modestly higher than under business as usual, the expected gains in service coverage and environmental outcomes would be substantial.

For high- and upper-middle-income countries, the high-ambition scenario offers an attractive pathway—municipal waste volumes decline sharply, total investment and annual costs fall, and unit costs per tonne rise only slightly. These countries already have well-developed infrastructure, so investments focus on optimization and greater efficiency. While upstream costs, such as those related to product redesign, material substitution, and consumption shifts, are not captured in these estimates, many high-income countries have already committed to ambitious waste prevention and diversion targets aligned with broader sustainability goals. For them, the high-ambition scenario aligns well with existing policy trajectories and environmental objectives.

7.2.1 Investment costs

Investment costs[5] have been calculated to include investments between 2022 and 2050 required to accomplish the three scenarios—business as usual, low ambition and high ambition.

Global investment costs: Figure 7.1 shows estimated total global investment costs over the period 2022–2050. The business-as-usual scenario has the highest investment cost of US$3.4 trillion, followed by the low-ambition scenario at US$3.2 trillion, and the high-ambition scenario at US$2.8 trillion. Despite its more ambitious environmental goals, the high-ambition scenario involves significantly lower waste generation, resulting in reduced long-term needs for collection, treatment, recovery, and disposal capacity.

Investment costs by country income group: Investment needs vary significantly between high- and upper-middle-income countries versus lower-income groups.

In both the low- and high-ambition scenarios, declining waste volumes in high- and upper-middle-income countries lead to lower investment costs compared with business as usual. Between 2022 and 2050, investment needs in high-income countries are estimated at US$1.3 trillion under business as usual, US$1.1 trillion in the low-ambition scenario, and US $0.9 trillion in the high-ambition scenario. For upper-middle-income countries, investment needs are projected at US$1.6 trillion under business as usual, US$1.4 trillion in the low-ambition scenario, and US$1.2 trillion in the high-ambition scenario.

By contrast, low-income countries face significant investment needs that increase with more ambitious scenarios. Under the business-as-usual scenario, cumulative investment costs through 2050 are estimated at US$50 billion, compared with US$55 billion in the low-ambition scenario and US$60 billion in the high-ambition scenario. These costs reflect improvements from a low baseline for both waste collection and waste treatment and disposal—such as waste collection coverage increases from 28 percent to 48 percent in business as usual and 100 percent in the high-ambition scenario, along with significant improvements in waste treatment and disposal.

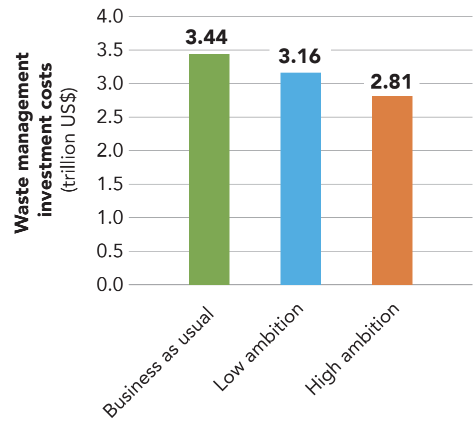
In lower-middle-income countries, investment costs follow a similar pattern and increase but with less dramatic differences between the business-as-usual and high-ambition scenarios, on account of a reduction in waste volumes and a relatively better baseline. Under the business-as-usual scenario, cumulative investment costs through 2050 are estimated at US$506 billion, compared with US$559 billion in the low-ambition scenario and US$577 billion in the high-ambition scenario.

Investment costs are also reflective of how waste is managed. Investment needs tend to be higher where the treatment mix includes costlier options such as incineration with energy recovery and mechanical biological treatment plants. By contrast, where landfilling remains a significant part of the treatment mix, investment costs per tonne are lower.

Investment costs by region: The distribution of investments for different waste management scenarios by region is presented in figure 7.2. Investment costs in East Asia, Europe and Central Asia, and North America are lower in the high-ambition scenario, reflecting reduced capacity needs driven by declining waste volumes. This is largely because these regions have large populations and high waste generation levels, and most residents live in upper-middle- and high-income countries where waste volumes decline under the high-ambition scenario.

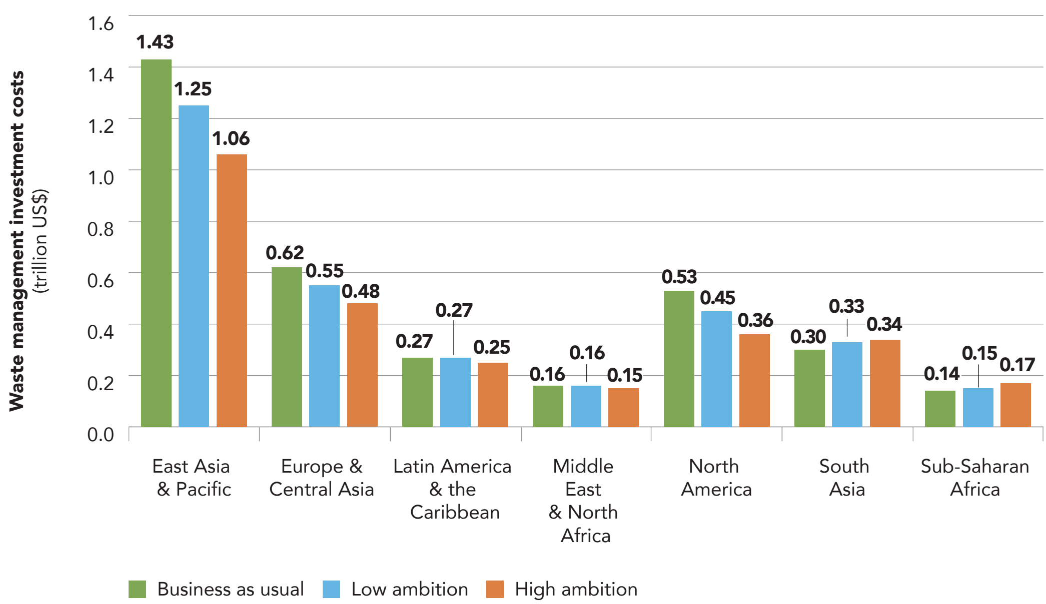
At the same time, investment requirements for South Asia and Sub-Saharan Africa—which host the majority of low- and lower-middle-income countries—range between US$0.4 and US$0.5 trillion in the business-as usual and high-ambition scenarios respectively, reflecting substantial needs to build collection, disposal, and treatment infrastructure.

Figure 7.1 Estimated global investment costs for waste management for 2022–2050 by scenario



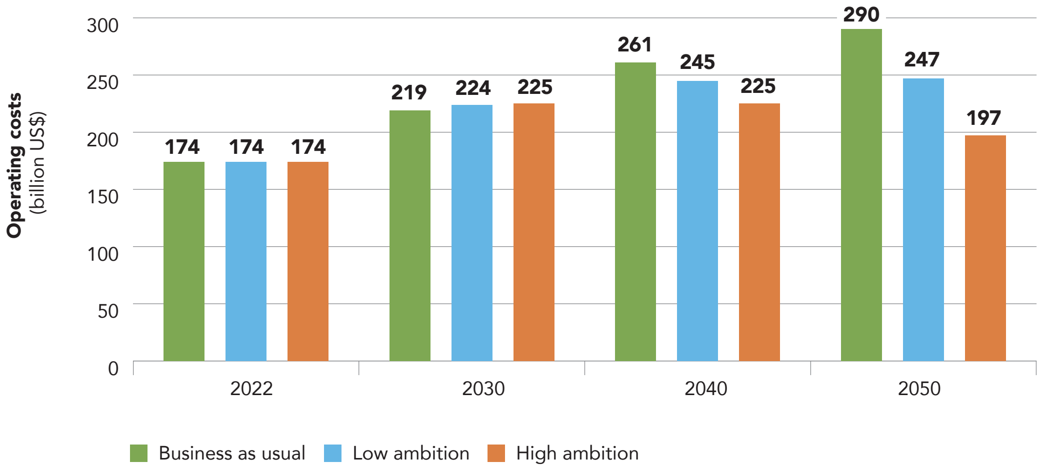
Source: Original figure for this report.

Figure 7.2 Estimated investment costs for waste management for 2022–2050 by region



Source: Original figure for this report.

Figure 7.3 Estimated operating costs for different scenarios in 2022, 2030, 2040, and 2050



Source: Original figure for this report.

7.2.2 Operating Costs

The annual operating costs[6] are calculated based on unit operating cost per tonne of waste[7] for each specific waste management operation, multiplied by the total quantity of waste designated to that operation in the respective year.

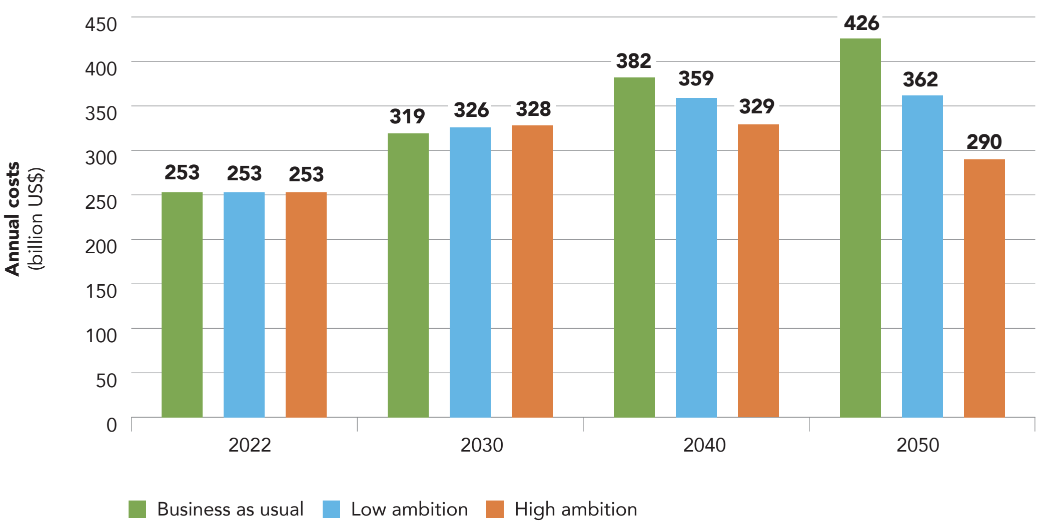
Global operating costs: Global average operating costs for waste management are estimated at US$174 billion in 2022 and projected to increase across all three scenarios until 2030 (figure 7.3). Between 2030 and 2040, operating costs continue to rise under the business-as-usual scenario and, to a lesser extent, under the low-ambition scenario, while remaining relatively stable under the high-ambition scenario. Operating costs from 2040 to 2050 increase for the business-as-usual scenario, remain stable for the low-ambition scenario, and decline for the high-ambition scenario. Differences in operating costs across scenarios reflect variations in waste generation and treatment mix: US$197 billion in the high-ambition scenario corresponds to 2.56 billion tonnes of waste in 2050, compared with US$290 billion for 3.85 billion tonnes in the business-as-usual scenario.

Operating costs by country income group: As with investment costs, operating costs vary by country income group. High-income, upper-middle-income, and to some extent lower-middle-income countries have lower total operating costs in the high-ambition scenario compared with the low-ambition and business-as-usual scenarios, due to reduced waste volumes. In low-income countries, per-tonne operating costs are projected to rise substantially, from about US$8 to roughly US$22 under business as usual and US$28 under the high-ambition scenario in 2050, reflecting service improvements from a very low baseline. By contrast, high-income countries experience more modest increases, from about US$120 to US$140 per tonne, as systems are already well developed and improvements are more incremental.

7.2.3 Annual costs

Global annual costs: Global annual costs include operating cost and depreciation in the respective year (figure 7.4). For the business-as-usual scenario, annual costs are projected to increase from approximately US$253 billion in 2022 to almost US$426 billion in 2050, representing a 68-percent rise. By contrast, the annual cost increase for the low-ambition scenario is significantly lower, reaching approximately US$326 billion in 2030—a 29-percent increase—followed by approximately US$359 billion in 2040 at 42 percent, and stabilizing at nearly US$362 billion in 2050. The high-ambition scenario has the highest annual costs in 2030, at about US$328 billion that stabilize at same level in 2040. However, following the initial increase, the annual costs decline after 2040 to approximately US$290 billion in 2050 owing to decrease in waste quantities generated. Figure 7.5 presents global annual costs in 2050 broken down by waste management operation, including waste collection, treatment, and disposal.

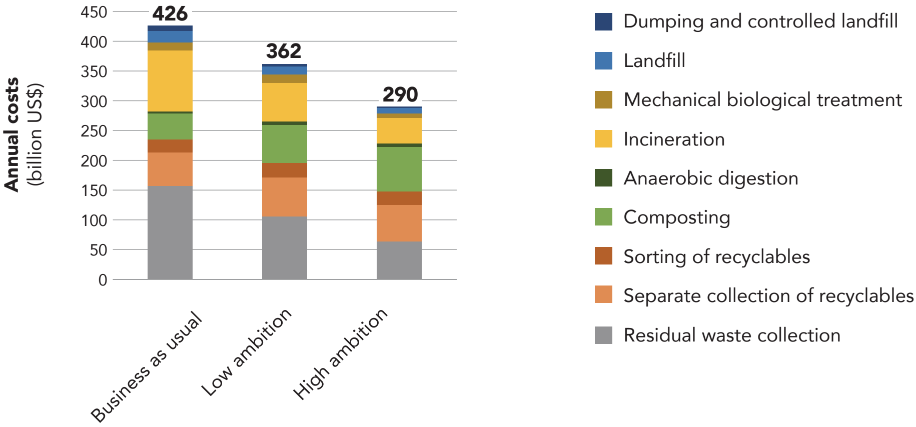
Figure 7.4 Estimated global annual costs for different scenarios in 2022, 2030, 2040, and 2050



Source: Original figure for this report.
Note: The share of operating costs is approximately 68% of total annual costs for all three scenarios in 2050 while depreciation accounts for the remaining 32%.

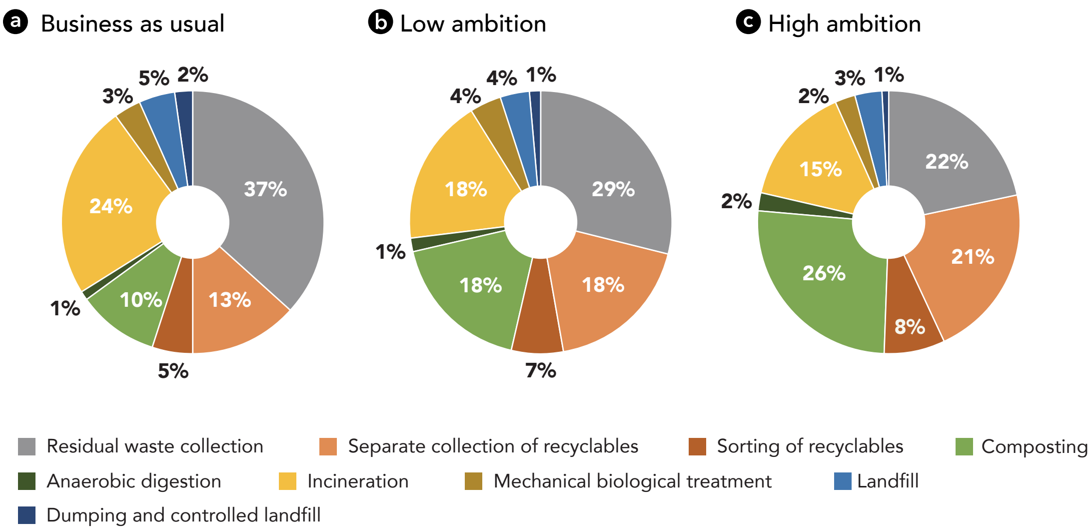
The distribution of annual costs across waste management operations differs significantly by scenario at the end of the planning period (figure 7.6). For example, residual waste collection accounts for 37 percent of annual costs in the business-as-usual scenario, 29 percent in the low-ambition scenario, and 22 percent in the high-ambition scenario. Similarly, incineration represents 24 percent of annual costs in business as usual, 18 percent in low ambition, and 15 percent in high ambition.

Figure 7.5 Estimated global annual costs per waste management operation in 2050 by scenario



Source: Original figure for this report.

Figure 7.6 Share of the various waste management operations in annual costs in 2050 by scenario



Source: Original figure for this report.

Annual costs per tonne of waste by country income group: Annual costs per tonne of waste generated at 2022 price level increase from the business-as-usual scenario to the low- and high-ambition scenarios across all income groups globally. However, the magnitude of the increase varies: in low-income countries, costs are more than twice as high in the low-ambition scenario and three times higher in the high-ambition scenario compared to business as usual; in lower-middle-income countries, the increase is approximately one and a half and two times, respectively. For upper-middle- and high-income countries, the cost per tonne remains relatively stable across scenarios (see table 7.6).

Table 7.6 Increase in annual costs per tonne of waste generated between 2022 and 2050 by scenario

Income group	Business as usual	Low ambition	High ambition
Low-income	234%	267%	305%
Lower-middle-income	157%	184%	219%
Upper-middle-income	126%	133%	137%
High-income	112%	116%	117%

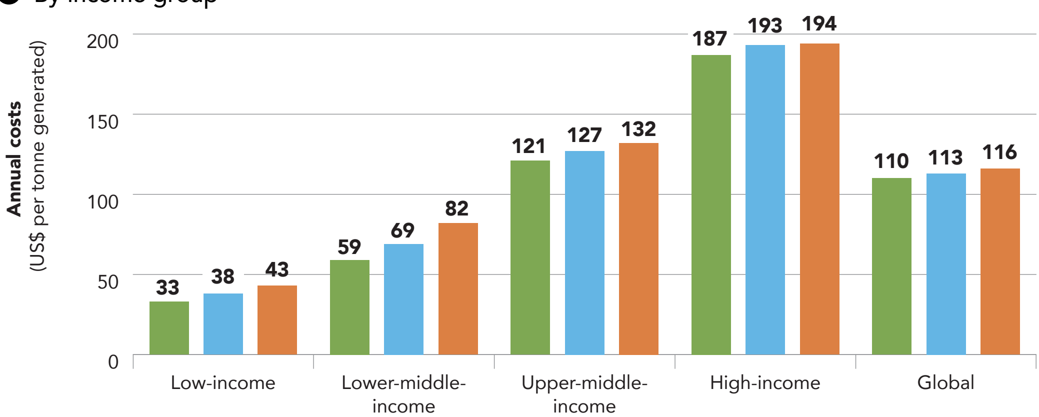
Source: Original table for this report.

In absolute terms, the annual costs per tonne of waste generated in 2050 differ significantly between the income groups (figure 7.7a). Under the high-ambition scenario, the cost per tonne remains below US$50 in low-income countries—compared with US$14 per tonne generated waste in 2022 or US$2.20 per capita —whereas in high-income countries it approaches US$200, compared with US$167 per tonne in 2022 or US$98.40 per capita. This is due to different waste management operations having different unit costs and share. In all three scenarios, low- and lower-middle-income countries have a lower share of composting and recycling, and a higher reliance on landfilling, which has a lower unit cost. By contrast, high- and upper-middle-income countries have higher rates of recycling and composting, along with greater use of incineration, which has a higher unit cost.

Annual costs per tonne and capita by region: Similarly, differences in costs per tonne are also observed between regions for all scenarios (figure 7.7b). The annual costs per tonne of waste generated in 2050 are highest in the North America region and lowest in the Sub-Saharan Africa region.

Figure 7.7 Estimated annual costs per tonne of waste generated in 2050 for each scenario

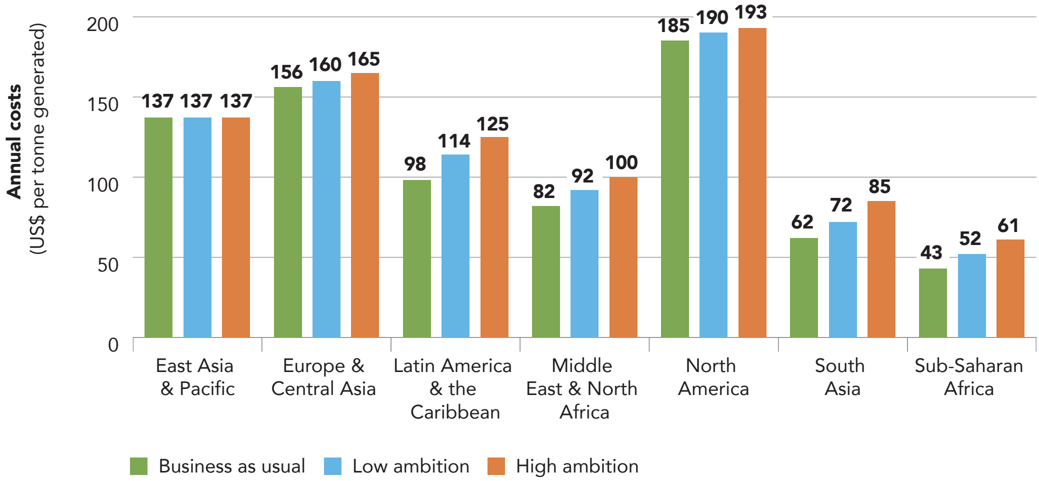
a By income group



Source: Original figure for this report.

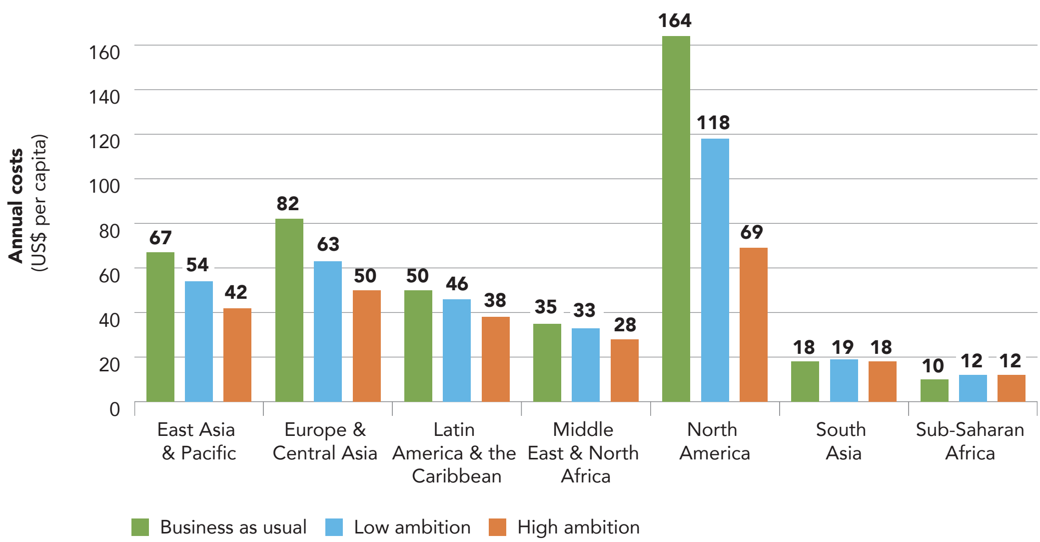
Figure 7.7 Estimated annual costs per tonne of waste generated in 2050 for each scenario *(contd.)*

b By region



Source: Original figure for this report.

Figure 7.8 Estimated annual costs per capita in 2050 by region and scenario



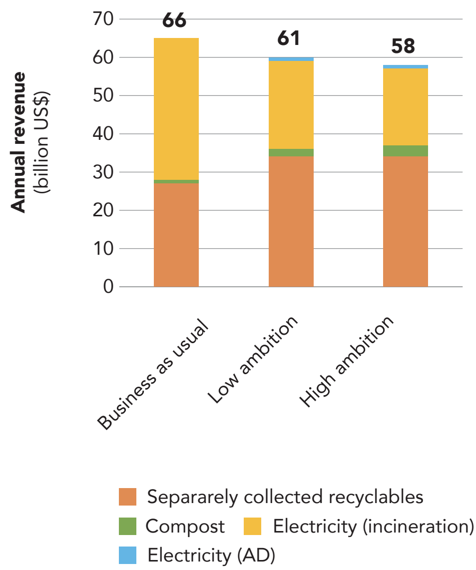
Source: Original figure for this report.

Significant differences in cost per capita are also observed across geographic regions (figure 7.8). These differences are explained by varying per capita waste generation across income groups, the distribution of populations by income level within regions, and differences in treatment mix. For example, North America, where the entire population lives in high-income countries and per capita waste generation is highest, is expected to have the highest per capita costs to meet the recycling and landfill diversion targets set in the scenarios.

7.2.4 Potential Revenues

A conservative estimate of potential revenues from the sales of separately collected and sorted recyclables,[8] compost and electricity produced from incineration[9] and anaerobic digestion are provided for the different scenarios (figure 7.9). It shall be noted that actual revenues could vary significantly over time between regions and depend on local conditions. The potential revenues from the sales of refuse-derived fuel (RDF)[10] are assumed to be absorbed by the transportation costs for delivery to final users and for that reason not taken into account and not shown in the figure.

Figure 7.9 Estimated annual revenue per waste management operation in 2050



Source: Original figure for this report.
Note: AD = anaerobic digestion.

The estimated revenues correspond to 15 percent of annual costs for the business-as-usual scenario, 17 percent for the low-ambition scenario, and 20 percent for the high-ambition scenario. It is also important to note that energy recovered from incineration constitutes a significantly higher share of the overall potential revenues under the business-as-usual scenario compared with the low- and high- ambition scenarios.

7.2.5 The Cost of Poor Waste Management

Social, environmental and economic impacts: This report finds that large volumes of global waste remain uncollected or are openly dumped. Waste discarded in the environment creates breeding grounds for disease, increasing the spread of illnesses such as dysentery, diarrhea, malaria, and dengue (Abubakar et al. 2022). Open dumping poses significant contamination risks, contributing to air pollution, odor pollution, flooding, and marine contamination through runoff. Open burning releases toxic pollutants, including dioxins, furans, and particulate matter, which can cause respiratory diseases and long-term health effects. If not properly managed, landfill disposal may also result in adverse environmental impacts and associated risks. Leachate formed during waste decomposition, which can seep into soil and groundwater, poses a risk to drinking water and agriculture (Dagwar and Dutta 2024).

Open burning of waste and anaerobic decomposition in open dumps are significant sources of GHG emissions, directly contributing to climate change. The waste sector is the third-largest anthropogenic source of methane globally, responsible for approximately 20 percent of total human-induced methane emissions (UNEP and

CCAC 2021). In addition, open burning generates black carbon, a short-lived climate pollutant with a global warming potential far exceeding that of carbon dioxide, exacerbating global climate impacts and contributing to local air pollution.

Floods are among the most damaging and recurrent urban hazards, with impacts that extend far beyond immediate physical destruction. Inadequate solid waste management is a key aggravating factor—as uncollected waste and debris block stormwater drains and waterways—reducing the capacity of urban drainage systems and leading to more frequent and severe inundation. The consequences include damage to infrastructure, disruption of transport and economic activity, and heightened risks to public health from waterborne diseases and pollution. Vulnerable communities—particularly those in informal settlements—are disproportionately affected, facing repeated displacement and loss of livelihoods. Intensifying rainfall patterns because of climate change and accelerating urbanization further exacerbate flood risk, compounding threats to community safety, economic stability, and long-term development.

Poor solid waste management has serious social and economic consequences, with low-income urban neighborhoods often bearing the brunt of these impacts. These communities typically receive the poorest services, resulting in more severe local effects. Informal waste collectors, who frequently serve these neighborhoods, remain among the most vulnerable, facing persistent health risks and social marginalization. Inadequate waste collection heightens risks to health, safety, and economic activity. Community dissatisfaction is common, as dumpsites located near residential areas often generate opposition and complaints, weakening social cohesion. Additionally, pollution of water resources and soil contamination undermine agriculture and fisheries, which are essential for food security and livelihoods.

Land used for waste disposal sites cannot be used for other essential needs such as housing, agriculture, or industrial development. Additionally, property values near these sites often decline, discouraging investment and limiting opportunities for economic growth. The limited development of recycling and reuse further restricts economic growth and reduces resource efficiency. When waste is not diverted through recycling, composting, or energy recovery, valuable resources are lost and potential economic benefits from recycled materials, waste-to-energy, and compost-derived fertilizers are missed.

Beach litter can lower tourism revenues and imperil jobs in a key growth sector for the global economy. Studies from the Republic of Korea, South Africa, and the United States show that beach litter can substantially cut the number of visitors and revenue from tourism, with reductions of 26 to 50 percent at severely polluted sites (Jang et al. 2014; Ballance et al. 2000; Ofiara and Brown 1999). Poor solid waste management in urban settings can also deter tourism development. Accordingly, the intention to develop tourism has spurred improvements in solid waste management in places such as Bali in Indonesia, the Maldives, and Montenegro.

Proper waste management brings significant economic benefits. It reduces the public health and environmental impacts of uncollected and poorly managed waste described above. In addition, it improves land value around former waste management sites, removes barriers to economic development in sectors such as tourism, fisheries, and agriculture, and reduces contributions to crossboundary concerns such as marine plastics and climate change. Although impact mechanisms are complex and diverse, and economic benefits therefore difficult to quantify, ample research confirms that the economic benefits of efficient waste sector improvements exceed their costs.

Cost considerations: In low-income countries, the cost of a basic waste management system that ensures waste collection and controlled disposal starts at approximately US$45 per tonne. At these cost levels, low-income countries would need about 0.78 percent of their combined 2022 GDP to achieve universal waste management coverage.

In middle-income countries, a basic municipal solid waste system—including regular collection, transport, basic treatment, and sanitary disposal—typically costs about US$70 to US$80 per tonne. Such expenditures are generally sufficient to achieve adequate and universal management of waste, with corresponding reductions in health and environmental risks. Managing all generated waste in 2022 at this level would amount to approximately 0.31 percent to 0.36 percent of the combined GDP of middle-income countries. More advanced systems that extend beyond basic service, with high level of recycling, resource recovery, and landfill diversion, would cost about US$120 per tonne or more for the combined overall waste management system. Managing all generated waste in 2022 at this level would amount to about 0.46 percent[11] of middle-income countries' combined GDP.

By comparison, reported public expenditure on solid waste management is less than 0.15 percent of GDP in about three-quarters of low- and middle-income countries and about 0.31 percent in high-income countries. While reported public spending in low- and middle-income countries falls well below estimated financing needs, actual outlays are likely higher, as budget data often exclude expenditures by private providers and state-owned enterprises outside formal public systems.

Many impacts are not systematically quantified and, therefore, estimating the total economic losses from inadequate waste management is challenging. Cost of environmental degradation (COED) studies estimate the economic burden of inadequate waste management at about 0.10 percent to 0.60 percent of GDP, and in some cases up to 1.5 percent, arising from health impacts, reduced land values around disposal sites, and the forgone value of unrecovered materials and energy.[12] These figures are conservative, as they omit negative impacts on development of economic sectors such as tourism, agriculture and fisheries, and other difficult-to-measure externalities as well as broader development benefits, such as climate mitigation, reduced marine pollution, and the gains from waste prevention.

A more comprehensive estimate of the average economic loss from uncollected waste places the cost at about US$375 per tonne for middle-income countries[13] in Southeast Asia (Engel, Stuchtey, and Vanthournout 2016). This broader estimate includes expenses associated with dumping, open burning, and the discharge of waste into land and waterways, as well as wider economic impacts on tourism, fisheries, healthcare, land values, and urban development. Applied across all middle-income countries and quantifying the economic impact of uncollected waste there, corresponds to approximately 0.43 percent of their combined GDP in 2022. For example, in Indonesia, where 37 percent of waste is uncollected and average generation is 0.54 kilogram per capita per day, the resulting losses from uncollected waste are estimated at about 0.6 percent of Indonesia's GDP in 2022. Additional impacts also arise from collected waste that is disposed of with limited environmental controls, which are not included in the economic costs that were assessed in this report for South-East Asia. Taken together, the economic costs are likely substantially higher than expenditures that typically would be required to ensure adequate management of all municipal waste.

As waste volumes continue to grow, the challenge is to meet both future demand and address existing shortfalls especially in low- and lower-middle-income countries where service coverage and infrastructure remain below adequate levels. Without accelerated investment, existing service gaps will widen, leaving countries further behind and locking in higher environmental, health, and economic costs. The urgency is therefore twofold: to expand systems fast enough to keep pace with rising waste volumes, and to raise performance well above prevailing baselines to avoid compounding the broader economic costs of inaction and damages from unmanaged waste.

Improving municipal solid waste systems is an environmental and public health priority and a sound economic strategy. Redirecting a modest share of GDP into well managed systems can offset larger losses, support job creation, improve urban livability, and advance climate and circular economy objectives. The principal challenges are institutional capacity, governance, and financing and mobilizing these at scale is essential to convert potential benefits into durable outcomes.

7.3 Waste Management Financing

Solid waste management is typically a locally managed service, with operations and financing falling under the responsibility of local governments. In low- and middle-income countries, waste management often competes with other essential services for limited public funding. As a result, financial allocations to the sector are frequently insufficient, affecting service quality and sustainability. Insufficient funding results in inadequate waste practices, open dumping, and burning which harm the environment, compromise public health, and erode trust in public services. Given the strong link between financial sustainability, environmental sustainability and urban well-being, efficient waste systems require clear and reliable funding mechanisms.

Cost recovery is important to reduce reliance on subsidies, national budgets and external funding. In practice, however, waste management is typically financed through a mix of user fees, general municipal revenues, and national transfers, particularly for capital expenditures. Investment finance draws from various sources, including municipal reserves, government grants, dedicated environmental funds, loans, international financial institutions, and private capital.[14] Direct investment by local authorities is usually limited to smaller-scale projects, such as purchasing waste collection containers and equipment or establishing civic amenity sites. Larger cities, typically in higher-income contexts, may have the capacity to fully fund major investments and waste treatment facilities, while smaller local authorities, especially in low- and middle-income countries, usually lack the financial resources for such projects.

In many countries, investment support for waste collection, treatment, and disposal is organized centrally, often at the national or regional level. Central budget allocations, either as direct transfers to local authorities or through designated investment programs, are common and may fully cover initial investment costs or require partial contributions from the beneficiary local authority. Some national programs focus on acquiring waste collection vehicles and containers, while others target large infrastructure projects or address the closure of noncompliant facilities and the remediation of environmental damage. In some cases, state financing is channeled through specialized central or regional funds established specifically for waste management investments.

7.3.1 Public Expenditure on Municipal Waste Management

The International Monetary Fund (IMF) reports on municipal waste expenditure as part of data on environmental protection expenditure.[15] Municipal waste expenditure has been defined as the costs of running solid waste management systems, including waste collection, treatment, and disposal services, as well as the administration, supervision, inspection, operation, construction, and maintenance costs of these systems (IMF 2001). The data provide insight into national government spending on waste and show significant variation in government allocations by income level. It should be noted, however, that actual spending is most likely higher than reported here since they do not capture spending outside formal government budgets, such as user fees paid directly to service providers.

Higher-income countries report higher public government expenditure per capita on waste services and, on average, allocate a larger share of GDP to waste management compared with lower-income countries (table 7.7). Funding typically comes from a mix of local government revenues, intergovernmental transfers, and external support through grants, loans, or subsidies for the construction, operation, maintenance, and upgrading of waste systems (IMF 2001).

Table 7.7 Mean expenditure per income group

Income group	Mean Expenditure (% of GDP)
Low-income	0.02
Lower-middle-income	0.04
Upper-middle-income	0.15
High-income	0.31

Source: Original table for this report based on data from IMF 2021.
Note: Mean expenditures across 83 countries included in the IMF database, span different income groups: 42 high-income countries, 25 upper-middle-income, 12 lower-middle-income, and 4 low-income countries. The primary reference year was 2021; where 2021 data were unavailable, the most recent available year between 2013 and 2020 was used.
Interpretation of data on the percentage of expenditure on waste management should take into account country-specific conditions. For example, countries with similar waste management costs may show different shares of expenditure allocated to waste management, depending on whether they use a municipal waste management tax or whether charges are paid directly by households to service providers and not recorded as revenues in local authority budgets. In such cases, countries with similar waste management costs may display different profiles for the proportion of public expenditure allocated to waste management.

By comparison, government spending on water supply in high-income, upper-middle-income, and lower-middle-income countries respectively, accounts for 0.17 percent, 0.23 percent, and 0.14 percent of GDP; and spending on wastewater accounts for 0.15 percent, 0.02 percent, and 0.01 percent of GDP, respectively. For all countries combined, government expenditure is reported at 0.18 percent of GDP for water supply and 0.09 percent for sanitation.[16,17]

Government expenditures vary significantly on waste management among countries within the same geographical region and income group. For example, in 2023 in the EU, total expenditure of general government on environmental protection amounted to 0.8 percent of GDP. Of this, the expenditure on waste management has the greatest share and amounted to 0.4 percent of GDP (Eurostat 2025). By comparison, both water supply and wastewater management accounted for 0.1 percent of GDP in 2023 for all the EU countries combined.[18] The highest ratios to GDP for waste management were reported by Greece at 0.9 percent of GDP, followed by the Bulgaria, Malta, Netherlands, all at 0.6 percent of GDP. The lowest expenditures are reported by Denmark and Ireland at below 0.1 percent of GDP and Austria, Slovenia, and Sweden at 0.1 percent of GDP (Eurostat 2025).

On average, solid waste management accounts for 6 percent of municipal budgets (table 7.8). Cities in low-income countries tend to spend a higher-than-average share, while those in high-income countries allocate approximately 4 percent. However, exceptions exist; some high-income cities spend over 10 percent, and some low-income cities allocate more than a quarter of their budgets for solid waste management.

Table 7.8 Solid waste management expenditures as percentage of municipal budgets

Income group	Number of cities in database	Number of cities with municipal budget and solid waste management budget data information	Number of cities selected for analysis (capital city or largest city from the country available in database)	Solid waste management as a percentage of municipal budget (where available)
Middle-income	161	32	19	6%
High-income	77	18	13	4%

Source: Original table for this report.
Note: City dataset. Few low-income countries reported municipal budget and solid waste management information.

Despite the substantial share of solid waste management expenditures in municipal budgets, low- and middle-income countries often face budget shortfalls for waste services, making cost reduction and fee recovery critical elements of sector development. In many cases, what low- and lower-middle-income countries, and even some upper-middle-income countries, spend on waste management yields limited results, as expenditures are not proportional to the actual costs required for effective service delivery.

7.3.2 Cost Recovery

Charging for municipal waste management services is a well-established practice in high-income countries, where the implementation of the polluter-pays principle[19] and the achievement of full cost recovery are key policy objectives. In low- and middle-income countries user fees as well as revenues from the sale of energy and materials usually only partially cover solid waste management costs owing to a combination of low user repayment capacity, political challenges in raising fees and taxes, lack of effective revenue collection mechanisms, poor enforcement, and other factors.

Table 7.9 presents average user fees charged to households across income levels and region. The household fees vary greatly with user fees in North America region found to be the highest and those in Sub-Saharan Africa the lowest (box 7.1). Fees also vary greatly by income level, with residents in high-income countries paying substantial fees for services.

In most high-income countries, waste management costs are well below the 1-percent threshold for the share of household income at which full cost recovery tariffs are considered affordable.[20] The affordability criteria have far greater relevance and influence on policy decisions in low- and middle-income countries where the full cost recovery objective can be difficult to achieve. In such countries, tariffs equivalent to 1 percent of household income might only partially cover the costs of collection and safe disposal of waste, whereas the future extension of services or the implementation of more advanced and costly treatment methods would make services unaffordable.

Table 7.9 Waste management user fees by income group and region

	Number of cities in database	Number of cities with data	Average user fee for households (US$/year)[a]
Income group			
Low-income	24	5	10–50 (World Bank estimates)
Lower-middle-income	80	27	56
Upper-middle-income	81	30	52
High-income	77	22	261
Region			
East Asia & Pacific	38	14	68
Europe & Central Asia	90	29	147
Latin America & the Caribbean	42	20	48
Middle East & North Africa	26	4	82 (20–50 for middle-income countries; 90–110 for high-income countries)
North America	6	3	552
South Asia	14	5	44
Sub-Saharan Africa	46	9	50 (10–64 for lower-income and lower-middle-income countries; 70–200 for upper-middle-income countries)

Source: Original table for this report based on city dataset and the World Bank Group Solid Waste Management Community of Practice.
Note:
a. All currency amounts are adjusted to constant 2022 US Dollars.

Common mechanisms for billing and fee collection from households for solid waste management include: (1) joint billing with property taxes or other utilities—typically water or electricity—in 40 percent of 77 cases; and (2) direct billing and collection by the municipality, in 30 percent of cases. Joint billing is more commonly used in middle- and high-income countries.

Legal entities are usually charged differently than households. In high-income countries, legal entities are commonly charged based on the volume or quantity of waste produced. In middle-income and low-income countries, however, businesses and institutions typically pay a flat fee based on the type of activity, as this approach is simpler to administer and collect. Low-income countries are less likely to consistently charge fees for waste services, and data availability on such practices is limited.

