International Scholars Journals

Advanced Journal of Environmental Science and Technology ISSN 2756-3251, Vol. 17 (11), pp. 001-008, November, 2026. Available online at www.internationalscholarsjournals.org © International Scholars Journals

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A Critical Review

From Linear Disposal to Circular Value: Municipal Solid Waste Management, Recycling, and the Transition to a Circular Economy

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Manuscript Timeline: Received 14 February, 2026; Revised 18 March, 2026; Accepted 02 April, 2026; Published 21 November, 2026.

Abstract

Municipal solid waste is one of the most visible and consequential outcomes of urbanisation, consumption, and industrial production. Cities worldwide generate more than two billion tonnes of municipal solid waste each year, and generation is projected to rise sharply by mid-century if current patterns continue. Much of this waste is still landfilled, openly dumped, or burned, with serious consequences for climate, water, soil, air quality, and public health. This critical review synthesises evidence on the scale and composition of municipal solid waste, the performance and limitations of collection, sorting, recycling, composting, anaerobic digestion, and energy recovery, and the wider shift from a linear take-make-dispose model to a circular economy. It shows that recycling alone cannot solve the waste problem: prevention, reuse, product redesign, and demand reduction are essential, while recycling works best when feedstocks are clean, markets are stable, and informal workers are included fairly. The review compares high-income and low- and middle-income contexts, examines policy instruments such as extended producer responsibility, deposit-return schemes, landfill taxes, and pay-as-you-throw systems, and evaluates digital and technological innovations including smart collection, artificial intelligence sorting, and chemical recycling. It argues that a just circular transition must combine technical improvement, economic incentives, inclusive governance, and behaviour change, and it identifies priorities for measurement, financing, and research.

Keywords: municipal solid waste; recycling; circular economy; waste management; extended producer responsibility; composting; landfill; informal sector

1. Introduction

Waste is often treated as an afterthought, something to be removed and forgotten. In reality, how societies manage waste reveals how they produce, consume, govern, and value resources (Hoornweg and Bhada-Tata, 2012; Kaza et al., 2018). The World Bank estimated that the world generated about 2.01 billion tonnes of municipal solid waste in 2016, and projected that generation could reach 3.40 billion tonnes by 2050 under business-as-usual trends (Kaza et al., 2018). High-income countries generate a disproportionate share per person, while low- and middle-income countries face the fastest growth and the weakest infrastructure (Hoornweg and Bhada-Tata, 2012; Kaza et al., 2018). In many cities, waste collection is incomplete, recycling is informal, and disposal relies on open dumps that pollute water and air and harm nearby communities (Wilson et al., 2012; Medina, 2008).

The environmental stakes are large. Landfills are a major source of methane, a potent greenhouse gas produced when organic waste decomposes without oxygen (Bogner et al., 2008; Intergovernmental Panel on Climate Change, 2022). Open burning releases particulate matter, dioxins, and other toxic pollutants (Wiedinmyer et al., 2014). Leachate can contaminate groundwater and surface water, while plastic waste fragments and enters rivers and oceans (Geyer et al., 2017; Borrelle et al., 2020). At the

same time, waste contains valuable materials, nutrients, and energy. Paper, glass, metals, plastics, food waste, and textiles all represent embodied energy, water, and labour (Geyer et al., 2017; Ellen MacArthur Foundation, 2013). Discarding them is therefore both an environmental burden and an economic loss.

This review has four aims. First, it describes the scale, composition, and drivers of municipal solid waste. Second, it evaluates the waste hierarchy and the performance of prevention, reuse, recycling, composting, anaerobic digestion, and energy recovery. Third, it analyses policy, economic, behavioural, and technological conditions that determine whether recycling and circular systems succeed. Fourth, it examines equity, informality, and governance, and identifies priorities for a just circular transition. The review focuses on municipal solid waste, while recognising links to industrial, construction, electronic, and hazardous waste. It draws mainly on peer-reviewed literature, World Bank and United Nations Environment Programme assessments, and circular economy research published between 2000 and 2025.

