International Scholars Journals

Advanced Journal of Environmental Science and Technology ISSN 2756-3251, Vol. 17 (11), pp. 001-006, November, 2026. Available online at www.internationalscholarsjournals.org © International Scholars Journals

Author(s) retain the copyright of this article.

A Critical Review

Municipal Solid Waste Management and Recycling in Rapidly Growing Cities: Collection, Sorting, Circular Economy, and Pathways Toward Zero Waste

Amara N. Okafor[1], James H. Mitchell[2], Li Wei Chen[3], Sofia R. Alvarez[4], Kenji Tanaka[5], Priya S. Sharma[6], Lars E. Johansson[7], Fatima A. Haddad[8]

[1] Department of Environmental Science, University of Lagos, Lagos, Nigeria.
[2] School of Geography and Environmental Science, University of Southampton, Southampton, United Kingdom.
[3] College of Environmental Sciences and Engineering, Peking University, Beijing, China.
[4] Instituto de Ciencias Ambientales, Universidad Nacional Autónoma de México, Mexico City, Mexico.
[5] Graduate School of Environmental Studies, Tohoku University, Sendai, Japan.
[6] Department of Civil and Environmental Engineering, Indian Institute of Technology Bombay, Mumbai, India.
[7] Department of Aquatic Sciences and Assessment, Swedish University of Agricultural Sciences, Uppsala, Sweden.
[8] Faculty of Science, American University of Beirut, Beirut, Lebanon.

Corresponding author: Amara N. Okafor — a.okafor@unilag.edu.ng

Manuscript Timeline: Received 11 January, 2026; Revised 06 April, 2026; Accepted 19 May, 2026; Published 21 November, 2026.

Abstract

Rapidly growing cities generate more municipal solid waste than their collection, sorting, and disposal systems were designed to handle. This review synthesises current evidence on municipal solid waste management and recycling, from generation and collection through sorting, treatment, and final disposal, and evaluates how circular economy approaches can reduce landfill dependence, greenhouse gas emissions, and public health risks. It examines why waste composition varies with income, season, and urban form; why collection coverage, source segregation, and informal recycling shape what is actually recovered; and why recycling performance differs sharply by material, with paper, glass, and metals generally recovered at higher rates than plastics, organics, and e-waste. The review compares mechanical, biological, and thermal treatment options, assesses policy instruments including extended producer responsibility, deposit-return schemes, landfill taxes, and pay-as-you-throw systems, and examines the social dimensions of waste work, including the livelihoods, safety, and inclusion of informal waste pickers. It argues that no single technology delivers zero waste: progress depends on prevention and reuse first, reliable segregated collection second, and markets for secondary materials third, supported by transparent data, financing, and enforcement. The review concludes with a research and policy agenda centred on standardised waste accounting, realistic recycling targets, integration of informal workers, and city-scale systems that keep materials in use for as long as possible.

Keywords: municipal solid waste; recycling; circular economy; source segregation; informal recycling; zero waste; urban sustainability.

1. Introduction

Cities are producing waste faster than they are building systems to manage it. Population growth, rising consumption, changing diets, e-commerce packaging, and construction activity have increased both the quantity and the complexity of municipal solid waste. At the same time, many cities face limited land for disposal, ageing collection fleets, constrained budgets, and public concern about odour, litter,

flooding, disease, and greenhouse gas emissions from dumpsites and landfills.

Municipal solid waste is usually defined as waste collected by or on behalf of a municipality, including household waste, waste from markets, offices, schools, and small businesses, and in many cities street sweepings and green waste. It excludes, in most accounting systems, industrial hazardous waste, medical waste, and large construction waste, although in practice these streams often mix at collection points and disposal sites. That mixing is one reason why reported waste figures are difficult to compare across cities: definitions, measurement points, and inclusion rules differ.

This review addresses four questions: (i) what is in municipal waste, and how does composition vary; (ii) how do collection, segregation, and sorting determine what is recovered; (iii) which treatment and policy options work, for which materials, and under what conditions; and (iv) what would a credible pathway toward zero waste require? It follows the journey of a discarded item, from generation to collection, sorting, treatment, and final fate, and evaluates each stage against environmental, economic, and social criteria.

