Global Gateway

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Solid Waste Management in Low and Middle-Income Countries:

Practical Advice

INTRODUCTION

Waste generated in low-income countries is expected to increase by more than three times by 2050,[1] driven by population growth, increased consumption and lifestyle changes due to urbanisation. Alarmingly, in regions where waste generation is growing more rapidly, more than half of the waste is openly dumped, burned or discharged into water bodies and ecosystems. On average, low-income countries collect only about 39 per cent of the waste produced.

Solid waste management (SWM) is concentrated in cities and, often the responsibility of local administrations, Cities in low —and middle— income countries face complex challenges. These include informal dumping and waste picking conditions, the accumulation of waste in public spaces — creating hazards, polluting key ecosystems and increasing health and environmental risks —and difficulties finding appropriate waste disposal space.

Waste management typically constitutes a significant share of urban local authorities' budgets. Waste management solutions are often not self-sustainable due to their high cost and complexity associated with managerial and technical challenges, multiple stakeholders (mostly informal or non-regulated), specific local conditions and numerous other factors and risks. However, developing waste systems in cities in low —and middle— income countries also offers opportunities to advance objectives of the Global Gateway, the Green Deal agenda and INTPA's areas of intervention (see box on key priorities).

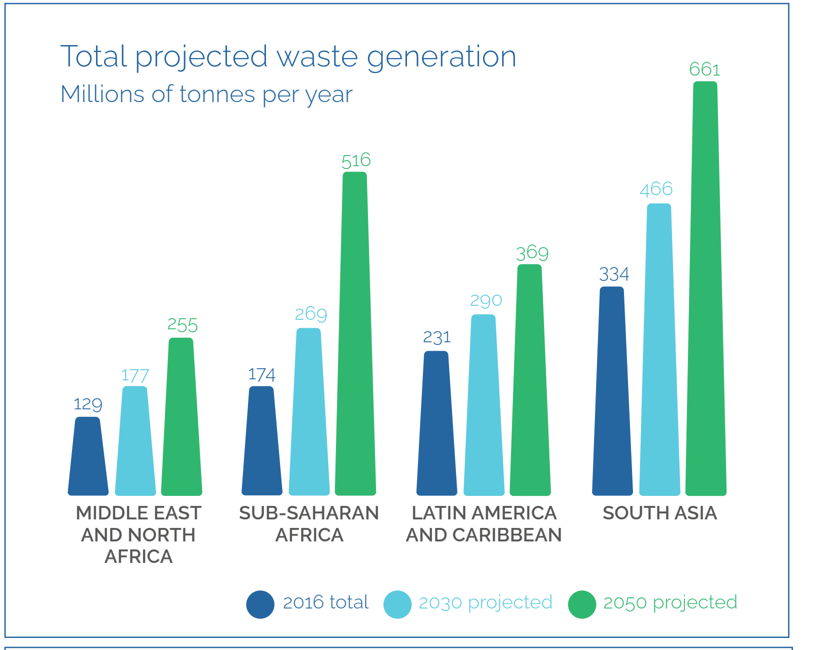
In response to SWM challenges and the EU agenda, many EU Delegations have waste management projects in their plans and project portfolios.

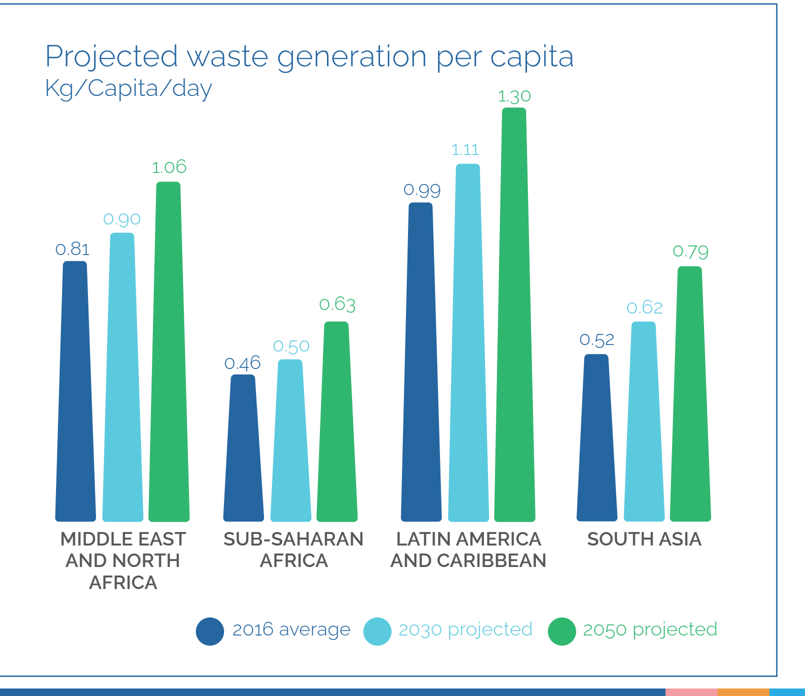
This publication is intended to support Delegations in their work and engagement with external stakeholders **and provides practice-oriented advice on key aspects** when preparing interventions in solid waste management. It is organized in two sections, the first focuses on the SWM Value Chain, and the second, in the Costs, Funding and Business Models of SWM systems. However, it does not cover all topics and all cases extensively, and it does not replace training or technical assistance from SWM experts.

[1] World Bank, What a Waste 2.0, 2018, p. 27 and 32.

Projected Waste Generation by Region

Source: "What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050"





INTPA KEY PRIORITIES AND SOLID WASTE MANAGEMENT

GREEN AND SMART CITIES

Minimising pollution from waste and leachates on public spaces and ecosystems like streams, riparian forests, wetlands, mangroves and oceans. Urban SWM contributes to the conservation, restoration and sustainable management of natural resources and ecosystems.

GREEN AND DECENT JOBS CREATION

Developing the whole waste and circular economy value chains, with private sector participation and improved working conditions for key stakeholders such as informal waste pickers. This contributes to the development of green and circular economies, sustainable industry and value chains and human development.

RISK MANAGEMENT & CLIMATE CHANGE ADAPTATION

Removing waste from urban drainage systems and water bodies contributes to water and flood management and minimises the release of harmful pollutants safeguarding public health and ecosystems. Treating hazardous waste from hospitals, industries and other sources in separate processes reducing cross-contamination and vector-borne diseases.