A central argument is that recycling is necessary but insufficient. A circular economy is not simply a better waste system; it is a redesign of production and consumption so that materials retain value, products last longer, and waste is prevented by design (Ellen MacArthur Foundation, 2013; Geissdoerfer et al., 2017). Recycling can recover materials, but it cannot compensate for rising consumption, poor product design, contaminated feedstocks, or weak markets for secondary materials (Geyer et al., 2017; Kirchherr et al., 2017). The review therefore treats recycling as one stage in a broader system, not as a substitute for prevention and reuse.

2. Scale, Composition, and Drivers of Municipal Solid Waste

Municipal solid waste includes household waste, waste from shops, offices, institutions, markets, and street sweepings, and in some definitions small commercial waste (Kaza et al., 2018; Hoornweg and Bhada-Tata, 2012). It excludes most industrial, mining, agricultural, and construction waste, although boundaries vary by country. Globally, organic waste is the largest fraction, followed by paper and cardboard, plastics, glass, metals, textiles, and other materials (Kaza et al., 2018). Figure 1 summarises this composition. Organic fractions are higher in low- and middle-income countries, where fresh food, markets, and limited packaging dominate, while paper, plastic, and packaging fractions are higher in high-income countries (Kaza et al., 2018; Wilson et al., 2012).

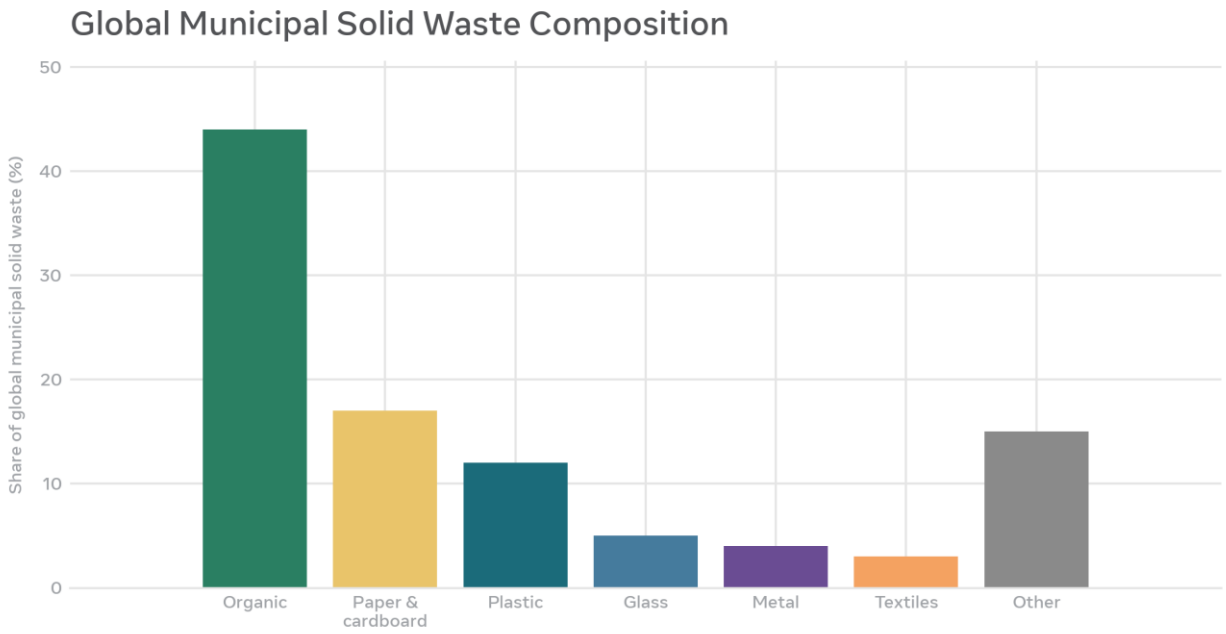


Figure 1. Global municipal solid waste composition, synthesised from Kaza et al. (2018) and Hoornweg and Bhada-Tata (2012). Shares vary by income, season, and city.