Box 7.1 Solid Waste Management Fees in Low-income and Lower-middle-income Countries: Discussion

In many low-income countries and lower-middle-income countries, solid waste management systems are characterized by a combination of primary and secondary collection. Primary collection typically involves small-scale operators, such as community-based organizations, small and medium-sized enterprises, or individuals who transport waste from households to communal collection points. By contrast, secondary collection—which includes transportation to treatment and disposal sites—is usually managed by municipal authorities, directly or via contracted operators, using larger vehicles and equipment.

Residents in low-income countries and lower-middle-income countries often pay primary collectors directly, and these funds are retained by them in full. In most cases, these payments range from US$1 to US$5 per household per month, translating to approximately US$12 to US$60 per household per year.

Given that an average household in low-income countries and lower-middle-income countries generates about 1 to 1.2 tonnes of municipal solid waste annually, implies that the fee collected by primary collectors ranges from approximately US$10 to US$60 per tonne.

The cost of a simple waste management system in low-income countries and lower-middle-income countries—short of significant distances—including collection, transport, and proper disposal at a sanitary landfill, is estimated at roughly US$50 to US$60 per tonne. This means that the fee households pay to primary collectors would cover between 20 percent and 100 percent of the full cost of a basic solid waste management system, including collection, transport, and disposal at a sanitary landfill. Taking a midpoint, it could realistically be assumed that the fee collected by primary collectors would hover around covering half of the solid waste management cost.

This is a significant point, as policy makers often assume that constituencies are unwilling or unable to pay the cost of solid waste management. People are already making significant payments; however, the proceeds are often applied solely toward the primary segment of the solid waste management system. In many cases, particularly in large urban centers and capital cities with higher affordability thresholds, these fees could nearly cover the cost of both primary and secondary collection through disposal.

Shifting from a franchise waste collection model to a contract model

A key reform in addressing the funding gap in solid waste management is shifting from a franchise model to a contract model. In a franchise model, private operators—such as community-based organizations or small and medium-sized enterprises—collect waste and directly charge households for their services. In practice, collectors often select or cherry-pick their customers among those willing and able to pay the service fee, leaving segments of the population unserved or underserved. This model often leads to fragmented service delivery and inefficiencies, and the revenues collected remain within the primary collection segment of the sector, leaving secondary collection underfunded.

By contrast, under a contract model, the local authority is typically responsible for billing residents and collecting fees centrally. The authority then contracts community-based organizations or small and medium-sized enterprises to provide primary collection services. The contract model ensures a more integrated and financially sustainable solid waste management system and the risk of non-payment remains with the public sector.

A successful example of this transition can be seen in Maputo, Mozambique, where the city discontinued the franchise model and now contracts 56 community-based organizations for primary collection. The city collects solid waste management fees, linking them to electricity bills, which enhances cost recovery and allows better financial allocation across the full waste management chain.

By adopting a contract-based system, municipalities can ensure that collected fees support the entire solid waste management process rather than just primary collection, leading to more effective waste management and improved environmental and public health outcomes.

Source: World Bank Group Solid Waste Management Community of Practice.

7.3.3 Other Common Sources of Revenue

Local authorities can leverage private sector resources and expertise to expand and improve solid waste management, especially where public financing is constrained or private skills, technologies, and economies of scale add value. Private firms frequently act as technology suppliers and operators of advanced treatment and recovery facilities, bringing operational know-how and capital that complement the public sector's roles in planning, regulation, and core service provision. Private participation is essential to complement public and other financing, given the scale of investment needed through 2050. Private participation however will materialize where returns are realistic and achievable. That, in turn, depends on bankable conditions anchored in sound tariff and charging policies, efficient fee collection, and reliable, predictable revenue streams from waste fees, alongside clear frameworks that reduce risk and support sustained private engagement (see box 7.3).

The sector has benefitted from long-term loans and grants provided by international financial institutions (box 7.2). External research estimates that from 2003 to 2021 about US$14.5 billion in official development finance was committed to solid waste management, including about US$1.8 billion in 2021. The share of total official development finance rose from 0.19 percent in 2003 to 0.41 percent in 2021 but remains below 0.5 percent and about ten times lower than water and sanitation, which was about 3.8 percent in 2003 and 3.6 percent in 2019. Over the eighteen-year period, most funding went to upper-middle-income countries at US$6.48 billion and lower-middle-income countries at US$5.90 billion; low-income countries received about US$1.05 billion. Sub-Saharan Africa accounted for about ten percent of the official development finance. The World Bank Group was the largest financier, followed by the Asian Development Bank, European Union institutions, and bilateral donors, especially Germany and Japan (Lerpiniere, Wilson, and Velis 2025).

Box 7.2 How the World Bank is Tackling the Growing Global Waste Crisis

The World Bank Group has been the world's largest financier of solid waste management (figure B7.2.1). It supports practical improvements in cities and countries by combining infrastructure financing with policy reform loans and results-based financing. From 2003 to 2021, the World Bank Group provided approximately US$5.1 billion in official development financing for solid waste management, accounting for about 35 percent of global official development financing in this sector (Lerpiniere, Wilson, and Velis 2025). Projects focus on expanding waste collection, reducing open dumping, managing landfill gas, and increasing diversion of organic and recyclable waste, along with waste minimization, separation, improved treatment, and stronger governance with reliable systems. The World Bank Group works with local and national governments to strengthen institutional and technical capacity, and to improve the financial and environmental sustainability of the sector, including cost recovery, tariff design, and performance monitoring. Social inclusion and enhanced citizen participation are integral elements of support. Private capital mobilization is pursued through transaction advisory, risk-mitigation instruments, and blended finance, supporting private sector participation across the value chain, including collection, recycling, treatment, and energy recovery, through public-private partnerships and direct private investment.

The World Bank Group also conducts extensive research to guide policy and investments such as this report in the *What a Waste* series.

Figure B7.2.1 Top ten sources of solid waste management official development finance between 2003–2021

Source: Lerpiniere, Wilson, and Velis 2025.

References

Lerpiniere, David J., David C. Wilson, and Costas A. Velis. 2025, "Official development finance in solid waste management reveals insufficient resources for tackling plastic pollution: A global analysis of two decades of data." *Resources, Conservation and Recycling*, Vol 212, 107918.

Economic instruments applied at the national level—such as product taxes on certain categories of single-use plastics and packaging, landfill taxes, deposits on beverage containers, and the increasing role of climate finance—can generate additional financial resources to support policy reforms in the waste management sector.

These instruments not only create revenue streams but also serve as incentives to reduce waste generation and encourage more sustainable practices. For instance, product taxes on single-use plastics can motivate manufacturers and consumers to shift toward reusable or more sustainable alternatives, while landfill taxes can encourage waste diversion and recycling. Deposit schemes for beverage containers can increase collection rates and improve material recovery. Integrating these economic instruments into waste management policies can help countries develop more sustainable financing models, reduce dependency on traditional funding sources, and advance toward circular economy goals.

Extended producer responsibility schemes for packaging and packaging waste, used batteries, waste electrical and electronic equipment and some other specific product categories and waste streams could be a significant source of finance and cover in full or considerable part of separate collection, sorting and treatment costs for these waste fractions. The extended producer responsibility for single use plastics could also support public litter cleaning campaigns. In this way, the costs for management of the specific waste streams are shifted from local authorities to producers, importers, and consumers of the respective products and packaging on the national markets. Extended producer responsibility is a well-established practice in high-income and some middle-income countries.

Plastic credits are an emerging results-based financing tool that connect public and private sector funding with targeted efforts—and often community-based initiatives—to combat plastic pollution. When applied responsibly, plastic crediting can enable organizations financially to support pollution reduction initiatives with quantified and verified results (World Bank 2024a). In addition to providing an alternative financing mechanism for plastic pollution reduction initiatives, plastic credits can also provide additional benefits, such as incentivize sustainable consumption patterns—like the reduction in single-use plastics—enhance accountability and transparency of plastic reduction initiatives, expenditures and claims, and empower marginalized groups through the sharing of benefits derived from improved social, economic, and environmental conditions required by certified plastic projects.

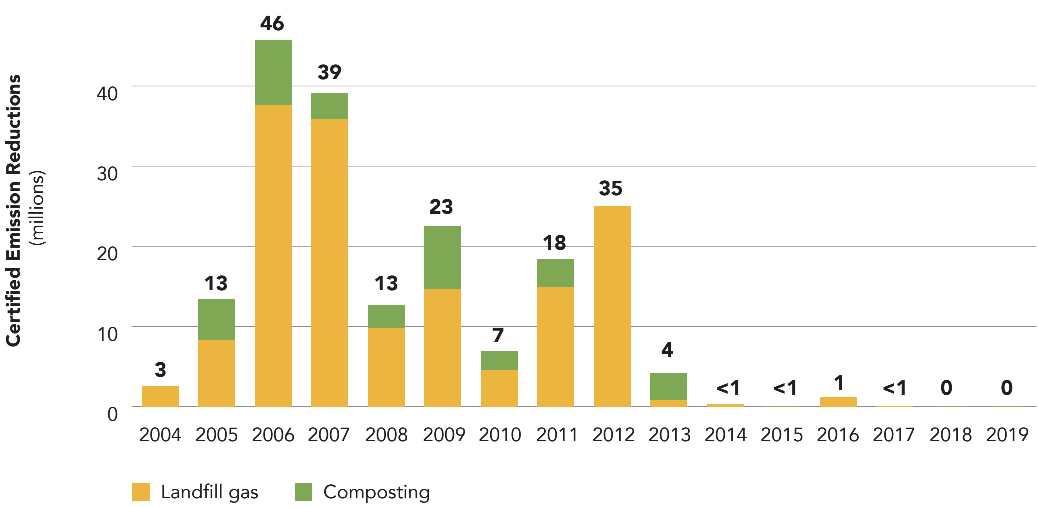
Plastic credits can be integrated into extended producer responsibility schemes to bolster compliance and mobilize additional resources. In markets where extended producer responsibility is in early stages, plastic crediting frameworks can serve as interim solutions during the transition to a fully regulated market, preparing organizations for compliance. Plastic credits can also be integrated with other financial mechanisms to support investments into plastic pollution reduction projects that are considered too risky for traditional finance. For example, the World Bank launched the plastic waste reduction-linked bond in 2024 enabling investors to fund plastic waste reduction initiatives and receive returns through the issuance of plastic credits, with verified carbon units under the Verra standards (World Bank 2024b). Bond investors may receive an extra payment at maturity if credit sales exceed expectations. The bond mobilizes financing for projects in Ghana[21] and Indonesia,[22] enabling them to fund recycling efforts, scale waste collection and management, and create job opportunities for marginalized groups.

While plastic crediting presents a valuable and innovative financial mechanism to support plastic pollution reduction efforts, it should be viewed as part of a broader environmental strategy. The plastic crediting market is still very new and rapidly developing, and challenges still need to be overcome in certain applications (World Bank 2024c). Policy makers can help enable the right environment for plastic crediting to thrive by developing targeted policies and regulations and ensuring transparency in the systems. Engaging private sector stakeholders and evaluating plastic credits as a compliance tool will be critical to scaling effectively.

7.3.4 Waste Management Financing through Carbon Markets

Climate finance mechanisms, such as carbon credits generated through methane capture or waste-to-energy projects, offer a dual benefit by mobilizing investment while mitigating environmental impacts. The waste sector has successfully engaged in carbon markets,[23] particularly through the Clean Development Mechanism. As of February 2025, a total of 1,011 waste-related Clean Development Mechanism activities were registered. China leads with 161 projects, followed by Brazil with 135, Mexico with 132, Malaysia with 118, and Indonesia with 84.[24] Since the inception of the Clean Development Mechanism, waste projects have generated over 202 million carbon credits. Figure 7.10 illustrates the volume of Clean Development Mechanism issuances for the waste sector since 2004.

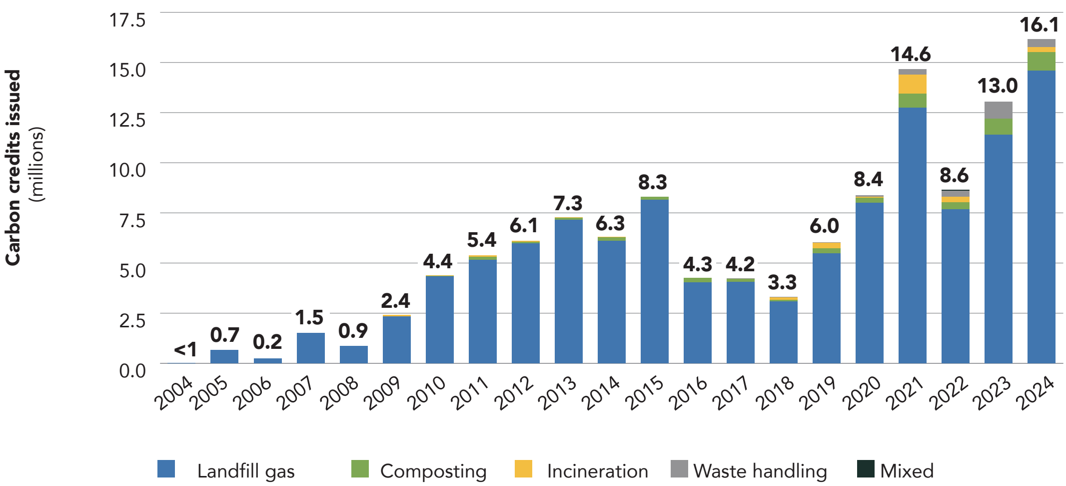
Figure 7.10 Certified emission reductions issued for waste sector projects under the Clean Development Mechanism



Source: Original table for this report.
Note: Based on UNFCCC's Clean Development Mechanism registry for project activities.

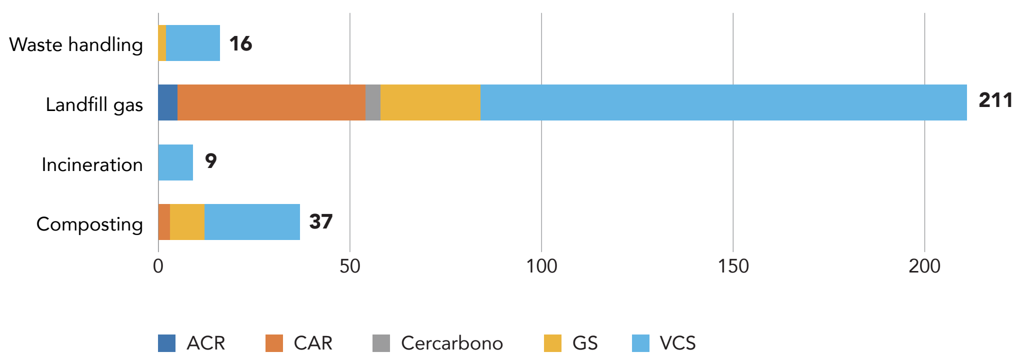
The development of carbon projects in the voluntary carbon market has grown substantially, with credit generation peaking in 2023 (figure 7.11).[25] The majority of credits originate from landfill gas flaring projects, which remain the most widely implemented waste sector technology in the voluntary carbon market. Between 2006 and 2024, 500 waste-related projects were registered under various carbon standards.[26] Other notable project types include waste incineration, composting, and broader waste management activities such as recycling. (figure 7.12).[27]

Figure 7.11 Number of carbon credits issued in the voluntary carbon markets since 2004



Source: Climate Focus. Voluntary carbon markets dashboard.

Figure 7.12 Number of projects registered in the voluntary carbon markets between 2006 and 2024



Source: Climate Focus. Voluntary carbon markets (VCM) Dashboard.
Note: Cercarbono is a voluntary carbon certification program and registry based in Latin America that issues carbon credits for climate mitigation projects, particularly in forestry and land-use sectors. ACR = American Carbon Registry, CAR = Climate Action Reserve, GS = Gold Standard, VCS = Verified Carbon Standard.

The waste sector has also been involved in building the technical readiness and piloting activities under Article 6 of the Paris Agreement. While the rules of Article 6 were still under negotiation, several countries initiated pilot projects to test practical approaches to implementing Article 6 carbon markets and to share lessons learned to inform the negotiation process (Climate Finance Innovators 2019). These pilots explored how Article 6 mechanisms could support project implementation across sectors, including waste. One such example is the Canada–Chile Reciclo Orgánicos program, which aims to build the host country's technical readiness to use Article 6 to support waste sector mitigation effort.[28]

Box 7.3 The Role of the Private Sector in Sustainable Waste Management

The private sector is playing an increasingly important role in waste management by contributing investment, operational capacity, technical expertise, and innovation. Although regional variations exist, a common sector trend is the increasing complexity and value-add of waste management services, with the transition from the traditional take–make–waste model to an emphasis on waste treatment, resource recovery, and circularity. This shift has elevated the strategic importance of private participation for achieving broader socioeconomic, environmental, and climate objectives, including job creation, technology transfer, and improved public health outcomes. Accordingly, in higher-income economies with stronger environmental regulation and greater ability to pay for more advanced waste management services, significant reliance rests on the private sector to finance, own, and operate critical waste infrastructure. Lower-income countries are also increasingly pursuing private sector solutions and financing. However, the actual level of private sector participation often falls short of policy ambitions, largely due to underdeveloped or fragmented regulatory frameworks, limited financial incentives and risk-mitigation mechanisms, and capacity constraints within public institutions.

The level and nature of private participation in waste management vary significantly across geographies and income levels. Advanced economies generally exhibit higher private sector involvement, while low-income countries have the lowest (table B7.3.1). This reflects differences in regulatory strength, the commitment of national and local government commitment to service modernization, and financial resources required for commercial viability.

Overview of private sector participation in waste management

Table B7.3.1 Characteristics of regional waste management participation

Geographic area and income-level	Level of participation	Key features
Europe, high-income	High	Strict regulation, EPR schemes, competitive tendering
North America, high-income	Very high	Privatized services, market-driven models
East Asia, high-income	Varied	Advanced markets
Latin America, middle-income	Moderate	Growing PPPs, informal sector integration
South Asia, middle-income	Emerging	Emerging PPPs
Africa, low-income	Low to moderate	Donor-supported, growing private initiatives

Source: World Bank Group Solid Waste Management Community of Practice.
Note: EPR = extended producer responsibility, PPP = public–private partnership.

According to this report, roughly half of municipal waste services in cities are publicly operated. The remainder is split between private and mixed public–private management, except in treatment and disposal where private operators account for about 36% of services. Beyond municipal operations, private firms play a pivotal role in managing industrial and hazardous waste, investing in collection, treatment, and disposal infrastructure, and providing the technology and expertise required for high-risk streams. They also drive innovation through advanced treatment systems, digital tracking, and circular economy models, while supporting compliance, liability management, and producer responsibility obligations in sectors such as chemicals, mining, healthcare, and manufacturing.

Globally, concession-based arrangements are the primary vehicle for private sector participation in the development, operation, and financing of waste services. Other models, such as direct service contracts with municipalities, businesses, or households, are also common. In practice, governments deploy a mix of approaches tailored to market maturity, regulatory capacity, and risk allocation, ranging from performance-based operations and maintenance contracts to design–build–operate–transfer (DBOT) schemes. Well-structured concessions can mobilize capital, improve service reliability, and transfer performance risk, while strong contractual oversight and transparent tariff setting are essential to ensure affordability and long-term sustainability.

While local governments have been the primary source of financing for solid waste collection, national and private sector funding plays a more significant role in treatment and disposal infrastructure, which typically require higher capital expenditure. Major private waste management companies in mature markets have a strong track record of accessing debt and equity capital markets, as well as institutional and commercial bank financing, to meet investment needs. Effective regulatory frameworks, creditworthy offtake arrangements, and predictable revenue streams, such as tariffs, gate fees, and extended producer responsibility funds, are essential to reduce financing costs and attract private capital.

When considering enabling factors, solid waste management laws and regulations provide the legal foundation for organizing, delivering, and enforcing waste-related activities, including those undertaken by the private sector. A range of regulatory instruments embedded in national, subnational, or sector-specific frameworks has been important in enabling private sector participation. Chief among these are public–private partnership (PPP) frameworks, which define risk-sharing and investment models between public authorities and private entities, as well as privatization and tendering laws, which promote transparent, competitive contracting of waste services. A conducive, stable policy and regulatory environment is essential for project viability.

Government policies and regulations that address cost recovery and financing needed to operate and maintain waste management services are central to encouraging private sector participation. Such mechanisms ensure that user fees and municipal budget allocations—supplemented by regional and central government support as needed—adequately cover capital expenditures and operations and maintenance (O&M) costs. Without these mechanisms, it is difficult to attract the private sector or secure the technical and human resource investments needed to deliver satisfactory services. This is a key reason for limited participation of the private sector in lower-income countries.

As noted in this report, high-income countries spend considerably more on waste management in absolute terms. In this context, opportunities for private waste management companies to realize additional revenues from the sale of energy, recyclables, and carbon credits generated from their waste treatment activities can provide important revenue streams. Schemes like extended producer responsibility, which hold manufacturers financially or administratively responsible for the treatment or disposal of post-consumer products, are gradually gaining traction in a number of middle-income countries, such as Brazil, India, and South Africa, and can provide additional avenues to increase financial flows into the waste sector, helping to improve the commercial viability of projects and services.

Key roles for the private sector in waste management

Private waste management companies range from those with billions of dollars in revenues and a global footprint across the waste value chain to small local recyclers. The depth of expertise, implementation capacity, and financial resources at their disposal therefore vary significantly. Accordingly, when turning to the private sector for waste management, across municipal, industrial, and other waste streams, careful attention must be given to the selection of companies with relevant capabilities and to structuring contracts that align incentives. When well designed, private waste companies can be strong partners in advancing sustainable waste management.

Delivering operational expertise: Private waste companies can bring knowledge and operational experience from their operations across multiple markets, and specialization in specific segments of the waste value chain. They can deploy trained personnel, implement efficient logistics, and apply solid solutions in areas such as recycling operations, anaerobic digestion, waste to energy, landfill management, and hazardous waste handling, improving operational standards, and service quality. Local capacity and market structure influence implementation approaches. For example, in Mozambique, private companies successfully provided collection services but had to import waste vehicles and spare parts owing to the absence of a local supply chain, which increased operating expenses. In Brazil, municipalities in São Paulo state leveraged local engineering capacity to develop modern sanitary landfills.

Enhancing economies of scale: Private companies usually manage fleets, facilities, and operations at a scale beyond the reach of many municipalities and industrial clients, reducing per unit costs and increasing service coverage. Through aggregation, private operators can invest in advanced infrastructure like mechanical biological treatment (MBT) facilities and waste to energy plants that require substantial throughput to be commercially viable. Within the European Union (EU), for example, as of 2022 nearly 50,000 enterprises were active in the waste collection, treatment, and disposal segments, employing about 1.1 million people and generating approximately €220 billion in turnover (Eurostat 2025). Their activities comprised operating thousands of sorting and recycling centers and hundreds of waste-to-energy plants, including large installations able to process over 500,000 tonnes of waste per year (CEWEP n.d.).

Mobilizing financing: With limited fiscal space and the significant capital expenditure needed for countries to modernize and expand waste management infrastructure, private capital will play a key role in addressing the waste infrastructure gap. Private waste companies can mobilize debt and equity capital through direct investment, joint ventures, or public–private partnerships, and municipalities can also tap into the private capital market for commercial financing of waste management. For example, waste management expenditure by private companies in France surpassed €9 billion in 2022, a growth of 14% in comparison to the previous year and the highest figure reported in over twenty years (Statista 2025). On the municipal financing side, in 2023 in Croatia, Zagreb Holding issued a €305 million sustainability-linked bond (SLB) on the Zagreb Stock Exchange, designed to fund investments in waste management and renewable energy. The bond, guaranteed by the City of Zagreb, was the first SLB by a municipal utility in central and southern Europe and received significant backing from the International Finance Corporation (IFC) and the European Bank for Reconstruction and Development (EBRD), each providing a €72.5 million subscription (World Bank Group and UN CDF 2024).

Advancing technology adoption: As seen in many countries, particularly high income ones, substantial potential exists to harness technology to make waste management more efficient and deliver higher quality services to end users. Examples include smart waste collection systems using internet of things (IoT) sensors, robotic sorting in recycling plants, and advanced waste valorization technologies. Waste valorization, whether in the form of material recovery and recycling or energy recovery and utilization, is capital intensive and increasingly a core component of an integrated waste management approach that emphasizes value creation from waste. Private waste companies are often early adopters, especially where operational and financial benefits are clear, and, when present in multiple markets, they can transfer lessons across contexts. Specialized firms focus on distinct segments—e-waste and metals recycling, waste-to-energy, anaerobic digestion—complementing full service operators.

Interest is growing in waste to energy technologies, particularly in large metropolitan areas that generate significant volumes of waste and view waste to energy as an effective solution for managing these substantial quantities. Energy recovery encompasses a range of advanced, proven technologies, including anaerobic digestion, production of refuse derived fuel (RDF), incineration, and landfill gas to energy. When tailored to local contexts, these technologies offer countries and municipalities a suite of viable options for developing long term waste management solutions.

Given the considerable capital investment required for energy recovery infrastructure and the operational expertise needed to run these facilities successfully, private sector participation is typically essential, especially for capital intensive waste to energy and anaerobic digestion plants. It is important to note that energy recovery infrastructure should be complementary to initiatives higher up the Waste Hierarchy, such as waste reduction, source separation, material sorting, and recycling or composting. Energy recovery supports the progressive implementation of these upstream initiatives by providing a means to recover value from residual waste.

An example is the evolution of waste management in England, where over the past thirty years a balanced focus on recycling and energy recovery has cut landfill disposal to just 5.5% of household waste in 2023, with recycling at 41.4% and energy recovery at 49.9%[a] (UK DEFRA 2025). The government aims to increase recycling to 65% by 2035. In middle-income contexts, São Paulo illustrates a similar shift; in 2024, the city signed two long-term concession contracts with private partners, each covering about half of municipal waste, to expand recycling services, build material recovery facilities, introduce anaerobic digestion, produce RDF, and incinerate residuals. If fully implemented, this strategy could substantially transform waste management in the city (SP Regula 2025).

Enabling factors to attract private sector in waste management

Several conditions are particularly important for accelerating private sector contributions to improved waste management services and outcomes in lower-income countries. These include:

Stable and transparent legal and regulatory environment: Well-aligned national and local policy commitments to improve waste management practices, clearly defined rules for engagement, and consistent enforcement track record can provide substantial comfort to attract private sector investment and operations.

In the EU, the Waste Framework Directive establishes the legal foundation for waste management in line with the Waste Hierarchy. EU policy drives the transition to a circular economy, with targets to recycle 55% of municipal waste by 2025, 60% by 2030, and 65% by 2035, and to reduce landfilling to 10% by 2035.[b] As a member state, Poland aligns its regulations with the directive through the National Waste Management Plan 2028 and key statutes, including the Act on Maintaining Cleanliness and Order in Municipalities, the Act on Waste, and the Act on the Management of Packaging and Packaging Waste. Since accession, Poland has undertaken major reforms, with rapid growth in private participation, particularly in municipal collection and treatment. Competitive tendering and EU compliance have attracted both domestic and international firms, professionalized operations, and spurred investment in modern recycling, recovery, and landfill facilities. Poland continues to expand capacity and integrate more sustainable practices. As of 2022, 41% of municipal waste was recycled or composted and 38% was landfilled (EEA 2025).

Sector financial sustainability: Weak user-fee structures and heavy reliance on municipal budgets, especially in fiscally constrained cities, can undermine private operator viability. Mitigation requires context-appropriate infrastructure planning, targeted public or donor support for capital and operating costs, and revenue models focused on cost recovery. In high-income markets, extended producer responsibility and policies that allocate a significant share of collection costs to local authorities help sustain recycling. In Turkiye, for example, investments in waste-to-energy projects have been supported by long-term contracts underpinned by stable feed-in tariff policies and predictable permitting processes.

Lower-income countries, on the other hand, need commercially viable models that do not overburden municipal finances. Consequently, value chains focus on a narrow set of high-value materials such as polyethylene terephthalate (PET) ferrous and non-ferrous metals, and cardboard, and often leverage the informal sector for source recovery and aggregation. Aggregators supply private recyclers for basic processing such as sorting, cleaning, and baling, who then sell materials to advanced processors producing high-purity, often exportable, commodities.

In nascent markets with many intermediaries, margins are thin and failure risk is high, particularly during commodity price downturns. Vertical integration can help by reducing intermediaries, capturing more value, and achieving scale—either downstream as midtier recyclers moving into higher-value processing, or upstream as manufacturers entering recycling.

A reliable revenue track record, combining user fees with municipal and other government funding, significantly increases private sector interest in delivering sound waste services. For example, Brazil's 2010 Solid Waste National Policy (PNRS) established the legal framework for sound waste management, recycling, and circular economy approaches, requiring municipalities to prepare integrated waste management plans to access federal funding. Together with the 2020 National Basic Sanitation Law, PNRS promotes public–private partnerships and recognizes waste picker cooperatives as service providers, encouraging investment in recycling. The National Solid Waste Management Plan (Planares), approved in 2022, advances these policies with targets to eliminate open dumping, raise recycling and composting to 48% by 2040, and expand energy recovery.[c] Supported by favorable regulations, private sector participation has grown, particularly through long-term concessions, with municipalities commonly contracting private firms for collection, treatment, and disposal, financed through user fees and municipal budgets. Planares also introduced a National Reverse Logistics Program and a Recycling Credit Certificate system to improve traceability, transparency, and financial incentives. However, recycling as a standalone business remains constrained by high costs, variable feedstock quality, and commodity price volatility, underscoring the need for continued regulatory and financial support (Gerden 2024; Kruger 2024).

Public–private partnerships (PPPs): Well-structured, long-term PPPs with balanced risk sharing can attract private financing, construction, and operation of waste infrastructure on a competitive basis. They may cover single segments such as sanitary landfills or waste-to-energy plants, or take the form of integrated concessions combining collection, transport, sorting, and treatment, including material and energy recovery and residual disposal. Effective design requires alignment with national regulations, infrastructure capacity, and sociocultural context, supported by reliable data on waste generation and composition. Contracts should include clear key performance indicators (KPIs) and enforcement mechanisms. For example, Morocco's urban collection PPPs specify KPIs such as coverage and cleanliness index, with bonuses and penalties verified through monthly audits.

In Belgrade, Serbia, the Vinča site, once Europe's largest unmanaged dump, was transformed through an integrated waste-to-energy PPP supported by an International Finance Corporation (IFC) advisory. The project includes a new waste-to-energy plant, remediation and closure of the old landfill, development of a sanitary landfill, and construction of a construction and demolition recycling facility. Structured as a competitively tendered, project-financed concession with long-term waste supply and energy offtake agreements, it mobilized international financing and blended climate funds with the help of a private consortium, Beo Čista Energija d.o.o.—comprising Veolia, ITOCHU, and Marguerite Fund II.[d]

Notes

a. The figures may not total 100% due to minor categories and rounding.

b. European Union, Directive (EU) 2018/851 of the European Parliament and of the Council of 30 May 2018 amending Directive 2008/98/EC on waste, *Official Journal of the European Union* L 150 (June 14, 2018): 109–140; and Directive (EU) 2018/850 of the European Parliament and of the Council of 30 May 2018 amending Directive 1999/31/EC on the landfill of waste, *Official Journal of the European Union* L 150 (June 14, 2018): 100–108.

c. *National Solid Waste Management Plan*, Brazil Ministry of Environment. https://portal-api.sinir.gov.br/wp-content/uploads/2022/07/Planares-B.pdf (in Portuguese).

d. *Belgrade's Waste-to-Energy Project Sparks Environmental Renaissance*, International Finance Corporation. https://www.ifc.org/en/stories/2023/belgrade-waste-to-energy-sparks-environmental-renaissance.

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Notes

1. Throughout this report, references to incineration refer to incineration with energy recovery.
2. For more information on planning municipal waste management systems and developing cost estimates, see *Municipal Solid Waste Cost Calculation Technical Guidelines for Low- and Middle-income Countries* (World Bank 2024). http://documents.worldbank.org/curated/en/099032224175084042.
3. The cost estimates presented in this section differ from those in the World Bank publication, *Banking on Cities: Investing in Low-Carbon and Resilient Urbanization* (2025). That study focuses exclusively on low- and middle-income countries and uses a different waste generation and treatment scenario, assuming an improved treatment mix but without reduction in waste generation volumes.
4. The presented cost estimates are based on the assumed waste generation scenarios and management operations. Applying them to specific local conditions may yield significant deviations owing to variations in waste quantities and composition, as well as local labor, fuel, energy, construction, and material costs.
5. These costs exclude land acquisition costs and costs required to establish additional recycling capacities such as paper and cardboard mills, plastics reprocessing plants, metal smelters, and glass treatment plants and furnaces; costs for the establishment of additional capacities for incineration or co-incineration of RDF resulting from MBT of residual waste; and remediation and cleanup of legacy disposal sites.

6. Operating costs include maintenance and repair, labor, consumables, administration, taxes, insurance, and company overheads.
7. Unit cost data for the different waste management operations were obtained from *Municipal Solid Waste Cost Calculation Technical Guidelines for Low- and Middle- Income Countrie*s (World Bank 2024) and in line with the cost ranges listed in section 7.1. The costs estimates are provided in 2025 prices, that is, without considering inflation.
8. Estimates based on unit prices for the sale of recyclable waste commodities ex-works from waste treatment facilities.
9. Only electricity sales are taken into account for the incineration, based on assumptions for 500 KWh of electricity produced in per tonne of input waste and electricity price of 0.085 US$/kWh.
10. The RDF price depends on the quality characteristics and market demand. Although the RDF price is usually negative in Europe, the cement industry is paying a minimum price for the supply of RDF in some counties in Asia. Within present estimates it is assumed that the net revenues from the sale of RDF will balance the transport costs from waste processing facility to cement plant or other waste-to-energy user.
11. The estimate incorporates potential revenues equivalent to 16 percent of total costs, attributable to recycling and energy conversion.
12. World Bank country environmental analysis and cost of environmental degradation (COED) studies (2010–2025), for Algeria, Chad, China, Arab Rep. of Egypt, Islamic Rep. of Iran, Iraq, Jordan, Kosovo, Kuwait, Lebanon, Morocco, Niger, Saudi Arabia, Syrian Arab Rep., and Tunisia. COED quantifies the economic damages from environmental harm—including health impacts, productivity losses, and ecosystem degradation—expressed as a share of GDP. These have been applied by the World Bank in multiple countries to capture the costs of inadequate waste, water, air, and land management.
13. Economic losses were estimated for five middle-income countries in Asia, including China, Indonesia, the Philippines, Thailand, and Viet Nam.
14. A distinction should be made among: (1) the actual costs of providing waste management services; (2) government expenditures on waste management, which may be lower than actual costs; and (3) the fees or charges paid by households and legal entities, which may partially or fully cover costs.
15. International Monetary Fund. Statistics Department. Government Finance Statistics (GFS) Database. Statistics Department (Government Finance Division) Questionnaire. https://data.imf.org/?sk=a0867067-d23c-4ebc-ad23-d3b015045405.
16. Average expenditures were analyzed across 68 countries included in the IMF database, spanning different income groups: 38 and 40 high-income countries for water supply and sanitation, respectively; 19 upper-middle-income countries for both sectors; and 9 and 8 lower-middle-income countries for water supply and sanitation, respectively. Expenditures for low-income countries are not shown separately due to the limited number of cases. The reference year for the expenditure data was 2021. Where 2021 data were unavailable, the most recent available year between 2017 and 2020 was used instead.
17. International Monetary Fund. GFS Government Expenditures by Function Sheet. https://data.imf.org/en/datasets/IMF.STA:GFS_COFOG.
18. Eurostat. *General government expenditure by function* (COFOG). https://ec.europa.eu/eurostat/databrowser/view/gov_10a_exp__custom_15941477/bookmark/table?lang=en&bookmarkId=1bc01903-74cf-4197-9570-9e64a5b8f35a.
19. A common principle in waste management, the polluter-pays implies that polluters and waste generators cover the full costs to society—including external environmental costs—resulting from their activities.
20. A measure of affordability is given by the affordability ratio; the share of average monthly household income that households might realistically spend on municipal solid waste services. A ratio of 1 percent of average household income is commonly used, although some countries use somewhat lower or higher ratios. One percent has commonly been applied internationally as the affordability benchmark.
21. ASASE Foundation. https://asasegh.com.
22. SEAcircular. 2025. https://www.searcularplastics.com/.
23. Carbon markets assign a price to greenhouse gas emissions and enable the trade of verified emission reductions, creating financial incentives to mitigate climate change. A carbon credit represents one tonne of CO2 equivalent reduced or removed, certified under recognized standards. Markets fall into three categories: (1) voluntary carbon markets, where companies and individuals buy credits to meet climate goals outside regulatory mandates; (2) international compliance markets, governed by frameworks like the Paris Agreement's Article 6.2 (bilateral trading of internationally transferred mitigation outcomes, or ITMOs) and Article 6.4 (a centralized UN crediting mechanism); and (3) domestic compliance markets, such as emissions trading systems in California or the UK, where entities must meet regulatory emissions limits using allowances or approved credits.
24. Based on UNFCCC's CDM Registry for project activities: https://cdm.unfccc.int/Projects/projsearch.html.

25. Climate Focus. Voluntary carbon markets dashboard. https://climatefocus.com/initiatives/voluntary-carbon-market-dashboard/.
26. Carbon credits are issued and certified according to the requirements set by carbon crediting programs or carbon standards. Carbon standards establish rules, methodologies, verification, validation, and monitoring procedures to certify the sequestration or avoidance of GHG emissions.
27. Climate Focus. Voluntary carbon markets dashboard. https://climatefocus.com/initiatives/voluntary-carbon-market-dashboard/
28. Government of Canada. 2024. *Reciclo Orgánicos Program in Chile*. https://climate-change.canada.ca/finance/details.aspx?id=2544. The pilot, implemented between 2017 and 2022, supported the Chilean government in adopting technologies to reduce methane emissions and explore the use of internationally transferred mitigation outcomes (ITMOs) under Article 6. The program worked with over 40 municipalities on 22 waste management initiatives, aiming to reduce approximately 9.5 million tonnes of CO2e annually by 2030. Activities included support for composting programs, landfill gas capture pilots, and trials in biodigestion and anaerobic digestion. With an initial investment of US$1 million, the program catalyzed over US$25 million in additional public and private sector financing. It also developed GHG measurement protocols for landfill gas recovery, composting, and anaerobic digestion, which were tested and applied in operational facilities across Chile.

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©Alamy/Hossain. Heavy machinery operating at an open dumpsite with informal waste picking and livestock grazing amid mixed municipal solid waste.

Appendix A
Waste Generation and Projections by Country or Economy

Table A.1 presents municipal solid waste generation and projections by country or economy. Table A.2 provides the sources/references and notes on data, if applicable, for the values provided in table A.1.