The structure follows that journey. Section 2 describes waste generation and composition. Section 3 reviews collection and segregation. Section 4 evaluates sorting and recycling. Section 5 assesses biological and thermal treatment and disposal. Section 6 examines policy, finance, and the informal sector. Section 7 proposes a research and policy agenda. Section 8 concludes.

2. Waste Generation and Composition

Waste generation rises with income, but not in a simple linear way. Higher-income households typically generate more packaging, electronics, and durable goods waste, while lower-income households generate a higher share of food and organic waste. Commercial districts, markets, and institutions create concentrated, often more homogeneous streams that are easier to collect and recover than dispersed household waste. Seasonal festivals, tourism, and harvest periods can create sharp peaks that overwhelm routine collection.

Composition is the most important determinant of what a city can recover. A city whose waste is dominated by wet organics needs composting or anaerobic digestion capacity; a city dominated by dry recyclables needs sorting and secondary-material markets; a city with a large construction fraction needs aggregate recovery and site controls. Table 1 summarises the main municipal waste streams, their typical characteristics, and their recovery routes. The shares shown are illustrative of patterns reported across rapidly growing cities, not a single city, and should be replaced with local waste-characterisation data for planning.

Table 1. Main municipal waste streams, characteristics, and recovery routes. Authors' synthesis.

Waste stream	Typical characteristics	Main recovery route	Key challenge
Organics (food, garden)	Wet, heavy, degradable, odorous	Composting, anaerobic digestion	Contamination, collection frequency
Paper and cardboard	Dry, bulky, easily soiled	Recycling, reuse	Wetting and mixing reduce value
Plastics	Light, varied polymers, films	Mechanical / chemical recycling	Sorting, low value for mixed films
Glass	Heavy, inert, breakable	Recycling, reuse	Breakage, transport cost
Metals	Dense, high scrap value	Recycling	Informal capture, safety
E-waste	Small, hazardous components	Dismantling, specialist recycling	Toxicity, informal burning
Construction & demolition	Heavy, inert, bulky	Aggregate recovery, reuse	Illegal dumping, site space

Two measurement problems recur. First, waste is often weighed only at disposal, so material recovered before disposal, especially by informal workers, is invisible in official statistics and recycling rates are understated. Second, moisture and contamination change the weight and value of waste between generation and treatment. A tonne of mixed, wet waste is not the same as a tonne of clean, segregated recyclables. Reporting should therefore distinguish waste generated, waste collected, waste sorted, and material actually reprocessed into new products.

3. Collection, Segregation, and the Informal Sector

Collection is the foundation of the whole system. If waste is not collected reliably, it accumulates in drains, open spaces, and waterways, where it blocks drainage and increases flood risk, harbours disease vectors, and leaks into the environment. Collection coverage is therefore a public-health indicator as well as an environmental one. In many rapidly growing cities, coverage is uneven: formal services reach planned neighbourhoods more reliably than informal settlements, peri-urban areas, and high-density low-income districts.

Source segregation, separating waste at the point where it is generated into two or three streams such as wet, dry, and hazardous, is the single most effective upstream intervention. It protects the value of recyclables, reduces odour and leachate, makes composting and digestion viable, and lowers sorting costs downstream. Yet segregation only works if collection keeps the streams separate, if households understand and trust the system, and if there is somewhere for each segregated stream to go. Asking

residents to segregate when all streams are mixed again in one truck quickly destroys participation.