CLIMATE CHANGE MITIGATION

Reducing energy use in production (through reuse and recycling) and transport processes (via waste reduction), minimising waste-generated GHG emissions (through separate treatment for each waste stream, incineration or biological treatment), and capturing landfill gas to burn it in a flare or use it for generating energy (as with biogas from anaerobic treatment). Transitioning to renewable energies for waste transport and processing.

KEY POINTS TO KNOW WHEN PREPARING AN INTERVENTION ON URBAN WASTE MANAGEMENT

After clarifying the drivers for the SWM intervention (i.e. the problems to be addressed), defining its structure is fundamental.

KNOWING THE SYSTEM

Analysis of current SWM Systems: Starting with a thorough analysis of current waste management arrangements and the policy and governance framework for the sector is helpful to establish the status quo and understand underlying factors.

Waste composition: Understanding waste characterisation and composition guides technical choices for the SWM system and for recovery and recycling opportunities. Management of sand (coastal cities), dust (areas with unpaved roads) and organic waste could — for instance — optimise transport and disposal costs.

REDUCTION, PREVENTION AND REUSE
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GOOD PRACTICES

Waste prevention: Given the expected increase in waste volumes, waste management interventions should be complemented by waste reduction strategies (e.g. single-use plastic bans, eco-design, packaging minimisation, etc.). It is imperative to first understand waste trends and evaluate existing waste prevention and/or re-use practices to define the scope for waste reduction in the country.

Waste separation: Separating different types of waste at the point of origin (households or local sorting centres) may facilitate recycling, reduce transport costs, increase landfill lifespan and improve the quality of recoverable material. Assessing already implemented public, private or NGO-driven separate collection of specific waste streams is a crucial starting point.

Recovery and recycling: Assessing existing composting and recycling practices and determining whether market demand exists or can be created for specific waste streams are fundamental in developing the circular economy, reducing negative impacts and diverting waste from landfills.

Disposal practices: Seeking alternatives to improve disposal practices is important when preparing an intervention. Reducing, reusing and recycling should be maximised, but sanitary landfills and the proper treatment and disposal of hazardous waste are still essential.

Municipal vision and planning: Landfill locations, collection routes, chosen collection and treatment models, business models and the interaction between waste management and other services such as urban drainage have important implications for city budgets and must be coherent. A common validated vision and a financial plan are needed.

Data management, monitoring and planning: A successful SWM strategy includes data access and analysis, monitoring and future planning. SWM systems are complex and have not been regulated for decades. It is helpful to monitor costs and impacts with the support of digital technologies. Understanding existing practices would help to maximise and scale up current systems and prevent overlaps with or disruption to services that are already working.

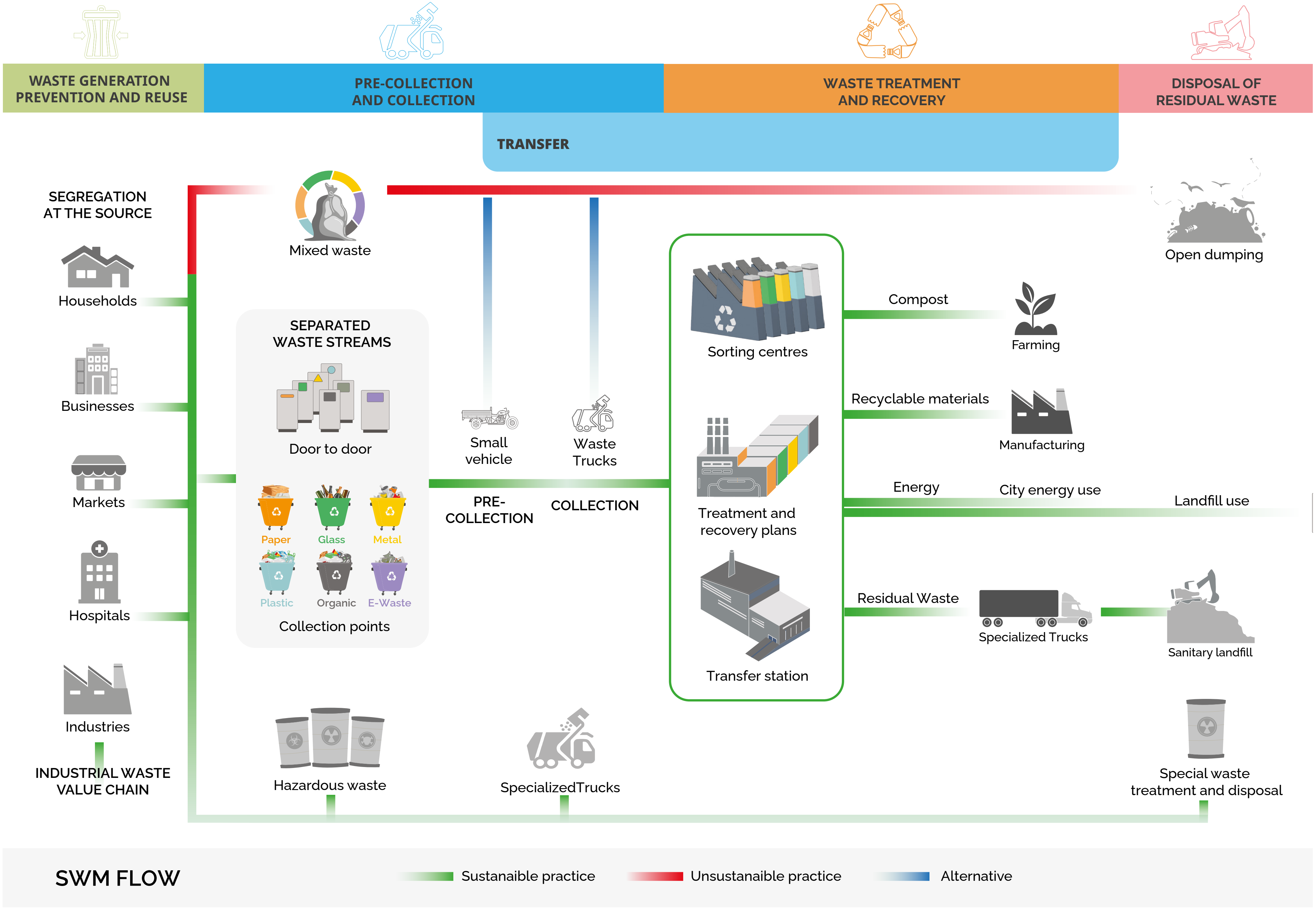
COSTS, FUNDING AND BUSINESS MODELS

Financial sustainability: SWM systems are expensive in terms of both capital and operational costs, **and they are not financially self-sustainable**. Different financing options should be assessed. In low- and middle-income countries, payment capacity is low for a proportion of the population. Household fees might only cover primary collection and sorting, making public funding also necessary. Assessing the costs of the current SWM system is key to identifying opportunities to reduce costs and generate revenue.