Table A.1 Waste generation and projections by country or economy

Country or economy	Region	Income group (2022)	Country dataset (original year reported)			2022 projected		2030 projected		2040 projected		2050 projected	
			MSW generation (tonnes per year)	Population (000s)	Year	MSW generation (tonnes per year)	Population (000s)	MSW generation (tonnes per year)	Population (000s)	MSW generation (tonnes per year)	Population (000s)	MSW generation (tonnes per year)	Population (000s)
Afghanistan	S. Asia	LIC	4,148,162	35,174	2017	3,268,836	40,293	4,125,553	49,372	5,922,888	62,637	8,015,088	76,239
Albania	Eur. & Cent. Asia	UMIC	754,094	2,866	2021	768,006	2,834	870,315	2,682	929,617	2,473	931,066	2,251
Algeria	Mid. East & N. Africa	LMIC	13,500,000	43,685	2020	14,286,747	45,123	16,600,806	49,909	19,433,867	54,636	23,020,603	59,355
American Samoa	E. Asia & Pacific	HIC	17,348	51	2019	16,894	49	15,427	43	14,414	40	13,950	38
Andorra	Eur. & Cent. Asia	HIC	37,950	78	2021	39,552	79	44,067	86	45,007	86	43,923	82
Angola	Sub-Saharan Africa	LMIC	7,786,460	26,666	2014	8,090,355	35,083	10,328,835	44,521	15,201,525	58,229	22,788,288	73,497
Antigua and Barbuda	L. Amer. & the Caribbean	HIC	30,300	87	2012	33,623	93	38,575	96	42,536	97	44,782	95
Argentina	L. Amer. & the Caribbean	UMIC	19,345,000	45,357	2022	19,345,000	45,357	20,900,587	46,515	23,028,380	47,769	25,033,508	48,312
Armenia	Eur. & Cent. Asia	UMIC	532,699	2,859	2022	532,699	2,859	548,994	2,861	591,665	2,675	595,568	2,504
Aruba	L. Amer. & the Caribbean	HIC	67,810	107	2019	70,122	108	76,080	108	76,452	105	75,321	100
Australia	E. Asia & Pacific	HIC	13,950,304	25,832	2021	14,201,100	26,081	15,860,054	28,073	17,827,020	30,252	19,743,820	32,402
Austria	Eur. & Cent. Asia	HIC	7,261,357	8,993	2022	7,261,357	8,993	7,531,005	9,086	7,615,285	8,942	7,603,304	8,738
Azerbaijan	Eur. & Cent. Asia	UMIC	3,890,000	10,154	2020	4,136,467	10,259	4,676,030	10,641	5,234,402	11,067	5,750,108	11,225
Bahamas, The	L. Amer. & the Caribbean	HIC	503,692	396	2021	519,298	397	580,631	410	620,734	420	653,623	424
Bahrain	Mid. East & N. Africa	HIC	1,563,487	1,515	2022	1,563,487	1,515	1,870,901	1,756	2,135,192	1,942	2,387,032	2,130
Bangladesh	S. Asia	LMIC	30,472,833	166,974	2021	31,644,329	168,343	35,834,221	185,080	40,265,156	201,909	50,663,364	214,180
Barbados	L. Amer. & the Caribbean	HIC	395,151	282	2021	407,564	282	458,588	283	500,360	277	532,955	265
Belarus	Eur. & Cent. Asia	UMIC	3,994,300	9,201	2022	3,994,300	9,201	3,995,934	8,719	3,934,084	8,095	3,843,350	7,486
Belgium	Eur. & Cent. Asia	HIC	7,915,113	11,586	2022	7,915,113	11,586	8,325,041	11,819	8,574,185	11,890	8,707,284	11,876

Table A.1 Waste generation and projections by country or economy (*contd.*)

Country or economy	Region	Income group (2022)	Country dataset (original year reported)			2022 projected		2030 projected		2040 projected		2050 projected	
			MSW generation (tonnes per year)	Population (000s)	Year	MSW generation (tonnes per year)	Population (000s)	MSW generation (tonnes per year)	Population (000s)	MSW generation (tonnes per year)	Population (000s)	MSW generation (tonnes per year)	Population (000s)
Belize	L. Amer. & the Caribbean	UMIC	100,000	353	2015	113,814	397	145,063	447	183,718	490	225,532	516
Benin	Sub-Saharan Africa	LMIC	–	–	–	1,492,998	13,585	1,860,609	16,437	2,360,735	20,247	3,599,344	24,237
Bermuda	N. Amer.	HIC	73,200	65	2021	74,404	65	74,406	64	72,055	61	67,665	57
Bhutan	S. Asia	LMIC	60,378	762	2019	60,388	778	72,459	818	87,345	861	100,123	882
Bolivia	L. Amer. & the Caribbean	LMIC	3,024,025	11,995	2022	3,024,025	11,995	3,593,408	13,325	4,617,630	14,831	6,035,129	16,057
Bosnia and Herzegovina	Eur. & Cent. Asia	UMIC	1,184,449	3,215	2022	1,184,449	3,215	1,296,961	3,026	1,327,918	2,760	1,263,161	2,469
Botswana	Sub-Saharan Africa	UMIC	241,000	2,251	2017	267,425	2,420	341,266	2,746	430,645	3,110	514,120	3,423
Brazil	L. Amer. & the Caribbean	UMIC	81,811,506	209,906	2022	81,811,506	209,906	90,464,116	215,806	104,004,516	219,188	117,564,893	217,704
British Virgin Islands	L. Amer. & the Caribbean	HIC	55,093	36	2019	57,952	38	63,906	41	67,701	41	68,938	40
Brunei Darussalam	E. Asia & Pacific	HIC	297,218	440	2019	303,148	454	329,097	481	354,665	505	367,509	519
Bulgaria	Eur. & Cent. Asia	UMIC	3,180,000	7,050	2018	3,358,340	6,838	3,550,658	6,486	3,530,484	5,935	3,398,913	5,426
Burkina Faso	Sub-Saharan Africa	LIC	457,771	21,738	2021	465,240	22,252	669,174	26,461	831,575	31,925	994,434	37,066
Burundi	Sub-Saharan Africa	LIC	–	–	–	374,735	13,138	548,268	15,999	703,339	19,926	870,741	23,950
Cabo Verde	Sub-Saharan Africa	LMIC	163,443	512	2015	180,233	518	192,453	537	242,748	557	281,093	566
Cambodia	E. Asia & Pacific	LMIC	4,780,000	16,591	2020	5,168,117	17,089	5,835,819	18,735	6,565,439	20,463	7,228,626	21,874
Cameroon	Sub-Saharan Africa	LMIC	6,000,000	27,268	2022	6,000,000	27,268	8,389,554	33,375	13,509,373	41,770	20,780,825	50,651
Canada	N. Amer.	HIC	30,452,356	37,043	2018	31,783,357	38,583	35,191,790	41,518	38,843,770	43,858	41,771,056	45,547
Cayman Islands	L. Amer. & the Caribbean	HIC	83,590	71	2022	83,590	71	92,427	82	102,348	94	108,732	104
Central African Republic	Sub-Saharan Africa	LIC	1,153,643	4,656	2014	1,364,647	5,131	1,735,029	6,378	2,360,458	8,425	3,032,409	10,508

Table A.1 Waste generation and projections by country or economy (*contd.*)

Country or economy	Region	Income group (2022)	Country dataset (original year reported)			2022 projected		2030 projected		2040 projected		2050 projected	
			MSW generation (tonnes per year)	Population (000s)	Year	MSW generation (tonnes per year)	Population (000s)	MSW generation (tonnes per year)	Population (000s)	MSW generation (tonnes per year)	Population (000s)	MSW generation (tonnes per year)	Population (000s)
Chad	Sub-Saharan Africa	LIC	–	–	–	1,022,677	18,143	1,393,639	23,866	1,861,515	30,950	2,383,192	38,470
Channel Islands	Eur. & Cent. Asia	HIC	60,949	167	2023	60,949	167	63,892	169	66,656	170	68,442	168
Chile	L. Amer. & the Caribbean	HIC	8,685,826	19,503	2022	8,685,826	19,503	9,450,049	20,203	10,306,455	20,540	10,932,700	20,344
China	E. Asia & Pacific	UMIC	502,607,448	1,426,098	2022	502,607,448	1,426,098	579,314,130	1,400,281	621,774,239	1,346,164	630,002,818	1,265,452
Colombia	L. Amer. & the Caribbean	UMIC	14,423,330	51,443	2022	14,423,330	51,443	17,172,106	55,535	20,804,469	58,491	23,842,622	59,384
Comoros	Sub-Saharan Africa	LMIC	110,705	842	2023	107,779	826	142,123	956	172,275	1,125	204,865	1,299
Congo, Dem. Rep.	Sub-Saharan Africa	LIC	13,144,574	72,025	2012	22,832,037	100,731	35,846,243	129,589	48,559,142	170,435	63,347,409	215,863
Congo, Rep.	Sub-Saharan Africa	LMIC	888,747	4,683	2012	853,424	5,962	1,105,318	7,199	1,606,141	8,990	2,329,404	10,910
Costa Rica	L. Amer. & the Caribbean	UMIC	1,615,689	5,049	2021	1,653,778	5,071	1,900,126	5,243	2,168,186	5,367	2,348,975	5,359
Côte d'Ivoire	Sub-Saharan Africa	LMIC	5,000,000	29,273	2021	5,269,506	30,006	6,563,924	36,289	10,523,625	45,259	15,408,669	55,241
Croatia	Eur. & Cent. Asia	HIC	1,844,382	3,911	2022	1,844,382	3,911	1,945,882	3,738	1,923,367	3,500	1,834,419	3,247
Cuba	L. Amer. & the Caribbean	UMIC	4,572,000	11,164	2021	4,612,957	11,080	4,996,764	10,726	5,260,903	10,159	5,290,499	9,423
Curaçao	L. Amer. & the Caribbean	HIC	213,000	185	2023	216,765	185	201,015	185	177,665	181	149,033	174
Cyprus	Eur. & Cent. Asia	HIC	614,620	1,325	2022	614,620	1,325	694,677	1,418	763,685	1,483	802,968	1,508
Czech Republic	Eur. & Cent. Asia	HIC	5,904,400	10,543	2021	5,905,029	10,519	6,038,028	10,440	6,128,995	10,122	6,152,359	9,840
Denmark	Eur. & Cent. Asia	HIC	4,503,000	5,840	2021	4,549,906	5,873	4,832,683	6,077	4,989,511	6,134	5,088,255	6,126
Djibouti	Mid. East & N. Africa	LMIC	–	–	–	189,510	1,129	216,922	1,255	249,105	1,399	327,618	1,525
Dominica	L. Amer. & the Caribbean	UMIC	13,000	67	2022	13,000	67	13,916	64	14,536	64	15,079	63
Dominican Republic	L. Amer. & the Caribbean	UMIC	4,293,944	11,068	2021	4,420,106	11,179	5,412,753	11,900	6,459,805	12,553	7,234,371	12,981

Table A.1 Waste generation and projections by country or economy (*contd.*)

Country or economy	Region	Income group (2022)	Country dataset (original year reported)			2022 projected		2030 projected		2040 projected		2050 projected	
			MSW generation (tonnes per year)	Population (000s)	Year	MSW generation (tonnes per year)	Population (000s)	MSW generation (tonnes per year)	Population (000s)	MSW generation (tonnes per year)	Population (000s)	MSW generation (tonnes per year)	Population (000s)
Ecuador	L. Amer. & the Caribbean	UMIC	5,253,810	17,746	2022	5,253,810	17,746	6,065,350	18,992	7,340,727	20,376	8,687,241	21,305
Egypt, Arab Rep.	Mid. East & N. Africa	LMIC	25,840,000	110,171	2021	26,957,734	111,743	35,470,303	126,256	48,587,288	144,307	61,610,200	160,904
El Salvador	L. Amer. & the Caribbean	UMIC	1,541,847	6,246	2021	1,572,087	6,265	1,841,099	6,476	2,214,393	6,636	2,633,186	6,665
Equatorial Guinea	Sub-Saharan Africa	UMIC	198,443	1,481	2016	198,324	1,782	195,785	2,147	264,437	2,640	354,756	3,121
Eritrea	Sub-Saharan Africa	LIC	–	–	–	219,099	3,380	278,247	3,961	371,119	4,824	472,175	5,656
Estonia	Eur. & Cent. Asia	HIC	495,000	1,333	2022	495,000	1,333	513,188	1,306	516,310	1,240	503,331	1,178
Eswatini	Sub-Saharan Africa	LMIC	238,341	1,153	2017	268,654	1,213	333,728	1,315	426,701	1,425	525,040	1,503
Ethiopia	Sub-Saharan Africa	LIC	4,453,000	117,298	2020	4,936,316	123,740	6,208,372	151,094	7,899,021	186,641	9,729,919	223,206
Faroe Islands	Eur. & Cent. Asia	HIC	56,000	48	2014	64,157	54	71,585	58	77,623	61	82,210	63
Fiji	E. Asia & Pacific	UMIC	177,263	916	2021	182,735	917	228,509	951	277,102	983	325,496	1,000
Finland	Eur. & Cent. Asia	HIC	2,898,043	5,548	2022	2,898,043	5,548	2,995,284	5,597	3,027,034	5,487	3,031,301	5,359
France	Eur. & Cent. Asia	HIC	36,606,000	66,173	2022	36,606,000	66,173	38,289,008	67,064	39,846,427	67,907	41,010,826	68,227
French Polynesia	E. Asia & Pacific	HIC	83,367	279	2020	85,785	280	90,193	285	93,975	289	94,953	285
Gabon	Sub-Saharan Africa	UMIC	386,358	2,129	2017	427,477	2,404	525,156	2,839	701,737	3,422	901,996	4,053
Gambia, The	Sub-Saharan Africa	LIC	282,378	2,134	2014	387,305	2,606	570,829	3,100	702,422	3,703	835,216	4,275
Georgia	Eur. & Cent. Asia	UMIC	1,117,396	3,797	2019	1,202,057	3,782	1,241,520	3,793	1,432,041	3,736	1,501,729	3,668
Germany	Eur. & Cent. Asia	HIC	49,699,000	83,772	2022	49,699,000	83,772	50,108,356	82,891	50,239,145	80,660	50,172,423	78,417
Ghana	Sub-Saharan Africa	LMIC	3,290,590	29,690	2017	3,976,074	32,831	5,298,152	37,904	7,694,741	44,256	10,537,762	50,270
Gibraltar	Eur. & Cent. Asia	HIC	16,417	37	2021	16,878	37	20,254	43	23,303	48	25,227	50

Table A.1 Waste generation and projections by country or economy (*contd.*)

Country or economy	Region	Income group (2022)	Country dataset (original year reported)			2022 projected		2030 projected		2040 projected		2050 projected	
			MSW generation (tonnes per year)	Population (000s)	Year	MSW generation (tonnes per year)	Population (000s)	MSW generation (tonnes per year)	Population (000s)	MSW generation (tonnes per year)	Population (000s)	MSW generation (tonnes per year)	Population (000s)
Greece	Eur. & Cent. Asia	HIC	5,381,000	10,683	2021	5,421,551	10,476	5,478,861	9,744	5,538,468	9,297	5,506,192	8,838
Greenland	Eur. & Cent. Asia	HIC	41,958	56	2022	41,958	56	42,529	55	41,938	53	40,642	50
Grenada	L. Amer. & the Caribbean	UMIC	34,000	117	2022	34,000	117	39,245	117	44,642	117	48,428	113
Guam	E. Asia & Pacific	HIC	141,500	166	2012	145,824	165	159,139	174	171,070	183	181,371	191
Guatemala	L. Amer. & the Caribbean	UMIC	6,533,833	17,486	2021	6,730,814	17,711	8,541,308	19,932	11,242,859	22,510	14,214,445	24,582
Guinea	Sub-Saharan Africa	LMIC	–	–	–	1,568,192	13,881	1,935,833	16,636	2,396,090	19,992	2,870,004	23,248
Guinea-Bissau	Sub-Saharan Africa	LIC	–	–	–	151,577	2,082	218,231	2,465	268,630	2,946	320,819	3,416
Guyana	L. Amer. & the Caribbean	HIC	250,353	812	2021	260,226	819	280,879	858	318,156	905	334,236	939
Haiti	L. Amer. & the Caribbean	LMIC	2,799,502	11,312	2021	2,759,482	11,438	2,967,926	12,489	3,348,304	13,679	3,698,040	14,668
Honduras	L. Amer. & the Caribbean	LMIC	3,234,671	10,206	2021	3,354,538	10,373	4,467,472	11,800	6,330,488	13,411	8,836,047	14,785
Hong Kong SAR, China	E. Asia & Pacific	HIC	5,975,150	7,479	2022	5,975,150	7,479	6,061,341	7,272	5,840,948	6,847	5,232,811	6,131
Hungary	Eur. & Cent. Asia	HIC	3,911,000	9,685	2022	3,911,000	9,685	4,103,447	9,467	4,183,959	9,086	4,170,527	8,741
Iceland	Eur. & Cent. Asia	HIC	227,000	376	2022	227,000	376	260,309	413	280,514	429	290,157	433
India	S. Asia	LMIC	202,254,010	1,409,264	2021	209,781,997	1,419,143	231,333,564	1,519,356	308,820,831	1,618,707	376,163,172	1,677,687
Indonesia	E. Asia & Pacific	UMIC	55,439,036	280,026	2023	53,546,427	277,635	68,020,062	294,942	83,503,910	311,157	95,755,530	320,462
Iran, Islamic Rep.	Mid. East & N. Africa	LMIC	20,453,100	88,946	2022	20,453,100	88,946	23,946,594	95,245	27,049,897	99,356	29,358,466	101,813
Iraq	Mid. East & N. Africa	UMIC	18,039,760	40,743	2019	18,034,279	43,551	21,262,695	51,440	26,270,576	61,704	37,835,198	71,476
Ireland	Eur. & Cent. Asia	HIC	3,170,388	5,003	2021	3,240,493	5,054	3,595,845	5,507	3,872,486	5,805	4,066,576	5,968
Isle of Man	Eur. & Cent. Asia	HIC	49,378	84	2023	49,453	84	50,861	84	51,693	82	51,393	78

Table A.1 Waste generation and projections by country or economy (*contd.*)

Country or economy	Region	Income group (2022)	Country dataset (original year reported)			2022 projected		2030 projected		2040 projected		2050 projected	
			MSW generation (tonnes per year)	Population (000s)	Year	MSW generation (tonnes per year)	Population (000s)	MSW generation (tonnes per year)	Population (000s)	MSW generation (tonnes per year)	Population (000s)	MSW generation (tonnes per year)	Population (000s)
Israel	Mid. East & N. Africa	HIC	6,189,622	9,015	2022	6,189,622	9,015	7,304,420	10,108	8,728,313	11,507	10,203,505	13,016
Italy	Eur. & Cent. Asia	HIC	29,051,310	59,674	2022	29,051,310	59,674	29,397,916	58,078	29,080,596	55,366	28,197,192	52,086
Jamaica	L. Amer. & the Caribbean	UMIC	1,229,527	2,837	2021	1,267,178	2,839	1,385,885	2,813	1,500,759	2,685	1,617,324	2,467
Japan	E. Asia & Pacific	HIC	40,344,000	125,324	2022	40,344,000	125,324	40,214,642	119,949	39,244,461	112,526	38,088,783	105,459
Jordan	Mid. East & N. Africa	LMIC	3,561,640	10,763	2020	3,768,839	11,165	4,465,561	12,349	5,901,859	14,360	7,850,315	16,283
Kazakhstan	Eur. & Cent. Asia	UMIC	4,142,952	20,196	2023	4,018,397	19,873	4,759,978	21,890	5,582,618	24,130	6,338,734	26,437
Kenya	Sub-Saharan Africa	LMIC	3,450,500	52,727	2021	3,596,047	53,711	5,163,261	62,540	7,661,733	73,586	10,671,917	83,161
Kiribati	E. Asia & Pacific	LMIC	14,263	127	2021	14,747	129	18,442	145	21,433	164	24,498	182
Korea, Rep.	E. Asia & Pacific	HIC	23,038,561	51,806	2022	23,038,561	51,806	23,955,080	51,255	23,826,400	49,103	22,596,402	45,374
Kosovo	Eur. & Cent. Asia	UMIC	501,000	1,727	2022	501,000	1,727	546,705	1,661	626,051	1,674	676,936	1,647
Kuwait	Mid. East & N. Africa	HIC	3,827,000	4,793	2023	3,536,173	4,386	4,384,475	5,301	5,027,566	5,805	5,681,269	6,341
Kyrgyz Republic	Eur. & Cent. Asia	LMIC	1,957,586	7,016	2023	1,981,456	6,895	2,657,947	7,754	3,626,102	8,710	4,723,673	9,603
Lao PDR	E. Asia & Pacific	LMIC	351,893	6,749	2015	455,561	7,506	592,601	8,311	811,925	9,134	1,040,193	9,734
Latvia	Eur. & Cent. Asia	HIC	869,000	1,894	2021	871,625	1,877	892,770	1,785	877,650	1,647	839,934	1,520
Lebanon	Mid. East & N. Africa	LMIC	2,044,000	5,708	2021	2,067,615	5,728	2,208,717	6,077	2,679,217	6,596	3,262,484	6,986
Lesotho	Sub-Saharan Africa	LMIC	–	–	–	178,344	2,274	211,696	2,481	301,423	2,745	420,312	2,983
Liberia	Sub-Saharan Africa	LIC	–	–	–	274,347	5,314	335,467	6,309	417,197	7,617	499,655	8,857
Libya	Mid. East & N. Africa	UMIC	3,200,000	6,373	2014	4,123,954	7,179	4,938,199	7,844	5,713,122	8,616	6,985,901	9,235
Liechtenstein	Eur. & Cent. Asia	HIC	32,424	39	2022	32,424	39	34,767	41	36,496	42	37,347	43
Lithuania	Eur. & Cent. Asia	HIC	1,317,000	2,792	2022	1,317,000	2,792	1,373,050	2,717	1,325,033	2,496	1,236,233	2,270

Table A.1 Waste generation and projections by country or economy (*contd.*)

Country or economy	Region	Income group (2022)	Country dataset (original year reported)			2022 projected		2030 projected		2040 projected		2050 projected	
			MSW generation (tonnes per year)	Population (000s)	Year	MSW generation (tonnes per year)	Population (000s)	MSW generation (tonnes per year)	Population (000s)	MSW generation (tonnes per year)	Population (000s)	MSW generation (tonnes per year)	Population (000s)
Luxembourg	Eur. & Cent. Asia	HIC	465,501	646	2022	465,501	646	519,508	711	561,085	761	583,120	791
Macao SAR, China	E. Asia & Pacific	HIC	443,039	700	2022	443,039	700	559,758	726	562,128	708	540,195	671
Madagascar	Sub-Saharan Africa	LIC	3,558,235	27,853	2019	3,652,904	30,061	5,229,833	36,293	6,594,788	44,432	8,067,134	52,769
Malawi	Sub-Saharan Africa	LIC	3,102,500	18,283	2018	3,420,595	20,305	4,584,250	24,857	5,888,165	30,998	7,251,331	37,062
Malaysia	E. Asia & Pacific	UMIC	13,963,724	29,410	2012	18,451,975	34,483	22,216,703	37,768	26,081,975	41,349	28,959,095	44,179
Maldives	S. Asia	UMIC	205,261	480	2019	225,022	523	284,072	539	330,774	563	366,728	589
Mali	Sub-Saharan Africa	LIC	–	–	–	1,709,133	22,729	2,490,584	28,606	3,316,197	36,980	4,222,595	45,716
Malta	Mid. East & N. Africa	HIC	306,109	527	2022	306,109	527	346,875	555	363,414	552	361,506	537
Marshall Islands	E. Asia & Pacific	UMIC	21,187	45	2019	20,051	41	14,567	32	13,418	27	13,678	25
Mauritania	Sub-Saharan Africa	LMIC	454,000	4,025	2016	562,644	4,803	797,048	5,985	1,247,222	7,598	1,842,978	9,328
Mauritius	Sub-Saharan Africa	UMIC	473,983	1,278	2022	473,983	1,278	535,303	1,252	569,499	1,199	570,096	1,112
Mexico	L. Amer. & the Caribbean	UMIC	47,670,613	127,241	2021	48,785,541	128,055	56,540,908	136,445	65,533,481	144,320	73,466,075	148,820
Micronesia, Fed. Sts.	E. Asia & Pacific	LMIC	27,375	112	2022	27,375	112	29,403	116	39,316	121	42,074	126
Moldova	Eur. & Cent. Asia	UMIC	948,880	3,090	2020	948,657	2,999	931,713	2,860	1,017,793	2,581	1,020,489	2,362
Monaco	Eur. & Cent. Asia	HIC	46,000	39	2024	45,613	39	45,498	37	45,796	37	46,990	37
Mongolia	E. Asia & Pacific	LMIC	1,612,000	3,200	2019	1,662,827	3,362	2,075,425	3,687	2,607,961	4,074	3,168,242	4,484
Montenegro	Eur. & Cent. Asia	UMIC	335,798	602	2022	335,798	602	392,029	614	397,960	576	385,879	535
Morocco	Mid. East & N. Africa	LMIC	7,433,045	36,774	2021	7,517,551	37,134	9,269,387	39,817	11,792,472	42,081	14,453,285	43,399
Mozambique	Sub-Saharan Africa	LIC	4,200,000	33,141	2023	3,997,445	32,172	5,158,733	40,309	6,794,983	51,548	8,549,979	62,972
Myanmar	E. Asia & Pacific	LMIC	7,475,200	52,456	2019	6,487,192	53,566	7,258,857	56,222	9,536,284	58,115	12,011,262	58,630

Table A.1 Waste generation and projections by country or economy (*contd.*)

Country or economy	Region	Income group (2022)	Country dataset (original year reported)			2022 projected		2030 projected		2040 projected		2050 projected	
			MSW generation (tonnes per year)	Population (000s)	Year	MSW generation (tonnes per year)	Population (000s)	MSW generation (tonnes per year)	Population (000s)	MSW generation (tonnes per year)	Population (000s)	MSW generation (tonnes per year)	Population (000s)
Namibia	Sub-Saharan Africa	UMIC	–	–	–	740,297	2,851	942,410	3,360	1,266,172	3,935	1,670,303	4,486
Nauru	E. Asia & Pacific	HIC	570	12	2020	603	12	752	12	953	14	1,178	16
Nepal	S. Asia	LMIC	1,788,500	28,699	2020	1,950,376	29,716	2,053,306	30,373	2,284,380	32,807	2,479,602	34,573
Netherlands	Eur. & Cent. Asia	HIC	8,370,000	17,789	2022	8,370,000	17,789	9,056,911	18,727	9,459,456	19,060	9,607,509	18,969
New Caledonia	E. Asia & Pacific	HIC	112,662	288	2023	111,072	286	122,807	306	133,751	327	141,542	340
New Zealand	E. Asia & Pacific	HIC	3,601,300	5,112	2022	3,601,300	5,112	3,941,444	5,395	4,277,401	5,608	4,534,129	5,750
Nicaragua	L. Amer. & the Caribbean	LMIC	1,518,162	6,605	2021	1,563,209	6,684	2,030,345	7,400	2,792,458	8,157	3,774,333	8,733
Niger	Sub-Saharan Africa	LIC	1,606,695	22,568	2019	1,856,517	24,897	2,836,326	32,044	3,812,354	41,816	4,882,819	51,998
Nigeria	Sub-Saharan Africa	LMIC	44,500,000	216,252	2021	45,737,275	220,807	57,316,754	259,866	82,516,989	310,248	113,768,450	357,001
North Macedonia	Eur. & Cent. Asia	UMIC	878,303	1,836	2023	873,083	1,844	940,452	1,768	971,369	1,648	967,846	1,519
Northern Mariana Islands	E. Asia & Pacific	HIC	29,340	47	2022	29,340	47	27,209	42	27,978	42	28,883	43
Norway	Eur. & Cent. Asia	HIC	4,189,000	5,425	2022	4,189,000	5,425	4,496,190	5,721	4,693,756	5,850	4,814,640	5,900
Oman	Mid. East & N. Africa	HIC	3,307,951	4,527	2022	3,307,951	4,527	4,605,128	6,072	5,544,119	6,889	6,552,467	7,781
Pakistan	S. Asia	LMIC	48,500,000	241,728	2022	48,500,000	241,728	62,101,107	274,580	92,718,583	322,538	136,137,316	369,611
Palau	E. Asia & Pacific	UMIC	13,048	18	2017	11,425	18	12,564	17	12,276	17	11,726	16
Panama	L. Amer. & the Caribbean	HIC	1,970,906	4,319	2021	2,054,578	4,372	2,536,122	4,809	2,964,306	5,267	3,297,915	5,616
Papua New Guinea	E. Asia & Pacific	LMIC	1,630,101	9,502	2019	1,661,790	10,110	2,084,980	11,582	3,095,739	13,295	3,558,295	14,836
Paraguay	L. Amer. & the Caribbean	UMIC	2,943,098	6,719	2022	2,943,098	6,719	3,594,109	7,370	4,431,584	8,057	5,259,094	8,616
Peru	L. Amer. & the Caribbean	UMIC	10,213,959	33,017	2021	10,405,827	33,295	12,369,343	36,044	15,051,272	38,684	17,693,488	40,516

Table A.1 Waste generation and projections by country or economy (*contd.*)

Country or economy	Region	Income group (2022)	Country dataset (original year reported)			2022 projected		2030 projected		2040 projected		2050 projected	
			MSW generation (tonnes per year)	Population (000s)	Year	MSW generation (tonnes per year)	Population (000s)	MSW generation (tonnes per year)	Population (000s)	MSW generation (tonnes per year)	Population (000s)	MSW generation (tonnes per year)	Population (000s)
Philippines	E. Asia & Pacific	LMIC	16,628,026	111,478	2020	17,440,185	113,517	19,140,800	120,958	25,446,097	129,206	30,275,595	134,244
Poland	Eur. & Cent. Asia	HIC	13,474,923	37,958	2022	13,474,923	37,958	14,324,017	37,287	14,431,633	35,291	13,883,674	32,939
Portugal	Eur. & Cent. Asia	HIC	5,274,483	10,403	2022	5,274,483	10,403	5,586,252	10,327	5,776,494	10,096	5,840,534	9,788
Puerto Rico	L. Amer. & the Caribbean	HIC	3,026,033	3,770	2007	2,616,935	3,242	2,663,630	3,154	2,547,779	2,870	2,320,697	2,522
Qatar	Mid. East & N. Africa	HIC	1,298,850	2,816	2020	1,328,224	2,839	1,581,399	3,317	1,766,590	3,690	1,979,564	4,140
Romania	Eur. & Cent. Asia	HIC	5,742,000	19,164	2022	5,742,000	19,164	6,014,334	18,415	6,020,037	17,268	5,816,034	16,087
Russian Federation	Eur. & Cent. Asia	UMIC	45,867,400	145,484	2022	45,867,400	145,484	47,288,998	142,089	49,134,500	138,415	50,687,762	136,256
Rwanda	Sub-Saharan Africa	LIC	–	–	–	1,186,145	13,499	1,447,811	15,998	1,795,169	19,258	2,730,685	22,560
Samoa	E. Asia & Pacific	LMIC	19,780	211	2020	17,711	215	20,453	225	27,156	246	38,047	272
San Marino	Eur. & Cent. Asia	HIC	18,020	35	2019	17,585	34	16,538	34	15,438	34	13,633	34
São Tomé and Príncipe	Sub-Saharan Africa	LMIC	24,249	199	2015	29,105	224	35,969	262	52,417	313	75,635	363
Saudi Arabia	Mid. East & N. Africa	HIC	20,751,133	31,483	2022	20,751,133	31,483	25,759,542	37,188	30,731,532	42,335	35,303,414	47,442
Senegal	Sub-Saharan Africa	LMIC	3,000,000	17,007	2021	3,106,279	17,435	4,565,085	20,934	5,742,830	25,567	8,368,204	30,138
Serbia	Eur. & Cent. Asia	UMIC	2,870,000	6,877	2021	2,907,618	6,794	3,211,316	6,484	3,346,698	6,011	3,312,714	5,554
Seychelles	Sub-Saharan Africa	HIC	49,170	98	2012	66,240	124	82,912	140	91,730	142	96,773	142
Sierra Leone	Sub-Saharan Africa	LIC	–	–	–	433,435	8,185	602,932	9,608	731,259	11,313	857,220	12,876
Singapore	E. Asia & Pacific	HIC	1,851,949	5,766	2023	1,787,655	5,534	1,974,930	6,018	2,063,438	6,196	2,033,048	6,091
Sint Maarten (Dutch)	L. Amer. & the Caribbean	HIC	14,446	41	2020	15,510	42	15,561	46	14,665	50	11,961	51
Slovak Republic	Eur. & Cent. Asia	HIC	2,597,457	5,430	2022	2,597,457	5,430	2,746,883	5,409	2,815,916	5,204	2,796,405	4,950

Table A.1 Waste generation and projections by country or economy (*contd.*)

Country or economy	Region	Income group (2022)	Country dataset (original year reported)			2022 projected		2030 projected		2040 projected		2050 projected	
			MSW generation (tonnes per year)	Population (000s)	Year	MSW generation (tonnes per year)	Population (000s)	MSW generation (tonnes per year)	Population (000s)	MSW generation (tonnes per year)	Population (000s)	MSW generation (tonnes per year)	Population (000s)
Slovenia	Eur. & Cent. Asia	HIC	1,064,576	2,113	2022	1,064,576	2,113	1,124,361	2,101	1,143,998	2,049	1,135,431	1,985
Solomon Islands	E. Asia & Pacific	LMIC	211,557	674	2017	229,828	772	282,898	928	353,593	1,126	420,594	1,301
Somalia, Fed. Rep.	Sub-Saharan Africa	LIC	–	–	–	828,484	17,572	1,137,903	22,575	1,532,679	29,522	1,969,714	36,834
South Africa	Sub-Saharan Africa	UMIC	7,995,632	62,797	2023	7,901,976	61,960	8,975,477	67,841	11,181,286	73,766	13,932,026	78,941
South Sudan	Sub-Saharan Africa	LIC	–	–	–	383,354	10,895	467,452	13,326	560,389	15,976	639,934	18,244
Spain	Eur. & Cent. Asia	HIC	28,088,510	47,722	2021	28,570,221	47,749	29,818,195	47,652	30,593,327	46,655	30,697,701	45,035
Sri Lanka	S. Asia	LMIC	2,971,830	22,636	2021	2,847,754	22,765	3,155,837	23,720	3,797,571	24,500	4,362,360	24,812
St. Kitts and Nevis	L. Amer. & the Caribbean	HIC	33,000	47	2022	33,000	47	35,904	47	37,248	46	37,176	44
St. Lucia	L. Amer. & the Caribbean	UMIC	81,705	179	2022	81,705	179	91,776	181	97,945	180	102,898	173
St. Martin (French)	L. Amer. & the Caribbean	HIC	14,446	33	2020	13,319	29	9,955	21	9,223	19	9,492	19
St. Vincent and the Grenadines	L. Amer. & the Caribbean	UMIC	31,886	102	2022	31,886	102	35,428	97	38,364	93	40,838	89
Sudan	Sub-Saharan Africa	LIC	7,945,893	43,539	2018	7,501,320	48,730	7,705,402	57,921	11,158,593	71,071	15,616,747	84,519
Suriname	L. Amer. & the Caribbean	UMIC	140,000	620	2022	140,000	620	159,808	663	190,311	705	219,938	733
Sweden	Eur. & Cent. Asia	HIC	4,139,000	10,453	2022	4,139,000	10,453	4,436,213	10,828	4,674,206	11,066	4,859,498	11,300
Switzerland	Eur. & Cent. Asia	HIC	5,940,000	8,741	2022	5,940,000	8,741	6,283,264	9,118	6,473,654	9,271	6,585,031	9,342
Syrian Arab Republic	Mid. East & N. Africa	LIC	3,576,050	19,200	2018	4,203,269	21,910	5,110,793	29,074	5,324,684	34,335	5,029,304	37,635
Taiwan, China	E. Asia & Pacific	HIC	11,579,543	23,370	2023	11,671,925	23,470	11,599,440	22,645	11,711,797	21,336	11,297,975	19,535
Tajikistan	Eur. & Cent. Asia	LMIC	1,500,000	9,196	2018	1,692,923	10,077	2,014,195	11,640	2,954,290	13,613	4,146,881	15,492

Table A.1 Waste generation and projections by country or economy (*contd.*)

Country or economy	Region	Income group (2022)	Country dataset (original year reported)			2022 projected		2030 projected		2040 projected		2050 projected	
			MSW generation (tonnes per year)	Population (000s)	Year	MSW generation (tonnes per year)	Population (000s)	MSW generation (tonnes per year)	Population (000s)	MSW generation (tonnes per year)	Population (000s)	MSW generation (tonnes per year)	Population (000s)
Tanzania	Sub-Saharan Africa	LMIC	14,800,000	61,894	2021	15,450,695	63,767	19,924,912	79,837	26,420,028	102,779	41,484,750	128,294
Thailand	E. Asia & Pacific	UMIC	26,950,000	71,716	2023	26,723,550	71,755	29,470,299	71,268	32,162,021	69,653	33,360,260	66,578
Timor-Leste	E. Asia & Pacific	LMIC	240,276	1,339	2021	201,508	1,362	213,144	1,509	311,786	1,709	353,408	1,881
Togo	Sub-Saharan Africa	LIC	348,000	9,196	2023	350,135	8,983	428,807	10,681	537,654	13,002	658,583	15,463
Tonga	E. Asia & Pacific	UMIC	9,476	106	2021	9,232	105	9,304	102	11,232	102	14,551	105
Trinidad and Tobago	L. Amer. & the Caribbean	HIC	780,000	1,484	2021	788,198	1,492	840,055	1,513	871,641	1,476	883,200	1,404
Tunisia	Mid. East & N. Africa	LMIC	2,810,000	11,929	2020	2,949,293	12,078	3,306,142	12,607	3,911,115	12,941	4,557,844	13,142
Türkiye	Eur. & Cent. Asia	UMIC	30,283,757	86,948	2022	30,283,757	86,948	34,435,116	88,890	38,020,274	90,951	40,030,989	91,311
Turkmenistan	Eur. & Cent. Asia	UMIC	750,000	6,433	2017	860,065	7,162	1,003,103	8,094	1,229,613	8,893	1,441,782	9,611
Turks and Caicos Islands	L. Amer. & the Caribbean	HIC	–	–	–	17,804	46	17,298	48	15,214	50	11,580	51
Tuvalu	E. Asia & Pacific	UMIC	1,643	11	2019	1,488	10	1,390	9	1,515	9	1,741	10
Uganda	Sub-Saharan Africa	LIC	10,554,334	46,644	2022	10,554,334	46,644	13,428,442	57,618	17,126,698	71,346	25,645,598	84,784
Ukraine	Eur. & Cent. Asia	LMIC	9,349,118	38,024	2023	11,161,413	44,073	11,453,278	38,505	12,590,190	35,427	12,889,404	32,165
United Arab Emirates	Mid. East & N. Africa	HIC	4,617,980	10,039	2022	4,617,980	10,039	5,892,146	12,123	6,860,709	13,614	7,786,395	15,279
United Kingdom	Eur. & Cent. Asia	HIC	31,418,575	67,422	2021	31,945,349	67,916	34,595,041	71,130	37,325,334	73,671	39,669,398	75,446
United States	N. Amer.	HIC	265,260,818	333,675	2018	274,658,377	340,593	295,060,574	354,856	313,933,391	369,568	328,445,978	380,413
Uruguay	L. Amer. & the Caribbean	HIC	1,250,583	3,400	2021	1,273,688	3,393	1,366,601	3,374	1,448,180	3,339	1,489,159	3,260
Uzbekistan	Eur. & Cent. Asia	LMIC	6,816,841	34,584	2022	6,816,841	34,584	8,109,623	39,944	11,442,214	45,751	14,835,789	51,905

Table A.1 Waste generation and projections by country or economy (*contd.*)

Country or economy	Region	Income group (2022)	Country dataset (original year reported)			2022 projected		2030 projected		2040 projected		2050 projected	
			MSW generation (tonnes per year)	Population (000s)	Year	MSW generation (tonnes per year)	Population (000s)	MSW generation (tonnes per year)	Population (000s)	MSW generation (tonnes per year)	Population (000s)	MSW generation (tonnes per year)	Population (000s)
Vanuatu	E. Asia & Pacific	LMIC	41,610	289	2019	40,185	309	50,503	369	63,131	447	77,068	530
Venezuela, RB	L. Amer. & the Caribbean	UMIC (2019)[a]	8,251,446	28,588	2020	8,281,901	28,175	9,120,460	29,082	10,204,127	30,444	11,000,980	31,078
Viet Nam	E. Asia & Pacific	LMIC	19,000,000	92,253	2015	21,071,803	99,332	22,725,550	104,008	29,161,554	108,276	32,946,361	110,021
Virgin Islands (U.S.)	L. Amer. & the Caribbean	HIC	146,500	106	2011	109,732	87	94,743	81	76,264	76	54,412	71
West Bank and Gaza	Mid. East & N. Africa	UMIC	1,580,000	4,904	2019	1,577,724	5,243	2,150,235	6,068	2,801,191	7,231	3,514,942	8,397
Yemen, Rep.	Mid. East & N. Africa	LIC	4,409,561	31,624	2016	5,764,174	37,651	8,033,879	47,084	11,223,727	58,602	14,877,902	70,388
Zambia	Sub-Saharan Africa	LMIC	4,352,733	19,875	2022	4,352,733	19,875	6,357,149	24,706	10,059,761	31,222	15,073,020	37,760
Zimbabwe	Sub-Saharan Africa	LMIC	2,500,000	15,394	2020	2,665,434	15,935	3,599,994	18,439	5,246,262	22,065	7,260,977	25,692

Sources: For country dataset (original year reported) sources, see table A.2. Population values for year of measurement and projections from 2022 onwards are from United Nations Department of Economic and Social Affairs Population Division. 2024. "World Population Prospects 2024: File Gen/01/Rev1: Demographic Indicators by Region, Subregion and Country, Annually for 1950-2100." Pop/Db/Wpp/Rev.2024/Gen/F01/Rev.1. Total Population, as of 1 January. https://population.un.org/wpp/downloads?folder=Standard%20Projections&group=Most%20used.
Note: The 'Year' under country dataset is the year in which date of measurement was recorded for 'MSW Generation (tonnes per year)'. 'Population' corresponds to the same 'Year' recorded in the country dataset section, for the methodology to calculate projections. Notes on individual data points are available in table A.2. All sources were accessed between December 2024 and October 2025.
To enable comparability of waste generation data, waste generation data were projected to a consistent baseline year of 2022 and also into the future for 2030, 2040, and 2050 (target years). This was done using a correlation between waste generation per capita and GDP per capita, PPP data (constant 2011 international $). The same correlation was used to estimate waste generation for the 16 countries for which data were unavailable. The 16 countries are Benin, Burundi, Chad, Djibouti, Eritrea, Guinea, Guinea-Bissau, Liberia, Lesotho, Mali, Namibia, Rwanda, Sierra Leone, Federal Republic of Somalia, South Sudan, and Turks and Caicos Islands. The estimated waste generation for each of the target years was multiplied by the United Nations population projections for those years. United Nations Department of Economic and Social Affairs Population Division. 2024. "World Population Prospects 2024: File Gen/01/Rev1: Demographic Indicators by Region, Subregion and Country, Annually for 1950-2100. Pop/Db/Wpp/Rev.2024/Gen/F01/Rev.1." https://population.un.org/wpp/downloads?folder=Standard%20Projections&group=Most%20used.
a. Venezuela, RB, classified as an upper-middle-income country until 2019, has been unclassified since then due to the unavailability of data.
MSW = municipal solid waste. Empty cells with "–" = not available.
Regional abbreviations: E. Asia & Pacific = East Asia and Pacific, Eur. & Cent. Asia = Europe and Central Asia, L. Amer. & the Caribbean = Latin America and the Caribbean, Mid. East & N. Africa = Middle East and North Africa, N. Amer. = North America, S. Asia = South Asia.
Income abbreviations: HIC = high-income country, LIC = low-income country, LMIC = lower-middle-income country, UMIC = upper-middle-income country.