Waste generation rises with income, urbanisation, and consumption, but the relationship is not fixed (Hoornweg and Bhada-Tata, 2012; Kaza et al., 2018). Higher incomes bring more packaged goods, single-use products, electronics, and fast fashion, while urban lifestyles increase food waste from restaurants, markets, and households (Parfitt et al., 2010; Gustavsson et al., 2011). Tourism, festivals, and seasonal migration can create sharp peaks in generation, straining collection in cities that already struggle with routine service (Kaza et al., 2018). Climate, culture, and infrastructure also matter: cities with widespread home composting, deposit schemes, or strong reuse markets generate less residual waste than cities with similar incomes but weaker systems (Wilson et al., 2012; Zaman, 2015).

Food waste deserves special attention because it is large, climate-relevant, and avoidable. Gustavsson et al. (2011) estimated that about one-third of food produced for human consumption is lost or wasted globally, with losses concentrated in production and storage in low-income regions and in retail and consumption in high-income regions. Parfitt et al. (2010) showed that household food waste in high-income countries is driven by over-purchasing, confusion over date labels, poor storage, and portion sizes, all of which are amenable to behaviour and policy intervention. When food waste is landfilled, it

generates methane; when it is prevented, it saves land, water, fertiliser, and energy across the supply chain (Intergovernmental Panel on Climate Change, 2022; Gustavsson et al., 2011).

Plastic waste has grown rapidly and presents distinct challenges. Geyer et al. (2017) estimated that cumulative plastic production reached 8,300 million tonnes by 2015, with only a small share recycled and a large share landfilled or leaked into the environment. Borrelle et al. (2020) projected that plastic waste generation would continue to grow and that without major intervention, leakage into aquatic systems would increase. Packaging is the largest plastic use and the shortest-lived, which explains why it dominates plastic waste (Geyer et al., 2017). Textile waste is also growing with fast fashion, and electronic waste is the fastest-growing waste stream in many countries, containing both valuable metals and hazardous substances (Baldé et al., 2017; Forti et al., 2020).

3. The Waste Hierarchy and the Circular Economy

The waste hierarchy ranks options from most to least preferred: prevention, reuse, recycling, other recovery, and disposal (European Commission, 2008; Zaman, 2015). Prevention avoids waste by reducing material use, designing durable products, and changing consumption. Reuse keeps products in use through repair, refurbishment, sharing, and second-hand markets. Recycling recovers materials, while composting and anaerobic digestion recover nutrients and energy from organics. Energy recovery captures heat or electricity from residual waste, while landfilling is the least preferred option because it buries value and creates long-term emissions (European Commission, 2008; Bogner et al., 2008). The hierarchy is a useful guide, but it is not absolute: life-cycle assessment sometimes shows that a lower-ranked option performs better for a specific material or context, for example when transport distances or contamination make recycling worse than energy recovery (Laurent et al., 2014).

The circular economy extends the hierarchy by emphasising design, business models, and systems (Ellen MacArthur Foundation, 2013; Geissdoerfer et al., 2017). In a circular economy, products are designed for durability, disassembly, repair, and recycling; materials circulate at high value; and biological nutrients return safely to soils (Ellen MacArthur Foundation, 2013). Kirchherr et al. (2017) reviewed more than one hundred definitions and found common emphasis on reducing, reusing, recycling, and recovering materials, but also variation in whether definitions include social and environmental goals. Geissdoerfer et al. (2017) distinguished the circular economy from sustainability, arguing that circularity is a means to sustainability, not an end in itself. This distinction matters because a system can be circular for one material while still increasing total consumption, a rebound effect that undermines environmental benefits (Zink and Geyer, 2017).

Zero waste is a related but distinct vision that aims to eliminate waste through redesign, prevention, and full resource recovery, often at city or community level (Zaman, 2015; Zaman and Lehmann, 2013). Zaman (2015) argued that zero waste requires systems thinking, community participation, and measurement beyond recycling rates, including waste generation per capita and residual waste. Critics note that zero waste is aspirational and difficult to define, but its value lies in shifting attention from end-of-pipe management to upstream prevention (Zaman and Lehmann, 2013). The review uses the hierarchy and circular economy as complementary frameworks: the hierarchy guides day-to-day choices, while circularity guides long-term redesign.