Recycling and organic waste recovery: While profitability depends on context, the environmental benefits of certain treatments might contribute to cost reduction.

Energy recovery: Energy recovery requires significant capital and operation expenses strict environmental standards and controls for incinerators and other combustion processes. A few low- and middle-income countries are exploring its potential.

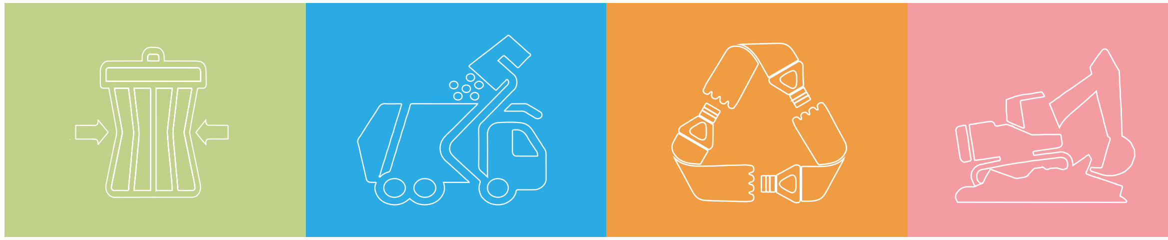
Social implications: Improvements to SWM processes may have indirect effects; for example, secured landfills might cause waste pickers to lose their source of revenue. Some EU projects have worked on improving waste pickers' working conditions to avoid marginalisation, strengthen inclusion and maximise their involvement in SWM. Unlike other urban services, such as water or energy, interventions related to SWM could interfere with the economic interests of incumbent stakeholders, leading to possible opposition.


WASTE GENERATION PREVENTION AND REUSE
PRE-COLLECTION AND COLLECTION
WASTE TREATMENT AND RECOVERY
DISPOSAL OF RESIDUAL WASTE
TRANSFER
SEGREGATION AT THE SOURCE
Households
Businesses
Markets
Hospitals
Industries
INDUSTRIAL WASTE VALUE CHAIN
Mixed waste
SEPARATED WASTE STREAMS
Door to door
Paper
Glass
Metal
Plastic
Organic
E-Waste
Collection points
Small vehicle
Waste Trucks
PRE-COLLECTION
COLLECTION
Sorting centres
Treatment and recovery plans
Transfer station
Compost
Farming
Recyclable materials
Manufacturing
Energy
City energy use
Landfill use
Residual Waste
Specialized Trucks
Sanitary landfill
Open dumping
Hazardous waste
SpecializedTrucks
Special waste treatment and disposal
SWM FLOW
Sustanaible practice
Unsustanaible practice
Alternative

URBAN SOLID WASTE MANAGEMENT VALUE CHAIN

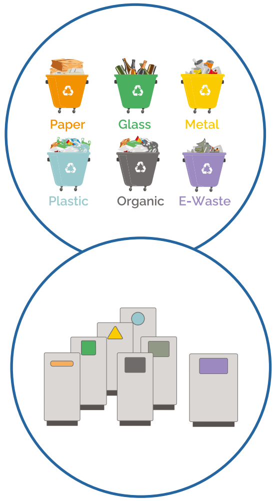
The first part of this booklet focuses on the urban solid waste management value chain. The complete chain is composed of **the collection and transfer, recycling and recovery** and **final disposal** stages, accompanied by **prevention, re-use** and **reduction** measures.

It is important to note that **waste generation** is caused by market conditions and people's behaviour, both of which **can be refocused** through prevention, re-use and reduction policies and regulations as well as and awareness campaigns.

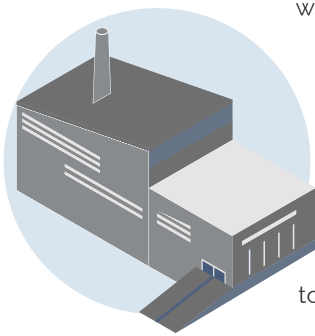


Sorting can occur at the waste source (households, businesses, markets, hospitals, etc.), at collection points or later in the chain. However, the sooner waste separation is put into practice, the more successful the implementation of waste reduction and recovery strategies. **Hazardous waste** should always be sorted, collected, treated and disposed of separately.

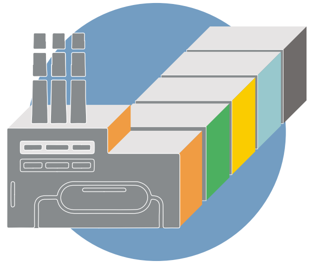
The **logistics** of the SWM system must factor in different urban conditions when resources are being designed and allocated. These include accessibility to different types of roads and neighbourhoods, route logic and distance between areas of waste collection and remotely located landfills.



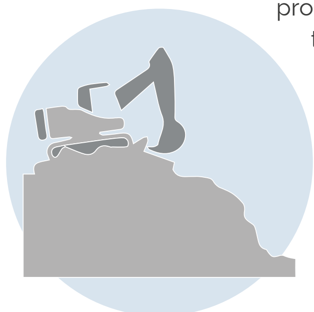
Different types of waste streams (mixed or separated) are **collected** door to door or through collection points in some cities or urban sectors; in other areas, informally organised individuals or community-based organisations collect waste with small vehicles (primary or pre-collection) and deliver these to transfer points or final disposal sites.