Table A.2 Sources/references for waste generation by country or economy

Country or economy	Source/Reference	Note
Afghanistan	Afghanistan, National Environmental Protection Agency. 2019. "Afghanistan's National Inventory Report (NIR) 2019 submission under the United Nations Framework Convention on Climate Change (UNFCCC)."	
Albania	Albania, Institute of Statistics. 2022. "Urban Solid Waste, 2022."	
Algeria	Algeria, National Waste Agency. 2020. "Report on the State of Waste Management in Algeria." Ministry of Environment.	
American Samoa	Pacific Community. 2019. "Municipal Solid Waste." Stat Explorer. Pacific Data Hub.	Based on 0.94 kg/capita/day.
Andorra	UNSD (United Nations Statistics Division). 2024. "Hazardous waste generated." UNSD Environmental Indicators.	
Angola	Almeida, A.R.V. 2017. "Problems of Urban Solid Waste Management in Angola: Case Study: Province of Huila Municipality of Lubango." November.	Mean of 0.5 to 1.1 kg/capita/day.
Antigua and Barbuda	Caribbean Community Secretariat. 2017. "The CARICOM Environment in Figures 2014." Regional Statistics Programme.	Value represents household (20,900 t/year) + "other economic activities excluding ISIC 38" (9,400 t/year).
Argentina	Argentina, Undersecretariat of Environment. 2023. "State of the Environment Report 2023." Ministry of Tourism, Environment, and Sports, Government of Argentina.	Based on 53,000 t/day.
Armenia	ARMSTAT (Statistical Committee of the Republic of Armenia). n.d. ''Waste generation by NACE, hazardous classes and years.''	
Aruba	Arcadis. 2019. "Waste Processing in Aruba: Environmental comparison of waste processing methods."	
Australia	Blue Environment. 2022. "National Waste Report 2022." The Department of Climate Change, Energy, the Environment and Water, Government of Australia & Blue Environment Pty. Ltd.	
Austria	Austria, BMK (Federal Ministry for Climate Protection, Environment, Energy, Mobility, Innovation and Technology). 2023. "Federal Waste Management Plan (BAWP) 2023."	Based on sum of "Municipal waste from households" (4,456,984 t/year) and "Municipal waste of other origins" (2,804,373 t/year).
Azerbaijan	World Bank. 2021. "Azerbaijan–ARP II Solid Waste Management Project. Independent Evaluation Group, Project Performance Assessment Report 162952." Washington, DC: World Bank.	
Bahamas, The	Solid Waste and Circular Economy Hub. 2021. "Material Flow Management Status: Municipal solid waste (MSW) for Latin America and the Caribbean."	
Bahrain	Bahrain Open Data Portal. 2025. "Management of Municipal Waste." Information & eGovernment Authority.	Value represents waste collected from households.

Table A.2 Sources/references for waste generation by country or economy (*contd.*)

Country or economy	Source/Reference	Note
Bangladesh	Bangladesh Bureau of Statistics. 2022. "Key Findings on Environmental Protection Expenditure, Resource and Waste Management Survey 2022." Ministry of Planning.	Based on 0.5 kg/capita/day.
Barbados	Solid Waste and Circular Economy Hub. 2021. "Material Flow Management Status: Municipal solid waste (MSW) for Latin America and the Caribbean."	
Belarus	Belarus, National Statistical Committee. 2022. "I.1. Waste Generation."	
Belgium	Belgium, Statbel. 2024. "12.3% decrease in municipal waste per capita." Directorate-General for Statistics of the Federal Public Service Economy.	
Belize	Belize, BSWaMA (Belize Solid Waste Management Authority). 2015. "National Solid Waste Management Strategy & Implementation Plan." Ministry of Natural Resources & Agriculture.	
Bermuda	Bermuda, Department of Statistics. 2022. "Environmental Statistics Compendium 2022."	Includes "waste from households" and "waste from other origins".
Bhutan	[1] Bhutan, National Statistics Bureau. 2021. "Annual Environmental Accounts Statistics 2021." [2] Bhutan, National Statistics Bureau. 2019. "Nation's waste on the scale - National Waste Inventory Survey (NWIS-2019) Bhutan."	Based on MSW generation constituting "general waste" from various sources, while excluding industrial sources and medical waste. General waste from health care centers is included as it does not contain medical waste.
Bolivia	Bolivia, Ministry of Environment and Water. 2024. "National Diagnosis of Integrated Solid Waste Management in Bolivia."	
Bosnia and Herzegovina	Bosnia and Herzegovina, Agency for Statistics. 2023. "Public collection and disposal of municipal waste." November 29.	
Botswana	UNSD (United Nations Statistics Division). 2024. "Municipal waste treatment (Latest year)." UNSD Environmental Indicators.	Value represents collected waste.
Brazil	Abrelpe. 2022. "Overview of Solid Waste in Brazil 2022."	
British Virgin Islands	British Virgin Islands, Department of Waste Management. 2019. "Materials Management Plan for the British Virgin Islands - Final Report." July. Ministry of Health & Social Development.	Based on 150.94 t/day.
Brunei Darussalam	Chang, Emily C.C. 2021. "No time to waste." February 8. News. APEC-Flows. Dep. of Agricultural Economics, National Taiwan University.	
Bulgaria	Bulgaria, Ministry of Environment and Water. n.d. "Strategic Documents - National Waste Management Plan, 2021-2028."	Household waste is 2,862,000 t/year, 90% of which comprises household and similar wastes.

Table A.2 Sources/references for waste generation by country or economy (*contd.*)

Country or economy	Source/Reference	Note
Burkina Faso	UNSD (United Nations Statistics Division). 2023. "Composition of Municipal Waste." UNSD Environmental Indicators.	
Cabo Verde	Cabo Verde, Council of Ministers. 2016. "Decree-Law No. 32/2016." April 21.	Based on 0.874 kg/capita/day.
Cambodia	Pheakdey, Dek Vimean, Nguyen Van Quan, Tran Dang Khanh, and Tran Dang Xuan. 2022. "Challenges and Priorities of Municipal Solid Waste Management in Cambodia." *International Journal of Environmental Research and Public Health* 19 (14): 8458.	
Cameroon	EC & UNEP-GRID (European Commission and United National Environment Programme). 2022. "Interactive Country Fiches: Cameroon." Global Resource Information Database.	
Canada	[1] Environment and Climate Change Canada. 2020. "National Waste Characterization Report: The Composition of Canadian Residual Municipal Solid Waste." [2] Statistics Canada. 2021. "Waste Materials Diverted, by Type and by Source." March 8.	Based on waste disposed (24,996,000 t/year) and residential waste diverted (5,456,356 t/year).
Cayman Islands	Cayman Islands, ESO (Economics and Statistics Office). 2022. "Compendium of Statistics 2022." Environmental Health 2022.	Value represents "waste collected from commercial and residential".
Central African Republic	EC & UNEP-GRID (European Commission and United National Environment Programme). 2022. "Interactive Country Fiches: Central African Republic." Global Resource Information Database.	Based on 247.75 kg/capita/year.
Channel Islands	[1] States of Jersey. n.d. "Waste per person." Waste Management Statistics, Open Data. [2] Guernsey Waste. 2023. "Annual Waste Management Report 2023." States of Guernsey.	Based on 1.095 kg/capita/day in Jersey and 0.838 kg/capita/day (household waste only) in Guernsey.
Chile	Chile, SUBDERE (National Solid Waste Program). 2024. "National Synthesis Diagnosis and National Registry of Municipal Solid Waste." Regional Investment Management Department.	Calculated based on waste collected (8,381,822 t/year) and waste collection rate (96.5%).

Table A.2 Sources/references for waste generation by country or economy (*contd.*)

Country or economy	Source/Reference	Note
China	[1] City waste generation: China, MoHURD (Ministry of Housing and Urban-Rural Development). 2024. "1-13-1 National Urban Environmental Sanitation in Past Years." [1-13-1 全国历年城市市容环境卫生情况]. In: 2022 Urban and Rural Construction Statistical Yearbook. Beijing: Ministry of Housing and Urban-Rural Development. [2] County seat waste generation: China, MoHURD (Ministry of Housing and Urban-Rural Development). 2024. "2-12-2 County Seat Environmental Sanitation (2022)." [2-12-2 县城市容环境卫生 (2022年)]. In: 2022 Urban and Rural Construction Statistical Yearbook. Beijing: Ministry of Housing and Urban-Rural Development. [3] Rural waste generation: Bo, Yue, Zhang Zhibin, Sun Yingjie, and Li Hailing. 2014. "Study on the Generation Characteristics of Domestic Waste in Rural Areas of My Country: Characteristics of Rural Household Solid Wastes in China." [我国农村生活垃圾的产生特征研究]. Environmental Science and Technology [环境科学与技术], X799.3. [4] Town permanent population: China, MoHURD (Ministry of Housing and Urban-Rural Development). 2024. "3-2-2 Summary of Towns (2022)." [3-2-2 建制镇基本情况 (2022年)]. In: 2022 Urban and Rural Construction Statistical Yearbook. Beijing: Ministry of Housing and Urban-Rural Development. [5] Special district at township level population: China, MoHURD (Ministry of Housing and Urban-Rural Development). 2024. "3-2-18 Summary of Special District at Township Level (2022)." [3-2-18 镇乡级特殊区域基本情况 (2022年)]. In: 2022 Urban and Rural Construction Statistical Yearbook. Beijing: Ministry of Housing and Urban-Rural Development. [6] Township level population: China, MoHURD (Ministry of Housing and Urban-Rural Development). 2024. "3-2-10 Summary of Townships (2022)." [3-2-10 乡基本情况 (2022年)]. In: 2022 Urban and Rural Construction Statistical Yearbook. Beijing: Ministry of Housing and Urban-Rural Development. [7] County permanent population: China, MoHURD (Ministry of Housing and Urban-Rural Development). 2024. "2-2-2 County Seat Population and Construction Land (2022)." [2-2-2 全国县城人口和建设用地 (2022年)]. In: 2022 Urban and Rural Construction Statistical Yearbook. Beijing: Ministry of Housing and Urban-Rural Development. [8] County seat temporary and permanent population: China, MoHURD (Ministry of Housing and Urban-Rural Development). 2024."2-2-1 National Changes in Number of Counties, Population and Area in Past Years." [2-2-1 全国历年县城数量及人口、面积情况]. In: 2022 Urban and Rural Construction Statistical Yearbook. Beijing: Ministry of Housing and Urban-Rural Development.	The total generated MSW in China (502,607,448 t/year) comprises MSW from cities and county seats (244,450,000 tonnes and 67,050,000 t/year, respectively, based on MoHURD data) and the estimated MSW from rural areas (191,107,448 t/year). Rural waste generation is estimated and is calculated by multiplying rural population by 0.76 kg/capita/day MSW, then multiplied by 365 days, and divided by 1,000 to present the waste generation in tonnes per year. Note that the rural population in MoHURD is not explicitly reported as is the case for urban and county populations; therefore, rural population was estimated by subtracting permanent and temporary populations in urban areas and county seats from total population.
Colombia	Colombia, Superintendent of Public Services. 2023. "National Report on Final Disposal of Solid Waste 2022."	Includes waste disposed and utilized, as well as recycled waste.
Comoros	UN-Habitat. 2023. "Union of Comoros." Country Brief.	Based on 303.3 t/day.
Congo, Dem. Rep.	GEF (Global Environment Facility). 2016. "Promotion of Waste to Energy Options for Sustainable Urban Management in the Demoncratic Republic of the Congo - GEF-6 Project Identification Form (PIF)."	Based on 0.5 kg/capita/day.

Table A.2 Sources/references for waste generation by country or economy (*contd.*)

Country or economy	Source/Reference	Note
Congo, Rep.	Scarlat, N., V. Motola, J.F. Dallemand, F. Monforti-Ferrario, & L. Mofor. 2015. "Evaluation of energy potential of Municipal Solid Waste from African urban areas." *Renewable and Sustainable Energy Reviews*, 50, 1269-86.	Based on 0.52 kg/capita/day
Costa Rica	Solid Waste and Circular Economy Hub. 2021. "Material Flow Management Status: Municipal solid waste (MSW) for Latin America and the Caribbean."	
Côte d'Ivoire	Cote d'Ivoire, Ministry of the Environment and Sustainable Development & ECOWAS (Economic Community of West African States). 2021. "Report on the State of the Environment."	
Croatia	Croatia, Ministry of Economy and Sustainable Development. 2023. "Report on municipal waste for 2022."	
Cuba	UNSD (United Nations Statistics Division). 2024. "Municipal waste collected." UNSD Environmental Indicators.	Value represents municipal waste collected.
Curaçao	EcoVision. 2024. "Waste Characterization Study Curaçao - Transforming Waste to Value." Selikor N.V.	
Cyprus	CYSTAT (Cyprus Statistical Service). n.d. "Generation and Treatment of Municipal Solid Waste, Annual."	
Czech Republic	Czech Republic, Ministry of the Environment. 2022. "Message about the environment Czech Republic."	
Denmark	European Union, Eurostat. 2024. "Municipal waste by waste management operations." Data Browser.	
Dominica	Abdurrahim, T., R.C. Worden, & A. Sitara. 2022. "SWM Guidebook for senior policy makers in OECS countries on DRM and climate resilient SWM." Washington, DC: World Bank.	
Dominican Republic	Solid Waste and Circular Economy Hub. 2021. "Material Flow Management Status: Municipal solid waste (MSW) for Latin America and the Caribbean."	
Ecuador	Ecuador, National Institute of Statistics and Census. 2022. "Economic Environmental Information Statistics in Autonomous Governments Decentralized Municipal."	Value represents collected waste (14,394 t/day).
Egypt, Arab Rep.	Egypt, Ministry of Environment. 2021. "Egypt State of the Environment Report 2021."	
El Salvador	Solid Waste and Circular Economy Hub. 2021. "Material Flow Management Status: Municipal solid waste (MSW) for Latin America and the Caribbean."	
Equatorial Guinea	WACA (West Africa Coastal Areas Management Program). n.d. "Equatorial Guinea." Washington, DC: World Bank.	

Table A.2 Sources/references for waste generation by country or economy (*contd.*)

Country or economy	Source/Reference	Note
Estonia	Statistics Estonia. 2022. "Waste and circular economy."	
Eswatini	Swaziland, SEA (Swaziland Environment Authority). 2017. "National Inventory on Open Burning Practices and Unintentional Persistent Organic Pollutants (UPOPs) Releases." Ministry of the Tourism and Environmental Affairs.	
Ethiopia	GIZ (Deutsche Gesellschaft für Internationale Zusammenarbeit). 2023. "Sector Brief Ethiopia: Waste management and recycling."	Based on 12,200 t/day.
Faroe Islands	Nordic Competition Authorities. 2016. "Competition in the Waste Management Sector: Preparing for a Circular Economy."	Includes industrial wastes as they are processed in the same facilities.
Fiji	PRIF (Pacific Regional Infrastructure Facility). 2021. "Waste Audit Report Fiji: Consultants' Final Report." Pacific Region Infrastructure Facility, Asian Development Bank.	Based on 0.53 kg/capita/day.
Finland	Statistics Finland. n.d. "Municipal waste by treatment method in Finland, 2018-2022." StatsFin Waste Statistics.	
France	European Union, Eurostat. 2024. "Municipal waste by waste management operations." Data Browser.	Estimated provisional number for waste generated.
French Polynesia	France, French Agency for Ecological Transition & French Development Agency. 2022. "Diagnostic Plan climat de la Polynésie française."	Based on an estimated 299 kg/capita/year.
Gabon	UNFCCC (United Nations Framework Convention on Climate Change). 2021. "National Greenhouse Gas Inventory Report."	
Gambia, The	WACA (West Africa Coastal Areas Management Program). 2022. "The Gambia Plastic Country Brief." Washington, DC: World Bank.	
Georgia	World Bank. 2021. "Georgia Solid Waste Sector Assessment Report."	
Germany	European Union, Eurostat. 2024. "Municipal waste by waste management operations." Data Browser.	
Ghana	Ghana Statistical Service. 2020. "Environment Statistics Compendium, 2020." Environmental Protection Agency.	Value represents household waste only.
Gibraltar	Gibraltar, Department of the Environment, Sustainability, Climate Change and Heritage. 2021. "2021 Statistics Report - Thinking Green Digest."	Excludes bulky items and mattresses.
Greece	European Union, Eurostat. 2024. "Municipal waste by waste management operations." Data Browser.	
Greenland	Nordic Statistics. 2022. "WASTE01: Development in municipal waste generation and treatment by reporting country, unit, treatment and time."	Based on 749 kg/capita/year.

Table A.2 Sources/references for waste generation by country or economy (*contd.*)

Country or economy	Source/Reference	Note
Grenada	Abdurrahim, T., R.C. Worden, & A. Sitara. 2022. "SWM Guidebook for senior policy makers in OECS countries on DRM and climate resilient SWM." Washington, DC: World Bank.	
Guam	Guam Environmental Protection Agency. 2013. "Reaching for Zero: A Blueprint for Zero Waste in Guam." Guam Zero Waste Master Plan Volume 1.	Average of 129,000 to 154,000 t/year.
Guatemala	Solid Waste and Circular Economy Hub. 2021. "Material Flow Management Status: Municipal solid waste (MSW) for Latin America and the Caribbean."	
Guyana	Solid Waste and Circular Economy Hub. 2021. "Material Flow Management Status: Municipal solid waste (MSW) for Latin America and the Caribbean."	
Haiti	Solid Waste and Circular Economy Hub. 2021. "Material Flow Management Status: Municipal solid waste (MSW) for Latin America and the Caribbean."	
Honduras	Solid Waste and Circular Economy Hub. 2021. "Material Flow Management Status: Municipal solid waste (MSW) for Latin America and the Caribbean."	
Hong Kong SAR, China	Hong Kong SAR, China, Environmental Protection Department. 2022. "Monitoring of Solid Waste in Hong Kong - Waste Statistics for 2022." Statistics Unit.	Sum of waste disposal at landfill (68%) and waste recovered (32%).
Hungary	Hungarian Central Statistical Office. n.d. "The Volume of Each Type of Waste by Method of Treatment."	
Iceland	European Union, Eurostat. 2024. "Municipal waste by waste management operations." Data Browser.	
India	[1] India, NSKFDC (National Safai Karamcharis Finance and Development Corporation). n.d. "Cities with 1 lakh and above population as Census 2011." Ministry of Social Justice and Empowerment. [2] Census of India. 2011. "Basic Population Figures of India, States, Districts, Sub-District and Town (Without Ward), 2011." Office of the Registrar General & Census Commissioner, India. [3] World Bank. 2018. "Urban population SP.URB.TOTL." World Bank staff estimates based on the United Nations Population Division's World Urbanization Prospects: 2018 Revision. [4] India, National Sample Survey Office. 2010. "Housing Condition and Amenities in India 2008-09." NSS Report No. 535 (65/1.2/1). Ministry of Statistics and Programme Implementation. [5] World Bank. 2018. "Rural population SP.RUR.TOTL." World Bank staff estimates based on the United Nations Population Division's World Urbanization Prospects: 2018 Revision.	Urban MSW generation rates are reported for three population groups: >1 million (0.55 kg/capita/day); 0.1-1 million (0.45 kg/capita/day); and <0.1 million (0.30 kg/capita/day) (MoHUA 2021). The urban population in each group per Census 2011 (NSKFDC n.d.) is as follows: >1 million (114,150,034); 0.1-1 million (108,117,401); and <0.1 million (154,838,690) derived as net population (subtracting NSKFDC values from "Basic Population Figures of India, States, Districts, Sub-District and Town (Without Ward), 2011" (Census 2011).

Table A.2 Sources/references for waste generation by country or economy (*contd.*)

Country or economy	Source/Reference	Note
India *(contd.)*	[6] NIRD (National Institute of Rural Development & Panchayat Raj). 2016. *Solid Waste Management in Rural Areas - A Step-by-Step Guide for Gram Panchayats*. Centre for Rural Infrastructure. [7] World Bank and Ministry of Drinking Water and Sanitation. 2012. *Handbook on Scaling up Solid and Liquid Waste Management in Rural Areas.* [8] India, Ministry of Rural Affairs and UNICEF. 2008. "Technical Note on Solid and Liquid Waste Management in Rural Areas." Ministry of Drinking Water and Sanitation, Government of India & UNICEF. [9] India, MoHUA (Ministry of Housing and Urban Affairs). 2021. *Swachh Bharat Mission - Urban 2.0: Making Cities Garbage Free - Operational Guidelines October 2021*. Government of India.	The overall growth (32%) in urban population between 2011 (377,106,125) (Census 2011) and 2021 (498,179,071) (World Bank 2018) is then used to project population for each population group for 2021: >1 million (150,798,818); 0.1-1 million (142,829,360); and <0.1 million (204,550,893). The population in each group is multiplied by the per capita waste generation rate to establish the waste generation in each urban group for 2021: >1 million (30,272,863 t/year); 0.1-1 million (23,459,722 t/year), <0.1 million (22,398,323 t/year), which totals 76,130,908 t/year. Rural waste generation (0.3 million t/day), per Ministry of Rural Affairs and UNICEF (2008), is then divided by the 2008 rural population (789,527,300) to obtain the per capita rate of 0.38 kg/capita/day. The per capita rate multiplied by the 2021 rural population (909,384,771) (World Bank 2018) and by 365 (number of days) gives a total of 126,123,102 t/year. Total generation rate was, thus, calculated as rural (126,123,102 t/year) + urban (76,130,908 t/year) waste generation, which equals 202,254,010 t/year.
Indonesia	Indonesia, SIPSN (Sistem Informasi Pengelolaan Sampah Nasional). 2024. Email communication with World Bank to request formal waste management data on Indonesia. 11 September 2024.	
Iran, Islamic Rep.	Golhosseini, Zeynab & Mahdi Jalili Ghazizade. 2024. "Municipal Solid Waste Status in Iran: From Generation to Disposal." *Environmental Protection Research*, January, 16–29.	Based on 0.63 kg/capita/day.
Iraq	JICA (Japan International Cooperation Agency). 2022. "Data Collection Study on Solid Waste Management in Iraq."	Based on 49,424 t/day.
Ireland	Ireland, Environmental Protection Agency. 2023. "Municipal waste statistics for Ireland."	
Isle of Man	Isle of Man, Department of Environment, Food and Agriculture. 2023. "2023 Isle of Man Waste Returns Report."	
Israel	Israel, Central Bureau of Statistics. 2022. "Household and Commercial Waste Collected, by Type of Treatment and Local Authority."	Value represents household and commercial waste collected.
Italy	National Institute for Environmental Protection and Research. 2023. "Municipal Waste Report 2023 edition."	

Table A.2 Sources/references for waste generation by country or economy (*contd.*)

Country or economy	Source/Reference	Note
Jamaica	Solid Waste and Circular Economy Hub. 2021. "Material Flow Management Status: Municipal solid waste (MSW) for Latin America and the Caribbean."	
Japan	Japan, Ministry of the Environment. 2024. "Waste disposal in Japan." Environmental Regeneration and Resource Recycling Bureau. [環境再生・資源循環局2024年。「日本の廃棄物処理」。環境省。]	
Jordan	Jordan, Department of Statistics. 2022. "Jordan in Figures 2022."	
Kazakhstan	Kazakhstan, Bureau of National Statistics. 2024. "On the Management of Municipal Waste in the Republic of Kazakhstan (2023)." Agency for Strategic Planning and Reforms of the Republic of Kazakhstan.	Based on total volume of collected waste, including waste from self-collecting enterprises.
Kenya	UNSD (United Nations Statistics Division). 2025. "Kenya (2022)." Country Files from the UNSD/UNEP Questionnaire on Environment Statistics.	Based on MSW generated in three counties (Nairobi, Mombasa, Kisumu) in 2021.
Kiribati	SPREP (Secretariat of the Pacific Regional Environment Programme). 2023. "Kiribati National Waste Audit Analysis Report." Apia, Samoa.	Based on household waste (112 kg/capita/year).
Korea, Rep.	Korean Environment Corporation. 2022. "Nationwide Waste Generation and Disposal Status (Living, Workplace)." Environmental Statistics Information.	
Kosovo	European Union, Eurostat. 2024. "Municipal waste by waste management operations." Data Browser.	
Kuwait	GCC Statistical Centre. 2023. "Waste." GCC-Stat Data Portal.	Based on waste collected from households (2,272,000 t/year) and other sources (1,555,000 t/year).
Kyrgyz Republic	Kyrgyz Republic, National Statistical Committee. 2024. "Kyrgyzstan - Brief Statistical Handbook."	Based on household waste (279 kg/capita/year).
Lao PDR	Lao PDR, Ministry of Natural Resources and the Environment. 2017. "National Pollution Control Strategy and Action Plan 2018-2025, with Vision to 2030."	Sum of the following areas (t/year): Vientiane Capital 9 district (214,905), Kaisone/Savannakhet (39,575), Thakek/Khammouan (26,593), Luangprabang (23,927), Xayabury (22,919), Pakse (23,974), representing about 33% of the country's population.
Latvia	European Union, Eurostat. 2024. "Municipal waste by waste management operations." Data Browser.	
Lebanon	Lebanon, Ministry of Environment. 2023. "Summary of the Lebanon Solid Waste Roadmap for 2023-2026. Towards and Integrated Solid Waste Management System."	Based on an estimated 5,600 t/day.
Libya	Hamad, T.A., A.A. Agll, Y.M. Hamad, and J.W. Sheffield. 2014. "Solid waste as renewable source of energy: current and future possibility in Libya." *Case Studies in Thermal Engineering*, 4, 144-152.	

Table A.2 Sources/references for waste generation by country or economy (*contd.*)

Country or economy	Source/Reference	Note
Liechtenstein	Liechtenstein Statistical Office. 2023. "Waste 2022 Tables." StatistikPortal.	
Lithuania	European Union, Eurostat. 2024. "Municipal waste by waste management operations." Data Browser.	
Luxembourg	European Union, Eurostat. 2024. "Municipal waste by waste management operations." Data Browser.	Based on 721 kg/capita/year.
Macao SAR, China	Macao SAR, China, Environmental Protection Bureau. 2022. "Report on the State of the Environment of Macao 2022."	Based on quantity of MSW disposed and recycled. High per capita value potentially attributed to tourism and rapid economic development.
Madagascar	Madagascar, Ministry of Environment. 2019. "Chapter 10 Waste."	Mean of 0.3 to 0.4 kg/capita/day.
Malawi	African Clean Cities Platform. 2022. "Malawi." Country Profile.	Based on 8,500 t/day.
Malaysia	Malaysia, Department of Statistics. 2022. "Compendium of Environment Statistics, Malaysia, 2022." Ministry of Economy.	
Maldives	Moosa, L. 2021. "Maldives National Waste Accounts 2018 & 2019 Final Report." United Nations Economic and Social Commission for Asia and the National Bureau of Statistics, Maldives.	Value represents household waste.
Malta	Malta National Statistics Office. 2023. "Municipal Waste: 2022."	Based on 581 kg/capita/year.
Marshall Islands	Pacific Community. 2019. Municipal Solid Waste. Stat Explorer. Pacific Data Hub.	Based on 1.3 kg/capita/day.
Mauritania	WACA (West Africa Coastal Areas Management Program). 2022. "Mauritania Plastic Country Brief." Washington, DC: World Bank.	
Mauritius	Statistics Mauritius. 2023. "Digest of Environment Statistics 2022." Environment Statistics Unit, Ministry of Environment, Solid Waste Management and Climate Change.	Value for the amount of domestic and commercial waste disposed of at Mare Chicose Landfill, the only landfill in Mauritius.
Mexico	Solid Waste and Circular Economy Hub. 2021. "Material Flow Management Status: Municipal solid waste (MSW) for Latin America and the Caribbean."	
Micronesia, Fed. Sts.	SPREP (Secretariat of the Pacific Regional Environment Programme). 2022. "Solid Waste Management Country Profile: Federated States of Micronesia." Apia, Samoa: SPREP (J-PRISM II).	Based on MSW generated by each state (t/day): Pohnpei (46), Chuuk (13), Kosrae (7), and Yap (9).
Moldova	Moldova, Ministry of Agriculture and Food Industry. n.d. "Annex No. 1 to Government Decision No. NATIONAL PROGRAM for waste management for the years 2022-2027."	
Monaco	CIA (Central Intelligence Agency). 2021. The World Factbook 2021. Monaco.	

Table A.2 Sources/references for waste generation by country or economy (*contd.*)

Country or economy	Source/Reference	Note
Mongolia	Mongolia, National Statistics Office. 2019. "Solid Waste Account 2018-2019 (Хатуу хог хаягдлын данс, 2018-2019)."	Assumed to be household waste, based on "Өрхөд бий болсон" translated as "Created in the family".
Montenegro	MONSTAT (Statistical Office of Montenegro). n.d. "Table 1 Generated and treated amounts of waste 2011-2022."	
Morocco	Kingdom of Morocco High Commission for Planning. 2023. "Statistical Yearbook of Morocco, Year 2023."	Value represents household waste in urban and rural areas.
Mozambique	Club of Mozambique. 2023. "Mozambique generates 4.2 million tonnes of solid waste per year." 9 June.	Value represents total solid waste.
Myanmar	IGES (Institute for Global Environmental Strategies). 2020. "Digging Through - An Inside Look at Municipal Waste Management in Myanmar."	Based on 20,480 t/day.
Nauru	SPREP (Secretariat of the Pacific Regional Environment Programme). 2023 "Nauru National Waste Audit Analysis Report." Apia, Samoa.	Based on household waste (49 kg/capita/year).
Nepal	Centre for Green Economy Development. 2023. "Plastic Waste Management in Nepal." Nepal.	Based on 4,900 t/day.
Netherlands	European Union, Eurostat. 2024. "Municipal waste by waste management operations." Data Browser.	
New Caledonia	SPREP (Secretariat of the Pacific Regional Environment Programme). 2022. "Cleaner Pacific 2025: Pacific Regional Waste and Pollution Management Strategy 2016 - 2025, Mid-term Review Report." Apia, Samoa.	Based on urban MSW per capita of 1.07 kg/capita/day.
New Zealand	OECD (Organisation for Economic Co-operation and Development). 2024. "Waste - Municipal waste: generation and treatment." OECD. Stat.	Based on scope of MSW, value contains a high proportion of C&D waste.
Nicaragua	Solid Waste and Circular Economy Hub. 2021. "Material Flow Management Status: Municipal solid waste (MSW) for Latin America and the Caribbean."	
Niger	Niger, Executive Secretariat. 2022. "Niger's First Biennial Update Report on Climate Change." Office of the Prime Minister.	
Nigeria	World Bank. 2024. "Improving Solid Waste and Plastics Management in Lagos State: A Way Forward." Washington, DC: World Bank.	
North Macedonia	North Macedonia, State Statistical Office. 2024. "Municipal waste, 2023."	

Table A.2 Sources/references for waste generation by country or economy (*contd.*)

Country or economy	Source/Reference	Note
Northern Mariana Islands	Commonwealth of the Northern Mariana Islands, Office of Planning and Development. 2023. "Comprehensive Integrated Solid Waste Management Plan for the Commonwealth of the Northern Mariana Islands."	Based on 3.8 lb/capita/day.
Norway	European Union, Eurostat. 2024. "Municipal waste by waste management operations." Data Browser.	
Oman	Oman, National Centre for Statistics & Information. 2022. "Municipal Waste Generated."	
Pakistan	Shafique, Saima & Tom Clark. 2022. "Waste Management in Pakistan." The European Commission, SWITCH-Asia Programme.	
Palau	SPREP (Secretariat of the Pacific Regional Environment Programme). 2017. "National Solid Waste Management Strategy: The Roadmap towards a Clean and Safe Palau 2017 to 2026." Apia, Samoa.	Based on Koror and Babeldaob Islands, which encompass ~97% of the country's population (2.008 kg/capita/day).
Panama	Solid Waste and Circular Economy Hub. 2021. "Material Flow Management Status: Municipal solid waste (MSW) for Latin America and the Caribbean."	
Papua New Guinea	SPREP (Secretariat of the Pacific Regional Environment Programme). 2020. "Indicators 28 and 29 of 31 in State of Environment and Conservation in the Pacific Islands: 2020 Regional Report." Apia, Samoa.	Based on an estimated 0.47 kg/capita/day.
Paraguay	Ministry of Environment and Sustainable Development (MADES). 2020. "National Plan for the Comprehensive Management of Urban Solid Waste in Paraguay." MADES, Paraguay. [Ministerio Del Ambiente Y Desarrollo Sostenible (MADES). 2020. "Plan Nacional para la Gestión Integral de Residuos Sólidos Urbanos del Paraguay." MADES, Paraguay.]	Based on 1.2 kg/capita/day.
Peru	Solid Waste and Circular Economy Hub. 2021. "Material Flow Management Status: Municipal solid waste (MSW) for Latin America and the Caribbean."	
Philippines	Philippines, Environmental Management Bureau. 2018. "National Solid Waste Management Status Report [2008-2018]." Department of Environment and Natural Resources.	
Poland	Statistics Poland. 2023. "Housing economy and municipal infrastructure in 2022."	Based on 355 kg/capita/year; combines both mixed and separate collections.
Portugal	Portuguese Environment Agency. 2023. "Annual Urban Waste Report." Amadora: AgÍncia Portuguesa do Ambiente.	Based on 507 kg/capita/year.
Puerto Rico	Circular Generation. 2021. "Toward a Circular Economy." July.	Based on 8,290.5 t/day.
Qatar	Qatar, Planning and Statistics Authority. 2022. "Environmental Statistics in State of Qatar."	
Romania	European Union, Eurostat. 2024. "Municipal waste by waste management operations." Data Browser.	

Table A.2 Sources/references for waste generation by country or economy (*contd.*)

Country or economy	Source/Reference	Note
Russian Federation	Russian Federation, Ministry of Natural Resources and Ecology. 2023. "On the state and protection of the environment of the Russian Federation in 2022."	
Samoa	SPREP (Secretariat of the Pacific Regional Environment Programme). 2023. "Samoa National Waste Audit Analysis Report." Apia, Samoa.	Based on 0.257 kg/capita/day.
San Marino	San Marino, AASS (Azienda Autonoma di Stato per i Servizi Pubblici). 2019. "Collection Data."	
São Tomé and Príncipe	São Tomé and Príncipe, GDE (General Directorate of the Environment). 2018. "Minamata Initial Assessment Report: São Tomé and Príncipe."	
Saudi Arabia	Saudi Arabia, General Authority for Statistics. 2023. "Environmental Statistics Publication 2022."	
Senegal	Trinomics. 2022. "Sector Report Circular Economy Senegal." The Netherlands, Ministry of Foreign Affairs, RVO (Netherlands Enterprise Agency).	
Serbia	Serbia, Ministry of Environmental Protection. 2022. "Waste Management in the Republic of Serbia In the Period 2011-2021."	
Seychelles	Talma, E. & Michele Martin. 2013. "The Status of Waste Management in Seychelles." Seychelles: Sustainability for Seychelles, GEF, SGP, & UNDP.	Based on waste received at landfills (Providence, Praslin, and La Digue).
Singapore	Singapore, National Environment Agency. n.d. "Waste Statistics and Overall Recycling - Key Highlights of the 2023 Waste and Recycling Statistics."	Based on 0.88 kg/capita/day.
Sint Maarten (Dutch)	[1] Sint Maarten, VROMI (Ministry of Public Housing, Spatial Planning, Environment & Infrastructure). 2020. "Draft Report for Short Term Plan & Pre-Feasibility Studies of Landfill Upgrade & Extension and Integrated Solid Waste Management Facility (ISWMF)." January 3. Sint Maarten Sustainable Solid Waste Management Project: Consultancy Services for Establishing Integrated Solid Waste Management System in Sint Maarten. [2] World Bank. 2024. "Sint Maarten Overview." Last updated April 11. Washington, DC: World Bank.	Waste generation rate, excluding C&D waste is 3.53 kg/capita/day.
Slovak Republic	Statistical Office of the Slovak Republic. 2023. "Waste in the Slovak Republic in 2022."	
Slovenia	SiStat (Slovenia Statistical Office). n.d. "Municipal waste generated and treatment (tonnes), Slovenia, annually."	
Solomon Islands	SPREP (Secretariat of the Pacific Regional Environment Programme). 2017. "Solid Waste Management in the Pacific - The Nine Countries Covered by J-PRISM II." Apia, Samoa: SPREP (J-Prism II).	Based on 860 g/capita/day.

Table A.2 Sources/references for waste generation by country or economy (*contd.*)

Country or economy	Source/Reference	Note
South Africa	South Africa, Department of Forestry, Fisheries and the Environment. 2023. South African Waste Information Centre (SAWIC). Database.	Value includes disposal (7,018,927.7 t/year), treatment (1,670 t/year), and waste recovery or recycling (975,034.6 t/year). Figure likely includes only formally managed waste.
Spain	Spain, Instituo Nacional de Estadística. n.d. "Waste generation by type of waste, hazardous nature and economic activity sectors."	Calculated as the sum of: Wholesale and retail trade, repair of motor vehicles and motorcycles, transportation and storage, hospitality, information and communications, financial and insurance activities, real estate activities, professional, scientific and technical activities, administrative activities and auxiliary services, administration public and defence, mandatory social security, education, health and social service, artistic, recreational and entertainment activities, repair of household items and other services, and HH: Homes.
Sri Lanka	Sri Lanka, Ministry of Environment. 2021. "Guidelines for Safe Closure and Rehabilitation of Municipal Solid Waste Dumpsites in Sri Lanka."	Based on 8,142 t/day.
St. Kitts and Nevis	Abdurrahim, T., R.C. Worden, & A. Sitara. 2022. "SWM Guidebook for senior policy makers in OECS countries on DRM and climate resilient SWM." Washington, DC: World Bank.	
St. Lucia	Abdurrahim, T., R.C. Worden, & A. Sitara. 2022. "SWM Guidebook for senior policy makers in OECS countries on DRM and climate resilient SWM." Washington, DC: World Bank.	
St. Martin (French)	Verde Environnement. SXM. 2022. "Rapport Annuel Dossier d'information Année 2021 Installation de Stockage de Déchets non Dangereux des Grandes Cayes. » Collectivité de Saint-Martin / DEAL Guadeloupe.	
St. Vincent and the Grenadines	Abdurrahim, T., R.C. Worden, & A. Sitara. 2022. "SWM Guidebook for senior policy makers in OECS countries on DRM and climate resilient SWM." Washington, DC: World Bank.	
Sudan	UNEP (United Nations Environmental Programme). 2020. "Sudan - First State of Environment and Outlook Report 2020."	Based on 0.5 kg/capita/day.
Suriname	Suriname, Ministry of Spatial Planning & Environment. 2022. "Preparation of an Integrated Waste Management Plan (IWMP) for Suriname - Final Report." Prepared by ILACO.	
Sweden	European Union, Eurostat. 2024. "Municipal waste by waste management operations." Data Browser.	