4. Collection, Sorting, and the Informal Sector

Collection is the foundation of waste management. Without reliable collection, segregation, recycling, and safe disposal are impossible (Wilson et al., 2012; Kaza et al., 2018). In high-income cities, collection coverage is near universal, with scheduled pickups, separate bins, and transfer stations. In many low- and middle-income cities, coverage is partial, irregular, or absent in informal settlements, leading to dumping in drains, rivers, and open land (Wilson et al., 2012; Medina, 2008). Poor collection also increases flooding, because waste blocks drains, and increases disease risk, because waste attracts vectors and contaminates water (Kaza et al., 2018).

Sorting determines recycling quality. Source separation by households, where residents separate organics, recyclables, and residual waste, generally produces cleaner feedstocks than mixed-waste sorting, but it requires clear rules, convenient bins, feedback, and trust that separated waste is not remixed (Dahlén and Lagerkvist, 2010; Rousta et al., 2015). Mechanical and biological treatment plants can sort mixed waste, but they produce lower-quality outputs and higher contamination (Laurent et al., 2014). Material recovery facilities use screens, magnets, eddy currents, optical sorters, and increasingly artificial intelligence to separate materials, yet their performance depends on input quality and market demand (Kaza et al., 2018; Wilson et al., 2012). Contamination remains a central problem: food residues, mixed polymers, and hazardous items can downgrade entire loads (Geyer et al., 2017).

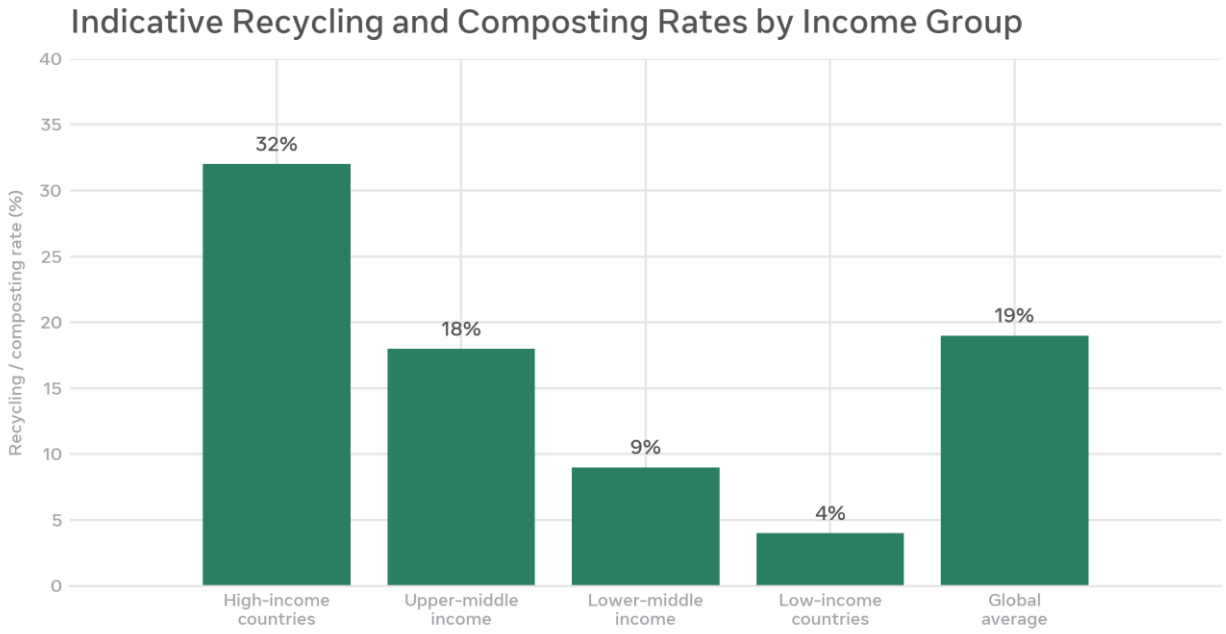
The informal sector is central to recycling in many countries. Waste pickers, itinerant buyers, small traders, and informal recyclers collect, sort, and trade materials that formal systems miss, often achieving high recovery rates for metals, cardboard, and plastics (Medina, 2008; Wilson et al., 2012). Medina (2008) documented that informal recycling in developing countries is driven by poverty, market demand, and the value of secondary materials, and that it provides livelihoods for millions. Wilson et al. (2012) argued that integrating informal workers into formal systems, with fair pay, safety, and recognition, improves both social outcomes and recycling performance. Excluding or criminalising informal workers, by contrast, can reduce recycling, increase dumping, and deepen poverty (Medina, 2008; Gutberlet, 2008). Cooperatives in Brazil, Colombia, and India show that formalisation can work when workers have contracts, protective equipment, and a voice in governance (Gutberlet, 2008).

