
# LAC Cities Study Tour
# Sector Notes: Solid Waste Management

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Disclaimer

This document was prepared as part of the series of sector notes that highlight the characteristics of selected urban infrastructure sectors, the roles of the private and public sector, and the financing mechanisms for the long-term funding of these urban interventions. The notes are prepared as background material for the Latin American and the Caribbean (LAC) Cities Study Tour offered to African Cities in the UMDF Cities Program. The sector note also highlights the experiences of the LAC region in finding solutions for the urban challenges as well as the lessons learned. The notes were prepared based on the experiences of the Inter-American Development Bank (IADB) with its Emerging and Sustainable Cities Initiative (ESCI) from 2012 thru 2017. The sector notes also benefited from consultations and recent work by development financial institutions and academic institutions in the sector.

This work is a product of an external consultants group led by Ellis J. Juan (former Urban Division Chief at the Inter-American Development Bank) with external contributions. The findings, interpretations, and conclusions expressed in this work do not necessarily reflect the views of the African Development Bank, its Board of Executive Directors, or the governments they represent. The African Development Bank does not guarantee the accuracy, completeness, or currency of the data included in this work and does not assume responsibility for any errors, omissions, or discrepancies in the information, or liability with respect to the use of or failure to use the information, methods, processes, or conclusions set forth.

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# Background

Approximately 2.01 million tons of municipal solid waste (MSW) are generated annually (2016), and this amount is expected to grow to 3.40 million tons per year by 2050. Poorly managed waste is one of the key drivers behind drainage clogging and flooding, loss of the aquifers, health respiratory issues and disease transmission, and ocean, lakes, and river water contamination, with the associated loss of bodies of water and their uses for economic activities (i.e., agricultural, recreational, and business activities). These outcomes represent the negative externalities of poorly managed MSW management systems.

As of 2016, 5% of the global GHG emissions were produced by solid waste management. From a mitigation viewpoint, there are other global activities that are responsible for a greater portion of HGH emissions (i.e., energy and transport). However, from an adaptation and resilience viewpoint, solid waste management practices have far more relevance in the today's global environmental challenges[1]. MSW is at the core of the attainment of the Sustainable Development Goals (SDG No. 11 for sustainable cities and No. 12 for reducing waste).

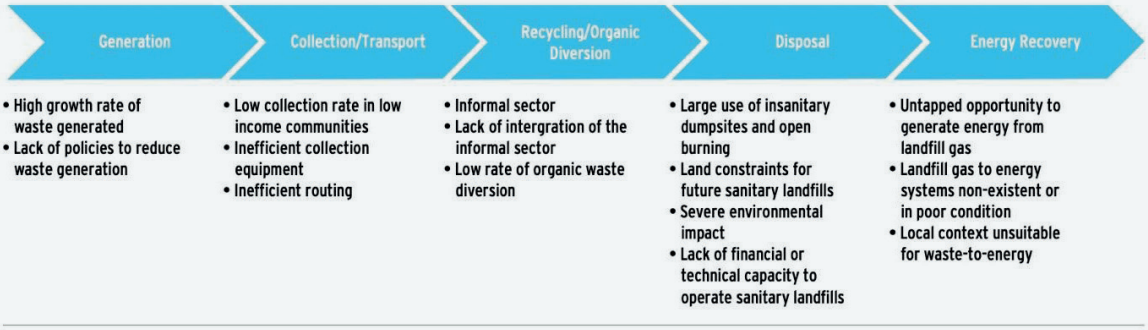
The World's waste generation is increasing faster that population growth. Waste generation is a function of income per capita growth, with the caveat that among developing countries waste tends to be more concentrated in food and green waste, while in richer countries, waste tends to be less on food and green (more recycling activities), and more in plastics and other more complex types of waste. Waste management includes many types of waste (i.e., industrial, agricultural, construction and demolition, medical, technology related, and consumer related). The waste generated by consumers (i.e., households, commercial business, public agencies and offices, e-waste, and electronic devices, etc.) is usually handled via municipal based systems and is known as municipal solid waste (MSW)[2]. Other types of waste are usually handled by different channels. The present note will focus exclusively on MSW management systems.

In developing countries, MSW management is the responsibility of local governments (as it is in developed economies). As political decentralization deepens, so did the transfer of public service provision responsibilities such as solid waste management. The rapid urbanization phenomenon experienced by Latin America and the Caribbean (LAC) cities, and now by African (AFR) cities, with the known impact of higher population growth, and urban expansion increased disproportionately the amount and types of solid waste generation. These local governments from LAC and AFR did not always have the financial resources and institutional capacities to effectively deal with the challenges of solid waste management. These challenges have given rise to the development of strong waste management strategies and demanding innovative and efficient solutions in the "value chain" of solid waste management (see figure No. 1 below).

1 World Bank. "Global waste to grow by 70 percent by 2050 unless urgent action is taken - World Bank report." World Bank, September 20, 2018, https://www.worldbank.org/en/news/press-release/2018/09/20/global-waste-to-grow-by-70-percent-by-2050-unless-urgent-action-is-taken-world-bank-report.