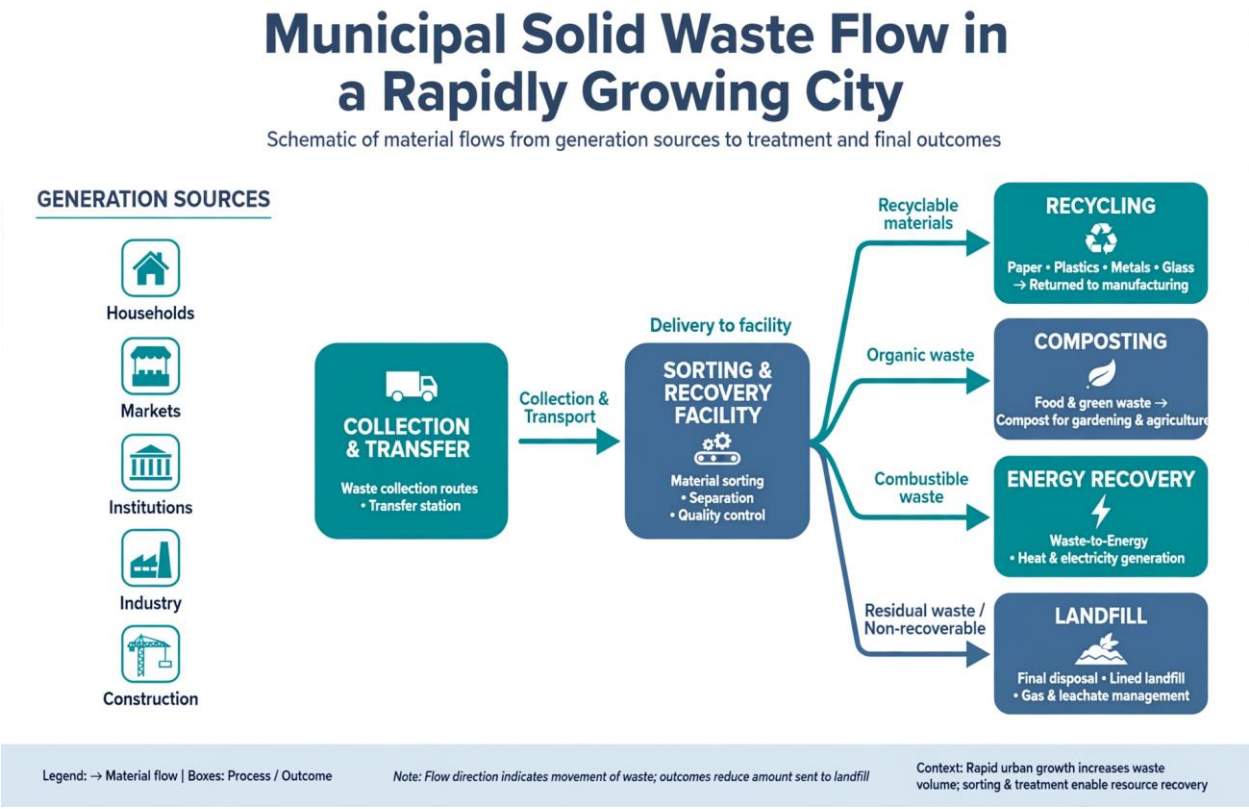


Figure 1. Municipal solid waste flow from generation sources through collection and sorting to recycling, composting, energy recovery, and landfill. Authors' synthesis.

The informal sector recovers a large share of recyclables in many cities, often without formal recognition, contracts, protective equipment, or social protection. Waste pickers, itinerant buyers, and small aggregators sort, clean, and sell materials that formal systems miss. Their work reduces landfill, saves municipalities money, and supplies secondary-material markets. At the same time, informal work can expose people, including children in the worst cases, to cuts, infections, toxic fumes from burning, and unstable incomes. Policies that formalise without displacing, through registration, fair payment for collection and sorting services, access to sorting space, safety equipment, and health services, perform better than bans or forced relocation.

4. Sorting, Recycling, and Material Markets

Sorting determines the quality and therefore the value of recovered material. Manual sorting is flexible and labour-intensive, and can handle variable waste, but is slow and exposes workers to hazards. Mechanical sorting using screens, magnets, eddy currents, air classifiers, and increasingly optical and artificial-intelligence-assisted sorters is faster and more consistent for large, homogeneous streams, but requires capital, maintenance, spare parts, and a steady feedstock. The best-performing systems combine the two: mechanical pre-sorting for bulk separation, and manual quality control for the fractions where human judgement adds most value.