Table 1. Stages of municipal solid waste management and factors that shape performance, synthesised from Wilson et al. (2012), Kaza et al. (2018), and Laurent et al. (2014).

Stage	Main function	Common challenges	What improves performance
Collection	Remove waste from households and streets	Incomplete coverage, irregular service, blocked drains	Reliable schedules, community collection points, inclusive planning
Source separation	Separate organics, recyclables, residual	Confusion, contamination, lack of feedback	Clear labels, convenient bins, feedback, incentives
Sorting / MRF	Separate materials by type	Contamination, mixed polymers, market volatility	Clean feedstocks, optical sorting, stable end markets
Recycling	Reprocess materials into new products	Downcycling, quality loss, price swings	Design for recycling, quality standards, green procurement
Organics treatment	Compost or digest food and garden waste	Contamination, odour, financing	Separate organics collection, quality compost markets
Disposal	Safely manage residual waste	Methane, leachate, open dumping	Engineered landfills, gas capture, landfill taxes

MRF = materials recovery facility. Source: synthesised from the sources cited in the caption.

Recycling rates vary sharply by income and material. Figure 2 shows indicative recycling and composting rates by income group, reflecting differences in infrastructure, markets, and measurement. High-income countries report higher formal recycling rates, but these figures often exclude informal recycling, exports, and losses during reprocessing, so they overstate true circularity (Kaza et al., 2018; Geyer et al., 2017). Low-income countries often have low formal rates but high informal recovery of valuable materials, which is undercounted in official statistics (Medina, 2008; Wilson et al., 2012).



Paper and cardboard are among the most recycled materials because collection systems are mature, fibre markets exist, and recycling saves energy and water compared with virgin production (Kaza et al. , 2018). However, fibres shorten with each cycle, and contamination with food, plastics, and coatings limits recyclability (Laurent et al., 2014). Glass is highly recyclable in principle, but it is heavy, fragile, and costly to transport, and mixed colours reduce value (Kaza et al., 2018). Metals, especially aluminium and steel, have strong recycling economics because reprocessing saves large amounts of energy and because scrap markets are well established (Geyer et al., 2017). Aluminium recycling can save up to 95 percent of the energy needed for primary production, which explains why informal collectors prioritise it (Medina, 2008).

Plastics are the most problematic recyclable. Mechanical recycling, which shreds, washes, and remelts plastics, works best for clean, single-polymer streams such as PET bottles and HDPE containers, but it degrades polymer quality and struggles with films, multi-layer packaging, and contaminated items (Geyer et al., 2017; Ragaert et al., 2017). Ragaert et al. (2017) reviewed mechanical recycling and concluded that design for recycling, better sorting, and stable markets are prerequisites for higher quality. Chemical recycling, which breaks polymers into monomers or feedstocks, can handle more contaminated and mixed plastics, but it is energy-intensive, costly, and not yet proven at scale for many polymers (Ragaert et al., 2017; Schyns and Shaver, 2021). Schyns and Shaver (2021) cautioned that chemical recycling should complement, not replace, mechanical recycling and prevention, and that its environmental benefits depend on energy source, yield, and avoided production. Downcycling, where recycled plastic becomes lower-value products such as lumber or fibres, is common and

should not be counted as equivalent to closed-loop recycling (Geyer et al., 2017).