2 IFC, Financing Waste Management, April 2022.

**Figure No. 1: MSW Value Chain and its Challenges in Cities from Developing Countries**




**Source: Global Partnership for Output Based Aid and World bank, Urban Development Series, Results Based Financing for MS, April 2014**

Latin American cities have urban challenges and within this context, effective waste management has emerged as a key element of sustainable development. According to UN Environment, the urban waste generation in LAC was 541,000 tons per day in 2014. It is estimated that by the year 2050, the annual generation of waste globally will increase by approximately 70% to 75%, reaching a total of 3.4 billion metric tons. Additionally, it is estimated that 40 million people lack access to waste collection, and 145,000 tons per day of waste are still disposed of in open dumps, including 17,000 tons per day of plastic waste.

Based on the World Bank's report "What a Waste 2.0"[3], the ranking of countries in LAC that generate the most waste start with Mexico (1.16 kilograms per capita per day), Chile (1.15 kilograms per day), Argentina (1.14 kilograms per day), the Dominican Republic (1.08 kilograms per day), and in fifth place, Brazil (1.04 kilograms per day). This data emphasizes the urgency for strategic waste management approaches to mitigate the environmental and social impacts associated with improper waste disposal.

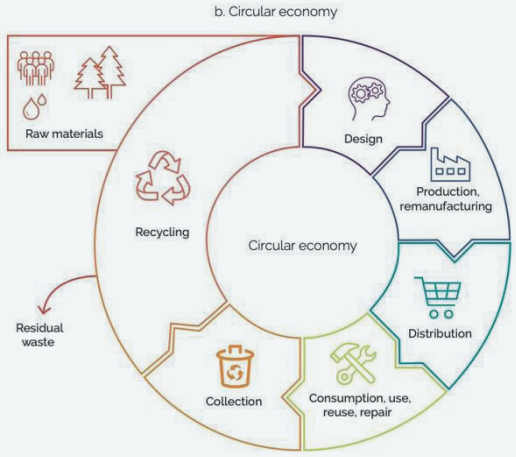
The solid waste industry serves as a substantial contributor to climate change, emitting pollutants like methane and black carbon. Concurrently, the services and infrastructure engaged in the entire waste management process collection, transportation, recycling, treatment, and disposal, are exceptionally vulnerable to climate stressors, including severe weather events. Consequently, improving waste management in urban areas holds the dual promise of mitigating the impacts of climate change and strengthening local resilience in the face of adverse climate-related effects.

Another angle to the challenges of MSW is the need to transition from the traditional linear economic model (i.e., "take-make-dispose") to more widely accepted sustainable alternatives such as the "waste hierarchy" and circular economy approaches. A waste hierarchy approach prioritizes waste prevention, reuse, recycling, and recovery before disposal. A circular economy closes the loop between extraction, manufacturing, and disposal by advocating for designing products to reduce waste, using products and materials for as long as possible, and recycling materials from end-of-life products back into the economy. Transitioning to circular economy models is not easy and requires larger amounts of funding to improve the capacities and systems for solid waste management and concerted action among the key stakeholders, in particular the end-users[4].

3 World Bank. "World Bank Open Data: Solid Waste Management." World Bank Data Catalog, https://datacatalog.worldbank.org/search/dataset/0039597

4 Towards a circular economy: Addressing the waste management threat. Victor Vergara and Ramachandra Jammi, April 7, 2022

**Figure No. 2: MSW Systems, Circular Economy**




**Source: World Bank, IEG, Solid Waste Management, Transitioning to a Circular Economy, 2022**

African cities are currently undergoing a significant urbanization transformation. This process attracts millions from rural areas, all seeking economic opportunities and an elevated quality of life within urban centers. Within the rapid pace of this urbanization, the waste management sector arises as a critical domain that requires focused attention.

This sector note aims to delve into the experiences of Latin American cities in navigating the complexities of solid waste management. It is worth mentioning that the treatment processes for solid waste management show similarities to those employed in waste water management. The focus will primarily be on examining the various strategies, challenges, and innovations related to the treatment phase of solid waste, drawing parallels where applicable to underscore the shared aspects with water waste management.

By exploring innovative approaches and showcasing successful case studies, this document seeks to extract valuable insights that may benefit African cities contending with parallel challenges. Subsequent sections will scrutinize the specific challenges faced by Latin American cities, the innovative solutions they've implemented, and case studies that demonstrate successful solid waste management practices, offering a platform for cross-regional knowledge exchange.

**Box No. 1: How does the solid waste sector contribute to climate change?**

The solid waste sector significantly contributes to climate change through the emission of pollutants such as methane and black carbon. These short-lived climate pollutants remain in the atmosphere for a shorter time than carbon dioxide but have a much higher global warming potential. Approximately 11% of global anthropogenic methane emissions and 5% of black carbon emissions come from the waste sector. In terms of their impact on climate change, these emissions represent about 2% of all global greenhouse gas emissions.