Recycling performance differs sharply by material, as illustrated in Figure 2. Paper, glass, and metals are generally easier to recycle, have established markets, and tolerate some contamination. Plastics are more difficult: many products combine multiple polymers, additives, and layers, films tangle in machinery, and food contamination reduces quality. Organics are not recycled in the same sense, but are recovered through composting or digestion into soil improvers and energy. E-waste contains valuable metals but also lead, mercury, and flame retardants, and requires specialist handling to avoid shifting pollution from one medium to another.

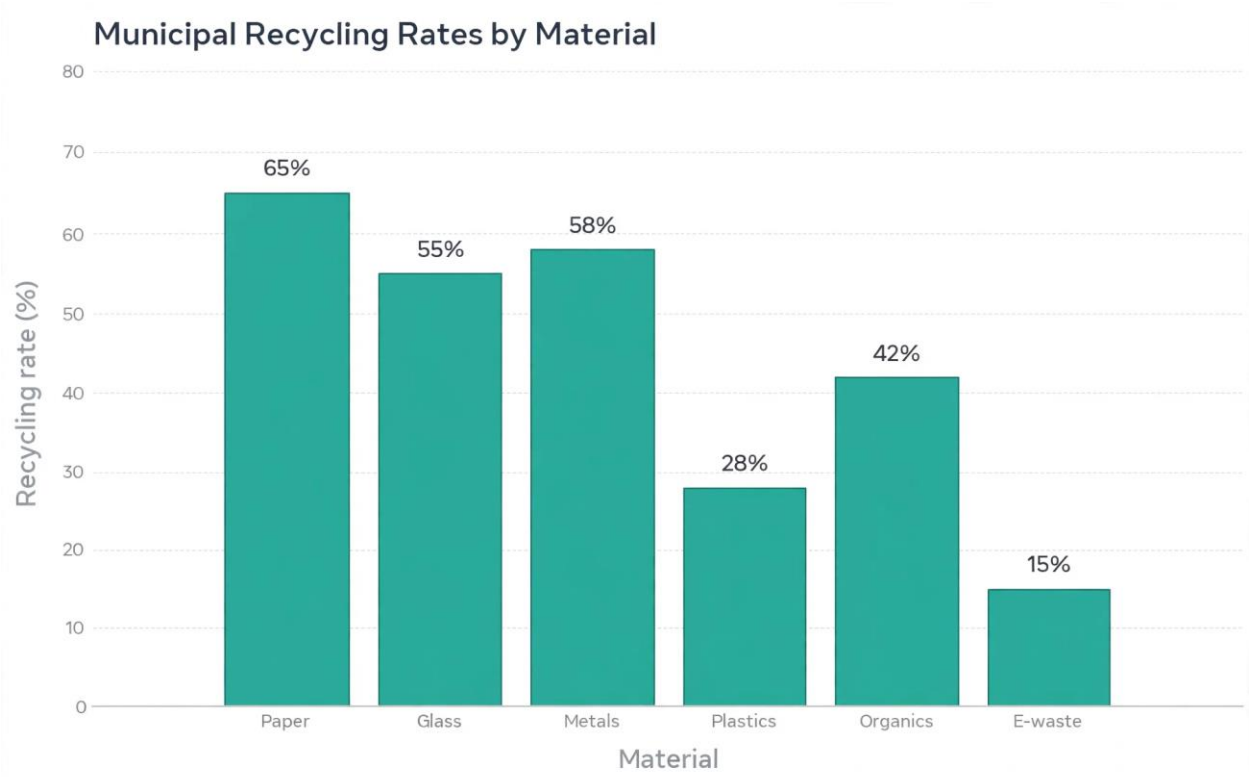


Figure 2. Municipal recycling rates by material. Values are illustrative of the relative pattern reported across cities, not a single city or year; paper, glass, and metals are typically recovered at higher rates than plastics, organics, and e-waste.

A central lesson is that recycling is a market, not just a technology. Collection without a buyer is storage; sorting without a buyer is delay. Secondary-material prices fluctuate with virgin-material prices, oil prices, transport costs, and import rules in destination markets. When prices fall, recyclers stop buying, material accumulates, and cities revert to disposal. Stable demand therefore matters as much as sorting capacity: procurement rules favouring recycled content, product standards that allow secondary materials, and long-term contracts with recyclers all help to stabilise the chain.