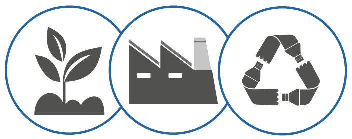
Transfer stations and long-distance transport in larger vehicles or containers can facilitate transfers at reduced costs compared to direct transport.



Once **reusable materials** (e.g. ready to be re-used elements, returnable packaging, containers and bottles), **recyclables** (paper and cardboard, plastics of different calibres, different types of glass and metal, etc.), **compostable and biodegradable materials** (such as leftover or surplus food) and **other types of materials** (e-Waste, textiles, bulky waste, fine materials: sand, dust, others) **are sorted**, they can be taken to further sorting, **transfer** and/or **recovery** stations, **treatment** plants and factories to be re-fed into production processes.



Compost, recycled materials, **energy** and other products and by-products can result from treatment and recovery processes. These processes should reduce as much waste as possible throughout the whole value chain and before the transfer of residual waste to **final disposal** in sanitary landfills or other specialised facilities (incinerators, biodigesters, etc.).



GENERATION, PREVENTION AND REUSE

Throw away less

Link to case studies

Generation, prevention and reuse are fundamental, considering that **waste generation** will triple **by 2050**. Increases in SWM costs threaten to deepen strains in municipal and national budgets and exacerbate environmental and social impacts. As such, avoiding the transformation of any material into waste, minimising waste generated and reusing any material when possible must be primary objectives.

Processes to reduce waste require strategies to reinforce existing sustainable practices and change unsustainable market conditions and consumer behaviour. Reductions may be achieved through:

- **Re-use and waste avoidance awareness campaigns** can educate businesses and citizens about using resources, holding on to unused pieces or materials, seeking out reusable materials instead of unnecessary packaging (e.g. single-use plastic) and preserving local sustainable practices. Awareness campaigns can also focus on understanding the impacts generated by increasing consumption patterns, the exponential effect created by population growth and the concentration effect created by urbanisation.

- **Local re-use approaches,** such as **maintenance** and **repair, returnable packaging** or **rentals**, that are in place should be used and maintained rather than replaced by new consumption patterns, such as low-cost disposable items or planned obsolescence.

- **Overseas secondhand products**, such as clothing, automobile parts and electronics, could reduce pressure on natural resources, but their trade **should be treated selectively,** avoiding additional waste generation, inappropriate recycling, and pollution.

Dialogue with national governments is key to promoting **prevention policies, regulations and incentives** to promote reduction practices, such as:

- **Extended producer responsibility (EPR)** models to make producers, importers and sellers responsible **for the entire life cycle** of a product and especially for its take back, recycling and final disposal. The life cycle includes designing, collecting used materials collection, feeding collected used materials into the manufacturing cycle to minimise new raw material consumption and taking care of the final disposal of residual waste.

- This process can **start with easy-to-implement product groups** such as packaging, returnable bottles and containers (e.g. beverages) and e-waste. **More durable packaging** helps to eliminate polluting materials and single-use items with the goal of reducing non-degradable waste. Products with **detachable materials** facilitate repair, separation and recycling, while fused materials necessarily go to waste.

- Policies and regulations must promote waste separation and dumping reduction to **incentivise** the use of **recoverable materials** and products and discourage the use of single-use and polluting materials and products. This can be accompanied by **financial instruments**, such as taxation of unsustainable practices or high landfill gate fees, combined with monitoring and enforcement to discourage landfilling. However, such policies must be carefully implemented as they might increase illegal dumping or burning of waste. Additional financial charges can make producers, importers and sellers internalise pollution costs, which is then passed down to increased product costs. While in the short term, these are usually transferred to consumers, in the long term, they encourage the private sector to develop less impactful products and reduce the use of unnecessary materials.

COLLECTION AND TRANSFER

Clean cities and sort waste

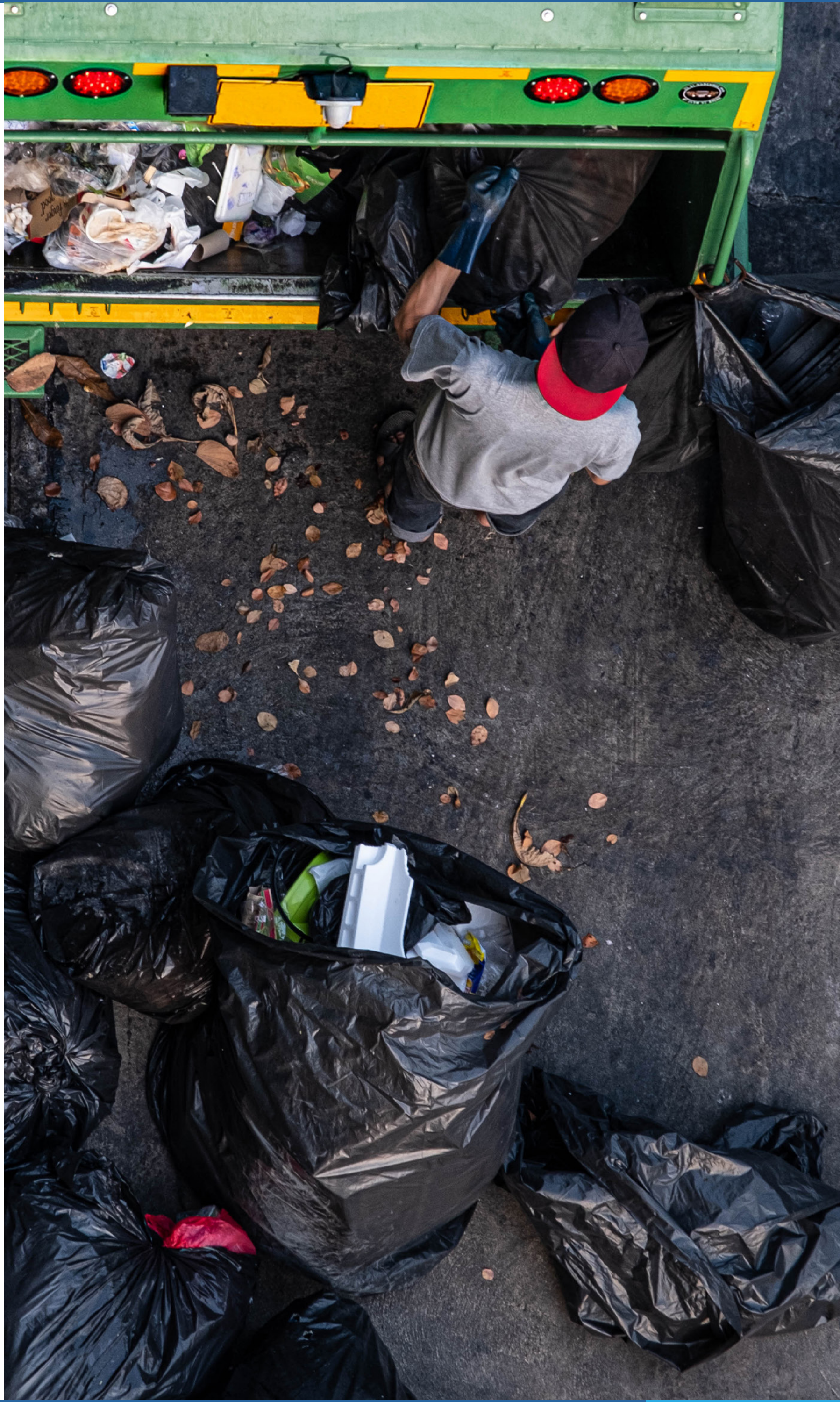
Improvements in urban waste collection and transport, the most visible actions in the SWM value chain, have a significant impact on citizens' satisfaction and their willingness to pay for related services. The main objective is to develop full coverage of a city or service area, but this effort can consume up to 70 per cent of the total cost of SWM[2]. However, high potential exists for cost saving through service optimisation. The following points should be considered:

Collecting waste requires urban space areas for waste collection and transfer facilities), **investments** in equipment (bins, containers, vehicles) and infrastructure (consolidation and sorting points, transfer stations, access roads). Road conditions, urban landscapes and distances often affect costs and system feasibility. Collection operations in low-density or unplanned urban areas with narrow or unpaved roads are more challenging. Decentralised treatment options might help to reduce costs.

Knowledge about waste composition and generation rates are important factors for the planning of a collection and transportation network (type and number of bins/containers, vehicles, collection points and transfer stations, logistics). The share of organic and recyclable waste defines the separate collection system. Other waste streams (business, institutional, markets, hospitals, shopping malls) must be considered as well. Hazardous waste must be collected, transported and treated separately to reduce cross-contamination and vector-borne diseases regardless of the approach chosen for waste segregation and collection.

Collection systems need to be carefully designed and adapted to local conditions. In some cases, the most efficient and cost-effective solution is to transport waste directly to the treatment or disposal facility in large, specialised trucks. A combination of collection types that fit diverse urban conditions could be considered as alternatives. These could include door-to-door collection, using non-motorised small vehicles, collection points, collection trucks, specialised trucks for different waste streams to recycling facilities and trailers from transfer stations to landfills (See options on the infographic on the previous page).

Awareness campaigns, in line with collection types, can improve household and business behaviour and reduce waste dumping and public space littering, minimising pollution from waste and leachates. Avoiding pollution and removing waste from urban drainage systems and water bodies contributes to water quality, flood management and climate change adaptation and could reduce vector-borne diseases and negative impacts on biodiversity and ecosystems.



[2] World Bank, What a Waste 2.0, p. 104.

COLLECTION AND TRANSFER

Clean cities and sort waste

Link to case studies

Separation at the source facilitates the sorting of relatively clean organic and recyclable materials, maximises unit price and minimises costs, increasing the chance of material recovery and profitability. Separation also contributes to reductions in transport and disposal costs.

The simplest separation at the source approach **is to separate wet** (biodegradable) and dry (recyclable and other) waste. The amount of organic waste varies significantly in low- and middle-income countries, averaging about 50% of all waste. Composting, anaerobic digestion and larvae breeding programmes may reduce waste and GHG emissions significantly.

- Once a wet/dry separation has been established successfully, recyclables can be separated into plastic, paper and glass streams, depending on market conditions. A next step could be to implement decentralised and specialised waste collection points to sort waste further by material and type, e.g. glass by colour, different types of metal, plastic calibres, e-waste and garden from other organics.

- Fine materials, such as sand in coastal cities or dust in urban areas with a high share of unpaved roads, could also be separated to reduce the need for collection equipment and unnecessary costs in collection, recovery and disposal processes.

- Separation of hazardous waste, including biological, chemical and radioactive waste, from households, businesses, hospitals and industrial areas is essential to avoid diseases, hazards and negative impacts on biodiversity.

- The separation at the source approach requires more awareness and resources from households and businesses, but it also produces better results in terms of SWM and cost recovery. Also, knowing waste composition in the local context, including the amount and types of profitable materials to be recovered, biodegradables and fine materials, would guide project design from sorting at the source to waste treatment and disposal.

In most developing countries, **waste pickers play a role in recycling systems that could be improved depending on the context.** Collection from households and sorting are often covered informally by individuals or small cooperatives at low cost. While their working conditions are poor, their efforts yield intelligence on profitable waste streams in terms of which materials can be recycled or not.

Optimising and professionalising the SWM system can have social and financial impacts. Improving working conditions might mean cost increases, making the recycling of certain materials less financially attractive. However, this can be counterbalanced through economies of scale and increased efficiency. The integration of the informal sector into new SWM systems can be successful when considering:

- Promoting the creation of cooperatives and micro, small and medium enterprises (MSMEs) through administrative reform to integrate informal entrepreneurs and support workers.

- Creating financial instruments such as microcredits for individuals and credits for MSMEs and cooperatives.

- Promoting the involvement of social companies in SWM systems.

- Establishing treatment facilities such as labour-intensive sorting and recovery plants where green jobs can be created.

RECOVERY
Make the most of waste

Link to case studies

Material Recovery: Recyclables and biodegradables are recoverable materials. While composting may be a common practice at the household level in smaller cities and rural areas in low- and middle-income countries, large-scale and systematic recycling and composting is usually less developed. However, the introduction of separation at the source (see collection and transfer) and the application of simple and adapted treatment technologies facilitates the implementation of recovery processes. Consider the following key points:

Cities can take advantage of material recovery. The profitability of recycling and composting depends on local conditions, especially on the market for the output.