Table A.2 Sources/references for waste generation by country or economy (*contd.*)

Country or economy	Source/Reference	Note
Switzerland	Switzerland, Federal Office for the Environment. n.d. "Waste Statistics."	
Syrian Arab Republic	Syria, Planning and International Cooperation Authority. 2020. "First Voluntary National Review of the Sustainable Development Goals 2020." United Nations Department of Economic and Social Affairs.	Based on 0.185 t/year.
Taiwan, China	Taiwan, China, Ministry of Environment. 2024. "Table 4-1 Generation and Treatment of Municipal Waste." Local Environmental Protection Bureaus.	
Tajikistan	UNEP (United Nations Environmental Programme). 2017. "Waste Management Outlook for Central Asia."	Mean of 1 to 2 million t/year.
Tanzania	Biswas, A. & Siddharth Ghanshyam Singh. 2021. "Tanzania: An Assessment of the Solid Waste-Management Ecosystem." Centre for Science and Environment.	Mean of 12.1 to 17.4 million t/year.
Thailand	Thailand, Pollution Control Department. 2023. "Information System for Community Solid Waste Management."	
Timor-Leste	SPREP (Secretariat of the Pacific Regional Environment Programme). 2022. "Waste Audit Report Timor Leste." Apia, Samoa.	Based on a weighted average of rural (69% of population): 0.56 kg/capita/day and urban (31%): 0.34 kg/capita/day.
Togo	West African Development Bank. 2023. "Etude sur la gestion durable des déchets ménagers et industriels en vue de la production d'énergie." [Study on Sustainable Management of Household and Industrial Waste in WAEMU Member States for Energy Production.]	Value represents household waste ("Dechets menagers").
Tonga	SPREP (Secretariat of the Pacific Regional Environment Programme). 2023. "Tonga National Waste Audit Analysis Report." Apia, Samoa.	
Trinidad and Tobago	Trinidad and Tobago, SWMCOL (Solid Waste Management Company). 2023. "D-5 Waste Characterization and Centroid Study Report - Final Report." Consulting Services for a Waste Characterization Study in Trinidad and Tobago.	
Tunisia	MALE & USAID (Ministry of Local Affairs and Environment & United States Agency for International Development). 2021. "Integrated Sustainable National Management Strategy for Household and Similar Waste 2020-2035."	
Türkiye	TurkStat (Turkish Statistical Institute). 2023. "Waste Statistics, 2022."	
Turkmenistan	UNEP (United Nations Environmental Programme). 2017. "Waste Management Outlook for Central Asia."	Mean of 0.5 to 1 million tonnes.

Table A.2 Sources/references for waste generation by country or economy (*contd.*)

Country or economy	Source/Reference	Note
Tuvalu	Sagapolutele, F., A. Wander, & A. Prince. 2019. "Tuvalu Waste Audit Report - Including analysis of waste generation and disposal data collected in September 2019." Pacific Region Infrastructure Facility (PRIF).	Based on type and quantity of materials produced.
Uganda	GGGI. 2025. *Uganda's Green Leap: New Waste Management Policy Paves the Way for a Sustainable Future.* March 19. Event Write-Ups.	
Ukraine	Ukraine, Ministry of Infrastructure. 2024. "Report on the status of household waste management in Ukraine for 2023: Report 1 - MSW section 1 for 2023."	Value represents amount of waste collected from households.
United Arab Emirates	UAE.Stat. 2023. "Quantity of Collected Non Hazardous Waste by Emirate, Source, Method of Treatment and Disposing." Federal Competitiveness and Statistics Centre.	
United Kingdom	[1] OECD (Organisation for Economic Co-operation and Development). 2021. "Municipal Waste." OECD.Stat. [2] OECD (Organisation for Economic Co-operation and Development). n.d. "Population."	Based on 0.466 t/capita/year.
United States	US Environmental Protection Agency. 2020. "Advancing Sustainable Materials Management: 2018 Fact Sheet: Assessing Trends in Materials Generation and Management in the United States."	292.4 million short tonnes converted to tonnes.
Uruguay	Solid Waste and Circular Economy Hub. 2021. "Material Flow Management Status: Municipal solid waste (MSW) for Latin America and the Caribbean."	
Uzbekistan	Uzbekistan, Ministry of Ecology, Environmental Protection and Climate Change. 2023. "National state of the environment report: Uzbekistan." International Institute for Sustainable Development.	
Vanuatu	SPREP (Secretariat of the Pacific Regional Environment Programme). 2022. "Solid Waste Management Country Profile: Vanuatu." Apia, Samoa.	Based on 114 t/day.
Venezuela, RB	UNSD (United Nations Statistics Division). n.d. "Generation of Municipal Waste." Venezuela. 2022 Environmental Statistics Questionnaire R3.	Value represents collected waste (22,606.7 t/day).
Viet Nam	GIZ (Deutsche Gesellschaft für Internationale Zusammenarbeit). 2018. "Country Profile Vietnam: Managing Municipal Solid Waste and Packaging Waste."	
Virgin Islands (US)	Davis, J., S. Haase, & A. Warren. 2011. "Waste-to-Energy Evaluation: U.S. Virgin Islands." Technical Report NREL/TP-7A20-52308. National Renewable Energy Laboratory (NREL), Office of Energy Efficiency and Renewable Energy, Department of Energy, Government of United States of America.	Based on 65,000 t/year collected in St. Thomas and 81,500 t/year collected in St. Croix.
West Bank and Gaza	Heinrich Boll Stiftung. 2020. "Palestine: Solid Waste Management under Occupation."	Based on 0.9 kg/capita/day in the West Bank and 0.7 kg/capita/day in Gaza.

Table A.2 Sources/references for waste generation by country or economy (*contd.*)

Country or economy	Source/Reference	Note
Yemen, Rep.	UNEP (United Nations Environmental Programme. 2019. "Waste Management Outlook for West Asia."	
Zambia	Makuyana, C.M., A. Chinyepe, N.M. Navarro, M. Derks, E.A. Amadi, R.O. Ombega, P. van den Oosterkamp, D. Kiplagat, & T. Bastein. 2022. "Development of a Waste Stream-Specific Roadmap for the Circular Economy Zambia: Sub Report Output 2 - Baseline Assessment and Analysis of Existing Circular Economy Initiatives and Key Players in Zambia." The Netherlands Organisation for Applied Scientific Research.	Based on an estimated 0.6 kg/capita/day of waste generated. Includes collected waste only.
Zimbabwe	Zimbabwe, MoECTHI (Ministry of Environment, Climate, Tourism and Hospitality Industry). 2021. "Zimbabwe's First Biennial Update Report 2020: Measurement, reporting and verification (MRV), Mitigation."	Data do not explicitly refer to MSW in source.

Note: C&D = construction and demolition, g = gram, kg = kilogram, t = tonne, lb = pound, MSW = municipal solid waste, SAR = Special Administrative Region, t/day = tonnes per day, t/year = tonnes per year.

Appendix B
Waste Treatment and Disposal by Country or Economy

Table B.1 presents the municipal solid waste treatment and disposal mix by country or economy. Table B.2 provides the sources/references and notes on data, if applicable, for the values provided in table B.1.

Table B.1 Proportion of waste treatment and disposal by country or economy

Country or economy	Region	Income group (2022)	Recycling (%)	Com-posting (%)	Anaerobic digestion (%)	Inciner-ation (%)	Mechanical biological treatment (MBT) (%)	Refuse-derived fuel (RDF) (%)	Sanitary landfill (%)	Con-trolled landfill (%)	Unspeci-fied landfill (%)	Open dumping (%)	Other (%)	Uncol-lected (%)	Unac-counted for (%)
Afghanistan	S. Asia	LIC	18.90%	6.50%	–	7.70%	–	–	–	–	23.10%		3.10%	40.80%	–
Albania	Eur. & Cent. Asia	UMIC	17.33%	–	–	4.07%	–	–	–	–	70.29%	0.09%	–	8.22%	–
Algeria	Mid. East & N. Africa	LMIC	7.00%	1.00%	–	–	–	–	–	32.00%	–	60.00%	–	–	–
American Samoa	E. Asia & Pacific	HIC	–	–	–	–	–	–	–	–	–	–	–	–	–
Andorra	Eur. & Cent. Asia	HIC	39.90%	–	–	57.60%	–	–	–	–	2.50%	–	–	–	–
Angola	Sub-Saharan Africa	LMIC	–	–	–	–	–	–	–	–	–	–	–	–	–
Antigua and Barbuda	L. Amer. & the Caribbean	HIC	–	–	–	–	–	–	–	49.50%	–	49.50%	–	1.00%	–
Argentina	L. Amer. & the Caribbean	UMIC	–	–	–	–	–	–	64.70%	24.60%	–	9.90%	–	–	0.80%
Armenia	Eur. & Cent. Asia	UMIC	0.20%	–	–	–	–	–	–	–	–	68.50%	–	–	31.30%
Aruba	L. Amer. & the Caribbean	HIC	12.95%	–	–	–	–	–	–	–	84.94%	–	2.11%	–	–
Australia	E. Asia & Pacific	HIC	36.16%	5.73%	–	0.04%	–	–	57.85%	–	–	–	0.22%	–	–
Austria	Eur. & Cent. Asia	HIC	51.47%	–	17.15%	29.25%	–	–	1.68%	–	–	–	0.46%	–	–
Azerbaijan	Eur. & Cent. Asia	UMIC	–	–	–	14.42%	–	–	–	–	53.24%	–	0.34%	32.00%	–

Table B.1 Proportion of waste treatment and disposal by country or economy *(contd.)*

Country or economy	Region	Income group (2022)	Recycling (%)	Com-posting (%)	Anaerobic digestion (%)	Inciner-ation (%)	Mechanical biological treatment (MBT) (%)	Refuse-derived fuel (RDF) (%)	Sanitary landfill (%)	Con-trolled landfill (%)	Unspeci-fied landfill (%)	Open dumping (%)	Other (%)	Uncol-lected (%)	Unac-counted for (%)
Bahamas, The	L. Amer. & the Caribbean	HIC	–	–	–	–	–	–	–	–	–	79.00%	–	21.00%	–
Bahrain	Mid. East & N. Africa	HIC	27.74%	0.04%	–	–	–	–	–	–	70.72%	–	1.49%	–	–
Bangladesh	S. Asia	LMIC	3.14%	–	–	0.29%	–	–	–	–	55.01%	1.00%	20.88%	19.37%	–
Barbados	L. Amer. & the Caribbean	HIC	4.28%	–	–	–	–	–	–	80.26%	–	–	–	10.00%	5.54%
Belarus	Eur. & Cent. Asia	UMIC	33.90%	–	–	–	–	–	–	–	66.09%	–	–	–	–
Belgium	Eur. & Cent. Asia	HIC	33.28%	18.55%	–	46.14%	–	–	0.18%	–	–	–	0.89%	–	0.97%
Belize	L. Amer. & the Caribbean	UMIC	–	–	–	–	–	–	–	–	–	72.77%	–	27.23%	–
Benin	Sub-Saharan Africa	LMIC	25.00%	–	–	–	–	–	–	–	–	–	–	–	75.00%
Bermuda	N. Amer.	HIC	1.64%	19.18%	–	65.48%	–	–	–	–	13.70%	–	–	–	–
Bhutan	S. Asia	LMIC	23.73%	–	–	–	–	–	–	–	42.33%	–	–	32.83%	1.12%
Bolivia	L. Amer. & the Caribbean	LMIC	3.89%	8.00%	–	–	–	–	34.20%	32.90%	–	–	–	29.86%	–
Bosnia and Herzegovina	Eur. & Cent. Asia	UMIC	–	–	–	–	–	–	–	78.37%	–	–	–	21.63%	–
Botswana	Sub-Saharan Africa	UMIC	0.63%	–	–	–	–	–	–	–	75.69%	–	–	23.69%	–

Table B.1 Proportion of waste treatment and disposal by country or economy *(contd.)*

Country or economy	Region	Income group (2022)	Recycling (%)	Com-posting (%)	Anaerobic digestion (%)	Inciner-ation (%)	Mechanical biological treatment (MBT) (%)	Refuse-derived fuel (RDF) (%)	Sanitary landfill (%)	Con-trolled landfill (%)	Unspeci-fied landfill (%)	Open dumping (%)	Other (%)	Uncol-lected (%)	Unac-counted for (%)
Brazil	L. Amer. & the Caribbean	UMIC	1.63%	–	–	–	–	–	67.37%	10.89%	–	13.10%	–	7.00%	–
British Virgin Islands	L. Amer. & the Caribbean	HIC	–	–	–	80.25%	–	–	–	–	–	19.74%	–	–	–
Brunei Darussalam	E. Asia & Pacific	HIC	11.30%	–	–	–	–	–	–	–	88.70%	–	–	–	–
Bulgaria	Eur. & Cent. Asia	UMIC	28.19%	2.76%	–	4.00%	–	–	–	–	59.08%	–	–	–	5.96%
Burkina Faso	Sub-Saharan Africa	LIC	–	–	–	–	–	–	–	–	17.00%	9.00%	11.00%	54.00%	9.00%
Burundi	Sub-Saharan Africa	LIC	–	–	–	–	–	–	–	–	–	–	–	–	–
Cabo Verde	Sub-Saharan Africa	LMIC	–	–	–	–	–	–	5.10%	–	–	94.50%	–	–	–
Cambodia	E. Asia & Pacific	LMIC	4.00%	2.00%	–	4.00%	–	–	–	–	44.00%	–	–	46.00%	–
Cameroon	Sub-Saharan Africa	LMIC	–	–	–	–	–	–	–	–	–	–	–	–	–
Canada	N. Amer.	HIC	35.52%	–	–	1.93%	–	–	–	–	62.54%	–	–	–	–
Cayman Islands	L. Amer. & the Caribbean	HIC	1.82%	–	–	0.27%	–	–	–	–	97.91%	–	–	–	–
Central African Republic	Sub-Saharan Africa	LIC	–	–	–	–	–	–	–	–	–	–	–	–	–
Chad	Sub-Saharan Africa	LIC	–	–	–	–	–	–	–	–	–	–	–	–	–

Table B.1 Proportion of waste treatment and disposal by country or economy *(contd.)*

Country or economy	Region	Income group (2022)	Recycling (%)	Com-posting (%)	Anaerobic digestion (%)	Inciner-ation (%)	Mechanical biological treatment (MBT) (%)	Refuse-derived fuel (RDF) (%)	Sanitary landfill (%)	Con-trolled landfill (%)	Unspeci-fied landfill (%)	Open dumping (%)	Other (%)	Uncol-lected (%)	Unac-counted for (%)
Channel Islands	Eur. & Cent. Asia	HIC	23.43%	4.24%	–	24.26%	–	7.93%	40.14%	–	–	–	–	–	–
Chile	L. Amer. & the Caribbean	HIC	0.73%	0.01%	–	–	–	–	80.01%	11.93%	–	1.43%	1.89%	4.00%	–
China	E. Asia & Pacific	UMIC	–	–	–	74.80%	–	–	18.46%	–	–	–	6.71%	0.30%	–
Colombia	L. Amer. & the Caribbean	UMIC	16.91%	–	–	–	–	–	66.99%	0.95%	–	1.36%	–	13.79%	–
Comoros	Sub-Saharan Africa	LMIC	–	–	–	–	–	–	–	–	–	–	–	–	–
Congo, Dem. Rep.	Sub-Saharan Africa	LIC	4.90%	–	–	–	–	–	–	–	19.70%	–	–	–	75.40%
Congo, Rep.	Sub-Saharan Africa	LMIC	26.20%	–	–	–	–	–	–	–	–	–	–	56.89%	16.91%
Costa Rica	L. Amer. & the Caribbean	UMIC	3.95%	2.70%	–	–	–	2.98%	–	–	79.21%	–	–	11.15%	–
Côte d'Ivoire	Sub-Saharan Africa	LMIC	–	–	–	–	–	–	–	–	–	–	–	–	–
Croatia	Eur. & Cent. Asia	HIC	26.09%	3.60%	0.90%	–	8.10%	–	50.38%	–	–	–	0.90%	–	10.03%
Cuba	L. Amer. & the Caribbean	UMIC	8.18%	–	–	–	–	–	–	–	–	91.82%	–	–	–
Curaçao	L. Amer. & the Caribbean	HIC	37.22%	–	–	–	–	–	–	57.92%	–	–	–	4.48%	–

Table B.1 Proportion of waste treatment and disposal by country or economy *(contd.)*

Country or economy	Region	Income group (2022)	Recycling (%)	Com-posting (%)	Anaerobic digestion (%)	Inciner-ation (%)	Mechanical biological treatment (MBT) (%)	Refuse-derived fuel (RDF) (%)	Sanitary landfill (%)	Con-trolled landfill (%)	Unspeci-fied landfill (%)	Open dumping (%)	Other (%)	Uncol-lected (%)	Unac-counted for (%)
Cyprus	Eur. & Cent. Asia	HIC	13.14%	1.65%	–	2.39%	–	–	–	–	59.08%	–	–	–	23.74%
Czech Republic	Eur. & Cent. Asia	HIC	30.13%	12.51%	–	11.92%	–	–	45.44%	–	–	–	–	–	–
Denmark	Eur. & Cent. Asia	HIC	31.22%	26.34%	–	41.35%	–	–	1.09%	–	–	–	–	–	–
Djibouti	Mid. East & N. Africa	LMIC	–	–	–	–	–	–	–	–	62.00%	–	–	–	38.00%
Dominica	L. Amer. & the Caribbean	UMIC	–	–	–	–	–	–	–	–	–	–	–	–	–
Dominican Republic	L. Amer. & the Caribbean	UMIC	6.00%	–	–	–	–	–	–	28.34%	–	55.24%	–	10.42%	–
Ecuador	L. Amer. & the Caribbean	UMIC	0.12%	0.59%	–	–	–	–	–	–	7.09%	73.11%	–	19.10%	–
Egypt, Arab Rep.	Mid. East & N. Africa	LMIC	12.50%	7.00%	–	–	–	–	7.00%	–	–	38.50%	–	35.00%	–
El Salvador	L. Amer. & the Caribbean	UMIC	–	0.65%	–	–	–	–	–	–	71.38%	–	–	27.96%	–
Equatorial Guinea	Sub-Saharan Africa	UMIC	–	–	–	–	–	–	–	–	–	–	–	–	–
Eritrea	Sub-Saharan Africa	LIC	–	–	–	–	–	–	–	–	–	–	–	–	–
Estonia	Eur. & Cent. Asia	HIC	32.88%	4.50%	–	47.75%	–	–	–	–	14.86%	–	–	–	–
Eswatini	Sub-Saharan Africa	LMIC	29.41%	–	–		–	–	–	–	25.95%	–	–	–	44.65%

Table B.1 Proportion of waste treatment and disposal by country or economy *(contd.)*

Country or economy	Region	Income group (2022)	Recycling (%)	Com-posting (%)	Anaerobic digestion (%)	Inciner-ation (%)	Mechanical biological treatment (MBT) (%)	Refuse-derived fuel (RDF) (%)	Sanitary landfill (%)	Con-trolled landfill (%)	Unspeci-fied landfill (%)	Open dumping (%)	Other (%)	Uncol-lected (%)	Unac-counted for (%)
Ethiopia	Sub-Saharan Africa	LIC	3.82%	–	–	1.82%	–	–	–	–	34.36%	–	–	60.00%	–
Faroe Islands	Eur. & Cent. Asia	HIC	29.57%	–	–	63.65%	–	–	–	–	6.79%	–	–	–	–
Fiji	E. Asia & Pacific	UMIC	5.45%	–	–	–	–	–	–	–	84.78%	–	–	–	9.77%
Finland	Eur. & Cent. Asia	HIC	29.11%	14.74%	–	55.79%	–	–	0.37%	–	–	–	–	–	–
France	Eur. & Cent. Asia	HIC	23.57%	18.23%	–	32.71%	–	–	23.69%	–	–	–	–	–	1.78%
French Polynesia	E. Asia & Pacific	HIC	39.00%	–	–	–	–	–	–	–	–	61.00%	–	–	–
Gabon	Sub-Saharan Africa	UMIC	–	–	–	–	–	–	–	–	56.00%	14.00%	–	30.00%	–
Gambia, The	Sub-Saharan Africa	LIC	–	–	–	–	–	–	–	–	–	–	83.60%	–	16.40%
Georgia	Eur. & Cent. Asia	UMIC	–	–	–	–	–	–	–	87.88%	–	–	–	12.12%	–
Germany	Eur. & Cent. Asia	HIC	46.99%	22.09%	–	29.53%	–	–	1.39%	–	–	–	–	–	–
Ghana	Sub-Saharan Africa	LMIC	–	–	–	–	–	–	–	–	–	–	–	–	–
Gibraltar	Eur. & Cent. Asia	HIC	–	–	–	–	–	–	–	–	–	–	–	–	–
Greece	Eur. & Cent. Asia	HIC	16.00%	5.00%	–	–	–	–	–	–	77.70%	–	1.30%	–	–
Greenland	Eur. & Cent. Asia	HIC	–	–	–	87.32%	–	–	–	–	12.68%	–	–	–	–

Table B.1 Proportion of waste treatment and disposal by country or economy *(contd.)*

Country or economy	Region	Income group (2022)	Recycling (%)	Com-posting (%)	Anaerobic digestion (%)	Inciner-ation (%)	Mechanical biological treatment (MBT) (%)	Refuse-derived fuel (RDF) (%)	Sanitary landfill (%)	Con-trolled landfill (%)	Unspeci-fied landfill (%)	Open dumping (%)	Other (%)	Uncol-lected (%)	Unac-counted for (%)
Grenada	L. Amer. & the Caribbean	UMIC	–	0.20%	–	–	–	–	–	98.30%	–	–	0.10%	1.40%	–
Guam	E. Asia & Pacific	HIC	38.20%	–	–	–	–	–	–	–	–	–	61.80%	–	–
Guatemala	L. Amer. & the Caribbean	UMIC	–	–	–	–	–	–	–	41.90%	–	–	–	58.10%	–
Guinea	Sub-Saharan Africa	LMIC	5.00%	–	–	–	–	–	–	–	–	–	–	–	95.00%
Guinea-Bissau	Sub-Saharan Africa	LIC	–	–	–	–	–	–	–	–	–	–	–	–	–
Guyana	L. Amer. & the Caribbean	HIC	–	–	–	–	–	–	–	–	55.00%		–	45.00%	–
Haiti	L. Amer. & the Caribbean	LMIC	–	–	–	–	–	–	–	–	–	43.00%	–	57.00%	–
Honduras	L. Amer. & the Caribbean	LMIC	–	–	–	–	–	–	7.63%	14.68%	–	30.30%	–	47.39%	–
Hong Kong SAR, China	E. Asia & Pacific	HIC	32.00%	–	–	–	–	–	68.00%	–	–	–	–	–	–
Hungary	Eur. & Cent. Asia	HIC	23.76%	8.81%	–	14.08%	–	–	50.52%	–	–	–	2.82%	–	–
Iceland	Eur. & Cent. Asia	HIC	20.70%	2.64%	–	15.42%	–	–	–	–	33.04%	–	–	–	28.19%
India	S. Asia	LMIC	–	–	–	–	–	–	–	–	18.40%	–	50.00%	4.60%	27.10%

Table B.1 Proportion of waste treatment and disposal by country or economy *(contd.)*

Country or economy	Region	Income group (2022)	Recycling (%)	Com-posting (%)	Anaerobic digestion (%)	Inciner-ation (%)	Mechanical biological treatment (MBT) (%)	Refuse-derived fuel (RDF) (%)	Sanitary landfill (%)	Con-trolled landfill (%)	Unspeci-fied landfill (%)	Open dumping (%)	Other (%)	Uncol-lected (%)	Unac-counted for (%)
Indonesia	E. Asia & Pacific	UMIC	8.86%	3.11%	–	–	–	–	6.87%	31.44%	0.18%	12.08%	–	37.47%	–
Iran, Islamic Rep.	Mid. East & N. Africa	LMIC	4.30%	7.30%	–	–	–	–	–	22.40%	–	65.40%	–	–	0.30%
Iraq	Mid. East & N. Africa	UMIC	0.06%	–	–	–	–	–	–	–	58.66%	–	–	41.28%	–
Ireland	Eur. & Cent. Asia	HIC	26.02%	15.38%	–	41.42%	–	–	15.91%	–	–	–	0.47%	–	0.81%
Isle of Man	Eur. & Cent. Asia	HIC	12.89%	–	–	81.32%	–	–	2.32%	–	–	–	3.47%	–	–
Israel	Mid. East & N. Africa	HIC	24.30%	–	–	–	–	–	–	–	75.74%	–	–	–	–
Italy	Eur. & Cent. Asia	HIC	21.86%	0.79%	17.46%	13.93%	22.95%	0.88%	13.58%	–	–	–	–	–	8.56%
Jamaica	L. Amer. & the Caribbean	UMIC	–	–	–	–	–	–	–	–	–	70.00%	–	30.00%	–
Japan	E. Asia & Pacific	HIC	15.71%	0.43%	0.34%	77.17%	–	1.22%	0.84%	–	–	–	4.28%	0.01%	–
Jordan	Mid. East & N. Africa	LMIC	7.00%	–	–	–	–	–	–	–	48.00%	45.00%	–	–	–
Kazakhstan	Eur. & Cent. Asia	UMIC	11.12%	–	–	–	–	–	–	–	68.62%	–	–	–	20.26%
Kenya	Sub-Saharan Africa	LMIC	–	–	–	–	–	–	–	–	68.24%	–	–	31.76%	–
Kiribati	E. Asia & Pacific	LMIC	0.25%	–	–	–	–	–	–	–	52.82%	–	–	46.93%	–
Korea, Rep.	E. Asia & Pacific	HIC	38.43%	21.41%	–	24.00%	–	–	10.23%	–	–	–	5.93%	–	–

Table B.1 Proportion of waste treatment and disposal by country or economy *(contd.)*

Country or economy	Region	Income group (2022)	Recycling (%)	Com-posting (%)	Anaerobic digestion (%)	Inciner-ation (%)	Mechanical biological treatment (MBT) (%)	Refuse-derived fuel (RDF) (%)	Sanitary landfill (%)	Con-trolled landfill (%)	Unspeci-fied landfill (%)	Open dumping (%)	Other (%)	Uncol-lected (%)	Unac-counted for (%)
Kosovo	Eur. & Cent. Asia	UMIC	2.59%	–	–	–	–	–	–	–	97.41%	–	–	–	–
Kuwait	Mid. East & N. Africa	HIC	–	–	–	–	–	–	–	–	100.00%	–	–	–	–
Kyrgyz Republic	Eur. & Cent. Asia	LMIC	–	–	–	–	–	–	–	–	47.00%	–	–	53.00%	–
Lao PDR	E. Asia & Pacific	LMIC	–	–	–	–	–	–	–	–	–	55.00%	–	45.00%	–
Latvia	Eur. & Cent. Asia	HIC	36.09%	7.93%	–	3.45%	–	–	52.41%	–	–	–	–	–	0.11%
Lebanon	Mid. East & N. Africa	LMIC	–	–	–	–	–	–	–	–	57.00%	42.00%	–	–	1.00%
Lesotho	Sub-Saharan Africa	LMIC	–	–	–	–	–	–	–	–	–	–	–	–	–
Liberia	Sub-Saharan Africa	LIC	–	–	–	–	–	–	–	–	–	64.00%	–	20.40%	15.60%
Libya	Mid. East & N. Africa	UMIC	–	–	–	–	–	–	–	–	–	67.00%	–	–	33.00%
Liechtenstein	Eur. & Cent. Asia	HIC	52.20%	23.47%	–	24.27%	–	–	–	–	–	–	0.05%	–	–
Lithuania	Eur. & Cent. Asia	HIC	26.50%	21.89%	–	37.96%	–	–	–	–	13.64%	–	0.01%	–	–
Luxembourg	Eur. & Cent. Asia	HIC	30.69%	21.99%	–	41.26%	6.06%	–	–	–	–	–	–	–	–
Macao SAR, China	E. Asia & Pacific	HIC	1.29%	0.11%	–	98.60%	–	–	–	–	–	–	–	–	–
Madagascar	Sub-Saharan Africa	LIC	–	–	–	–	–	–	–	–	–	–	–	–	–

Table B.1 Proportion of waste treatment and disposal by country or economy *(contd.)*

Country or economy	Region	Income group (2022)	Recycling (%)	Com-posting (%)	Anaerobic digestion (%)	Inciner-ation (%)	Mechanical biological treatment (MBT) (%)	Refuse-derived fuel (RDF) (%)	Sanitary landfill (%)	Con-trolled landfill (%)	Unspeci-fied landfill (%)	Open dumping (%)	Other (%)	Uncol-lected (%)	Unac-counted for (%)
Malawi	Sub-Saharan Africa	LIC	4.00%	–	–	–	–	–	–	–	–	–	–	26.00%	70.00%
Malaysia	E. Asia & Pacific	UMIC	0.12%	–	–	0.19%	–	–	2.54%	14.08%	–	–	–	–	83.06%
Maldives	S. Asia	UMIC	–	–	–	–	–	–	–	–	–	79.00%	–	21.00%	–
Mali	Sub-Saharan Africa	LIC	–	–	–	–	–	–	–	–	–	–	–	–	–
Malta	Mid. East & N. Africa	HIC	12.12%	–	–	1.25%	–	–	–	–	83.24%	–	–	–	3.38%
Marshall Islands	E. Asia & Pacific	UMIC	–	–	–	–	–	–	–	–	38.80%	–	43.90%	17.30%	–
Mauritania	Sub-Saharan Africa	LMIC	8.00%	–	–	–	–	–	–	37.30%	–	54.70%	–	–	–
Mauritius	Sub-Saharan Africa	UMIC	4.00%	–	–	–	–	–	–	–	96.00%	–	–	–	–
Mexico	L. Amer. & the Caribbean	UMIC	7.45%	0.63%	–	–	–	0.65%	28.90%	39.22%	–	3.08%	–	16.17%	3.90%
Micronesia, Fed. Sts.	E. Asia & Pacific	LMIC	–	–	–	–	–	–	–	–	–	–	–	64.49%	35.51%
Moldova	Eur. & Cent. Asia	UMIC	6.10%	–	–	–	–	–	–	–	35.10%	58.80%	–	–	–
Monaco	Eur. & Cent. Asia	HIC	8.30%	–	–	91.70%	–	–	–	–	–	–	–	–	–
Mongolia	E. Asia & Pacific	LMIC	8.74%	–	–	–	–	–	–	–	70.30%	–	0.09%	20.87%	–

Table B.1 Proportion of waste treatment and disposal by country or economy *(contd.)*

Country or economy	Region	Income group (2022)	Recycling (%)	Com-posting (%)	Anaerobic digestion (%)	Inciner-ation (%)	Mechanical biological treatment (MBT) (%)	Refuse-derived fuel (RDF) (%)	Sanitary landfill (%)	Con-trolled landfill (%)	Unspeci-fied landfill (%)	Open dumping (%)	Other (%)	Uncol-lected (%)	Unac-counted for (%)
Montenegro	Eur. & Cent. Asia	UMIC	0.30%	–	–	–	–	–	–	–	89.05%	–	3.90%	–	6.74%
Morocco	Mid. East & N. Africa	LMIC	8.10%	–	–	–	–	–	–	55.00%	–	32.90%	–	4.00%	–
Mozambique	Sub-Saharan Africa	LIC	1.50%	–	–	–	–	–	–	–	–	98.50%	–	–	–
Myanmar	E. Asia & Pacific	LMIC	11.00%	–	–	–	–	–	3.00%	30.00%	–	18.00%	–	38.00%	–
Namibia	Sub-Saharan Africa	UMIC	–	–	–	–	–	–	–	–	–	–	–	–	–
Nauru	E. Asia & Pacific	HIC	–	–	–	–	–	–	–	–	–	–	–	14.00%	86.00%
Nepal	S. Asia	LMIC	–	–	–	–	–	–	–	–	23.05%	–	–	37.70%	39.25%
Netherlands	Eur. & Cent. Asia	HIC	28.12%	29.41%	–	41.05%	–	–	1.41%	–	–	–	–	–	–
New Caledonia	E. Asia & Pacific	HIC	–	–	–	–	–	–	–	–	–	–	–	–	–
New Zealand	E. Asia & Pacific	HIC	9.20%	–	–	–	–	–	–	–	90.80%	–	–	–	–
Nicaragua	L. Amer. & the Caribbean	LMIC	–	–	–	–	–	–	–	–	–	–	–	42.00%	58.00%
Niger	Sub-Saharan Africa	LIC	–	–	–	–	–	–	–	–	–	–	–	–	–
Nigeria	Sub-Saharan Africa	LMIC	–	–	–	–	–	–	–	–	–	–	–	–	–
North Macedonia	Eur. & Cent. Asia	UMIC	0.30%	–	–	–	–	–	–	–	66.70%	–	–	33.00%	–

Table B.1 Proportion of waste treatment and disposal by country or economy *(contd.)*

Country or economy	Region	Income group (2022)	Recycling (%)	Com-posting (%)	Anaerobic digestion (%)	Inciner-ation (%)	Mechanical biological treatment (MBT) (%)	Refuse-derived fuel (RDF) (%)	Sanitary landfill (%)	Con-trolled landfill (%)	Unspeci-fied landfill (%)	Open dumping (%)	Other (%)	Uncol-lected (%)	Unac-counted for (%)
Northern Mariana Islands	E. Asia & Pacific	HIC	–	–	–	0.06%	–	–	–	–	85.00%	–	–	–	14.94%
Norway	Eur. & Cent. Asia	HIC	27.48%	9.74%	8.07%	50.38%	–	–	3.58%	–	–	–	0.74%	–	–
Oman	Mid. East & N. Africa	HIC	30.00%	20.40%	–	0.10%	–	–	–	49.60%	–	–	–	–	–
Pakistan	S. Asia	LMIC	–	–	–	–	–	–	–	–	–	–	–	–	–
Palau	E. Asia & Pacific	UMIC	8.20%	–	–	–	–	–	–	–	82.60%	–	–	8.80%	0.40%
Panama	L. Amer. & the Caribbean	HIC	–	–	–	–	–	–	–	–		–	–	35.80%	64.20%
Papua New Guinea	E. Asia & Pacific	LMIC	–	–	–	–	–	–	–	–	12.33%	–	–	87.67%	–
Paraguay	L. Amer. & the Caribbean	UMIC	–	–	–	–	–	–	–	–	57.95%	–	–	42.05%	–
Peru	L. Amer. & the Caribbean	UMIC	0.93%	0.82%	–	–	–	–	–	–	61.18%	–	–	5.83%	31.24%
Philippines	E. Asia & Pacific	LMIC	–	–	–	–	–	–	–	–	–	–	–	45.02%	54.98%
Poland	Eur. & Cent. Asia	HIC	26.70%	14.00%	–	21.00%	–	–	38.10%	–	–	–	–	–	–
Portugal	Eur. & Cent. Asia	HIC	16.00%	8.00%	–	15.00%	–	–	57.00%	–	–	–	2.00%	–	2.00%

Table B.1 Proportion of waste treatment and disposal by country or economy *(contd.)*

Country or economy	Region	Income group (2022)	Recycling (%)	Composting (%)	Anaerobic digestion (%)	Incineration (%)	Mechanical biological treatment (MBT) (%)	Refuse-derived fuel (RDF) (%)	Sanitary landfill (%)	Controlled landfill (%)	Unspecified landfill (%)	Open dumping (%)	Other (%)	Uncollected (%)	Unaccounted for (%)
Puerto Rico	L. Amer. & the Caribbean	HIC	14.00%	–	–	–	–	–	–	–	–	86.00%	–	–	–
Qatar	Mid. East & N. Africa	HIC	0.31%	–	–	–	–	–	–	–	99.69%	–	–	–	–
Romania	Eur. & Cent. Asia	HIC	7.43%	5.39%	–	7.95%	–	–	–	–	78.83%	–	–	–	0.39%
Russian Federation	Eur. & Cent. Asia	UMIC	6.57%	–	–	2.48%	–	–	–	80.25%	–	–	–	10.70%	–
Rwanda	Sub-Saharan Africa	LIC	–	–	–	–	–	–	–	–	–	–	–	–	–
Samoa	E. Asia & Pacific	LMIC	2.66%	–	–	0.59%	–	–	–	–	23.35%	–	3.25%	70.44%	–
San Marino	Eur. & Cent. Asia	HIC	42.96%	–	–	–	–	–	–	–	–	–	57.04%	–	–
São Tomé and Príncipe	Sub-Saharan Africa	LMIC	–	–	–	–	–	–	–	–	–	–	–	–	–
Saudi Arabia	Mid. East & N. Africa	HIC	3.73%	–	–	0.25%	–	–	88.30%	–	–	–	–	–	7.73%
Senegal	Sub-Saharan Africa	LMIC	–	–	–	–	–	–	–	5.10%	–	43.80%	4.70%	–	46.40%
Serbia	Eur. & Cent. Asia	UMIC	18.10%	0.30%	–	0.36%	–	–	–	–	80.58%	–	–	–	0.66%
Seychelles	Sub-Saharan Africa	HIC	4.80%	–	–	–	–	–	–	79.60%	–	6.10%	–	10.00%	–
Sierra Leone	Sub-Saharan Africa	LIC	–	–	–	–	–	–	–	–	–	–	–	–	–
Singapore	E. Asia & Pacific	HIC	52.00%	–	–	43.00%	–	–	–	5.00%	–	–	–	–	–

Table B.1 Proportion of waste treatment and disposal by country or economy *(contd.)*

Country or economy	Region	Income group (2022)	Recycling (%)	Com-posting (%)	Anaerobic digestion (%)	Inciner-ation (%)	Mechanical biological treatment (MBT) (%)	Refuse-derived fuel (RDF) (%)	Sanitary landfill (%)	Con-trolled landfill (%)	Unspeci-fied landfill (%)	Open dumping (%)	Other (%)	Uncol-lected (%)	Unac-counted for (%)
Sint Maarten (Dutch)	L. Amer. & the Caribbean	HIC	10.00%	–	–	–	–	–	–	–	–	90.00%	–	–	–
Slovak Republic	Eur. & Cent. Asia	HIC	20.46%	29.06%	–	7.84%	–	–	–	–	39.33%	–	3.30%	–	–
Slovenia	Eur. & Cent. Asia	HIC	46.09%	15.88%	–	12.61%	–	–	–	–	7.79%	–	–	1.75%	15.88%
Solomon Islands	E. Asia & Pacific	LMIC	–	–	–	–	–	–	–	9.54%	–	–	–	–	90.46%
Somalia, Fed. Rep.	Sub-Saharan Africa	LIC	–	–	–	–	–	–	–	–	–	–	–	–	–
South Africa	Sub-Saharan Africa	UMIC	8.37%	–	–	–	–	–	–	–	60.22%	–	0.11%	31.40%	–
South Sudan	Sub-Saharan Africa	LIC	–	–	–	–	–	–	–	–	–	–	–	–	–
Spain	Eur. & Cent. Asia	HIC	17.35%	2.63%	–	10.06%	20.52%	–	–	–	49.44%	–	–	–	–
Sri Lanka	S. Asia	LMIC	–	13.88%	–	8.60%	–	–	0.06%	–	–	24.81%	–	52.65%	–
St. Kitts and Nevis	L. Amer. & the Carib-bean	HIC	–	–	–	–	–	–	–	–	–	–	–	–	–
St. Lucia	L. Amer. & the Carib-bean	UMIC	–	–	–	–	–	–	–	–	–	–	–	–	–
St. Martin (French)	L. Amer. & the Carib-bean	HIC	–	–	–	–	–	–	–	–	–	–	–	–	–

Table B.1 Proportion of waste treatment and disposal by country or economy *(contd.)*

Country or economy	Region	Income group (2022)	Recycling (%)	Com-posting (%)	Anaerobic digestion (%)	Inciner-ation (%)	Mechanical biological treatment (MBT) (%)	Refuse-derived fuel (RDF) (%)	Sanitary landfill (%)	Con-trolled landfill (%)	Unspeci-fied landfill (%)	Open dumping (%)	Other (%)	Uncol-lected (%)	Unac-counted for (%)
St. Vincent and the Grenadines	L. Amer. & the Carib-bean	UMIC	–	0.03%	–	–	–	–	–	–	99.97%	–	–	–	–
Sudan	Sub-Saharan Africa	LIC	–	–	–	–	–	–	–	–	27.06%		5.94%	67.00%	
Suriname	L. Amer. & the Carib-bean	UMIC	5.00%	–	–	–	–	–	–	–	–	95.00%	–	–	–
Sweden	Eur. & Cent. Asia	HIC	24.10%	15.50%	–	55.40%	–	–	–	–	1.60%	–	3.40%	–	–
Switzerland	Eur. & Cent. Asia	HIC	28.52%	23.64%	–	47.84%	–	–	–	–	–	–	–	–	–
Syrian Arab Republic	Mid. East & N. Africa	LIC	1.74%	1.02%	–	–	–	–	–	–	13.92%	55.75%	–	27.50%	–
Taiwan, China	E. Asia & Pacific	HIC	54.18%	4.13%	–	38.17%	–	–	1.40%	–	–	–	1.39%	–	0.73%
Tajikistan	Eur. & Cent. Asia	LMIC	–	–	–	–	–	–	–	–	–	100.00%	–	–	–
Tanzania	Sub-Saharan Africa	LMIC	7.50%	–	–	–	–	–	–	–	–	14.40%	–	78.10%	–
Thailand	E. Asia & Pacific	UMIC	34.55%	–	–	–	–	–	–	–	–	–	–	27.72%	37.00%
Timor-Leste	E. Asia & Pacific	LMIC	–	–	–	–	–	–	–	–	–	–	–	–	100.00%
Togo	Sub-Saharan Africa	LIC	–	–	–	–	–	–	–	–	–	–	–	–	–
Tonga	E. Asia & Pacific	UMIC	9.10%	–	–	–	–	–	32.20%	–	–	–	–	9.46%	49.24%

Table B.1 Proportion of waste treatment and disposal by country or economy *(contd.)*

Country or economy	Region	Income group (2022)	Recycling (%)	Com-posting (%)	Anaerobic digestion (%)	Inciner-ation (%)	Mechanical biological treatment (MBT) (%)	Refuse-derived fuel (RDF) (%)	Sanitary landfill (%)	Con-trolled landfill (%)	Unspeci-fied landfill (%)	Open dumping (%)	Other (%)	Uncol-lected (%)	Unac-counted for (%)
Trinidad and Tobago	L. Amer. & the Carib-bean	HIC	–	–	–	–	–	–	–	–	–	–	–	–	–
Tunisia	Mid. East & N. Africa	LMIC	4.00%	5.00%	–	–	–	–	–	–	70.00%	21.00%	–	–	–
Türkiye	Eur. & Cent. Asia	UMIC	11.99%	0.34%	–	–	–	–	–	–	81.15%	–	–	–	6.52%
Turkmenistan	Eur. & Cent. Asia	UMIC	1.00%	–	–	–	–	–	–	–	–	99.00%	–	–	–
Turks and Caicos Islands	L. Amer. & the Carib-bean	HIC	–	–	–	–	–	–	–	–	–	–	–	–	–
Tuvalu	E. Asia & Pacific	UMIC	6.27%	–	–	–	–	–	–	–	–	35.43%	–	5.31%	52.99%
Uganda	Sub-Saharan Africa	LIC	–	–	–	–	–	–	–	–	–	–	–	–	–
Ukraine	Eur. & Cent. Asia	LMIC	4.96%	1.00%	–	1.51%	–	–	–	83.37%	–	–	–	–	9.16%
United Arab Emirates	Mid. East & N. Africa	HIC	8.96%	0.53%	–	0.06%	–	–	–	–	90.45%	–	–	–	–
United Kingdom	Eur. & Cent. Asia	HIC	26.18%	16.25%	–	45.39%	–	–	–	–	9.21%	–	2.97%	–	–
United States	N. Amer.	HIC	24.10%	8.80%	6.30%	11.70%	–	–	49.10%	–	–	–	–	–	–
Uruguay	L. Amer. & the Carib-bean	HIC	–	–	–	–	–	–	64.84%	29.92%	–	4.99%	–	–	0.25%
Uzbekistan	Eur. & Cent. Asia	LMIC	5.20%	–	–	–	–	–	–	–	80.86%	–	–	13.94%	–

Table B.1 Proportion of waste treatment and disposal by country or economy *(contd.)*

Country or economy	Region	Income group (2022)	Recycling (%)	Com-posting (%)	Anaerobic digestion (%)	Inciner-ation (%)	Mechanical biological treatment (MBT) (%)	Refuse-derived fuel (RDF) (%)	Sanitary landfill (%)	Con-trolled landfill (%)	Unspeci-fied landfill (%)	Open dumping (%)	Other (%)	Uncol-lected (%)	Unac-counted for (%)
Vanuatu	E. Asia & Pacific	LMIC	1.50%	0.20%	–	–	–	–	–	–	–	40.21%	–	58.10%	–
Venezuela, RB	L. Amer. & the Carib-bean	UMIC (2019)[a]	–	–	–	–	–	–	–	–	78.11%	–	–	21.89%	–
Viet Nam	E. Asia & Pacific	LMIC	7.50%	3.00%	–	10.50%	–	–	15.00%	–	32.25%	–	6.75%	25.00%	–
Virgin Islands (U.S.)	L. Amer. & the Carib-bean	HIC	–	–	–	–	–	–	–	–	–	–	–	–	–
West Bank and Gaza	Mid. East & N. Africa	UMIC	3.00%	–	–	–	–	–	–	–	6.00%	29.00%	–	8.00%	–
Yemen, Rep.	Mid. East & N. Africa	LIC	–	–	–	–	–	–	–	–	17.70%	–	–	82.30%	–
Zambia	Sub-Saharan Africa	LMIC	6.00%	–	–	–	–	–	–	–	–	–	–	–	94.00%
Zimbabwe	Sub-Saharan Africa	LMIC	–	–	–	–	–	–	–	–	–	–	–	–	–

Sources: For sources, see table B.2.
Note: Notes on individual countries or economies are provided in table B.2. Occasionally, data may be derived from more than one source, resulting in more than one year and source being provided. Values may not add up to 100% due to rounding errors.
The 'Other' waste treatment category refers to waste that is treated or disposed of in a way that does not align with any of the other provided categories. 'Uncollected' waste refers to waste that is not formally collected. In cases where disposal, treatment, and uncollected did not add up to 100 percent, the remaining amount was categorized as 'Unaccounted for'.
MSW = municipal solid waste. Empty cells with "–" = not available.
Regional abbreviations: E. Asia & Pacific = East Asia and Pacific, Eur. & Cent. Asia = Europe and Central Asia, L. Amer. & the Caribbean = Latin America and the Caribbean, Mid. East & N. Africa = Middle East and North Africa, N. Amer. = North America, S. Asia = South Asia.
Income abbreviations: HIC = high-income country, LIC = low-income country, LMIC = lower-middle-income country, UMIC = upper-middle-income country.
Treatment and disposal abbreviations: AND = anaerobic digestion, COM = composting, INC = incineration, LCO = controlled landfill, LSA = sanitary landfill, LUN = unspecified landfill, MBT = mechanical biological treatment, OPD = open dump, OTH = other, RDF = refuse-derived fuel, REC = recycling, UNA = unaccounted for, UNC = uncollected.