Table 2. Recycling and treatment options: strengths and limitations. Authors' synthesis.

Option	Best for	Strengths	Limitations / needs
Manual sorting	Mixed, variable waste	Flexible, low capital, jobs	Slow, worker exposure, quality varies
Mechanical sorting	Large, dry recyclable streams	Fast, consistent	Capital, maintenance, steady feedstock
Composting	Source-separated organics	Soil improver, low tech options	Space, odour control, market for compost
Anaerobic digestion	Wet organics, food waste	Biogas + digestate	Capital, feedstock quality, gas handling
Mechanical recycling	Single-polymer plastics, paper, metals	Keeps material in use	Sorting, contamination, downcycling
Chemical recycling	Mixed / contaminated plastics	Handles difficult polymers	Energy, cost, still maturing
Waste-to-energy	Residual, combustible waste	Volume reduction, energy	Emissions control, may crowd out recycling

5. Biological and Thermal Treatment, and Disposal

For the organic fraction, which is often the largest share in rapidly growing cities, biological treatment is the most direct route to value. Composting converts organics into a soil improver that can support urban agriculture and landscaping, provided the feedstock is clean and the process is managed to control odour, pathogens, and moisture. Anaerobic digestion produces biogas for heat, electricity, or cooking, plus digestate that can be used as fertiliser, but requires more capital, skilled operation, and consistent feedstock. Both options fail when organics arrive mixed with plastics and hazardous waste, which is why segregation and treatment must be planned together.

Thermal treatment, including incineration with energy recovery and other waste-to-energy technologies, reduces waste volume sharply and can generate electricity or heat. It is most appropriate for residual, combustible waste that remains after prevention, reuse, and recycling, not as a substitute for them. If waste-to-energy plants are paid by the tonne burned, or are locked into long-term feedstock guarantees, they can create a perverse incentive to keep

generating waste and to divert recyclables from higher-value uses. Emissions control, ash management, and transparent monitoring are essential, as is honest accounting of net greenhouse gas effects compared with landfilling and recycling alternatives.

Landfill remains the dominant final fate in many cities, but not all landfills are equal. Controlled, engineered landfills with liners, leachate collection, gas capture, daily cover, and groundwater monitoring are very different from open dumps where waste is burned, leachate enters soil and water, and waste pickers work without protection. Closing open dumps without providing alternative collection, sorting, and disposal capacity simply displaces dumping. Landfill should be the last resort for residual waste, not the default for everything.

6. Policy, Finance, and Governance

The waste hierarchy, prevention, reuse, recycling, recovery, and disposal in that order, is a useful guide, but it is not self-implementing. Policy instruments translate the hierarchy into incentives. Extended producer responsibility makes producers responsible for the end-of-life of their products and packaging, and can fund collection and recycling if fees are set to reflect real costs and are enforced. Deposit-return schemes create a direct incentive to return bottles and cans, and typically achieve high return rates. Landfill taxes and pay-as-you-throw systems make disposal more expensive relative to prevention and recycling, but can increase illegal dumping if enforcement and alternatives are weak.

Financing is a persistent constraint. Collection and disposal are often funded from general municipal budgets that are already stretched, while recycling revenue is volatile. Successful cities diversify funding: user fees linked to service quality, producer fees, landfill charges, compost and recyclables sales, and where appropriate climate finance for methane reduction from diverted organics. Transparency matters: publishing collection coverage, costs, and recycling rates, by neighbourhood and by material, builds public trust and makes it harder for funds to leak.



Figure 3. Circular economy loop for municipal waste: design, production, consumption, collection, sorting, recycling, and remanufacturing, with landfill and leakage to be minimised. Authors' synthesis.

Governance must match the scale of the problem. Waste crosses neighbourhood, municipal, and sometimes national boundaries, through markets for recyclables and through rivers and drains that carry litter downstream. Coordination between waste, water, drainage, health, and planning departments is therefore essential, especially where blocked drains link waste failure directly to flooding. Community engagement, school programmes, market associations, and faith and neighbourhood groups can sustain behaviour change far more effectively than one-off campaigns.