Because organics dominate waste in many cities, diverting them from landfill is the single largest lever for reducing methane (Bogner et al., 2008; Kaza et al., 2018). Composting produces soil amendment, improves soil structure, and reduces the need for synthetic fertiliser, but it requires clean feedstocks, space, odour control, and markets for compost (Laurent et al., 2014). Anaerobic digestion produces biogas for heat or electricity and digestate for soil, and it can handle wet food waste that composting struggles with (Mata-Alvarez et al., 2000). Mata-Alvarez et al. (2000) reviewed anaerobic digestion and highlighted the importance of feedstock composition, temperature, and process stability. In practice, many composting and digestion plants fail because of contamination, poor financing, or lack of demand for outputs, not because the technology itself is flawed (Wilson et al., 2012). Home and community composting can complement centralised plants, especially where collection is limited, but it requires training and ongoing support (Zaman, 2015).

Textile waste is growing with fast fashion, and recycling is limited by fibre blends, dyes, and finishes (Ellen MacArthur Foundation, 2017). Reuse through second-hand markets, repair, and rental often delivers greater benefits than recycling, because it preserves the value of the finished garment (Ellen MacArthur Foundation, 2017). Electronic waste contains gold, copper, and rare earths, but also lead, mercury, and flame retardants (Baldé et al., 2017; Forti et al., 2020). Forti et al. (2020) reported that global e-waste generation reached 53.6 million tonnes in 2019, with only a small share formally collected and recycled. Informal e-waste recycling, often by burning or acid leaching, recovers metals but exposes workers and communities to toxins (Baldé et al., 2017). Construction and demolition waste is large by mass and highly recyclable in principle, but it is often excluded from municipal statistics and requires separate sorting and crushing infrastructure (Kaza et al., 2018).

6. Energy Recovery, Landfills, and Residual Waste

Even with ambitious prevention and recycling, residual waste remains. Energy recovery through incineration with energy recovery, gasification, or pyrolysis can reduce volume, destroy pathogens, and generate electricity or heat, but it is capital-intensive, requires stable feedstocks, and produces ash and air emissions that must be controlled (Laurent et al., 2014; Kaza et al., 2018). Incineration can create lock-in, where cities must supply waste to feed plants, undermining prevention and recycling incentives (Zaman, 2015; Geissdoerfer et al., 2017). Life-cycle assessments show that energy recovery performs better than landfilling for many materials, but worse than prevention, reuse, and high-quality recycling (Laurent et al., 2014). The choice therefore depends on local energy mix, waste composition, and whether the plant displaces fossil fuels or cleaner energy.

Landfills remain the dominant disposal method in many countries, ranging from engineered sanitary landfills with liners, leachate collection, and gas capture to open dumps with no controls (Bogner et al., 2008; Kaza et al., 2018). Engineered landfills can capture methane for energy and reduce leachate, but capture is incomplete and emissions continue for decades (Bogner et al., 2008). Open dumps pose acute risks: they attract vectors, contaminate water, and expose waste pickers to injury and disease (Medina, 2008; Wilson et al., 2012). Closing dumps and upgrading to sanitary landfills is a priority in many cities, but it must be paired with livelihood support for workers who depend on dumps (Gutberlet, 2008). Landfill mining, which excavates old landfills to recover materials and energy, has been proposed, but it is costly and rarely justified on material recovery alone (Kaza et al., 2018).

Table 2. Comparison of waste management options across the hierarchy, synthesised from Laurent et al. (2014), Ragaert et al. (2017), and Kaza et al. (2018).

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Option	Best for	Key benefits	Key risks and limits
Prevention	All materials, especially packaging and food	Avoids production, transport, disposal	Requires behaviour, design, and policy change
Reuse / repair	Durable goods, textiles, electronics	Preserves product value, creates jobs	Needs logistics, standards, and consumer trust
Mechanical recycling	Clean PET, HDPE, paper, metals, glass	Proven, lower energy than virgin	Downcycling, contamination, market volatility
Chemical recycling	Mixed / contaminated plastics	Can handle harder streams	Energy, cost, yield, and scale uncertain
Composting	Garden and clean food waste	Soil amendment, low tech	Contamination, odour, compost markets
Anaerobic digestion	Wet food waste	Biogas + digestate	Capital, process stability, feedstock quality
Energy recovery	Residual, non-recyclable waste	Volume reduction, energy	Emissions, ash, lock-in, high cost
Sanitary landfill	Residual waste only	Containment, gas capture	Methane, leachate, long-term liability

PET = polyethylene terephthalate; HDPE = high-density polyethylene. Source: synthesised from the sources cited in the caption.