Table B.2 Sources/references for waste treatment and disposal by country or economy

Country or economy	Year of data	Source/Reference	Note
Afghanistan	2017	Afghanistan, National Environmental Protection Agency. 2019. "Afghanistan's National Inventory Report (NIR) 2019 submission under the United Nations Framework Convention on Climate Change (UNFCCC)."	REC: Reported as "Recycling/reuse". INC: Reported as "Thermal treatment - incineration - Energy Use". OTH: Reported as "Farmers". UNC: Comprises "Illegal dumping in districts/villages - garbage pit" (4%), "Illegal dumping in rivers/lakes" (4%), "Backyard dumping" (2.8%), and "Open burning" (30%) in source.
Albania	2022	Albania, Institute of Statistics. 2022. "Urban Solid Waste, 2022."	OPD: Reported as "free disposal". LUN: Reported as "landfill deposits". INC: Includees "energy burning" and "burning for elimination".
Algeria	2012	GIZ (Deutsche Gesellschaft für Internationale Zusammenarbeit) and SWEEP-Net. 2014. "Report on the Solid Waste Management in Algeria."	OPD: Average of "~60-65%". LCO: Average of "~30-35%". COM: Reported as "~1%". REC: Reported as "~7%".
American Samoa		No data found.	
Andorra	2014	CEWEP (Confederation of European Waste-to-Energy Plants). 2016. "CEWEP Country Report 2016: Andorra."	
Angola		No data found.	
Antigua and Barbuda	2012	Caribbean Community Secretariat. 2017. "The CARICOM Environment in Figures 2014." Regional Statistics Programme.	
Argentina	2020	Argentina, Ministry of Environment and Sustainable Development. 2020. "State of the Environment Report." Urban Solid Waste.	UNA: There is evidence of waste sent to uncontrolled landfills, MBT and recycling, but MSW tonnages are unknown.
Armenia	2019	World Bank. 2024. "Armenia SWM Sector Assessment and Reform Plan. Sector Assessment Report."	REC: Calculated based on tonnage of plastics recycled relative to waste generation provided in source. Estimates for paper, metal and glass materials sent to recycling plants unavailable. The actual recycling rate is likely higher. OPD: Calculated based on tonnage disposed of at municipal dumpsites relative to waste generation provided in source.
Aruba	2019	Arcadis. 2019. "Waste Processing in Aruba: Environmental comparison of waste processing methods."	LUN: Source reports 84.94% as RDF, but based this is mixed, stabilized waste that baled and sealed in lining, which is placed in unspecified landfills (personal communication); hence classified as LUN. OTH: Prior to recycling and processing of waste, a total of 1,430 tonnes of water is extracted in the garbage trucks and treated offsite.

Table B.2 Sources/references for waste treatment and disposal by country or economy *(contd.)*

Country or economy	Year of data	Source/Reference	Note
Australia	2020	INC, OTH: Australia, Department of Climate Change, Energy, the Environment and Water. 2022. "National Waste Report 2022." DCCEEW and Blue Environment Pty. Ltd. COM, LSA, REC: Australia, Department of Climate Change, Energy, the Environment and Water. n.d. "Waste and Resource Recovery Data Hub - National Waste Data Viewer."	INC: Recalculated to account for uncollected (2%) waste. Reported as "energy recovery". Recalculated to account for uncollected waste. LSA: Reported as "landfill". COM: 4.70 million tonnes of food organic waste generated, with 3.90 million tonnes landfilled and around 0.8 million tonnes composted. REC: Recalculated by excluding composting.
Austria	2021	European Union, Eurostat. 2024. "Municipal waste by waste management operations." Data Browser.	AND: Includes composting and anaerobic digestion. INC: Includes incineration and energy recovery. OTH: Calculated based on tonnage provided for "preparing for reuse".
Azerbaijan	INC, LUN, OTH: 2022 UNC: 2020	INC, LUN, OTH: The State Statistical Committee of the Republic of Azerbaijan. 2023. "Waste movement in 2022." Department of Information Technologies. UNC: World Bank. 2021. "Azerbaijan ARP II Solid Waste Management Project." Independent Evaluation Group, Project Performance Assessment Report 162952. Washington, DC: World Bank.	INC, LUN, OTH: Adjusted to account for waste collection.
Bahamas, The	2021	Solid Waste and Circular Economy Hub. 2023. *Material Flow Management Status: Municipal solid waste (MSW) for Latin America and the Caribbean*. ["Estado de la gestión de flujo de materiales:residuos sólidos municipales (RSM) para América Latina y el Caribe, año 2021."]	OPD: Reported as "inadequate final disposal".
Bahrain	2022	Bahrain Open Data Portal. 2025. "Management of Municipal Waste." Information & eGovernment Authority.	
Bangladesh	INC, LUN, OPD, OTH, REC: 2020 UNC: 2021	Bangladesh Bureau of Statistics. 2022. "Key Findings on Environmental Protection Expenditure, Resource and Waste Management Survey 2022." Ministry of Planning.	Recalculated based on % uncollected and total MSW generation per year. OPD: Reported as "dumping near river or canal". LUN: Reported as "dumping in landfills". OTH: Reported as "other disposal".

Table B.2 Sources/references for waste treatment and disposal by country or economy *(contd.)*

Country or economy	Year of data	Source/Reference	Note
Barbados	2021	Solid Waste and Circular Economy Hub. 2023. *Material Flow Management Status: Municipal solid waste (MSW) for Latin America and the Caribbean*. [“Estado de la gestión de flujo de materiales:residuos sólidos municipales (RSM) para América Latina y el Caribe, año 2021."]	
Belarus	2022	LUN: National Statistical Committee of the Republic of Belarus. 2023. “Environmental Protection in the Republic of Belarus." REC: National Statistical Committee of the Republic of Belarus. 2022. “I.1. Waste Generation.” [Нацыянальны статыстычны камітэт Рэспублікі Беларусь. 2022. "I.1. Образование отходов."]	LUN: Value calculated based on proportion of waste generated that was not recovered, relative to total waste generated. REC: Reported as MSW recovered. Recovery refers to the use of waste for manufacturing products, electricity generation, performing works, and provision of services.
Belgium	2022	Belgium, Statbel. 2024. "12.3% decrease in municipal waste per capita." Directorate-General for Statistics of the Federal Public Service Economy. [België Statistieken (Statbel). 2024. "Gemeentelijk afval per inwoner is met 12,3% gedaald." Directoraat-generaal Statistiek van de Federale Overheidsdienst Economie.]	COM: Includes composted and "fermented". UNA: Calculated as the proportion of MSW treated relative to total municipal waste generated.
Belize	UNC: 2021 OPD: 2015	UNC: Alarcón Montero, Pablo Andrés, Salvador Acosta Acevedo, Magda Correal, Carolina Piamonte, Alfredo Rihm, Linda Breukers, Lourdes Durón, Guillermo González, Carlos Hernández López, Carlos Sagasti, Arcelia Rojas Gutiérrez. 2023. "Regional Material Flow Assessment: Municipal Solid Waste EVAL for Latin America and the Caribbean 2023." October. Inter-American Development Bank. [“Evaluación Regional de Flujo de Materiales: Residuos Sólidos Municipales Para América Latina y El Caribe EVAL 2023.”] OPD: Government of Belize, Ministry of Natural Resources & Agriculture Belize Solid Waste Management Authority. 2015. "National Solid Waste Management Strategy & Implementation Plan." Draft Final Report. Consultancy to Prepare a National Solid Waste Management Policy and Strategy and Update the National Solid Waste Management Plan.	OPD: Assumed to be collected waste.
Benin	REC: 2005 UNA: 2022	REC: CIA (Central Intelligence Agency). 2021. The World Factbook 2021. Benin. UNA: UNSD (United Nations Statistics Division). 2025. "Benin (2022)." Country Files from the UNSD/UNEP Questionnaire on Environment Statistics.	
Bermuda	2021	Bermuda, Department of Statistics. 2022. "Environmental Statistics Compendium 2022."	LUN, REC: Estimated based on prior years.

Table B.2 Sources/references for waste treatment and disposal by country or economy *(contd.)*

Country or economy	Year of data	Source/Reference	Note
Bhutan	2019	[1] Bhutan, National Statistics Bureau. 2021. "Annual Environmental Accounts Statistics 2021." [2] Bhutan, National Statistics Bureau. 2019. "Nation's waste on the scale - National Waste Inventory Survey (NWIS-2019) Bhutan."	UNA: Composting and burning are classified as uncollected waste.
Bolivia	2022	Bolivia, Vice Ministry of Drinking Water and Basic Sanitation. 2024. "National Diagnosis of the Integrated Management of Solid Waste in Bolivia." [Viceministerio de Agua Potable y Saneamiento Basico. 2024. "Diagnóstico Nacional de la Gestion Integral de Residuos Solidos en Bolivia."]	
Bosnia and Herzegovina	2021	Bosnia and Herzegovina, Agency for Statistics. 2022. "First Release: Environment Public Transportation and Disposal of Municipal Waste." Sarajevo. ["OKOLIŠ - JAVNI ODVOZ I ODLAGANJE KOMUNALNOG OTPADA, 2021."]	LCO: Of the waste that was collected, 100% was disposed of. UNC: Calculated based on tonnage of MSW collected and generated.
Botswana	2017	Statistics Botswana. 2021. "Botswana Selected Environmental Indicators Digest 2020." Environment Statistics Unit.	LUN: Calculated based on tonnage provided in source. REC: Calculated based on tonnage "salvaged" in relation to total waste generated. UNC: Includes waste dumped in rubbish pits, roadside dumping, and/or burnt.
Brazil	2022	UNC: ABREMA. 2023. "Panorama of residual solid waste in Brazil." [ABREMA. 2023. "Panorama dos residuos solidos no Brasil."] LCO, LSA, OPD, REC: Brazil, Sistema Nacional de Informações sobre Saneamento. 2023. "Thematic Diagnosis of Municipal Solid Waste Management." [Brazil, Sistema Nacional de Informações sobre Saneamento. 2023. "Diagnóstico Temático Serviços de Água e Esgoto."]	UNC: Calculated based on tonnage provided in source, including formal collection and uncollected portion. LCO, LSA, OPD, REC: Calculated based on tonnage provided in source and accounting for uncollected portion.
British Virgin Islands	2005	UNSD (United Nations Statistics Division). 2024. "Total population served by municipal waste collection." The Environment Statistics Database.	OPD: Reported as "dumpsite".
Brunei Darussalam	2019	Chang, Emily C.C. 2021. "No time to waste." February 8. News. APEC-Flows. Dep. of Agricultural Economics , National Taiwan University.	
Bulgaria	2020	UNA: European Union, Eurostat. 2024. "Generation of Waste by Waste Category, Hazardousness and Nace Rev. 2 Activity." Data Browser. COM, INC, LUN, REC: European Union, Eurostat. 2024. "Municipal waste by waste management operations." Data Browser.	Calculated based on tonnage provided in source.

Table B.2 Sources/references for waste treatment and disposal by country or economy *(contd.)*

Country or economy	Year of data	Source/Reference	Note
Burkina Faso	2009	IMF (International Monetary Fund). 2012. "Burkina Faso: Strategy for Accelerated Growth and Sustainable Development 2011." IMF Country Report No. 12/123.	OPD: Reported as "public dump". OTH: Includes removal bins (10%) and other (1%). UNC: Reported as "Street/road/spontaneous dump" and incineration, which is assumed to be open burned. UNA: Calculated based on tonnage provided in source.
Burundi		No data found.	
Cabo Verde	2013	Institute of National Statistics of Cabo Verde. 2017. "Survey on Collection and Treatment of Urban Waste - 2012 and 2013." [Instituto Nacional de Estatística Cabo Verde. 2017. "Inquérito sobre Recolha e Tratamento de Resíduos Urbanos – 2012 e 2013."]	
Cambodia	2018	Pheakdey, Dek Vimean, Nguyen Van Quan, Tran Dang Khanh, and Tran Dang Xuan. 2022. "Challenges and Priorities of Municipal Solid Waste Management in Cambodia." International Journal of Environmental Research and Public Health, 19 (14): 8458.	
Cameroon		No data found.	
Canada	2022	[1] Statistics Canada. 2018. "Disposal of Waste, by Source." June 27. [2] Canada, Environment and Climate Change. 2010. "Municipal Solid Waste and the Environment." Program results. January 11. [3] Statistics Canada. 2021. "Waste Materials Diverted, by Type and by Source." March 8.	INC, LUN: Calculated based on waste requiring final disposal sent to landfills and waste incinerated. REC: Calculated based on residential sources of diverted materials sent for recycling.
Cayman Islands	2022	Cayman Islands Government. 2023. "The Cayman Islands' Compendium of Statistics 2022." July. George Town: Economics and Statistics Office.	Calculated based on tonnage provided in source.
Central African Republic		No data found.	
Chad		No data found.	
Channel Islands	2022	[1] States of Jersey. n.d. "Waste Management Statistics." Information and public services for the Island of Jersey. [2] Guernsey Waste. 2023. "Annual Waste Management Report 2022." States of Guernsey.	Calculated based on tonnage in source for recycling & reuse, commercial recycling, composting, RDF, EfW, and other disposal for Guernsey and Jersey.

Table B.2 Sources/references for waste treatment and disposal by country or economy *(contd.)*

Country or economy	Year of data	Source/Reference	Note
Chile	LCO, LSA, OPD, OTH: 2022 COM, REC, UNC: 2021	LCO, LSA, OPD, OTH: Chile, SUBDERE (National Solid Waste Program). 2024. "National Synthesis Diagnosis and National Registry of Municipal Solid Waste." Regional Investment Management Department. ["Sintesis Nacional Diagnóstico y Catastro Nacional de RSD."] COM, REC, UNC: Solid Waste and Circular Economy Hub. 2023. *Material Flow Management Status: Municipal solid waste (MSW) for Latin America and the Caribbean 2021*. ["Estado de la gestión de flujo de materiales:residuos sólidos municipales (RSM) para América Latina y el Caribe, año 2021."]	Calculated based on tonnage in source and adjusted to account for uncollected quantity.
China	2022	City waste generation: China, MoHURD (Ministry of Housing and Urban-Rural Development). 2024. 1-13-2 Urban Environmental Sanitation [1-13-2 城市市容环境卫生(2022年)]. In: 2022 Urban and Rural Construction Statistical Yearbook. Beijing: Ministry of Housing and Urban-Rural Development. County seat waste generation: China, MoHURD (Ministry of Housing and Urban-Rural Development). 2024. 2-12-2 County Seat Environmental Sanitation (2022) [2-12-2 县城市容环境卫生 (2022年)]. In: 2022 Urban and Rural Construction Statistical Yearbook. Beijing: Ministry of Housing and Urban-Rural Development (MoHURD). MSW generated, urban: China, MoHURD (Ministry of Housing and Urban-Rural Development). 2024. 1-13-1 Quantity of Collected and Transported for city.)]. In: 2022 Urban and Rural Construction Statistical Yearbook. Beijing: Ministry of Housing and Urban-Rural Development (MoHURD). MSW generated, county seat: China, MoHURD (Ministry of Housing and Urban-Rural Development). 2024. 2-12-2 Quantity of Collected and Transported for county seat.)]. In: 2022 Urban and Rural Construction Statistical Yearbook. Beijing: Ministry of Housing and Urban-Rural Development (MoHURD). UNC: Ministry of Ecology and Environment. 2020. Annual Report on the Prevention and Control of Solid Waste Pollution in Large and Medium-sized Cities in China in 2020. Beijing, China: Ministry of Ecology and Environment. [生态环境部. 2020. 2020年全国大、中城市固体废物 污染环境防治年报. 中国北京：生态环境部。]	The treatment mix presented is for urban areas only: Urban population: (1) Urban (564,881,700), calculated from MoHURD (permanent plus temporary population for city built-area); (2) County seat (156,089,800), assumed urban, calculated from MoHURD (population plus temporary population for County Seat). MSW generated, urban: (1) Urban waste (244,450,000 t/year); (2) County seat, assumed urban (67,050,000 t/year). Treatment (LSA, INC and OTH) calculated as % weight on the basis of urban waste (all rural areas and small conurbations are excluded) and presented as proportion of generated waste. Urban waste (311,500,000 t/year) is calculated as the sum of waste generated in cities (244,450,000 t/year) and county seats (assumed urban) (67,050,000 t/year). LSA: Calculated the landfill rate in urban areas by weighting the proportion of landfilled in city areas (12% - MoHURD 1-13-2) and the proportion of landfilled for county seats (42% - MoHURD 2-12-2 - sanitary landfill as proportion of "harmlessly treated") by waste generation, and then summing the weighted percentages. INC: Calculated the incineration rate in urban areas by weighting the proportion of incinerated in city areas (80% - MoHURD 1-13-2) and the proportion of incinerated for county seats (56% - MoHURD 2-12-2 – incineration as proportion of "harmlessly treated") by waste generation, and then summing the weighted percentages. OTH: Calculated the other treatment rate in urban areas by weighting the proportion of other in city areas (8% - MoHURD 1-13-2) and the proportion of other for county seats (2% - MoHURD 2-12-2 – other as proportion of "harmlessly treated") by waste generation, and then summing the weighted percentages. UNC: Refers to urban waste (all rural areas and small conurbations are excluded).

Table B.2 Sources/references for waste treatment and disposal by country or economy *(contd.)*

Country or economy	Year of data	Source/Reference	Note
Colombia	LCO, LSA, LUN, OPD, REC: 2022 UNC: 2023	LCO, LSA, LUN, OPD, REC: Colombia, Superintendent of Public Services. 2023. "National Report on Final Disposal of Solid Waste 2022." ["Informe Nacional de Disposición Final de Residuos Sólidos 2022."] UNC: DANE (National Administrative Department of Statistics of Colombia). 2023. "National Quality of Life Survey (NQLS) 2023."	LCO, LSA, OPD: Calculated assuming that the proportion of households whose waste is not collected regularly is similar to uncollected waste. UNC: It is assumed that the proportion of household waste not collected regularly is similar to uncollected waste.
Comoros		No data found.	
Congo, Dem. Rep.	LUN, REC, UNA: 2005	REC: CIA (Central Intelligence Agency). 2021. The World Factbook 2021. Congo, Dem. Rep. LUN: Democratic Republic of Congo, National Institute of Statistics. 2015. "Statistical Yearbook 2014." Ministry of Planning and Implementation of Modernity Revolution. ["Annuaire Statistique 2014."]	
Congo, Rep.	REC: 2005 UNC: 2012	REC: CIA (Central Intelligence Agency). 2021. The World Factbook 2021. Congo, Rep. UNC: Scarlat, N., V. Motola, J.F. Dallemand, F. Monforti-Ferrario, & L. Mofor. 2015. "Evaluation of energy potential of Municipal Solid Waste from African urban areas." Renewable and Sustainable Energy Reviews, 50, 1269–1286.	
Costa Rica	2021	Solid Waste and Circular Economy Hub. 2023. *Material Flow Management Status: Municipal solid waste (MSW) for Latin America and the Caribbean.* ["Estado de la gestión de flujo de materiales:residuos sólidos municipales (RSM) para América Latina y el Caribe, año 2021."]	
Côte d'Ivoire		No data found. JICA (Japan International Cooperation Agency). 2022. *Étude de collecte d'informations relatives à la gestion des déchets municipaux solides dans les villes d'Afrique – Rapport Final*. Data Collection Study on Municipal Solid Waste Management in African Cities – Final Report (English translation). https://openjicareport.jica.go.jp/pdf/1000048190.pdf.	While data for the country was not found, the region of Abidjan reports that 4,441 t/day of MSW is generated, of which 90% (equivalent to 4,000 t/day) is collected. Around 222 t/day, or 5%, is recycled (JICA 2022).

Table B.2 Sources/references for waste treatment and disposal by country or economy *(contd.)*

Country or economy	Year of data	Source/Reference	Note
Croatia	2022	AND, COM, LSA, MBT, OTH, REC: Croatia, Ministry of Economy and Sustainable Development. 2023. "Report on municipal waste for 2022." UNA: European Union, Eurostat. 2024. "Generation of Waste by Waste Category, Hazardousness and Nace Rev. 2 Activity." Data Browser.	LSA: Calculated based on the quantity of waste collected and the number of landfills that are being prepared for or have begun "rehabilitation". AND: Calculated based on the quantity of waste collected and the biogas facilities receiving MSW (12,291 t/year). COM: Calculated based on the quantity of waste collected and the composting plants receiving MSW (80,977 t/year). REC: Calculated based on the quantity of waste collected and the amount recycled (630,882 t/year), which also includes composting and AND. OTH: Calculated based on the quantity of waste collected; includes pretreatment procedures including mixing or repacking.
Cuba	2020	Cuba, National Office of Statistics and Information. 2021. "Annual Statistics of Cuba 2020." ["ANUARIO ESTADÍSTICO DE CUBA 2020."]	OPD: Calculated based on tonnage provided in source for landfilling. REC: Calculated based on tonnage provided in source for recycling; includes composting.
Curaçao	2023	EcoVision. 2024. "Waste Characterization Study Curaçao- Transforming Waste to Value." Selikor N.V.	LCO: Calculated based on quantity landfilled in relation to total (collected + uncollected) waste. REC: Calculated based on quantity recycled in relation to total (collected + uncollected) waste. UNC: Calculated based on tonnage provided in source relative to total MSW generated.
Cyprus	2022	COM, INC, LUN, REC: CYSTAT (Cyprus Statistical Service). n.d. “Generation and Treatment of Municipal Solid Waste, Annual.” ["Παραγωγή και Επεξεργασία Αστικών Στερεών Αποβλήτων, Ετήσια."] UNA: European Union, Eurostat. 2024. "Generation of Waste by Waste Category, Hazardousness and Nace Rev. 2 Activity." Data Browser.	COM, LUN, REC: Calculated based on the quantity of waste collected. INC: Calculated based on the quantity of waste collected and the amount used for "energy recovery". UNA: Calculated based on the quantity of waste collected.
Czech Republic	2021	European Union, Eurostat. 2024. "Municipal waste by waste management operations." Data Browser.	LSA: Calculated based on tonnage of waste landfilled in source. COM: Calculated based on the quantity of waste composted (762 t/year); includes anaerobically digested waste. REC: Calculated based on tonnage of waste recycled in source. INC: Calculated based on the tonnage of waste incinerated in source.

Table B.2 Sources/references for waste treatment and disposal by country or economy *(contd.)*

Country or economy	Year of data	Source/Reference	Note
Denmark	COM, INC, LSA, REC: 2021 UNC: 2022	COM, INC, LSA, REC: European Union, Eurostat. 2024. "Municipal waste by waste management operations." Data Browser. UNC: Statistics Denmark. 2022. "Proportion of municipal solid waste collected and managed in controlled facilities out of total municipal waste generated, by cities." [Danmarks Statistik. 2022. "Andel af kommunalt affald, der indsamles og håndteres på regulerede affaldsbehandlingssteder, ud af den samlede genererede mængde kommunalt affald, opdelt efter by."]	
Djibouti	2004	IMF (International Monetary Fund). 2004. "Djibouti: Poverty Reduction Strategy Paper."	LUN: Reported as waste "put in the garbage dump, without any type of sorting or prior treatment". UNA: Reported as "land disposal".
Dominica		No data found.	
Dominican Republic	LCO, OPD, UNC: 2021 REC: 2015	LCO, OPD, UNC: Solid Waste and Circular Economy Hub. 2023. *Material Flow Management Status: Municipal solid waste (MSW) for Latin America and the Caribbean*. ["Estado de la gestión de flujo de materiales:residuos sólidos municipales (RSM) para América Latina y el Caribe, año 2021."] REC: Wolf, Judith. 2018. "Current Situation of Waste Management in the Dominican Republic An Analysis Based on Databases Collected within the Framework of the ZACK Project." GIZ. [Wolf, Judith. 2018. "Informe Final Estado GIRS en República Dominicana." GIZ.	Recalculated assuming that treatment comprises uncollected waste and recycling, in addition to open dumping and controlled landfilling.
Ecuador	2021	Solid Waste and Circular Economy Hub. 2023. *Material Flow Management Status: Municipal solid waste (MSW) for Latin America and the Caribbean*. ["Estado de la gestión de flujo de materiales:residuos sólidos municipales (RSM) para América Latina y el Caribe, año 2021."]	OPD: LCO classified as OPD "due to lack of administrative and financial stability, end[ing] up as open-air dumps".
Egypt, Arab Rep.	2016	Nassa, H., M. Biltagy, and A.M. Safwat. 2023. "The role of waste-to-energy in waste management in Egypt: a techno-economic analysis". Review of Economics and Political Science.	Recalculated based on collection rate and fraction of collected waste that is recycled, composted, and disposed of in sanitary landfills, while the remaining is disposed of in OPD or open burned.
El Salvador	2021	Solid Waste and Circular Economy Hub. 2023. *Material Flow Management Status: Municipal solid waste (MSW) for Latin America and the Caribbean*. ["Estado de la gestión de flujo de materiales:residuos sólidos municipales (RSM) para América Latina y el Caribe, año 2021."]	
Equatorial Guinea		No data found.	

Table B.2 Sources/references for waste treatment and disposal by country or economy *(contd.)*

Country or economy	Year of data	Source/Reference	Note
Eritrea		No data found.	
Estonia	2022	European Union, Eurostat. 2024. "Municipal waste by waste management operations." Data Browser.	LUN: Reported as "Disposal - landfill and other". COM: Reported as "Recycling - composting and digestion". REC: Reported as "Recycling - material". INC: Reported as "Disposal - incineration and recovery - energy recovery".
Eswatini	2017	Eswatini Environment Authority. 2020. "Review and update of the State of the Environment Report – Restoring the Environment for Climate Resilient Economic Recovery." Ministry of Tourism and Environmental Affairs.	UNC: Calculated based on other treatment routes.
Ethiopia	INC: 2021 LUN, REC, UNC: 2022	INC: JICA (Japan International Cooperation Agency). 2022. "Data Collection Survey on Municipal Solid Waste Management in African Cities - Final Report." LUN, REC, UNC: Traide. 2023. "Factsheet: Waste Economy in Ethiopia."	LUN: According to source, most waste is dumped at uncontrolled landfills, while a small amount is recycled. REC: Roughly 4% of waste is recycled. This has been removed from remaining treated waste, which is disposed of at landfill/incineration facilities.
Faroe Islands	2023	Faroe Islands, IRF. 2024. "Annual Report 2023." ["Ársfrásøgn 2023."].	Waste treatment data aggregated from two sources representing all waste entering two treatment facilities in the Faroe Islands; passenger cars removed from total waste/recycling figure.
Fiji	LUN, REC, UNA: 2011	REC: Pariatamby, A. & M. Tanaka. 2014. "Municipal Solid Waste Management in Asia and the Pacific Islands - Challenges and Strategic Solutions." LUN, UNA: SPREP (Secretariat of the Pacific Regional Environment Programme). 2023. "Fiji National Waste Audit Analysis Report." Apia, Samoa.	REC: Data for Nadi Town and Lautoka City. LUN: Calculated based on tonnage provided in source relative to total MSW generation.
Finland	2022	Statistics Finland. n.d. "Municipal waste by treatment method in Finland, 2018-2022." StatsFin Waste Statistics. [Tilastokeskus. n.d. "Yhdyskuntajätteet Suomessa käsittelytavoittain, 2018-2022." Tilastokeskus.]	LSA: Reported as "'Landfilling and other disposal". COM: Includes anaerobic digestion and composting. REC: Includes preparation for reuse. INC: Includes with and without energy recovery.

Table B.2 Sources/references for waste treatment and disposal by country or economy *(contd.)*

Country or economy	Year of data	Source/Reference	Note
France	2021	European Union, Eurostat. 2024. "Municipal waste by waste management operations." Data Browser.	REC: Calculated based on quantity recycled relative to total municipal waste generated. UNA: Calculated as the difference between MSW generated and MSW treated.
French Polynesia	2014	SPREP (Secretariat of the Pacific Regional Environment Programme). 2016. "Cleaner Pacific 2025: Pacific Regional Waste and Pollution Management Strategy, 2016-2025." Apia, Samoa.	
Gabon	2017	UNFCCC (United Nations Framework Convention on Climate Change). 2021. "National Greenhouse Gas Inventory Report." ["Rapport national d'inventaire des gaz à effet de serre."]	Calculated based tonnage provided in source. OPD: Reported as "burnt in a dump" in source. LUN: Based on value in source for disposal in a landfill where it is not possible to determine the level of control.
Gambia, The	2014	WACA (West Africa Coastal Areas Management Program). 2022. "The Gambia plastic country brief." Washington, DC: World Bank.	OTH: Includes all mismanaged waste, such as open dumping and some reuse of materials like plastic bags and bottles at the household level.
Georgia	2019	World Bank. 2021. "Georgia Solid Waste Sector Assessment Report." Washington, DC: World Bank.	
Germany	2022	European Union, Eurostat. 2024. "Municipal waste by waste management operations." Data Browser.	Calculated based on tonnage provided in source relative to total MSW generation.
Ghana		No data found.	
Gibraltar		No data found.	
Greece	2019	European Environment Agency. 2022. "Early warning assessment related to the 2025 targets for municiapl waste and packaging waste – Greece." Country Profile. June.	
Greenland	2022	Nordic Statistics. 2022. "WASTE01: Development in municipal waste generation and treatment by reporting country, unit, treatment and time."	INC, LUN: Calculated based on treated waste per capita provided in source.
Grenada	2011	Grenada, Ministry of Finance. 2011. "Population and Housing Census 2011."	
Guam	2017	Guam Environmental Protection Agency. 2023."FOR IMMEDIATE RELEASE: Guam's Recycling Rate is 38.2% – up 8.99 percentage points from last year."	

Table B.2 Sources/references for waste treatment and disposal by country or economy *(contd.)*

Country or economy	Year of data	Source/Reference	Note
Guatemala	2018	INE (Instituto Nacional de Estadística). 2019. "Principales resultados Censo 2018 – Infografías."	LCO: 41.9% of the population receives municipal or private service, which is assumed to be disposed of in controlled landfill. UNC: Comprises 42.8% burning, 7.5% other, 3.5% burying, and 4.3% dumping.
Guinea	2005	CIA (Central Intelligence Agency). 2021. The World Factbook 2021. Guinea.	
Guinea-Bissau		No data found.	
Guyana	2021	Solid Waste and Circular Economy Hub. 2023. *Material Flow Management Status: Municipal solid waste (MSW) for Latin America and the Caribbean*. ["Estado de la gestión de flujo de materiales:residuos sólidos municipales (RSM) para América Latina y el Caribe, año 2021."]	
Haiti	2021	Solid Waste and Circular Economy Hub. 2023. *Material Flow Management Status: Municipal solid waste (MSW) for Latin America and the Caribbean*. ["Estado de la gestión de flujo de materiales:residuos sólidos municipales (RSM) para América Latina y el Caribe, año 2021."]	
Honduras	2021	Solid Waste and Circular Economy Hub. 2023. *Material Flow Management Status: Municipal solid waste (MSW) for Latin America and the Caribbean*. ["Estado de la gestión de flujo de materiales:residuos sólidos municipales (RSM) para América Latina y el Caribe, año 2021."]	
Hong Kong SAR, China	2022	Hong Kong SAR, China, Environmental Protection Department. 2022. "Monitoring of Solid Waste in Hong Kong - Waste Statistics for 2022." Statistics Unit.	REC: Includes recycling sent abroad and composting and reuse.
Hungary	2022	Hungarian Central Statistical Office. n.d. "Recovery and Disposal of Municipial Waste." Dissemination database.	LSA: Reported as amount of waste disposed of at "landfill sites meeting all technical requirements". COM: Calculated based on tonnage provided in source for composting. REC: Calculated based on tonnage provided in source for recycling and reuse. INC: Calculated based on tonnage provided in source for incineration with energy recovery. OTH: Calculated based on tonnage provided in source for waste disposed of as residues from other operations.
Iceland	2022	European Union, Eurostat. 2024. "Municipal waste by waste management operations." Data Browser.	

Table B.2 Sources/references for waste treatment and disposal by country or economy *(contd.)*

Country or economy	Year of data	Source/Reference	Note
India	2020	India, NSO. 2023. "EnviStats-India 2023: Vol.I: Environment Statistics." National Statistical Office, Ministry of Statistics & Programme Implementation, Government of India, New Delhi.	LUN: Urban only. Calculated as [Amount of waste landfilled (29,427.2 t/day)]/[Amount of waste generated (160,038.9 t/day)] as reported by NSO 2023. UNC: Urban only. The compliment of the [Amount of waste collected (152,749.5 t/day)]/[Amount of waste generated (160,038.9 t/day)] as reported by NSO 2023. OTH: Treatment not specified in source. UNA: Source reports 31.7% as unaccounted for; value is adjusted here by subtracting the reported share of uncollected waste (4.6%). AND, COM, INC: These treatment types reported to take place but no values available. Assumed to be included in OTH.
Indonesia	2023	Indonesia, SIPSN (Sistem Informasi Pengelolaan Sampah Nasional). 2024. Email communication with World Bank to request formal waste management data on Indonesia. 11 September 2024.	LCO, LSA, LUN, OPD: Landfill type allocated according to SIPSN: Open dumpsites (23.9%); controlled landfill 62.2%); sanitary landfill (13.6%); and unspecified landfill (0.4%). COM: Treated waste is assumed to be composted. UNC: Unmanaged waste is assumed to be uncollected.
Iran, Islamic Rep.	2023	Golhosseini, Zeynab, and Mahdi Jalili Ghazizade. 2024. "Municipal Solid Waste Status in Iran: From Generation to Disposal." Environmental Protection Research, January, 16–29.	
Iraq	2019	JICA (Japan International Cooperation Agency). 2022. "Data Collection Study on Solid Waste Management in Iraq."	Calculated based on tonnage provided in source for waste sent to disposal sites, recycling facilities, and amount uncollected, relative to total MSW generation.
Ireland	2021	Ireland, Environmental Protection Agency. 2023. "Municipal waste statistics for Ireland."	
Isle of Man	2023	Isle of Man, Department of Environment, Food and Agriculture. 2023. "2023 Isle of Man Waste Returns Report."	LSA: Calculated based on MSW disposed of on land (1,144 t/year) relative to total waste generation. REC: Includes "recycled on island". INC: Includes "EfW on island". OTH: Includes "recovery and recycled off island".

Table B.2 Sources/references for waste treatment and disposal by country or economy *(contd.)*

Country or economy	Year of data	Source/Reference	Note
Israel	2022	Israel, Central Bureau of Statistics. 2022. "Household and Commercial Waste Collected, by Type of Treatment and Local Authority."	LUN: Calculated based on tonnage provided in source for landfilling relative to total waste generation. REC: Calculated based on tonnage provided in source for recycling and recovery relative to total waste generation.
Italy	UNA: 2021 AND, COM, INC, LSA, MBT, RDF, REC: 2022	UNA: European Union, Eurostat. 2024. "Municipal waste by waste management operations." Data Browser. AND, COM, INC, LSA, MBT, RDF, REC: National Institute for Environmental Protection and Research. 2023. "Municipal Waste Report 2023 edition." ["Rapporto Rifiuti Urbani Edizione 2023."]	AND, COM, INC, LSA, MBT, RDF, REC: Recalculated based on % uncollected and total MSW generation per year.
Jamaica	2021	Solid Waste and Circular Economy Hub. 2023. *Material Flow Management Status: Municipal solid waste (MSW) for Latin America and the Caribbean*. ["Estado de la gestión de flujo de materiales:residuos sólidos municipales (RSM) para América Latina y el Caribe, año 2021."]	
Japan	2022	Japan, Ministry of the Environment. 2024. "Waste disposal in Japan." Environmental Regeneration and Resource Recycling Bureau. [環境再生・資源循環局2024年。「日本の廃棄物処理」。環境省。]	LSA: Value reflects only direct landfill. AND: Reported as going to "methanation facility". COM: Includes input to composting facility, not recycled amount. REC: Includes community collection, direct recycle, intermediate treatment and recycle, and recycled to feed. INC: Includes direct incineration after collection and incineration of intermediate treatment residue. RDF: Reported as going to "waste fueling facility". OTH: Reported as going to "bulky MSW facility". UNC: Reported as "in house treatment".
Jordan	2012	GIZ (Deutsche Gesellschaft für Internationale Zusammenarbeit) and SWEEP-Net. 2014. "Country Report on the Solid Waste Management in Jordan."	
Kazakhstan	2019	Ministry of National Economy of the Republic of Kazakhstan. 2020. "Final Waste Disposal." Committee on Statistics. June 1. (In Rödl & Partner. 2021. "Effectiveness of Waste Management in Kazakhstan: New Environmental Code 'Quo vadis'." April 7.	LUN: Reported as "municipal waste deposited". REC: Reported as "municipal waste reused and recycled". UNA: Calculated based on unauthorized landfill sites and illegal dumping sites that are still in use.