- It is essential to have a good understanding of the market situation for each of the recoverable materials. Both the material sought and processed and the resulting output material or product should be demand-driven. Even the best technology and input materials do not generate profit if there is no solid market for related recyclables or compost.

- Plastics, metal, and paper recycling operations are more readily profitable because of the traditionally large demand for these products. Other materials like glass, textile, construction waste, e-waste and compost, among others, can only be profitable when enabling conditions are in place, such as a beverage industry for glass bottles or a large demand for compost as a soil improver.

Recovering energy from urban solid waste can play an important role in diverting waste from landfills and as an alternative energy source that would replace fossil fuels with high calorific waste. The following must be considered:

- Incineration with energy recovery of urban solid waste is useful to reduce massive amounts of waste sent to landfills in large urban areas with scarce landfill space. This should be applied after recyclables and organic waste have been separated to avoid burning recoverable materials. Conversion of heat into steam-driven generators for electricity is an efficient process to reduce large quantities of waste to about 20% of residual ash. It is suitable for large urban areas that generate large quantities of waste (several thousand tonnes per day) and face a lack of landfill space (e.g. megacities in China, India and Indonesia). It requires a minimum calorific value of the waste (approx. 6 MJ/t) but also results in high investment and operation costs. It also needs highly qualified staff and efficient environmental monitoring to guarantee an optimal incineration process and flue gas cleaning. Highly professional private sector participation is recommended.

- In anaerobic treatments to generate biogas, organic matter is fermented to generate biogas with methane that can be burnt in special gas engines to generate electricity. It depends greatly on a pure organic waste input and a high feed-in tariff to justify the high cost.

- Co-incineration of refuse-derived fuel or solid-recovered fuel is an internationally recognised method applied in specially equipped cement factories as a substitute for fossil fuel. It requires a mechanical-biological treatment plant as a preparatory step to generate the high-calorie RDF material and then a feed-in mechanism at the cement plant. While there are successful plants operating this technology in Europe and Asia, the technology is largely incipient in Africa (mostly implemented in South Africa).

- Special thermal processes, such as pyrolysis and gasification with a lack or absence of oxygen, produce charcoal-like substances. That and syngas, or plasma burning as a high-temperature waste incineration process, are being tested all over the world. While there is no current operation at an industrial scale, these technologies offer future potential.

- Converting non-recyclable waste materials into usable heat, electricity, or fuel is usually a side effect of a main objective to eliminate large quantities of waste. Apart from some cases with well-developed systems to utilise electricity and heat, the revenues do not cover even the operation costs. However, the environmental benefits of decarbonisation and the saved landfill space can compensate for the financial gap.

DISPOSAL

The least possible volume

Link to case studies

In low-and middle-income countries, more than half of the waste is openly dumped under uncontrolled conditions with negative environmental and social consequences. Public space occupation, water contamination and water flow blockages, groundwater contamination due to leachate infiltration, air polluting emissions (including greenhouse gases and smoke from landfill fires), as well as odours and vermin attracted by decomposing organic matter are common and pose **risks to human health and biodiversity.**

Waste pickers working at existing dump sites are exposed to these conditions. In addition, some waste pickers increase environmental and social risks by employing untechnical methods for gas extraction and igniting fires when burning materials. The following considerations are directed at improving final disposal:

- **Rehabilitating or closing existing dumpsites** will help prevent environmental risks and recover urban and natural spaces. Similarly, sealing and greening sites and (depending on the age and size of the dumpsite) transporting waste to a sanitary landfill could be viable options. Mechanical biological treatment can reduce volume and emissions through a pre-composting process. Landfill mining can recover materials by sieving, sorting and magnetic separation.

- **Landfills will still be needed in the medium to long term and should be constructed and operated under sanitary conditions** to minimise environmental harm. Ideally, these sites should only treat residues and non-recoverable waste and follow proper disposal considerations:

- **Landfills should be located** in places **where impacts** on health and the environment **are avoided or minimised and transportation** costs could be **optimised**. In general terms, landfills should not be located near water bodies, aquifer recharge or discharge areas, protected ecosystems, arable land or health and education facilities, airports or any sensitive infrastructure and should have at least 1km distance from human settlements and follow local regulations.

- **Environmentally sound disposal cells,** including bottom liners, impermeable cover technologies and leachate drainage, are necessary to prevent leakages that pollute soil, water and ecosystems. Leachate should be collected and treated to purify the liquid and allow drainage in surface water.

- Modern landfills have an **efficient operating management system** where waste is (i) registered to provide invoices and plans for future development of the SWM system and (ii) disposed of in an orderly process to maximise the landfill capacity and reduce negative environmental impacts.

Some treatment and recovery processes are performed at the landfill site

- **Capturing and treating gas reduces air pollution, GHG emissions and hazards.** The minimum requirement is to burn landfill gas in a flare. However, depending on the gas flow rate and the methane content, the use of landfill gas to generate energy via a special gas engine can also be an option. In all scenarios, the landfill gas is collected and burned to destroy all contaminants. The burning process reduces the greenhouse gas potential of methane by a factor of 28, as only CO2 is generated.

- Treating hazardous waste through **chemical-physical processes** is key to eliminating some pollutants. Furthermore, **biological** processes transform other pollutants into harmless products, contributing to the reduction of hazards. Waste from industrial processes should be disposed of in special hazardous waste landfills after being conditioned to immobilise contaminants, or the hazardous waste should be incinerated in special waste incinerators.

- Treatment often uses bioreactors to provide the environment for biological processes to transform raw materials into biochemical products and/or by-products.

SWM does not end with disposal. Waste treatment and landfills require monitoring to avoid risks.

- **Landfills** have a maximum active lifetime of around 20 years but **remain a potentially contaminated area** for many decades thereafter (>50 years).

- Although technology associated with the disposal of waste is comparatively low in cost, the overall cost increases significantly due to expenses such as land acquisition, potential contamination risk from barrier system failures, landfill post-closure care ,and the long-term operation costs spanning at least 50 years.