Green public procurement, recycled-content mandates, and product standards can create stable demand for secondary materials (Geissdoerfer et al., 2017; Kirchherr et al., 2017). Without demand, collected recyclables have no value and may be stockpiled or dumped. Plastics taxes, such as the European Union levy on non-recycled plastic packaging, aim to make virgin plastics less attractive, but their effectiveness depends on design and on the availability of recycled alternatives (Borrelle et al., 2020). Bans on single-use plastics, plastic bags, and microbeads have reduced specific items, but they must be designed to avoid substitution with equally harmful materials (Borrelle et al., 2020; Geyer et al., 2017). Policy coherence matters: a city that bans plastic bags but has no composting or recycling infrastructure will see limited benefits.

Financing is a persistent barrier. Waste management is often underfunded, with fees that do not cover costs, and with budgets that prioritise collection over recycling and prevention (Kaza et al., 2018; Wilson et al., 2012). In low-income cities, user fees are difficult to collect, and informal systems fill gaps without public funding (Medina, 2008). International finance, climate finance, and private investment can help, but they must be aligned with local needs and must not impose technologies that are unaffordable or inappropriate (Kaza et al., 2018). Transparency, data, and accountability are essential: cities cannot manage what they do not measure, and residents cannot hold systems accountable without information on costs, coverage, and outcomes (Hoornweg and Bhada-Tata, 2012).

8. Behaviour, Culture, and Digital Innovation

Household behaviour shapes every stage of waste management. Sorting accuracy depends on knowledge, convenience, habits, and trust (Dahlén and Lagerkvist, 2010; Rousta et al., 2015). Rousta et al. (2015) found that clear information, feedback, and convenient infrastructure improved source separation in Swedish households, while confusion and inconsistent rules reduced it. Nudges, such as smaller residual bins, default separation, and social norms, can help, but they are not substitutes for infrastructure (Dahlén and Lagerkvist, 2010). Food waste behaviour is shaped by planning, shopping, storage, cooking, and cultural norms around hospitality and freshness, which vary across contexts (Parfitt et al., 2010; Gustavsson et al., 2011). Interventions that are culturally tailored, such as community cooking, meal planning, and date-label reform, tend to work better than generic awareness campaigns.

Digital innovation is changing waste systems. Smart bins with fill-level sensors can optimise collection routes, reduce fuel use, and prevent overflow (Kaza et al., 2018). Artificial intelligence sorting can improve material recovery, especially for plastics, by identifying polymers and colours faster than manual sorting (Ragaert et al., 2017). Digital platforms can connect households, collectors, and recyclers, and can track materials through blockchain or QR codes, improving traceability for extended producer responsibility (Geissdoerfer et al., 2017). However, digital tools require connectivity, data governance, and maintenance, and they can exclude informal workers if they are not designed inclusively (Wilson et al., 2012). Technology should augment, not replace, human systems, and its benefits should be evaluated against cost, energy, and equity.

Repair, sharing, and reuse cultures are also being revived through repair cafés, tool libraries, second-hand markets, and online platforms (Ellen MacArthur Foundation, 2013; Zaman, 2015). These initiatives reduce waste, build skills, and create social connections, but they remain small compared with mainstream consumption (Zink and Geyer, 2017). Scaling them requires product design that supports repair, spare parts availability, and policies such as right-to-repair legislation (Geissdoerfer et al., 2017). Education, from schools to workplaces, can build circular literacy, but it must be paired with opportunities to act; otherwise, awareness without infrastructure breeds frustration (Zaman, 2015).