Table 3. Policy instruments for municipal waste and recycling: strengths and limitations.

Instrument	How it works	Strengths	Limitations / needs

Extended producer responsibility	Producers fund end-of-life management	Shifts cost, incentivises eco-design	Enforcement, fee-setting, free-riders
Deposit-return	Refundable deposit on return	High return rates, clean material	Collection points, fraud control
Landfill tax / disposal fee	Charge per tonne landfilled	Discourages disposal	May increase illegal dumping
Pay-as-you-throw	Households pay by waste set out	Rewards prevention, segregation	Equity, monitoring, alternatives
Source-segregation mandate	Legal duty to separate streams	Improves sorting, composting	Collection must keep streams separate
Recycled-content standards	Minimum recycled share in products	Stabilises demand for recyclables	Testing, supply, price effects

7. Future Research and Policy Agenda

Five priorities emerge. First, standardise waste accounting. Cities need agreed definitions for waste generated, collected, sorted, recycled, and landfilled, measured at the same points, with informal recovery included, so that recycling rates are comparable and progress can be verified. Second, study segregation in context. Research should test which combinations of bins, collection frequency, feedback, incentives, and enforcement sustain segregation in different housing types, not just in pilot neighbourhoods.

Third, build markets for secondary materials. Future work should evaluate recycled-content procurement, product standards, and long-term contracts, and track whether they stabilise prices and quality. Fourth, integrate informal workers into formal systems in ways that improve incomes, safety, and dignity, and evaluate those models against displacement and exclusion. Fifth, link waste to flooding, health, and climate. Research on blocked drains, open burning, and methane from dumps can make the co-benefits of better waste management visible to finance and planning ministries, not only to environment departments.

8. Conclusion

Municipal solid waste is not only a disposal problem; it is a resource, health, and governance problem. Cities that prevent waste first, segregate it at source, collect it reliably, sort it well, and create stable markets for what is recovered can reduce landfill, cut emissions, protect drainage and public health, and support livelihoods. Cities that rely on disposal alone will keep paying more for worse outcomes. The pathway toward zero waste is not a single technology, but a system: prevention and reuse, segregated collection, quality sorting, biological and material recovery, honest accounting, and policies that make it cheaper to keep materials in use than to throw them away.

Acknowledgements

The authors thank municipal waste managers, waste pickers, recyclers, and community monitors whose work informs this review. No specific funding was received for this review. The authors declare no competing interests.

References

Hoornweg, D., and Bhada-Tata, P. (2012). What a Waste: A Global Review of Solid Waste Management. World Bank, Washington, DC.

Kaza, S., Yao, L., Bhada-Tata, P., and Van Woerden, F. (2018). What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050. World Bank, Washington, DC.

Wilson, D. C., Rodic, L., Modak, P., Soos, R., Rogero, A. C., Velis, C., Iyer, M., and Simonett, O. (2015). Global Waste Management Outlook. United Nations Environment Programme, Nairobi.

Ellen MacArthur Foundation. (2019). Completing the Picture: How the Circular Economy Tackles Climate Change. Ellen MacArthur Foundation, Cowes.

Wilson, D. C., Velis, C., and Cheeseman, C. (2006). Role of informal sector recycling in waste management in developing countries. Habitat International, 30(4), 797–808.

Geyer, R., Jambeck, J. R., and Law, K. L. (2017). Production, use, and fate of all plastics ever made. Science Advances, 3(7), e1700782.

Lau, W. W. Y., Shiran, Y., Bailey, R. M., Cook, E., Stuchtey, M. R., Koskella, J., Velis, C. A., Godfrey, L., Boucher, J., Murphy, M. B., Thompson, R. C., and others. (2020). Evaluating scenarios toward zero plastic pollution. Science, 369(6510), 1455–1461.

United Nations Environment Programme. (2024). Global Waste Management Outlook 2024: Beyond an Age of Waste. United Nations Environment Programme, Nairobi.