SWM COSTS, FUNDING AND BUSINESS MODELS

Urban SWM systems in low- and middle-income countries have a high potential for savings, as services provided are often not cost-efficient.

SWM systems are costly and usually not self-sustainable. However, urban SWM systems in low- and middle-income countries have a high potential for savings, as existing services are often not cost-efficient.

A well-developed municipal financial management system also allows for **medium- to long-term planning of the SWM system** regarding investments, service performance, service coverage extensions and private sector participation. The following considerations can guide the project design process:

PAGE 12-13
COSTS
Investment and operation order of magnitude per Value Chain Stage

PAGE 14
FUNDING
Consideration on fees and taxes, national support and revenues

PAGE 15
BUSINESS MODELS
Business and contract models and the role of the private sector

Investments and operational plans **based on** real city **data** on SWM can reduce costs and improve performance.

SWM system planning can optimise technical aspects, such as collection coverage, transport, transfer of waste and improved tariff systems, with impacts on the cost and quality of service.

Scale matters and metropolitan and regional agreements could optimise resources and extend coverage.

Strengthened urban management capacities improve service provisions and enhance private sector participation where the public sector does not have the capacity.

Source: UDTF 2024.

[3] Cost data taken from "What a Waste 2.0" as well as from available project documentations.

COSTS

Understanding cost distribution according to local conditions is key to designing an optimal SWM system. As seen in the table below, collection and transport constitute the highest block of cost in the SWM value chain.

While recycling and composting are costly and are often not financially viable on their own, factoring in the benefits of avoided landfill costs and environmental benefits can render these solutions more economically appealing. **Landfill closure** and **aftercare** costs are generally not included in SWM system budgets. Aftercare can last from 20 to 50 years after the end of the active lifetime of a landfill (leachate treatment and landfill gas management might continue for a long time).

As examples of **order of magnitude, investment and operation costs** for the following measures have been estimated for cities in low-income countries:[3]

Collection and transfer

Collection and transfer investment for a city with approximately 1 million inhabitants and approximately 150,000 tonnes of waste per year, assuming an 80% collection efficiency, would be around EUR 3-5 million. The corresponding operating expenses would be around EUR 20-30 per tonne of waste.

INHABITANTS	COLLECTION RATE	WASTE / YEAR	OPEX
1 M	80%	150,000 tonnes	20-30 € /Tonne 3-5 M€ /YEAR

Recovery processes

Recovery processes such as recycling, composting and energy generation:

- a medium-sized recycling plant for around 50,000 tonnes of waste per year would have capital expenses of EUR 2–4 million.
- a composting plant of approx. 20,000 tonnes per year for green waste would be approximately EUR 1.5–2 million.
- waste to energy plants have capital expenses in the range of EUR 70–100 million for a 350,000 tonnes per year incineration plant and between EUR 15-20 million for a 50,000 tonnes per year anaerobic waste treatment plant.

Corresponding operation cost would be around:

- EUR 5–10 per tonnes for simple windrow composting.
- EUR 10–15 per tonnes for recycling pants with mechanical sieving and manual sorting lines.
- EUR 50–100 per tonnes for waste incineration, as well as EUR 30–50 per ton for digestion plants.

CAPEX MEDIUM SIZED RECYCLING PLANT
50.000 tonnes
3-4 M€

OPEX
10-15 €/Tonne

CAPEX ENERGY PLANT (INCINERATION)
350.000 tonnes
70-100 M€

OPEX
50-100 €/Tonne

CAPEX COMPOSTING PLANT
20.000 tonnes
1.5-2 M€

OPEX
5-10 €/Tonne

CAPEX ENERGY PLANT (ANAEROBIC)
50.000 tonnes
15-20 M€

OPEX
30-50 €/Tonne

Final disposal

Examples of the cost for establishing a modern sanitary landfill include one in Grand Lomé (1.5 million inhabitants in Togo) of EUR 21 million for accommodating 250,000 tonnes/ year. And in Grand Conakry (3 million inhabitants, Guinea), a EUR 50 million landfill project will receive about 950 000 tonnes[4]. For these facilities and treatment plants, economy of scale plays a big role. The larger the plant, the lower the cost per unit becomes. Operating expenses for a modern landfill for a city like Lomé would be around 10-15 EUR per tonnes or 2.5 - 3.8 million EUR per year.

[4] Both projects include access roads. Lomé's project also a leachate treatment plant (plant-based filter basin) and a landfill gas extraction network and flare installation. Conakry's project includes access control, weigh bridge, sheds and hangars, laboratory, sanitary facilities, workshops, fencing and gates, biogas recovery for the landfill electricity (potentially to the grid later) and leachate treatment.

INHABITANTS IN GRAND LOMÉ
1.5 M

WASTE DISPOSED
250.000 TONNES /YEAR

CAPEX
21 M€

OPEX
10-15 € /Tonne
2.5-3.8 M€ /YEAR

Consider reducing waste as a strategy to reduce impacts and costs: In general, reducing waste weight and volume would reduce overall SWM costs. Charging less for recoverable materials (reusables, recyclables, organics) and more for non-recoverable waste can incentivise sorting at the source and selection of products that generate little or no waste. Households could even offset part of SWM costs by receiving credits for the collection of recoverable materials and contributing to waste volume reductions. In some cities, the collection of recoverable materials is free, while non-recoverable waste collection is charged by volume (by bag), incentivising households to separate recoverable material.

As an example, for total operational costs, the SWM master plan for the city of Conakry and neighbouring municipalities (Republic of Guinea) estimates a total operational cost of EUR 45.8 million a year for an 80% collection rate, resulting in about EUR 50 per ton for the entire SWM chain. Estimated fees recovered from citizens and businesses show that payment capacity is significantly lower than operational cost.

OPEX
45.8 M€ / YEAR

COLLECTION RATE
80%

FOR THE WHOLE SWM CHAIN
50 €/Tonne

	LOW-INCOME COUNTRIES	LOWER MIDDLE-INCOME COUNTRIES	UPPER-MIDDLE INCOME-COUNTRIES	HIGH-INCOME COUNTRIES
Collection and Transfer	18-47	28-70	47-94	84-188
Controlled Landfill to Sanitary Landfill	9-18	14-37	18-61	37-94
Open Dumping	1.8-7.5	2.8-9.4	-	-
Recycling	0-23	4.7-28	4.7-4.7	28-75
Composting	4.7-28	9-37	18-70	32-84

Table: Costs per tonnes (in EUR). Source: World Bank Solid Waste Community of Practice and Climate and Clean Air Coalition. Original costs in USD, converted to Euros at 2023 rates.