Table B.2 Sources/references for waste treatment and disposal by country or economy *(contd.)*

Country or economy	Year of data	Source/Reference	Note
Kenya	2021	UNSD (United Nations Statistics Division). 2025. "Kenya (2022)." Country Files from the UNSD/UNEP Questionnaire on Environment Statistics.	LUN: All collected waste is reported to be landfilled.
Kiribati	2021	SPREP (Secretariat of the Pacific Regional Environment Programme). 2023. "Kiribati National Waste Audit Analysis Report." Apia, Samoa.	LUN: Calculated based on quantities of MSW collected and recycled. REC: Calculated based on quantities of PET plastic and aluminium cans collected for recycling.
Korea, Rep.	2022	Korea Environment Corporation. 2022. "Nationwide Waste Generation and Disposal Status (Living, Workplace)." Resource Circulation Information System.	COM: Food recycling is assumed to be composted. REC: Recycling excludes composting.
Kosovo	2022	European Union, Eurostat. 2024. "Municipal waste by waste management operations." Data Browser.	
Kuwait	2022	[1] Kuwait, Central Statistics Bureau. 2022. "Annual Statistical Bulletin of Environment 2022." [2] Kuwait Environment Public Authority. 2022. "Waste Management Atlas of Kuwait."	
Kyrgyz Republic	2022	UNECE. 2024. Environmental Performance Reviews - Kyrgyzstan. Third review. Environmental Performance Reviews Series No. 57.	LUN: Assumed that "storage in containers" is sent to landfill. UNC: Calculated based on 9% buried, 24% burned, and 20% dumped.
Lao PDR	2018	Borongan, G., and S.K.M. Huno. 2020. "Capacity Mapping for Monitoring and Assessment of Plastic Pollution in the Lower Mekong." Asian Institute of Technology, Regional Resource Centre for the Asia and the Pacific, Thailand.	OPD, UNC: Average of 40%-70%.
Latvia	2021	European Union, Eurostat. 2024. "Municipal waste by waste management operations." Data Browser.	
Lebanon	2022	Lebanon, Ministry of Environment. 2023. "Summary of the Lebanon Solid Waste Roadmap for 2023-2026. Towards and Integrated Solid Waste Management System."	
Lesotho		No data found.	
Liberia	2019	Liberia, Environmental Protection Agency. 2024. "National Solid Waste Management Policy."	UNC, UNA: Calculated based on 84.4% of "inadequately managed" waste.
Libya	2024	World Bank. 2023. *Libya Storm and Flooding 2023 Rapid Damage and Needs Assessment*.	

Table B.2 Sources/references for waste treatment and disposal by country or economy *(contd.)*

Country or economy	Year of data	Source/Reference	Note
Liechtenstein	2022	Liechtenstein Statistical Office. 2023. "Waste 2022 Tables." StatistikPortal.	
Lithuania	2022	Lithuania, Environmental Protection Agency. 2024. "Municipal Waste." ["KomunalinÄ–s atliekos."]	OTH: Includes recovery of waste for backfilling (not including recycling, composting or incineration).
Luxembourg	2021	Lu'Stat. 2023. "Production and treatment of domestic waste (in 1000 tonnes)." Luxembourg Statistics Portal (STATEC).	MBT: Treated material goes to landfill.
Macao SAR, China	2022	Macao SAR, China, Environmental Protection Bureau. 2022. "Report on the State of the Environment of Macao 2022."	COM: Calculated based on amount of food waste collected. REC: Calculated based on amount of recycled waste collected.
Madagascar		No data found.	
Malawi	2022	Sustainable Inclusive Business. 2022. "Assessment of the Current Status of the Circular Economy in the waste sector for developing a waste stream specific roadmap in Malawi. Fact Sheet."	
Malaysia	2022	Malaysia, Ministry of Housing and Local Government Malaysia. "Statistik KPKT 2022." ["Statistik KPKT 2022."]	Calculated based on tonnage provided in source.
Maldives	2016	Maldives, Ministry of Environment and Energy. 2017. "State of the Environment Report 2016."	
Mali		No data found.	
Malta	2022	Malta National Statistics Office. 2023. "Municipal Waste: 2022."	
Marshall Islands	2021	SPREP (Secretariat of the Pacific Regional Environment Programme). 2021. “Waste Audit Report Republic of the Marshall Islands.”	LUN: Calculated based on waste sent to Majuro Landfill only. OTH: Some sorting/processing of waste through the DRS (e.g., cans, bottles) takes place at Majuro Landfill. UNC: Excludes waste collected and waste sent to Majuro Landfill.
Mauritania	2013	GIZ (Deutsche Gesellschaft für Internationale Zusammenarbeit) and SWEEP-Net. 2014. "Report on Solid Waste Management in Mauritania."	
Mauritius	COM: 2022 LUN, REC: 2021	COM: Mauritius, Ministry of Environment, Solid Waste management and Climage Change. 2022. "Carting Away of Waste from from La Chaumiere Compost Plant to Mare Chicose Landfill Procurement." November 18. Press Notice, Invitation for Bids. LUN, REC: Ramjeawon, T. 2022. "Circular Economy in the Republic of Mauritius - Situational Analysis and Scoping Study to identify Focus Areas and Potential Actions - Final Report." UNEP, SwitchAfrica Green, EU.	COM: Composting facility was closed in 2017, and organic waste is sent to landfill. REC: Reported as “being recycled locally or exported for recycling”.

Table B.2 Sources/references for waste treatment and disposal by country or economy *(contd.)*

Country or economy	Year of data	Source/Reference	Note
Mexico	2021	Solid Waste and Circular Economy Hub. 2023. *Material Flow Management Status: Municipal solid waste (MSW) for Latin America and the Caribbean*. [“Estado de la gestión de flujo de materiales:residuos sólidos municipales (RSM) para América Latina y el Caribe, año 2021."]	
Micronesia, Fed. Sts.	2023	SPREP (Secretariat of the Pacific Regional Environment Programme). 2023. “Federated States of Micronesia National Waste Audit Analysis Report.” Apia, Samoa.	
Moldova	2021	Moldova, Ministry of Environment. 2022. "Waste Management in the Republic of Moldova in 2021." Environment Agency. ["Gestionarea Deșeurilor în Republica Moldova în Anul 2021."]	OPD: MSW is disposed of at waste disposal sites, mainly dumpsites, only a few of which are authorized, and none are in compliance with the minimum requirements of the EU landfill directive. LUN: Calculated based on tonnage provided in source for MSW disposed of in authorized landfill. REC: Calculated based on tonnage provided in source for recovered quantity, which includes recycling.
Monaco	2009	UNDESA. 2011. Environmental Indicators - Waste - Muncipal Waste Treatment.	REC: Includes recycling and composting. INC: Calculated as the remainder after subtracting recycling; source reports 132.6% because household waste is imported from France and Italy for energy recovery through incineration.
Mongolia	2019	Mongolia, National Statistics Office. 2019. "Solid Waste Account 2018-2019 (Хатуу хог хаягдлын данс, 2018-2019)."	LUN: Calculated based on the sum of "common waste" categories under landfilled category, excluding construction and auto-parts. REC: Calculated based on the sum of "common waste" categories under "For intermediate use in other industries" category, assumed to be recycling. Excludes construction and auto-parts. OTH: Calculated based on the sum of "common waste" categories under exported, excluding construction and auto-parts. UNC: Source indicates 8.88% of the generated waste is ‘burned’, which is assumed to be open burning of uncollected waste, and added to uncollected fraction.
Montenegro	2022	MONSTAT (Statistical Office of Montenegro). n.d. "Table 9 treatment of municipal waste, 2011-2022."	OTH: Excludes exported waste. UNA: Calculated as the difference between MSW generated and MSW landfilled, recycled, and exported.

Table B.2 Sources/references for waste treatment and disposal by country or economy *(contd.)*

Country or economy	Year of data	Source/Reference	Note
Morocco	2021	UNC: UNECE (United Nations Economic Commission for Europe). 2022. "2nd Environmental Performance Review of Morocco." LCO, OPD, REC: Kingdom of Morocco High Commission for Planning. 2023. "Statistical Yearbook of Morocco, Year 2023."	LCO, OPD, REC: Represents treatment for "urban MSW" only. Treatment categories in source recalculated to account for uncollected %. OPD: Calculated based on amount of controlled waste left at the dump (Mise en décharge - Décharge contrôlée). REC: Represents treatment for "urban MSW" only. Calculated based on quantity recycled.
Mozambique	2017	Mitigation Action Facility. n.d. "Mozambique - Waste Management - Sustainable Waste Management for a Circular Economy."	OPD: Average of 98-99% of "collected waste is disposed of in uncontrolled dumpsites". REC: Average of 1-2% of the collected waste is "reused/recycled through informal networks".
Myanmar	2019	IGES (Institute for Global Environmental Strategies). 2020. "Digging Through - An Inside Look at Municipal Waste Management in Myanmar."	
Namibia		No data found.	
Nauru	2020	SPREP (Secretariat of the Pacific Regional Environment Programme). 2023. "Nauru National Waste Audit Analysis Report." Apia, Samoa.	
Nepal	2013	ADB (Asian Development Bank). 2013. "Solid Waste Management in Nepal: Current Status and Policy Recommendations."	LUN: Categorized as LUN as source states that material is "disposed of in sanitary landfills, although not necessarily in a sanitary manner."
Netherlands	2022	European Union, Eurostat. 2024. "Municipal waste by waste management operations." Data Browser.	
New Caledonia		No data found.	
New Zealand	2023	New Zealand, Ministry for the Environment. 2024. "Waste facilities and disposal."	LUN: Calculated based on tonnage provided in source for Class 1 (municipal) landfills. REC: Calculated based on tonnage provided in source for Class 1 facility type.
Nicaragua	2021	Solid Waste and Circular Economy Hub. 2023. *Material Flow Management Status: Municipal solid waste (MSW) for Latin America and the Caribbean*. ["Estado de la gestión de flujo de materiales:residuos sólidos municipales (RSM) para América Latina y el Caribe, año 2021."]	
Niger		No data found.	

Table B.2 Sources/references for waste treatment and disposal by country or economy *(contd.)*

Country or economy	Year of data	Source/Reference	Note
Nigeria		No data found.	
North Macedonia	LUN, REC: 2022 UNC: 2011	LUN, REC: OECD. 2024. A Roadmap towards Circular Economy of North Macedonia. UNC: North Macedonia, Ministry for the Environment and Spatial Planning. 2021. "Waste Management Plan of the Republic of Northern Macedonia for 2021-2031."	LUN: Calculated based on the difference between collected waste and other treatment.
Northern Mariana Islands	2022	Northern Mariana Islands, Office of Planning and Development. 2023. "Comprehensive Integrated Solid Waste Management Plan for the Commonwealth of the Northern Mariana Islands." Office of the Governor.	INC, LUN: Calculated based on tonnage provided in source. UNA: Calculated based on tonnage provided in source for the remainder not landfilled or incinerated.
Norway	2023	Statistics Norway. 2023. "Household waste, by material, treatment and downstream system (M) 2015 - 2024."	
Oman	2022	Oman, National Centre for Statistics & Information. 2022. "Waste disposal and treatment method."	
Pakistan		No data found.	
Palau	2017	SPREP (Secretariat of the Pacific Regional Environment Programme). 2017. "National Solid Waste Management Strategy: The Roadmap towards a Clean and Safe Palau 2017 to 2026." Apia, Samoa.	REC: On-site recycling discounted from total recycling figure.
Panama	2021	Solid Waste and Circular Economy Hub. 2023. *Material Flow Management Status: Municipal solid waste (MSW) for Latin America and the Caribbean*. ["Estado de la gestión de flujo de materiales:residuos sólidos municipales (RSM) para América Latina y el Caribe, año 2021."]	
Papua New Guinea	2021	SPREP (Secretariat of the Pacific Regional Environment Programme). 2023. "Papua New Guinea National Waste Audit Analysis Report." Apia, Samoa.	
Paraguay	2021	Solid Waste and Circular Economy Hub. 2023. *Material Flow Management Status: Municipal solid waste (MSW) for Latin America and the Caribbean*. ["Estado de la gestión de flujo de materiales:residuos sólidos municipales (RSM) para América Latina y el Caribe, año 2021."]	

Table B.2 Sources/references for waste treatment and disposal by country or economy *(contd.)*

Country or economy	Year of data	Source/Reference	Note
Peru	UNC: 2016 COM, LUN, REC, UNA: 2022	UNC: Peru, Ministry of the Environment. 2019. "National Report on Solid Waste Management 2019." [Peru, Ministerio del Ambiente (MINAM). 2019. "Informe Nacional Sobre la Gestion de lost Residuos Solidos 2019."] COM, LUN, REC, UNA: Peru, Information System for Solid Waste Management. 2023. "MSW Indicators Year 2022." Ministry of the Environment. [Peru, SIGERSOL (Sistema de Informacion para la Gestion de Residuos Solidos). 2023. "Indicadores RSS Ano-2022." Ministerio del Ambiente.	COM: Calculated based on tonnage provided in source for organic recovered waste relative to total MSW generation per year. REC: Calculated based on tonnage provided in source for inorganic recovered waste relative to total MSW generation per year.
Philippines	2022	GIZ (Deutsche Gesellschaft fur Internationale Zusammenarbeit). 2025. *Integrating Solid Waste Management and Circular Economy in the Comprehensive Development Plan of LGUs*. Urban-Act Policy Brief series No. 1.	
Poland	2022	Statistics Poland. 2023. "Housing economy and municipal infrastructure in 2022."	LSA: Calculated based on tonnage provided in source for waste disposed of in a landfill. COM: Calculated based on tonnage provided in source for waste disposed of in a composting facility. REC: Calculated based on tonnage provided in source for waste disposed of in a recycling facility. INC: Calculated based on tonnage provided in source for energy recovery and incinerated without energy recovery.
Portugal	2022	Portugese Environment Agency. 2023. "Annual Urban Waste Report." Amadora: AgÍncia Portuguesa do Ambiente. [AgÍncia Portuguesa do Ambiente. 2023. "RelatÛrio Anual ResÌduos Urbanos 2022."]	
Puerto Rico	2020	REC: US EPA & FEMA (United States Environmental Protection Agency & Federal Emergency Management Agency). 2020. "Municipalities Mitigating for Future Disasters Today." Infographic. OPD: Mejias, C.C. 2021. "Trash Crisis Leaves Puerto Rico Near 'the Brink'." Global Press Journal.	REC: 10% recycling rate comes from two public MRFs, with an additional 4% assumed to be composted at two composting facilities.
Qatar	2020	Qatar, Planning and Statistics Authority. 2022. "Environmental Statistics in State of Qatar."	LUN: Total domestic waste is assumed landfilled minus recycled domestic waste.
Romania	2022	European Union, Eurostat. 2024. "Municipal waste by waste management operations." Data Browser.	

Table B.2 Sources/references for waste treatment and disposal by country or economy *(contd.)*

Country or economy	Year of data	Source/Reference	Note
Russian Federation	2022	Ministry of Natural Resources and Ecology of the Russian Federation (MNRERF). 2023. "On the state and protection of the environment of the Russian Federation in 2022." ["О состоянии и об охране окружающей среды Российской Федерации в 2022 году."]	INC: Includes incineration and disinfection at specialized facilities.
Rwanda		No data found.	
Samoa	INC, LUN, OTH, REC: 2016 UNC: 2017	INC, LUN, OTH, REC: Samoa Bureau of Statistics. 2019. "Samoa's Experimental Solid Waste Accounts FY2013-14 to FY2015-2016." UNC: Samoa, Ministry of Natural Resources and Environment. n.d. "National Waste Management Strategy 2019-2023." Samoa, MNRE and SPREP.	Recalculated based on collected waste (29.56%) and total MSW generation per year. OTH: Exported waste is classified as "Other". UNC: Based on collection coverage in Upolu and Savaii.
San Marino	2019	Azienda Autonoma di Stato per i Servizi Pubblici. 2019. "Collection Data."	
São Tomé and Príncipe		No data found.	
Saudi Arabia	2022	Saudi Arabia, General Authority for Statistics. 2023. "Environmental Statistics Publication 2022."	
Senegal	2014	Senegal, National Agency of Statistics and Demography. 2014. "General Census of Population and Housing, Agriculture and Livestock." Final Report. [Senegal, Agence Nationale de la Statistique et de la Démographie. 2014 "Recensement Général de la Population et de l'Habitat, de l'Agriculture et de l'Elevage. Rapport Definitif."]	
Serbia	2022	European Union, Eurostat. 2024. "Municipal waste by waste management operations." Data Browser.	
Seychelles	2017	COWI. 2020. "Solid Waste Masterplan for Seychelles (2020-2035)." Delegation of the European Union to the Republic of Mauritius and to the Republic of Seychelles.	For household waste only. Calculated based on tonnage provided in source.
Sierra Leone		No data found.	
Singapore	INC, LCO: 2014 REC: 2023	[1] Singapore, National Environment Agency. n.d. "Waste Management: Waste Statistics and Overall Recycling." [2] IGES (Institute for Global Environmental Strategies). 2017. "State of the 3Rs in Asia and the Pacific - The Republic of Singapore."	INC: Of the remaining 48% after recycling, about 90% is incinerated and 10% landfilled.

Table B.2 Sources/references for waste treatment and disposal by country or economy *(contd.)*

Country or economy	Year of data	Source/Reference	Note
Sint Maarten (Dutch)	2019	Sint Maarten, Ministry of Public Housing, Spatial Planning, Environment & Infrastructure (VROMI). 2020. "Draft Report for Short Term Plan & Pre-Feasibility Studies of Landfill Upgrade & Extension and Integrated Solid Waste Management Facility (ISWMF)." Sint Maarten Sustainable Solid Waste Management Project: Consultancy Services for Establishing Integrated Solid Waste Management System in Sint Maarten. January 3. Revised February 17, 2020.	OPD: Source states that waste is deposited in uncontrolled landfill. REC: Informal collection and diversion of recyclables from the main stream makes up less than 10% of total waste collected.
Slovak Republic	2022	Statistical Office of the Slovak Republic. 2023. "Waste in the Slovak Republic in 2022."	
Slovenia	2022	COM, INC, LUN, REC, UNA: European Union, Eurostat. 2024. "Municipal waste by waste management operations." Data Browser. UNC: SiStat (Slovenia Statistical Office). n.d. "Municipal waste generated and treatment (tonnes), Slovenia, annually."	COM, INC, LUN, REC: Calculated based on tonnage provided in source and adjusted for collected %. UNA: Calculated as the difference between MSW generated and MSW treated.
Solomon Islands	2019	SPREP (Secretariat of the Pacific Regional Environment Programme). 2023. "Waste Audit Report: Solomon Islands." Apia, Samoa.	LCO: Actual landfill % likely to be higher, given the inability to audit all landfills. Tonnages are estimated based on vehicle capacity and compaction rather than actual weights. UNA: Excludes waste landfilled at Honirara.
Somalia, Fed. Rep.		No data found.	
South Africa	2023	South Africa, Department of Forestry, Fisheries and the Environment. 2023. South African Waste Information Centre (SAWIC). Database.	Calculated based on tonnage provided in source and adjusted for collected %.
South Sudan		No data found.	
Spain	2020	Spain, Ministry for Ecological Transition and the Demographic Challenge. n.d. "Initial Version of the State Waste Management Framework Plan (PEMAR) 2023-2035." [España, Ministerio Para la Transición Ecologica y el Reto Demográfico. n.d. "Versión Inicial del Plan Estatal Marco de Gestión de Residuos (PEMAR) 2023-2035."]	LUN: Includes "dumping of rejects" and "discharge without treatment". COM: Excludes home and community composting, MBT composting, and anaerobic digestion. MBT: Includes recyclable and compostable waste recovered from MBT only. Residual waste is already included in landfill and incineration.
Sri Lanka	2016	Sri Lanka, Ministry of Environment. 2021. "Guidelines for Safe Closure and Rehabilitation of Municipal Solid Waste Dumpsites in Sri Lanka."	Calculated based on tonnage provided in source.

Table B.2 Sources/references for waste treatment and disposal by country or economy *(contd.)*

Country or economy	Year of data	Source/Reference	Note
St. Kitts and Nevis		No data found.	
St. Lucia		No data found.	
St. Martin (French)		No data found.	
St. Vincent and the Grenadines	2020	Statistical Office of St Vincent and the Grenadines. 2020. "Compendium of Environmental Statistics." Central Planning Division. Ministry of Finance, Economic Planning & Information Technology.	
Sudan	LUN, OTH: 2003 UNC: 2018	LUN, OTH: IPCC (Intergovernmental Panel on Climate Change). 2006. "IPCC Guidelines for National Greenhouse Gas Inventories: Volume 5, Waste. Chapter 2: Waste Generation, Composition and Management Data." National Greenhouse Gas Inventories Programme. Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (Eds). Japan: Institute for Global Environmental Strategies. UNC: UNEP (United Nations Environmental Program). 2020. "Sudan - First State of Environment and Outlook Report 2020."	LUN: Adjusted to account for uncollected %. OTH: 18% is treated (unspecified); value is adjusted to account for uncollected %.
Suriname	2022	ILACO. 2022."Preparation of an Integrated Waste Management Plan (IWMP) for Suriname - Final Report." Suriname, Ministry of Spatial Planning and the Environment.	
Sweden	2022	Avfall Sverige. 2022. “Swedish Waste Management 2022.” ["Svensk Avfallshantering."]	INC: Reported as "Energy recovery". OTH: Reported as "Recycling of construction material".
Switzerland	2022	European Union, Eurostat. 2024. "Municipal waste by waste management operations." Data Browser.	
Syrian Arab Republic	COM, LUN, OPD, REC: 2010 UNC: 2016	COM, LUN, OPD, REC: GIZ (Deutsche Gesellschaft für Internationale Zusammenarbeit) and SWEEP-Net. 2010. "Country Report on the Solid Waste Management in Syria." UNC: UNEP (United Nations Environmental Program). 2019. “Waste Management Outlook for West Asia.”	Adjusted to account for uncollected %. COM: Average of 1-2% composted. REC: Average of 2-3% recycled.

Table B.2 Sources/references for waste treatment and disposal by country or economy *(contd.)*

Country or economy	Year of data	Source/Reference	Note
Taiwan, China	2023	Taiwan, China, Ministry of Environment. 2024. "Table 4-1 Generation and Treatment of Municipal Waste." Local Environmental Protection Bureaus.	Calculated based on tonnage provided in source relative to total waste generation.
Tajikistan	2024	ADB (Asian Development Bank). 2024. "Tajikistan National Urban Assessment: Making the Case for Accelerated Urbanization."	OPD: Unsorted waste is dumped in landfills/open sites throughout the country; waste is commonly left in yards, streets, and open fields for long periods of time.
Tanzania	2020	[1] Tanzania, Vice President's Office. 2020. "Investment Guide on Waste Management in Tanzania." [2] Tanzania, NBS (National Bureau of Statistics). 2023. "Statistical Abstract 2022: Basic Demographic and Socio-Economic Profile." Ministry of Finance and Planning.	OPD: Source states "More than 90% of MSW in Tanzania is believed to be disposed of in an unsatisfactory manner." Calculated based on difference between collected waste and other treatment. REC: Average of 5-10%.
Thailand	2023	Thailand, Pollution Control Department. 2023. "Information System for Community Solid Waste Management." (กรมควบคุมมลพิษ. 2566. ข้อมูลสถานการณ์ขยะมูลฝอยของประเทศ.)	REC: Calculated based on quantity of waste recycled in relation to total waste generated. UNC: Calculated based on quantity of waste that is disposed of incorrectly in relation to total waste generated. UNA: Includes waste that is "managed properly", but does not specifiy how.
Timor-Leste	2021	SPREP (Secretariat of the Pacific Regional Environment Programme). 2022. "Waste Audit Report Timor Leste." Apia, Samoa.	UNA: Only pits/dumpsites observed for areas of Covalima, Baucau, and Dili. No further treatment values available.
Togo		No data found.	
Tonga	LSA, REC, UNA: 2013 UNC: 2021	LSA, REC, UNA: SPREP (Secretariat of the Pacific Regional Environment Programme). 2016. "Cleaner Pacific 2025: Pacific Regional Waste and Pollution Management Strategy, 2016-2025." Apia, Samoa. UNC: SPREP (Secretariat of the Pacific Regional Environment Programme). 2023. "Tonga National Waste Audit Analysis Report." Apia, Samoa.	LSA: Calculated based on 5,969 tonnes of waste accumulating in two sanitary landfills in Tonga. REC: Reported as "amount exported or recycled/reused locally", equal to 9% of recycled waste.
Trinidad and Tobago		No data found.	
Tunisia	2012	GIZ (Deutsche Gesellschaft für Internationale Zusammenarbeit) and SWEEP-Net. 2014. "Country Report on the Solid Waste Management in Tunisia."	
Türkiye	2021	European Union, Eurostat. 2024. "Municipal waste by waste management operations." Data Browser.	

Table B.2 Sources/references for waste treatment and disposal by country or economy *(contd.)*

Country or economy	Year of data	Source/Reference	Note
Turkmenistan	2017	Zoi Environment Network. 2017. "Waste Management Outlook for Central Asia." United Nations Environment Programme.	
Turks and Caicos Islands		No data found.	
Tuvalu	OPD, REC, UNA: 2011 UNC: 2019	OPD, REC, UNA: SPREP (Secretariat of the Pacific Regional Environment Programme). 2016. "Cleaner Pacific 2025: Pacific Regional Waste and Pollution Management Strategy, 2016-2025." Apia, Samoa. UNC: SPREP (Secretariat of the Pacific Regional Environment Programme). 2023. "Tuvalu National Waste Audit Analysis Report." Apia, Samoa.	OPD: Calculated based on quantity of 582 tonnes of waste that are landfilled or dumped. Facilities are "unregulated", non-engineered, and have no pollution control measures.
Uganda		No data found.	
Ukraine	2023	Ukraine, Ministry of Infrastructure. 2024. "Report on the status of household waste management in Ukraine for 2023: Report 1 - MSW section 1 for 2023." [Міністерство інфраструктури України. 2024. "Звіт про стан поводження з побутовими відходами в Україні за 2023 рік: Звіт 1 - ТПВ розділ 1 за 2023 рік."]	UNA: Calculated as the difference between MSW collected and MSW treated.
United Arab Emirates	2022	UAE.Stat. 2023. "Quantity of Collected Non Hazardous Waste by Emirate, Source, Method of Treatment and Disposing." Federal Competitiveness and Statistics Centre.	LUN: Includes waste sent to municipal landfills with basic control and open dumpsites.
United Kingdom	2022	OECD (Organisation for Economic Co-operation and Development). 2024. "Waste - Municipal waste: generation and treatment." OECD.Stat.	LUN: Calculated based on quantity landfilled. COM: Calculated based on quantity composted. REC: Calculated based on quantity recycled. INC: Calculated based on quantity incinerated with energy recovery + incinerated without energy recovery. OTH: Calculated based on quantity of material for "Other recovery" and "Other disposal".
United States	2018	United States, Environmental Protection Agency. 2020. "Advancing Sustainable Materials Management: 2018 Fact Sheet: Assessing Trends in Materials Generation and Management in the United States."	LSA: Calculated based on quantity of material landfilled. AND: Calculated based on tonnage managed through "other food management pathways". COM: Calculated based on quantity of material composted. REC: Calculated based on quantity of material recycled. INC: Reported as "Combustion with energy recovery".

Table B.2 Sources/references for waste treatment and disposal by country or economy *(contd.)*

Country or economy	Year of data	Source/Reference	Note
Uruguay	2021	LCO, LSA, OPD: Ministerio de Ambiente. 2021. "Uruguay + Circular: Plan Nacional de Gestión de Residuos 2022 - 2032." UNC: Uruguay + Circular National Waste Management Plan, 2021. OAN. Observatorio Ambiental Nacional. Ministerio de Ambiente.	
Uzbekistan	LUN, REC: 2024 UNC: 2022	LUN, REC: Uzinfocom. 2025. World Cleanup Day: 55.7 Tons of Waste Collected in Uzbekistan. Press service. Ministry of Ecology, Environmental Protection and Climate Change. UNC: Ministry of Ecology, Environmental Protection and Climate Change of the Republic of Uzbekistan. 2023. "National state of the environment report: Uzbekistan." International Institute for Sustainable Development.	LUN: Calculated as the difference between waste disposed of and waste recycled. UNC: Calculated based on difference between collected waste and other treatment.
Vanuatu	UNC: 2020 COM, OPD, REC: 2019	UNC: SPREP (Secretariat of the Pacific Regional Environment Programme). 2023. "Vanuatu National Waste Audit Analysis Report." Apia, Samoa. COM, OPD, REC: Vanuatu, Department of Environmental Protection and Conservation. 2019. "National Waste Management Flow in Vanuatu."	OPD: Disposal sites are considered unregulated and categorized as open dumps. COM: Composting occurs for "market compost and animal feeding". REC: All material is exported for recycling.
Venezuela, RB	2021	Solid Waste and Circular Economy Hub. 2023. *Material Flow Management Status: Municipal solid waste (MSW) for Latin America and the Caribbean*. [“Estado de la gestión de flujo de materiales:residuos sólidos municipales (RSM) para América Latina y el Caribe, año 2021."]	
Viet Nam	UNC: 2019 COM, INC, LSA, LUN, OTH, REC: 2018	UNC: Phuong, N.T.L., H. Yabar, and T. Mizunoya. 2021. "Characterization and Analysis of Household Solid Waste Composition to Identify the Optimal Waste Management Method: A Case Study in Hanoi City, Vietnam." Earth, 2(4), 1046-1058. COM, INC, LSA, LUN, OTH, REC: Van Den Berg, K., and T.C. Duong. 2018. "Solid and industrial hazardous waste management assessment: Options and action area to implement the national strategy." Washington, DC: World Bank.	COM, INC, LSA, LUN, OTH, REC: Recalculated to account for portion of uncollected waste.
Virgin Islands (US)		No data found.	

Table B.2 Sources/references for waste treatment and disposal by country or economy *(contd.)*

Country or economy	Year of data	Source/Reference	Note
West Bank and Gaza	UNC: 2011 LUN, OPD, REC: 2019	UNC: GIZ (Deutsche Gesellschaft für Internationale Zusammenarbeit) and SWEEP-Net. 2014. "Country Report on the Solid Waste Management in Occupied Palestinian Territories." LUN, OPD, REC: Heinrich Boll Stiftung. 2020. "Palestine: Solid Waste Management under Occupation."	LUN, OPD: Recalculated based on MSW collected. REC: Recalculated based on MSW collected; includes reuse (2%) and recycling (1%).
Yemen, Rep.	2016	UNEP (United Nations Environment Programme). 2019. "Waste Management Outlook for West Asia."	100% of MSW reported as "disposal". LUN: 17.7% of MSW is estimated to be collected and assumed is landfilled.
Zambia	2024	Finland, Ministry of Foreign Affairs. 2024. Zambia Circular Economy Study. Tandem Circular Economy Consultants and Embassy of Finland, Lusaka.	
Zimbabwe		No data found.	

Note: Treatment and disposal abbreviations: AND = anaerobic digestion, COM = composting, INC = incineration, LCO = controlled landfill, LSA = sanitary landfill, LUN = unspecified landfill, MBT = mechanical biological treatment, OPD = open dump, OTH = other, RDF = refuse-derived fuel, REC = recycling, UNA = unaccounted for, UNC = uncollected.
C&D = construction and demolition, DRS = deposit return scheme, EfW = energy from waste, EU = European Union, MRF = materials recovery facility, MSW = municipal solid waste, PET = polyethylene terephthalate, RDF = refuse-derived fuel, t/day = tonnes per day, t/year = tonnes per year, WTE = waste-to-energy.

Appendix C
Summary Methodology

This *What a Waste 3.0* report comprises municipal solid waste management data for cities and countries from various sources and provides analysis which can be used by policy makers and researchers.

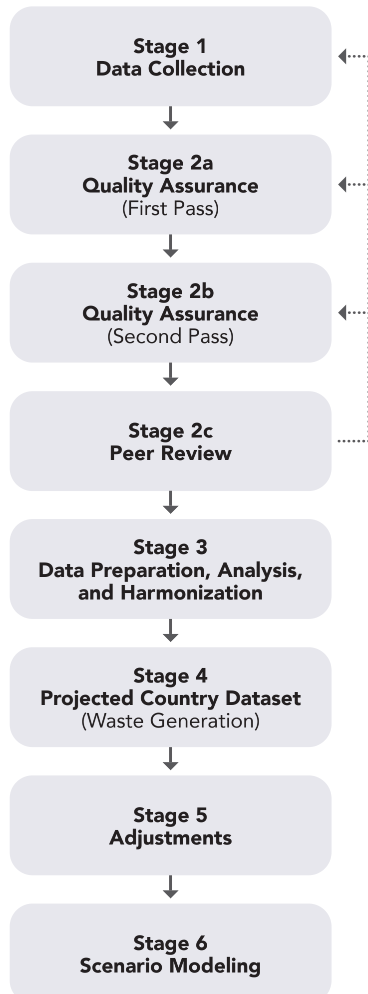
The research comprised six main stages (figure C.1). Solid waste management data were collected, and quality assured during 2024 and 2025, and analyzed late 2024 and 2025.

C.1 Data Collection

Data were gathered online, prioritizing official government sources, namely official statistical data and formally published public sector data. Where official data were not available, information was gathered from documents published by international organizations, multilateral and bilateral agencies, and academic journals. Data were obtained in the original language and translated where necessary. Additionally, regional World Bank solid waste experts provided insights beyond the data collected.

Data were obtained for 217 countries and economies and 262 cities and loaded into individual country spreadsheets. Metadata were recorded for each datapoint, including method of measurement, point of measurement (system process), date of measurement, source website link, source reference, and page/table/figure number. In many cases, data underwent minor processing to present in a harmonized format. For example, where a waste composition was presented as a mass in the original source, the data were converted to a percentage and recorded. Where processing took place, it was recorded in a notes section. All metadata are available in a codebook, which accompanies the country data set.

Figure C.1 Methodological steps undertaken to collect, analyze, and model data collected for *What a Waste 3.0*



Source: Authors' presentation.

C.2 Quality Assurance

C.2.1 Quality Assurance - First Pass

Data were quality assured during the data collection process to ensure they were recorded correctly, processed accurately, and that the relevant metadata were recorded alongside. This process was overseen by project team members who were not involved in the collection of data to ensure objectivity. Where necessary, estimates were tested against further sources as a crosscheck. Data quality assurance checkers also worked to ensure that a harmonized approach was taken across the data collection team.

C.2.2 Quality Assurance – Second Pass

Following the Stage 2a data quality assurance step, data were aggregated into tabular format. The data distributions were visually assessed using boxplots, histograms, and then plotted against socioeconomic indicators to identify outliers and assess whether they were part of the natural variation in the data or whether they were errors. Errors include those made during data collection and interpretation, and those in the original measurement. In all cases, potential errors were highlighted and returned to the original data collector for reassessment. Often it was not possible to affirmatively attribute potential errors being made during the original measurement, in which case the data point was left in the dataset. As a general rule, every effort was made to present the data as officially reported while ensuring logical coherence. Priority was given to recording data from official sources, even when it did not align with expectations. Explanatory notes were included to clarify any perceived anomalies.

C.2.3 Peer Review

Completed data tables were assessed by third-party data integrity checkers for accuracy and consistency. Data gaps were also highlighted where it was believed that data existed but had not been recorded by the original data collectors. Potential errors were highlighted and screened again and where necessary passed back to the original data collector for re-assessment.

C.3 Data preparation, Analysis, and Harmonization

C.3.1 Overview of Outputs

In *What a Waste 3.0*, the approach to analysis of data and presentation was updated since *What a Waste 2.0* to improve cross-comparability between countries, income groups, and regions, and to present the most realistic appraisal of global waste management. This updated approach has attempted to stay as close to the originally reported data as possible, while acknowledging and attempting to correct data that are not measured consistently between countries and cities, and which may not include certain flows such as uncollected waste, informal waste sector collection, and nonhousehold municipal solid waste. Therefore, in this report, three datasets are created as summarized in table C.1, and adjustments made to data for purposes of statistical analyses only.

The country dataset comprises data exactly as they were collected without undergoing any processing beyond the basic harmonization steps explained in section C.1.1. In other words, the data in the country dataset were unadjusted as it was the case in *What a Waste 2.0*. The projected country dataset presents waste generation data according to a consistent baseline year of 2022 and also projects it for 2030, 2040, and 2050.

Table C.1 Three business-as-usual datasets used in *What a Waste 3.0*

Dataset name	Description	Purpose	Availability and usage
Country dataset	Includes all national data collected during the research in its original partially harmonized format. Data reported in this dataset are broadly presented as they were originally reported or converted to percentages or mass where necessary. They are reported for the most recent year that data were available.	Repository of official data is available for analysis at country level.	• https://www.worldbank.org/en/publication/what-a-waste/ • Used for regression modeling • Used to present individual country data
Projected country dataset	Waste generation data only are projected for 2022, 2030, 2040, and 2050 using growth rates linked to a regression function that used gross domestic product (GDP) per capita, purchasing power parity (PPP), constant 2021 international $,[a] and the growth rate of GDP from the SSP2 scenario of the Shared Socioeconomic Pathways (SSP) projections of GDP per capita PPP produced by the OECD (Dellink et al. 2024).	Enables comparison of waste generation according to consistent years based on as close as possible to the country data reported in the source.	• Available as appendix A • https://www.worldbank.org/en/publication/what-a-waste/ • Used for individual country data on waste generation for base and future years
City dataset	Includes all city data collected during the research in its original format. Data reported in this dataset are broadly presented as they were originally reported or converted to percentages or mass where necessary. They are reported for the most recent year that data were available.	Repository of official data available for analysis at city level.	• https://www.worldbank.org/en/publication/what-a-waste/ • Used to present individual city data

Source: Original table for this report.
Note: Waste management processes were projected by linking them to the growth rates in GDP per capita PPP or GNI per capita. These projections were derived by using the growth rate in GDP per capita projections from the Shared Socioeconomic Pathways (SSP) project and applying the growth rates to the GDP per capita, PPP and GNI per capita datasets. The SSP2 projection was used because it represents the most central estimate, but readers are cautioned that more pessimistic and optimistic pathways are also modeled in the SSP project, and though they are not used in projections for *What a Waste 3.0*, we recommend that investigators consider them when modeling future scenarios.
a. World Bank Group. *GDP Per Capita, PPP (Constant 2021 International $)*. https://data.worldbank.org/indicator/NY.GDP.PCAP.PP.KD.

A third dataset, the city dataset, was compiled to collate city-level data across multiple indicators. This dataset is not harmonized and includes data points from various years. It is intended primarily as a repository of city-specific data.

In all cases, users are encouraged to consult the accompanying codebook for detailed information on each data point and apply them as appropriate.

In order to carry out statistical analyses at global, country income group, and regional level, a series of processing steps were undertaken that improve comparability between countries, regions, and income groups, including imputing missing data and managing data points outside reasonable margins ('outliers') considering benchmark parameters, such as economic development. Waste generation, collection coverage, treatment, and disposal were adjusted to account for flows of waste that are not typically recorded or measured, such as the amount of uncollected waste, the waste collected by the informal sector, and nonhousehold municipal solid waste. Readers should note that such corrections were made on a highly conservative basis, meaning that it is possible that some flows are still unaccounted for and that, for example, waste generation may be even higher than indicated. Waste composition was adjusted to harmonize categories and assumptions were made to distribute waste reported under categories such as "other". The adjustments were then projected for 2022, 2030, 2040, and 2050 using growth rates linked to a regression function and either gross domestic product (GDP) per capita, purchasing power parity (PPP) (constant 2021 international $) or gross national income (GNI) per capita, Atlas method (current US$).

Adjusted data were used for statistical analyses at global, regional, and income category charts and narrative. These data were also used to develop three scenarios at country group level, that is, business-as-usual scenario, low- and high-ambition scenarios. It is important to note that since modeled, they are a departure from data reported by individual countries in official statistics, and therefore not intended to be used at country level.