9. Equity, Health, and Environmental Justice

Waste burdens are unevenly distributed. Low-income neighbourhoods, informal settlements, and communities near dumps, incinerators, and recycling plants often face higher exposure to odour, dust, leachate, and toxic emissions, while receiving fewer services (Medina, 2008; Gutberlet, 2008). Waste pickers, many of whom are women, children, and migrants, face injury, infection, and stigma, yet they provide essential environmental services (Medina, 2008; Wilson et al., 2012). Open burning, which is common where collection is absent, releases fine particles and dioxins that harm respiratory health, especially for children and older people (Wiedinmyer et al., 2014). Landfill workers and nearby residents may be exposed to methane, hydrogen sulphide, and leachate, while e-waste workers face lead, mercury, and flame retardants (Baldé et al., 2017; Forti et al., 2020).

A just transition must therefore centre workers and affected communities. Formalisation should improve pay, safety, and dignity, not simply replace informal workers with machines or private firms (Gutberlet, 2008; Wilson et al., 2012). Siting decisions for landfills, incinerators, and recycling plants should involve communities, assess cumulative exposure, and provide benefits such as jobs, green space, and infrastructure, not only burdens (Kaza et al., 2018). Gender matters: women often manage household waste, sorting, and informal recycling, yet they are underrepresented in decision-making (Gutberlet, 2008). Youth, who will inherit waste systems, should have a voice in design and governance. Equity is not an add-on; it is a condition for effectiveness, because systems that ignore workers and communities are less likely to be used, maintained, and trusted.

10. Research Gaps and Future Directions

Several gaps deserve priority. First, measurement needs improvement: many cities lack data on generation, composition, collection, and recycling, and definitions vary so widely that comparisons are difficult (Kaza et al., 2018; Hoornweg and Bhada-Tata, 2012). Standardised, low-cost methods, including waste audits, material flow analysis, and digital tracking, are needed, especially for informal flows (Wilson et al., 2012). Second, life-cycle and

systems research should evaluate interventions across environmental, economic, and social dimensions, not only recycling rates, to avoid burden-shifting and rebound effects (Laurent et al., 2014; Zink and Geyer, 2017). Third, chemical recycling, digital sorting, and other innovations need independent, transparent evaluation of energy, yield, emissions, and scalability (Ragaert et al., 2017; Schyns and Shaver, 2021).

Fourth, research on prevention and reuse is underdeveloped compared with recycling technology. More evidence is needed on what reduces consumption, extends product life, and scales repair and sharing, and on how these interventions interact with income, culture, and infrastructure (Geissdoerfer et al., 2017; Kirchherr et al., 2017). Fifth, research on financing, governance, and informality should identify models that work in low-resource settings, including cooperatives, community enterprises, and blended finance (Medina, 2008; Wilson et al., 2012). Sixth, research on climate, health, and equity should quantify the benefits of diverting organics, reducing open burning, and improving worker safety, and should centre affected communities in design and evaluation (Bogner et al., 2008; Wiedinmyer et al., 2014). Finally, transdisciplinary research that combines engineering, economics, sociology, and design is needed, because waste is a socio-technical system, not a purely technical problem.

11. Conclusion

Municipal solid waste management is at a turning point. The linear model of extraction, consumption, and disposal is environmentally unsustainable, economically wasteful, and socially unjust (Kaza et al., 2018; Ellen MacArthur Foundation, 2013). Recycling is essential, but it cannot by itself create a circular economy. Prevention, reuse, repair, and redesign must come first, supported by clean feedstocks, stable markets, and inclusive governance (Geissdoerfer et al., 2017; Kirchherr et al., 2017). Organics diversion is the largest climate lever, plastics recycling needs better design and honest accounting, and informal workers must be recognised as partners, not obstacles (Bogner et al., 2008; Medina, 2008; Ragaert et al., 2017). Policy instruments such as extended producer responsibility, deposit-return schemes, landfill taxes, and pay-as-you-throw can shift incentives, but they work only when infrastructure, financing, and behaviour align (Lindhqvist, 2000; Dahlén and Lagerkvist, 2010). The path forward is to build systems that are technically sound, economically viable, and socially just, so that waste becomes a resource for communities rather than a burden on them.

Acknowledgements

The authors thank municipal officials, waste workers, and community organisations whose practical experience informed this synthesis. No specific grant is claimed for this review.

Conflict of Interest

The authors declare no conflict of interest.

Data Availability

This review is based on published literature cited in the reference list. No new experimental data were generated. Figures present synthesised indicative values from the cited sources.

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