FINANCING

SWM systems require fees and taxes

It is preferable to use fees under the concept of pay-per-use to capture fair contributions from waste generators such as businesses, institutions and citizens. However, cost recovery through fees in low- and medium-income countries is often constrained due to limited economic capacity. Cost recovery constraints make funding from taxes almost always necessary since the SWM system fees and revenues (if any) cannot cover the full cost of investment and operation or even operation alone.

An efficient tariff structure could have different levels and could improve affordability

Tariff structures could have different fee levels for groups of waste generators. Fee design should consider the household's income level and apply fees in proportion to the household's payment capacity. For example, some cities charge higher fees in higher-income neighbourhoods and lower fees according to the distribution of cadastre or census parameters. Other cities charge higher fees for more lucrative land uses, such as commercial areas, and lower fees for residential areas. Differences in fee levels allow for cross-subsidies using surplus from high-income customers to cover lower-income customers' payment capacity deficit.

Municipalities often require support from national budgets

It is estimated that local governments can cover about half of the investment costs and need support from the national level to cover the remaining cost and operation costs of SWM systems. In addition, cities, regions or nations could use other financing sources to supplement fees and taxes, such as taxes on products which will turn into waste someday (Tunisia offers one example of a SWM tax on products) or Extended Producer Responsibility models (EPR) that include the responsibility of producers in the financing of SWM services.

Cities should develop and operate SWM systems and apply fee systems in parallel with awareness campaigns

Citizens who receive good services and are sensitised are more willing to pay. The implementation of a new cost-covering tariff structure should go hand in hand with the improvement of service provision through investment in new equipment and infrastructure.

Landfills for treated waste are usually less costly.

A landfill for treated urban solid waste (i.e. the organic waste is stabilised) or mineral waste will require significantly less operation efforts and cost during its lifespan, aftercare and closure.

SWM fees can be estimated and collected through other services' fees or taxes

SWM fee collection can be performed through electricity or water bills - known as joint billing, which estimates SWM fees based on service consumption and links the provision to timely payments - or property tax (estimated by property value). Both systems solve the difficulties of calculating the service used and citizens' unwillingness to pay for a service perceived as less essential.

Recycling, composting, and energy generation processes are only profitable in exceptional cases

For example, if prices for recycled materials are high or if a high feed-in tariff for the generated electricity can be achieved. While sales of recoverable materials and waste by-products (e.g. recycled materials, compost and fertilisers, energy generation) may yield some profits , they often struggle to cover even their own processing cost. However, despite this financial challenge, these processes significantly contribute to minimising environmental impacts and diverting waste, thereby reducing transportation and disposal costs.

[5] WB, What a Waste (2018)..

BUSINESS MODELS AND ROLE OF PRIVATE SECTOR

Business models play an important role in service provision and, as such, in the financial sustainability of a SWM system. Whenever the private sector is involved, a range of different business or contract models is applied for various services:

Cities also contract **management companies** to operate existing treatment or disposal facilities for ongoing operations. In low- and middle-income countries, they often refer to simple treatment plants with low efficiency and disposal on open dump sites. These are implemented through management contracts with or without own assets (mainly mobile operation equipment such as bulldozers, wheel loaders and trucks).

Involving a **well-qualified private company** usually offers a more **cost-efficient solution** and operational advantages for the public sector, which lacks technical and management capacity and knowledge. While **institutional strengthening** takes time and is hampered by restrictions in recruiting new staff and providing appropriate salaries, the private sector works under business-oriented management structures with skilled staff, better salaries and adapted efficient operational procedures.

In some cities in low- and medium-income countries, the **private sector may not be well developed** in the waste sector, resulting in less qualified services. Cities are often slow in paying private operators, affecting service performance. Service contracts are sometimes too short to allow investment in proper equipment.

Well-prepared contracts based on proper procurement processes with performance indicators for the operator and well-developed contract monitoring system by the public side **are essential.** Contracts should also look for full coverage and service, avoiding practices like cherry-picking by private operators who limit work to high-income areas where the service can be provided more easily and collecting fees to recover operation costs is easier than in low-income areas.

Management contracts are often used for the provision of waste collection and transport services. In its simplest model, the city owns the assets (trucks and containers) but hires a private company to operate them. In other cases, cities outsource the service in a dedicated area to a company, and the company brings its own assets to operate over the contract period. In this case, **franchise models** can be implemented, where the city gives service contracts for each dedicated service zone to one company after conducting a bidding process. Contract duration should be at least 5–7 years to allow the private company to invest in new and efficient trucks. However, some cities chose short, one-to-two-year contracts, resulting in companies bringing used equipment with frequent downtimes and high maintenance costs.

More complex models such as **design/build** (DB), **design/build/operate/(transfer)** (DBOT)) and/or **design/finance/build/operate and transfer** (DFBOT) are generally applied for new and modern treatment plants with a higher degree of mechanisation and treatment efficiency and reduction or recovery.

- **DB** models are more common, especially if the works are funded by grants or loans (reducing the payment risk for the private sector).
- **DBOT** models, with a higher risk degree for the private sector if the operations are (totally or in part) paid by gate fees, can also be realistic for low- and middle-income countries.
- **DFBOT** models, where the private sector incurs higher risks (whether remuneration comes only from public sector transfers or also from users' fees), are less likely.

The more advanced the private business model is, the higher the requirements are on the public side to provide proper and strong contract management.

For certain business cases, like the operation of recycling plants, construction and demolition waste management, and e-waste management, the **formal or informal sector might be more qualified** as this requires strong ties to factories as off-takers of the recovered material. The private sector is usually more flexible to adjust to varying market conditions and provide these services. The integration of the informal sector into a formal system and its own formalisation provides lots of opportunities in using this job potential and its strong knowledge of recycling operations.

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Cover image: Organic matter to compost. 2001. Sofonia/Ratoma composting unit, Conakry, Guinea.
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