C.3.2 Socioeconomic Indicators

Data were projected to consistent target years—2022, 2030, 2040, and 2050. To do this, it was necessary to explore correlations between the various measurements of waste management activity and independent variables. These correlations could then be used to predict the flows and destinations of waste managed at national level, and subsequently to make projections.

Previous research identified correlations between socioeconomic indicators and waste management activity (Velis et al. 2023). In *What a Waste 2.0* (Kaza et al. 2018) and the subsequent *More Growth, Less Garbage* publication (Kaza, Shrikanth, and Chaudhary 2021), a correlation was found between waste generation and GDP per capita, PPP (constant 2021 international $). Based on these findings, five socioeconomic variables were corelated with various waste management data (table C.2).

Before the correlation analysis could be started, it was necessary for each of the socioeconomic variable datasets to include entries for each of the 217 countries

Table C.2 Socioeconomic indicators used in correlation analysis

Indicator	Explanation	Scope of socioeconomic indicator dataset	Source
GDP per capita, PPP (constant 2021 international $)[a]	Mean economic output per capita, adjusted for differences in the cost of living across countries	239–246 countries and economies between 2000 and 2023	The World Bank Group (2024)
GNI per capita, Atlas method (current US$)[b]	Mean income per capita including income from abroad	236–248 countries and economies between 2000 and 2023	The World Bank Group (2024)
Human development index (HDI)[c]	A composite indicator to assess countries development based on life expectancy at birth; mean and expected years of schooling; and GNI per capita, PPP	161 countries	Liu et al. (2024)
Social progress index (SPI)[d]	A composite measure that assesses the social and environmental well-being of a country independently of economic indicators. Three dimensions are: basic human needs; foundations of well-being; opportunity.	169 countries	Social Progress Imperative (2022)
Social progress index opportunity (SPIO)[d]	A subset of SPI which addresses the level of opportunity available to the population, for example, personal rights, freedom, inclusiveness, and access to advanced education	169 countries	Social Progress Imperative (2022)

Sources:
a. World Bank Group. *GDP Per Capita, PPP (Constant 2021 International $).* https://data.worldbank.org/indicator/NY.GDP.PCAP.PP.KD.
b. World Bank Group. *GNI Per Capita, Atlas Method (Current US $).* https://data.worldbank.org/indicator/NY.GNP.PCAP.CD.
c. Liu, Kedi, Ranran Wang, Inge Schrijver, and Rutger Hoekstra. 2024. "Can We Project Well-Being? Towards Integral Well-Being Projections in Climate Models and Beyond." *Humanities and Social Sciences Communications* 11, no. 1 (2024/03/28 2024): 457. https://doi.org/10.1057/s41599-024-02941-6.
d. Social Progress Imperative. Social Progress Index Time Series. https://www.socialprogress.org.
Note: Multiple sources were used for interpolation and projection on a case-by-case basis. The sources listed indicate the main sources used.

and economies within the scope of *What a Waste 3.0*, for every year that data were presented. This meant imputing or interpolating gaps in the datasets and estimating the variables for countries for which there were no data at all. In addition, it was necessary to obtain estimates for future socioeconomics. This meant finding third party estimates or using regression analysis to project them.

Although correlation analysis was carried out using five socioeconomic variables, only GDP per capita, PPP (constant 2021 international $), and GNI per capita, Atlas method (current US$) were used for projections as they provided a better partial explanation of the data and offered a more reliable projection capability. Therefore, only GDP per capita PPP and GNI per capita are discussed in detail in this section. As almost all of the datapoints were after year 2000, this was set as the earliest date for which indicators were needed, whereas 2050 was the latest because it was used for projections.

GDP per capita, PPP

GDP per capita, PPP (constant 2021 international $) data were obtained from the World Bank Group.[1] Of the 217 countries and economies in scope for *What a Waste 3.0*, 177 had a full set of data from 2000 to 2022.

An ordinary least squares regression for a further 21 countries[2] used historical GDP data to project the indicator backwards and forwards as necessary to impute missing values (equation 1).

$$\hat{y} = ax + b \qquad \textit{Equation 1}$$

Where:

$\hat{y}$ is the GDP per capita, PPP for the predicted year (x)

x is the year in which GDP per capita, PPP is predicted for

a is the slope of the regression based on known GDP per capita, PPP calculated using equation 2

$$a = \frac{\sum (x_i - \bar{x})(y_i - \bar{y})}{\sum (x_i - \bar{x})^2} \qquad \textit{Equation 2}$$

Where:

x_i is each known year

y_i is each known GDP per capita, PPP value

$\bar{x}$ is the mean of the years for the known GDP per capita, PPP values

$\bar{y}$ is the mean of the known GDP per capita PPP values

b is the intercept of the regression line calculated using equation 3

$$b = \bar{y} - a\bar{x} \qquad \textit{Equation 3}$$

Eighteen further countries and economies did not report a GDP per capita, PPP. As there is no straightforward way to calculate it, the following assumptions were made:

- For six countries,[3] the GDP per capita (current US$) was used (World Bank 2024a);
- American Samoa, Guam, New Caledonia, and Northern Mariana were assumed the same as the United States;
- French Polynesia, Monaco, and St. Martin (French) were assumed as France;
- British Virgin Islands, Channel Islands, Gibraltar, Isle of Man, were assumed as UK; and

- For Cuba, a third-party source was used (Australia DFAT 2024).

It is acknowledged that these assumptions will have had a small effect on the correlation analysis because they would result in under- or over-estimations of the true GDP per capita PPP values. With more detailed investigation, it is possible that more suitable equivalents can be found that would provide greater accuracy. However, the impact of any slight differences on the overall analysis was considered to be very small and it was not deemed necessary to obtain more accurate estimates.

Following projections and imputation of missing values, the growth rates in GDP per capita from the Shared Socioeconomic Pathways Project were used to project data for 178 countries and economies each year from 2023 until 2050 (Dellink et al. 2024). The SSP2 scenario was selected from five possible pathways because it represents the most central projection of future growth. Users of this method that wish to replicate its findings are encouraged to consider the development of models that explore scenarios according to the other four pathways. The ordinary least squares regression method using historical GDP data was used for the projections for the remaining countries, which are not covered by the SSP2.

GNI per capita

GNI per capita, Atlas method (current US$) data were obtained from the World Bank.[4] Of the 217 countries and economies in scope for *What a Waste 3.0*, 185 had a full set of data from 2000 to 2022.

For the rest of the countries, the mean growth rate for their income group was used to project the most recent GNI per capita value. Alternatively, the ordinary least squares regression method was used to project both forward and backward to complete the historical dataset.

As with the GDP projections, the growth rate in GDP per capita from the SSP2 was used to project GNI data (Dellink et al. 2024). The ordinary least squares regression method was used for the projections for countries not covered by the SSP2.

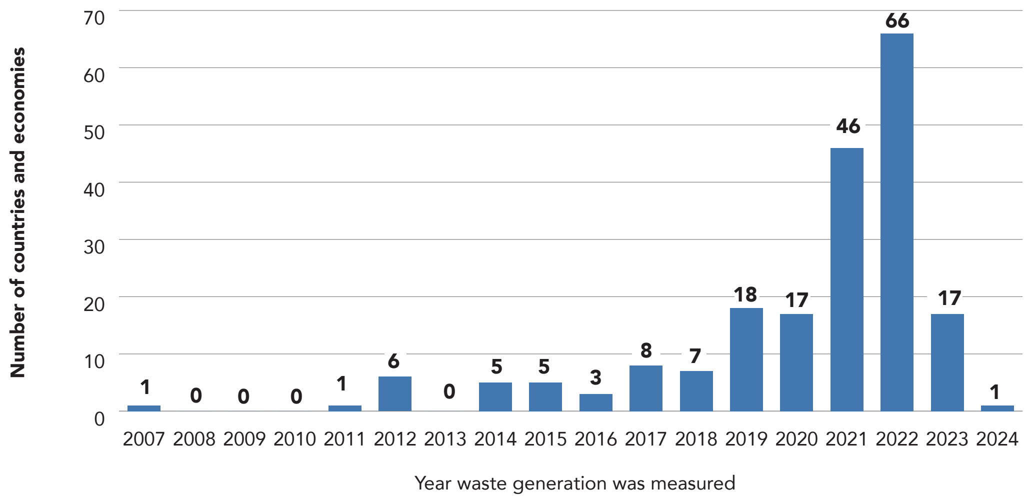
C.4 Projected Country Dataset

C.4.1 Waste Generation

Country Dataset

In the country dataset, waste generation data were reported for the most recent year available for 201 out of 217 countries and economies within the scope of this study. Approximately 88 percent of countries (177) had reported new data since 2016, which was the temporal scope of the last edition of *What a Waste* (Kaza et al. 2018); and updated in *More Growth, Less Garbage* (Kaza, Shrikanth, and Chaudhary 2020).

Figure C.2 Distribution of the year of measurement for waste generation data reported for 201 countries and economies



Source: Authors' presentation.

Approximately 88 percent of the waste generation dataset came from reports since 2016, however the remainder came from measurements spanning back as far as 2007 (figure C.2). To assist with comparability, a method based on the approach in *More Growth, Less Garbage* was used to project data from its year of measurement to a consistent target year. For the baseline comparison, the year 2022 was chosen because that was the year that was most commonly reported in the dataset. In addition, the method was used to estimate the waste in each country over the coming decades, for 2030, 2040, and 2050. The results of these projections on a country-by-country basis are presented in appendix A.

The steps undertaken to carry out the waste generation projections are summarized in figure C.3.

Projected Country Dataset

Waste generation data were projected to a consistent baseline year of 2022 to enable comparability of waste generation data and also into the future for 2030, 2040, and 2050, the target years. This was done using a correlation between waste generation per capita and gross domestic product (GDP) per capita, PPP data (constant 2021 international $).[5] This correlation was also used to estimate waste generation for the 16 countries that it was not available for. The estimated waste generation for each of the target years was multiplied by United Nations population projections for those years (UNDESA 2024).

Figure C.3 Summary of steps undertaken to project country waste generation data from the year in which it was measured to target years

Raw waste generation data	• Quality assurance and peer review carried out to identify majority of errors • Metadata recorded where available
Plot against socioeconomic indicators	• Explanatory variables investigated: GDP per capita PPP; GNI per capita; HDI; SPI and SPI Opportunity • Visual inspection to identify correlation patterns and identify candidate functions that partially explain variability in waste generation (kg per capita per day)
Model fitting	• Functions (curves) ranked to longlist models that partially explain variability in waste generation • GDP per capita PPP emerged as best explanatory variable
Sensitivity analysis	• Assessment of influence of outlying datapoints on each function • Datapoints excluded above GDP US$90,000 and waste generation above 2.4 kg per capita per day • Two erroneous or incongruent datapoints identified and excluded from analysis
Model fitting	• Functions (curves) ranked to create shortlist of candidates that can be used for projections
Model selection	• Behavior of shortlisted functions assessed against GDP per capita PPP of the most extreme case (country) in 2050 (~US$350,000) • Exclusion of functions that exhibited behavior that prohibited use over timescale of model • Expert opinion consensus selected suitable model
Imputation and projection of waste generation	• Countries (n=16) with missing waste generation data imputed using regression • Waste generation per capita for countries with existing waste generation measurements projected to 2022, 2030, 2040, and 2050 by multiplying the growth rate of the regression between the measurement and target year by the waste generation measurement • Projected per capita waste generation multiplied by population in target years to calculate absolute waste generation of each country

Source: Authors' presentation.
Note: GDP = gross domestic product, GNII = gross national income, HDI = Human Development Index, PPP = purchasing power parity, SPI = Social Progress Index.

C.5 Adjustments

C.5.1 Waste Generation

For statistical analyses, in order to account for flows of waste that are not typically recorded or measured—such as the amount of uncollected waste, the waste collected by the informal sector, and nonhousehold municipal solid waste if explicitly reported—some waste generation rates were adjusted. Corrections were made conservatively, and it is possible that waste generation reported here is still underestimated for some regions and income groups. The adjustments resulted in collectively adding a total of approximately 4.6 percent to the total global waste generated. The results of these adjustments are shown only on an aggregated regional, income group, and global level.

In addition, technical corrections were made where evidence suggests that material recycling is not included in official government statistics. The adjustments resulted in adding a total of 3.8 percent to the total global waste generated. Similar to the above, the results of these adjustments are shown only on an aggregated regional, income group and global level.

A correlation between adjusted waste generation per capita and gross domestic product (GDP) per capita, PPP data (constant 2021 international $) (Kaza, Shrikanth, and Chaudhary 2021) was used to project the per capita waste generation to 2022, 2030, 2040, and 2050 United Nations population projections were then multiplied by the per capita rates to obtain absolute waste generation in each of the target years.[6]

C.5.2 Collection Coverage

Country Dataset

Three types of collection coverage data were recorded at urban, rural, and national levels for the country dataset, where available: (1) proportion of waste generated that is collected (weight percent); (2) proportion of households served (percent); and (3) proportion of population served (percent). If multiple values were reported, the collection rate with the most recent data in combination with the strongest data pedigree[7] was used.

Adjustments

Waste collection coverage was harmonized to a single category (weight percent) for urban, rural, and national by prioritizing, in order, waste collection rates by: (1) weight; (2) population; and (3) households. The correlation between the harmonized single category and (GDP) per capita, PPP data (constant 2021 international $) was used to project collection coverage to 2022, 2030, and 2040 to enable comparison between countries in a consistent year.[8]

City Dataset

Four types of waste collection coverage data were recorded for the city dataset where available: (1) proportion of waste generated that is collected (weight percent); (2)

proportion of households served (percent); (3) proportion of population served (percent); and (4) proportion of geographical area covered (percent). If multiple values were reported, the collection rate with the most recent data were used.

C.5.3 Treatment

Country Dataset

Waste treatment and disposal data were reported for 11 waste treatment and disposal types: Open dumpsite; controlled landfill; sanitary landfill with landfill gas management system; landfill unspecified; anaerobic digestion; compost; recycling; incineration; mechanical biological treatment; refuse-derived fuel; and other. In addition, a twelfth category was added to represent uncollected waste. Where waste treatment and disposal type could not be identified or in cases where disposal, treatment, and uncollected percentages did not add up to 100 percent, the remaining amount is categorized as waste "unaccounted for".

The three types of land disposal were harmonized with the Waste Wise Cities Ladder of Control (UN-Habitat 2021) for land disposal: (1) sanitary landfills with landfill gas collection systems; (2) controlled landfills that are engineered but for which landfill gas collection systems do not exist or are unknown; and (3) dumpsites, that is, land disposal facilities, which are used for collected waste but for which there are no controls in place. Where the type of land disposal site was not specified, they were categorized as unspecified landfills.

Adjustments

In order to carry out statistical analysis, treatment and disposal data underwent a series of adjustments to improve comparability between regions and income levels. The thirteen categories were first rationalized to seven categories: Recycling; composting and anaerobic digestion; incineration; sanitary landfill; controlled landfill; and dumpsites. Each of the treatment types underwent processing to adjust for missing flows (recycling) and fill in missing values (recycling and land disposal). The correlation between each of the treatment types and either GNI per capita, Atlas method (current US$)[9] or GDP per capita, PPP data (constant 2021 international $) was used to project values to consistent target years—2022, 2030, 2040, and 2050—and fill in missing values.[10]

Recycling Rate

Recycling rates reported in official statistics sometimes include a mixture of waste collected by both the formal and informal sectors. In other cases, they may include one or the other. However, what is included and excluded is almost never reported. In the adjustment, an attempt was made to conservatively account for these informal sector activities by adding mass to the treatment mix in cases where it was assessed to be unaccounted for. The adjustments resulted in adding a total of 2 percent to the total global waste generated.

Though conservatively applied, the adjustments are likely to be imprecise at lower scale and are intended for analysis at regional and income group level. Once these adjustments had been made, the recycling rates (World Bank Group 2024b) were projected to consistent target years—2022, 2030, 2040, and 2050—using a correlation with GNI per capita, Atlas method (current US$).

Composting and Anaerobic Digestion

Composting and anaerobic digestion mass were combined for the adjusted data resulting in an estimate for 69 countries for this category. The proportion was projected to consistent target years —2022, 2030, 2040, and 2050—using a correlation with GNI per capita, Atlas method (current US$).

Because informal sector activities related to composting and anaerobic digestion are expected to be minimal, all such activities are assumed to be formal when separated waste is collected. In other words, the decision to introduce and scale up composting or anaerobic digestion depends on explicit public policy choices. Although a correlation was observed between the prevalence of these treatment methods and gross national income (GNI) per capita—Atlas method, current US$—this edition of *What a Waste 3.0* does not model future policy decisions. As such, projecting adoption based solely on income levels was not deemed appropriate. To avoid introducing assumptions about future national policy choices, countries that do not currently report composting or anaerobic digestion are assumed not to introduce these technologies over the projection period.

Incineration

The proportion of waste reported to be incinerated was projected to consistent target years—2022, 2030, 2040, and 2050—using a correlation with GDP per capita, PPP data (constant 2021 international $). As with composting and anaerobic digestion, the decision to implement waste incineration is a matter of public policy and cannot be assumed based on a country's socioeconomic status alone. This edition of *What a Waste* does not model future policy choices; therefore, it does not project the adoption of incineration solely on the basis of income level or development indicators. For this reason, when incineration is not reported, incineration is not assumed over the projection period.

Land Disposal

Of the 168 countries that reported waste being sent to land disposal, 77 cases did not report the type of land disposal site and were therefore allocated to "unspecified". The unspecified category could not be used in projections and without any additional information a basic allocation was made as follows:

- Low-income and lower-middle-income countries assumed dumpsite
- Upper-middle-income countries assumed controlled landfill
- High-income countries assumed sanitary.

It is acknowledged that these allocations are approximate, may not represent the actual state of landfill standards, and are used to make projections on a regional and income level scale.

C.5.4 Waste Composition

Country Dataset

Material composition was obtained for 182 countries and reported as a percentage of total municipal solid waste generated. Where the original source reported the composition as weights, the percentage was calculated using the total mass of all components. In a few cases, composition values did not add up to 100 percent or sum to more than 100 percent in the original source. Values provided are presented as they were reported in the original source. Both point of measurement and method of measurement were recorded for waste composition data.

Thirteen categories were recorded as follows: organic; glass; metal; paper and cardboard; plastic; rubber and leather; wood; garden; textiles; waste electrical and electronic equipment; hazardous; diapers and hygiene; and other. Most countries reported between six and nine categories, with approximately 24 percent reporting more and just a handful reporting less.

Adjustments

Several sequential adjustments were made to composition data for statistical purposes. The adjustments were applied conservatively.

A small adjustment was made to several engineered material categories—paper, cardboard, plastics, metals, glass, other—where it was assessed unlikely that the informal waste sector had been included in composition data. This was done to include otherwise unmeasured material that had already been collected by the informal sector prior to measurement.

(1) Where garden waste was not reported but there was a “food (organic)” category, some of the composition was redistributed to garden waste

(2) Where large “other” categories were reported, the category was redistributed as follows:

   a. Where inert waste was reported, it was used to create a new category using income group medians;

   b. Where waste electrical and electronic equipment was not reported, data from the E-Waste Monitor was used (Baldé et al. 2024);

   c. Where other categories were missing, the median of categories from, each income group was used.

Composition was normalized in cases where the sum did not equal 100 percent.

C.6 Scenario Projections

In addition to the business-as-usual scenario, two further scenarios were developed to model potential futures for waste management worldwide (table C.3). They explore two potential levels of ambition—high-ambition and low-ambition scenarios—over the coming decades where waste is reduced, brought within human control, and where it is utilized as a resource to reduce burdens on the environment and human health. The levels of ambition were built on those used to create similar scenarios presented in *The Global Waste Management Outlook 2024* (UNEP 2024), which is understood to be based on data from *What a Waste 2.0* (Kaza et al. 2018).

In each of the high- and low-ambition scenarios, business-as-usual expectations will remain the same in 2022 and 2030. After this, in 2040 and 2050, the high-ambition scenario explores ambitious targets, which would result in the entire municipal solid waste fraction being brought under a basic level of control by 2050. In addition, substantial efforts would be made to increase recycling and composting, doubling the global recycling rate in 2050 compared to the business-as-usual rate in 2022. The most ambitious aspiration in the high-ambition scenario is that waste generation would be capped at the same quantity as in 2022, despite anticipated population increase of 1.6 billion people and anticipated economic growth on GDP per capita basis. The low-ambition scenario is approximately half the ambition of the high-ambition scenario across all targets.

Table C.3 Overview of scenario projection targets for 2050 explored in *What a Waste 3.0*

Scenario	Waste generation	Waste collection as proportion of waste generated (weight)	Recycling, composting and anaerobic digestion as proportion of waste generated (weight)	Waste managed in controlled facilities (weight) – SDG 11.6.1 indicator
Business as usual	3.9 billion tonnes	89%	• Global 27% • High-income 44% • Upper-middle-income 22% • Lower-middle-income 23% • Low-income 5%	80%
Low ambition	3.2 billion tonnes	94%	• Global 41% • High-income 57% • Upper-middle-income 41% • Lower-middle-income 36% • Low-income 13%	89%
High ambition	2.6 billion tonnes	100%	• Global 54% • High-income 70% • Upper-middle-income 60% • Lower-middle-income 50% • Low-income 20%	100%

Source: Authors' presentation.
Note: SDG = Sustainable Development Goal.

For each of the targets, adjustments were made to the relevant process for each country sequentially. Constraints were applied to prevent infeasible activity, for example a recycling rate that exceeds the amount of material available to recycle in a particular country. Therefore, as the sequential adjustments were made, and some countries reached their constraint ceiling, the adjustment applied to fewer and fewer other countries until the target was reached, which is discussed in more detail in the following sections.

C.6.1 Waste Generation

Adjustments to waste generation in both scenarios were made by applying percentage weight reductions to each individual country depending on its income level (table C.4). Constraints were placed on these reductions to prevent unrealistically low reductions being implemented on a per country basis. The constraint was set to prevent waste generation per capita going lower than the 5th percentile (low-ambition scenario) or the 25th percentile (high-ambition scenario) of all per capita waste generation rates in each income group in 2022 business as usual.

Table C.4 Percentage multipliers applied at country level with constraints to prevent unrealistically low waste generation ambition

Income level	Low-ambition scenario			High-ambition scenario		
	Decrease multiplier		Constraint[a]	Decrease multiplier		Constraint[b]
	2040	2050		2040	2050	
High-income countries	85%	70.0%	0.93	71%	42.5%	0.89
Upper-middle-income countries	90%	80.0%	0.46	81%	61.0%	0.42
Lower-middle-income countries	96%	92.5%	0.32	89%	77.5%	0.26
Low-income countries	100%	100.0%	0.28	100%	100.0%	0.24

Source: Authors' presentation.
Note: Decrease in waste generation constrained not to go below the: (a) 5th percentile and (b) 25th percentile of business-as-usual waste generation in 2022 (kilogram per capita per day).

C.6.2 Waste Collection

The high-ambition scenario aspires to a world where 100 percent of the population has access to waste collection by 2050. With this level of ambition set, the low-ambition scenario achieved collection coverage on a country-by-country basis so that the income level collection coverage was halfway between 100 percent and the collection coverages anticipated under business as usual.

C.6.3 Recycling and Composting Rates

Recycling and composting rates were increased sequentially until each of the income group targets was reached in 2050. The 2040 targets were then adjusted to represent half the increase between 2030 business as usual and 2050.

Constraints were applied to the amount of material that could be recycled or composted. This was done by limiting the recycling rate so that no more than 75 percent of engineered materials—glass, metal, paper and cardboard, plastic, wood, textiles, waste electrical and electronic equipment, and inert and rubble—could be recycled and no more than 80 percent of organic, food and garden waste, could be composted in any one country. In the high-income group, which had the most challenging recycling and composting targets for 2050, these constraints limited the recycling and composting rate for many countries and limited the feasibility of recycling rates surpassing the overall aspiration of the income group level in the high-ambition scenario.

C.6.4 Waste Managed in Controlled Facilities

As with collection coverage, the high-ambition scenario aspired to a world where 100 percent of the world's waste is managed in controlled facilities by 2050, in line with the Sustainable Development Goal (SDG) target indicator 11.6.1. In the scenarios, most of this aspiration was achieved across the income categories by a combination of the previously implemented targets: waste generation reduction; 100 percent collection coverage; and increased recycling, composting, and anaerobic digestion. The remaining uncontrolled landfill was removed from the high ambition scenario by sequentially adjusting the controlled and sanitary landfill processes until the dumpsite process had reached zero (table C.5).

Table C.5 Increases in controlled and sanitary landfilling at country level by income group

	Low-ambition scenario				High-ambition scenario			
	Sanitary as % weight land disposal		Controlled as % weight non-sanitary landfill		Sanitary as % weight land disposal		Controlled as % weight non-sanitary landfill	
Income level	**2040**	**2050**	**2040**	**2050**	**2040**	**2050**	**2040**	**2050**
High-income countries	25%	50%	0%	0%	0%	0%	0%	0%
Upper-middle-income countries	0%	5%	0%	0%	0%	0%	0%	0%
Lower-middle-income countries	1%	10%	0%	8%	0%	25%	0%	50%
Low-income countries	5%	10%	40%	51%	10%	20%	65%	95%

Source: Authors' presentation.
Note: Individual country results constrained to 100%.

C.7 Greenhouse Gas Emissions

Greenhouse gas emissions from solid waste management activities were estimated using the *2006 IPCC Guidelines for National GHG Inventories – Volume 5* (Waste) and the 2019 refinements (IPCC 2006a and 2019a, respectively) for the following three components:

- 4A: Solid Waste Disposal
- 4B: Biological Treatment of Solid Waste
- 4C: Incineration and Open Burning of Waste

The rate of open burning could not be determined at the global level, therefore, only incineration was considered under 4C. Likewise, it was assumed that uncollected waste was deposited on land in conditions equivalent to disposing of waste in shallow landfills. It was assumed that GHG emissions from uncollected waste are equivalent to emissions from disposing of waste in shallow landfills.

Methane and nitrous oxide emissions are converted to carbon dioxide equivalent (table C.6) using their global warming potential (GWP) values relative to carbon dioxide over a 100-year time horizon (Greenhouse Gas Protocol 2024).

Table C.6 Global warming potential values

Greenhouse gas	Chemical formula	GWP values for 100-year time horizon from IPCC AR6
Carbon dioxide	CO_2	1.0
Methane – non-fossil (used in 4A and 4B)	CH_4	27.0
Methane – fossil (used in 4C)	CH_4	29.8
Nitrous oxide	N_2O	273.0

Source: IPCC AR6 2015.
Note: AR6 = Sixth Assessment Report, GWP = global warming potential, IPCC = Intergovernmental Panel on Climate Change.

C.7.1 Solid Waste Disposal

Emissions from solid waste disposal were estimated following chapter 3 of the *IPCC Guidelines Volume 5 Waste* (IPCC 2006b) and the 2019 refinement of the chapter using the first order decay (FOD) method (IPCC 2019b). Accordingly, in the absence of site-specific recovery data, methane recovery was set to zero for all sites except sanitary landfills, where an average of 50 percent recovery was assumed based on the review of international best practices (Lair et al. 2024; IPCC 2007). Emissions from landfill gas flaring were not included, as the carbon dioxide produced from the combustion of biogenic methane is considered biogenic carbon dioxide, and the associated methane and nitrous oxide emissions from flaring are negligible.

The methane correction factors (MCF) used in the first order decay model for each land disposal site type were sourced from table 3.1 of the 2019 refinement to the *IPCC Guidelines Volume 5, Chapter 3 Waste* (IPCC 2019b). The MCF value for this disposal site category was then reduced by 50 percent to account for the 50 percent methane recovery in the sanitary landfill sites.

The degradable organic carbon (DOC) and the decomposable fraction of DOC (DOCf) were taken from the same source—chapter 3, 2019 Refinement (IPCC 2019b)—and correspond to typical waste categories such as food, wood, paper, and textiles.

C.7.2 Biological Treatment of Solid Waste

GHG emissions from composting and anaerobic digestion of waste were estimated using the methodology in chapter 4 of the *IPCC Guidelines Volume 5 Waste* (IPCC 2006c).

Emissions from flaring in anaerobic digestion facilities are ignored because the carbon dioxide emissions from flaring biogenic methane from biological treatment of organic waste are biogenic, and methane and nitrous oxide emissions from flaring are insignificant.

For anaerobic digestion sites, it was assumed that all methane generated is recovered and, thus, excluded from the emission estimates.

The emission factors for methane and nitrous oxide used for calculating the methane and nitrous oxide emissions are sourced from the IPCC guidelines, where the emission factors on a wet waste basis were used (table C.7).

Table C.7 Emission factors for methane and nitrous oxide

Type of biological treatment	CH4 emission factors (g CH4/kg of waste treated)	N2O emission factors (g N2O/kg of waste treated)
Composting	4.0	0.24
Anaerobic digestion	0.8	0

Source: IPCC 2006c.
Note: CH4 = methane, g = grams, kg = kilogram, N2O = nitrous oxide.

It was assumed that 75 percent (by weight) of the organic waste undergoing biological treatment is composted, while the remaining 25 percent is sent to anaerobic digestion. Moreover, to account for the methane recovery in anaerobic digestion sites, the methane emission factor for the anaerobic digestion sites was set to zero. Using this proportional split between composting and anaerobic digestion, the weighted averages of the emission factors were applied to the total biological treatment of waste to estimate the resulting methane and nitrous oxide emissions.

C.7.3 Incineration and Open Burning of Waste

Estimation of GHG emissions from incineration of waste is based on chapter 5 of the *IPCC Guidelines Volume 5, Waste* (IPCC 2006d) and the 2019 refinement of the chapter (IPCC 2019c). The IPCC recommended values[11] are used for the different waste composition categories.

The fossil carbon content of the waste combusted is then multiplied by the oxidation factor to estimate the amount of fossil carbon oxidized, which is then multiplied by the conversion factor for converting carbon to carbon dioxide (table C.8).

Table C.8 Conversion factor for fossil carbon content

Type of treatment	Oxidation factor (OF)	Conversion factor C to CO2 (=44/12)
Incineration	100%	3.67

Source: IPCC 2006d and IPCC 2019c.
Note: C = carbon, CO2 = carbon dioxide.

The emission factors for methane and nitrous oxide used for calculating methane and nitrous oxide emissions from the incineration of waste are sourced from the IPCC guidelines, where the emission factors on a wet waste basis were used. For the methane and nitrous oxide emission factors for waste incineration, the IPCC Guidelines provide emission factors for various types of incineration methods or technologies—for example, continuous incineration, semicontinuous incineration, and batch-type incineration using either stoker or fluidized bed. In the absence of data on incineration techniques used, averages of the methane and nitrous oxide emission factors for the different incineration techniques are used (table C.9).

Table C.9 Emission factors for methane and nitrous oxide

Type of treatment	CH4 emission factor (kg CH4/1,000 tonnes of waste treated)	N2O emission factor (kg N2O/1,000 tonnes of waste treated)
Incineration	81.87	55

Source: IPCC 2006d and IPCC 2019c.
Note: CH4 = methane, kg = kilogram, N2O = nitrous oxide.

C.8 Projections for the Future Waste Management Costs

Municipal waste management costs were estimated for the period 2022 to 2050 for the business-as-usual, low-ambition, and high-ambition scenarios.

Waste management costs depend on the technical and organizational solutions adopted to achieve system objectives. Estimating these costs typically involves population forecasts, projections of waste quantities and composition, definition of management objectives, and the development of technical scenarios for each system element. Each step has a significant influence on overall costs.

Data on population, municipal waste generation, waste composition, and quantities of municipal waste designated to different waste management operations for the years 2022, 2030, 2040, and 2050 were used as input values for cost calculations under the three scenarios: business as usual, low, and high ambition. A linear dependence is assumed for the calculation of these parameters in the years between 2022, 2030, 2040, and 2050, meaning that values are estimated based on a constant rate of change between each set of benchmark years.

C.8.1 Cost Estimation

Cost estimates were calculated at the country income, regional, and global levels. In addition, total costs are disaggregated by waste management operation. Baseline costs in 2022 reflect prevailing practices; for instance, the comparatively low investment costs in low-income countries stem largely from continued reliance on open dumping.

Table C.10 summarizes which measures are included in the costing of the solid waste management scenarios. Total municipal waste management costs include estimates for the following operations: separate collection of recyclable materials—paper, cardboard, plastics, glass, and metals; sorting of recyclables; separate collection and composting of green and other biowaste from public spaces, markets, and households; separate collection and anaerobic digestion of food waste; collection of residual municipal waste; mechanical biological treatment of residual or mixed municipal waste; incineration; and landfilling.

The cost estimates exclude the following: land acquisition for the waste treatment and disposal sites; capital investments to expand co-incineration capacity needed to utilize RDF from mechanical and biological treatment such as modifications to cement plants for RDF storage, preparation and feeding or flue gas handling; investments in new recycling infrastructure to process increased volumes of separated recyclables such as paper mills; and costs associated with remediation and clean-up of legacy disposal sites.

Estimated waste quantities—measured in tonnes by type of waste—and the corresponding treatment shares are used to determine the capacity requirements for each component of the municipal waste management system. These capacity estimates form the basis for calculating the associated investment and operating costs. Unit cost data for the different waste management operations were obtained from *Municipal Solid Waste Cost Calculation Technical Guidelines for Low and Middle Income Countries* (World Bank 2024a).

Costs are calculated without value added tax (VAT) and other taxes. The cost estimates are provided in current prices, that is, without considering future inflation or discounting.[12]

Investment and operating costs per tonne of waste generated and per capita are estimated for each waste management activity. These costs are disaggregated by key components of the municipal waste system, for example, collection, sorting, treatment type, and disposal, and further categorized into capital expenditures (investments), operations and maintenance costs, and depreciation. Estimates are provided by country income group and by geographic region.

Table C.10 Activities and measures costed and not costed

	Activities and measures costed	Activities and measures not costed
Recyclables	Separate collection of household recyclable waste (paper and cardboard, plastics, glass, and metals). Sorting of separately collected recyclable waste.	Investment in additional capacity—such as paper and cardboard mills, plastics reprocessing plants, metal smelters, and glass treatment plants and furnaces—to handle increased quantities of separated materials processed outside the waste sector. Recyclable waste collected by informal sector.
Food waste	Separate collection of household food waste. Anaerobic digestion of food waste.	–
Green/garden waste	Separate collection of green waste from public green areas, markets, and households. Composting of separately collected green waste	Home composting
Residual waste	Collection of residual municipal waste. Mechanical biological treatment (MBT) of residual waste, including MBT refuse-derived fuel. Incineration of residual municipal waste.	Investment costs for the establishment of additional capacities for incineration or co-incineration of refuse-derived fuel (RDF) resulting from MBT of residual waste. Litter cleaning costs
Landfill	Landfilling Dumping and controlled landfilling are treated as a single category.	Remediation and clean-up of legacy disposal sites
Land acquisition	None	Land acquisition for municipal waste treatment sites. Land acquisition for sites where recovery and disposal infrastructure will be established.

Source: Authors' presentation.

- Annual operating costs are calculated based on unit operating costs per tonne of waste for the respective waste management operation and the total quantities of waste designated to the same operation in the respective year. Operating costs include the costs for maintenance and repair; labor; consumables; administration; taxes and insurance.
- Depreciation costs are calculated based on unit depreciation costs per tonne of waste and category of assets, and the total quantities of waste designated to the same operation in the respective year.
- Investment costs are estimated based on the calculated depreciation costs per main categories of assets and their respective lifetime. The following lifetimes of different asset types are used for the calculation of depreciation and investment

costs: civil works = 30 years; mechanical works (low wear and tear) = 15 years; mechanical works and stationary equipment (normal wear and tear) = 10 years; vehicles and mobile equipment = 10 years; containers = 7 years; and individual landfill cell = 5 years. The investment costs calculated in this way include the asset replacement costs and the costs for landfill closure.

Certain unit costs are differentiated by income group. Labor costs in lower-middle-income countries are assumed to be 65 percent higher than in low-income countries and 50 percent lower than in upper-middle-income countries.[13] Different unit costs for MBT of residual waste are used for low-income, lower-middle-income, upper-middle-income, and high-income countries based on different technical complexity of installations and follow the approach in the *Municipal Solid Waste Cost Calculation Technical Guidelines for Low and Middle Income Countries* (World Bank 2024a).

C.8.2 Revenues

A conservative estimate of potential revenues from the sales of separately collected and sorted recyclables, and electricity produced from incineration was calculated. The potential revenues are estimated based on unit prices for sale of recyclable waste commodities ex-works at waste treatment facility. Only electricity sales are taken into account for the incineration, based on conservative assumptions for electricity produced in kilowatt hour per tonne of input waste.

The potential revenues from the sales of RDF are assumed to be absorbed by the transportation costs for delivery to final user and for that reason not taken into account.[14]

C.9 Jobs

Employment estimates are based on data from 63 cities included in the city database, which report total numbers of formal or informal waste workers. For each city, the number of waste workers per 100,000 urban residents was calculated using city-level population data.

Average employment rates—waste workers per 100,000 urban residents—were then calculated separately for each country income group. These rates were then applied to the corresponding global urban population by income group, and the results summed to estimate the total number of urban waste workers worldwide.

The estimates draw on reported data for formal employment in high-income countries, both formal and informal workers in upper-middle- and lower-middle-income countries, and predominantly informal workers in low-income countries.

The estimates presented reflect only direct employment in waste collection, sorting, and recycling. Indirect employment generated through related economic activities—such as the use of recovered materials in manufacturing, construction, and product redesign—is not captured in this analysis and remains outside the scope of the employment estimates presented.

Notes

1. World Bank Group. *GDP Per Capita, PPP (Constant 2021 International $)*. https://data.worldbank.org/indicator/NY.GDP.PCAP.PP.KD.
2. The 21 countries and economies are Andorra, Afghanistan, Bermuda, China, Curacao, Djibouti, Dominica, Faroe Islands, Greenland, St. Kitts and Nevis, Kosovo, the Marshall Islands, Nauru, Palau, Saint Maarten (Dutch), San Marino, Syrian Arab Republic, Turks and Caicos Islands, Taiwan, China, Tuvalu, Virgin Islands (US), and West Bank and Gaza.
3. The six countries include Eritrea, Lichtenstein, South Sudan, Turkmenistan, R.B. de Venezuela, and the Republic of Yemen.
4. World Bank Group. *GNI Per Capita, Atlas Method (Current US $)*. https://data.worldbank.org/indicator/NY.GNP.PCAP.CD.
5. World Bank Group. *GDP Per Capita, PPP (Constant 2021 International $)*. https://data.worldbank.org/indicator/NY.GDP.PCAP.PP.KD.
6. World Bank Group. *GDP Per Capita, PPP (Constant 2021 International $)*. https://data.worldbank.org/indicator/NY.GDP.PCAP.PP.KD.
7. Data pedigree refers to the documented origin, history, and quality of a dataset. It encompasses consideration of the methods used to process and validate that data. It includes metadata on the methods, instruments, sampling protocols, temporal and spatial resolution, data transformations, and the degree of uncertainty or error. A robust data pedigree enables reproducibility, supports the evaluation of data reliability, and informs the suitability of the data for specific analyses or models.
8. World Bank Group. *GDP Per Capita, PPP (Constant 2021 International $)*. https://data.worldbank.org/indicator/NY.GDP.PCAP.PP.KD.
9. World Bank Group. *GNI Per Capita, Atlas Method (Current US $)*. https://data.worldbank.org/indicator/NY.GNP.PCAP.CD.
10. World Bank Group. *GDP Per Capita, PPP (Constant 2021 International $)*. https://data.worldbank.org/indicator/NY.GDP.PCAP.PP.KD.
11. IPCC (Intergovernmental Panel on Climate Change). 2006. *2006 IPCC Guidelines for National Greenhouse Gas Inventories*: Chapter 2: Waste Generation, Composition and Management Data. IGES. https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_2_Ch2_Waste_Data.pdf.
12. An annual increase of 3% of waste management unit costs is assumed for the period between 2023 and 2025.
13. This analysis draws on median income data by country income group from 2011–2021, sourced from Our World in Data, 2025: "Median income or consumption per day." https://ourworldindata.org/grapher/daily-median-income, which compiles data from the World Bank *Poverty and Inequality Platform* (PIP). https://pip.worldbank.org/. Comparing the raw difference in median income across country income groups may conflate differences in economic structure with differences in wage levels. The analysis instead assumes that half of the increment in median incomes between income groups (low-income to lower-middle-income countries, and lower-middle-income to upper-middle-income countries) is due to differences in economic structure, and half is due to differences in wage levels within sectors—resulting in a 65% wage increment from low-income to lower-middle-income countries and 50% from lower-middle-income to upper-middle-income countries.
14. The price of refuse-derived fuel (RDF), which depends on its quality characteristics and market demand, is typically negative in Europe, reflecting the cost of disposal. However, the cement industry in some Asian countries pays a minimum price for its supply. In the current estimates, it is assumed that net revenues from the sale of RDF will balance the transport costs from the waste processing facility to the cement plant or other waste-to-energy user.

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