The three main pollutants in the solid waste sector affecting climate change are carbon dioxide, methane, and black carbon. Carbon dioxide, a greenhouse gas with a long atmospheric life, arises from fossil fuel-powered vehicles, equipment, anaerobic decomposition, and waste incineration. Methane, a potent greenhouse gas with a 12-year lifespan, is released from the anaerobic decomposition of organic waste. Black carbon, a component of particulate matter formed by incomplete combustion, is released from burning fossil fuels and waste. Throughout the various stages of solid waste management, emissions affecting climate change originate from different sources.

Collection in low-income countries, with less than 40% waste collection coverage, often leads to informal disposal methods like open burning, releasing carbon black and carbon dioxide. Transportation emissions result from diesel-powered trucks and tractors used to transport waste. Recycling, particularly in developing countries, involves informal workers who may resort to burning waste, emitting carbon black and carbon dioxide. Improper handling of refrigerant-containing waste by informal recyclers may release fluorinated gasses with high global warming potential.

Overall, the solid waste sector contributes significantly to climate change through diverse emission sources in waste management stages such as collection, transportation, and recycling.

Source: U.S. Environmental Protection Agency (EPA). "Solid Waste Management and Climate Change." EPA 2023, https://www.epa.gov/system/files/documents/2023-09/swm_climate-spanish.pdf.

# Experience from LAC

The urbanization process in Latin America, marked by a notable shift from rural to urban regions, introduces a dynamic landscape with both opportunities and barriers. These challenges involve a variety of factors, including high population density, varying socio-economic conditions, and limited infrastructure.

Cities face the task of developing innovative waste management strategies to address the growing needs of their dynamic populations. As mentioned before, the management of solid waste remains a responsibility of local governments, deeply established among citizens as a mandatory governmental duty. This perception, added to the inherent complexity of the waste management sector, obstructs the efficient administration of services. To handle associated costs, governments often resort to imposing high fees on citizens, resulting in community tensions.

Moreover, the treatment phase becomes crucial amid climate change challenges, such as increased rainfall and natural disasters causing substantial waste accumulation. Rapid urbanization further necessitates new treatment methods to mitigate environmental impacts. In response to these challenges, Latin American cities have adopted forward-thinking approaches, including raising public awareness. The practice of separating household waste by product type (organic, non-organic, waste, etc.) not only facilitates subsequent treatment but also helps reduce associated costs.

Beyond traditional methods, LAC cities have pioneered initiatives such as community engagement through educational programs promoting responsible solid waste practices, waste-to-energy projects, the utilization of technology and data-driven solutions for efficient solid waste collection, and the establishment of robust recycling systems. This synthesis of innovation aims not only to address immediate challenges but also to foster a sustainable and resilient waste management ecosystem.

To address the impact of solid waste management on climate change, specific actions must be considered. Understanding waste composition is crucial for focusing efforts on waste minimization and prevention. Studies characterizing waste can identify non-recyclable materials that should be targeted in waste prevention strategies. The active involvement of stakeholders is essential for implementing strategies that reduce waste generation. This involves public communication and outreach regarding waste minimization through reduced consumption, recycling, and home composting.

Additionally, managing garden and food waste from meal preparation and leftovers at the household level is a strategy that doesn't solely rely on governmental actions. The technology and capacity for treating waste at home depend on factors such as available space, and various options for home composting exist.

Efficient waste management plays a critical role in addressing climate change, employing practices such as source separation, collection fees, expanded coverage, and prohibition on open burning. For instance, Pay-As-You-Throw (PAYT) programs, which establish fees based on the quantity of generated waste, exemplify the effectiveness of offering flexibility in these fees. Furthermore, optimizing collection routes and implementing eco-friendly fleets contribute significantly to emissions reduction. Sustainable practices exemplified using compressed natural gas from landfill gas in Rio de Janeiro, Brazil, demonstrate the viability and effectiveness of these measures.

As African cities undergo expansion, they grapple with a multitude of challenges in waste management, necessitating creative solutions. The experiences of Latin American cities prove invaluable in this context, as they have faced similar urbanization pressures, albeit at varying scales. Latin American cities have effectively implemented innovative waste management solutions, markedly improving their waste disposal procedures and contributing to sustainable urban development. By drawing insights from these experiences, African cities can tailor and adopt proven strategies to enhance their waste management systems, mitigate environmental impact, and establish sustainable waste disposal practices. Some of these cases serve as examples of successful implementations, providing visible lessons and best practices that can inspire innovative approaches for sustainable waste management in the ever-developing urban landscape of Latin America.[5]

## Waste-to-Energy Projects:

Energy recovery involves converting non-recyclable materials into heat, electricity, or usable fuel through various processes, commonly referred to as waste-to-energy conversion. By transforming these materials into electricity and heat, it generates a source of energy that helps reduce carbon emissions by offsetting the need for energy from fossil fuels.

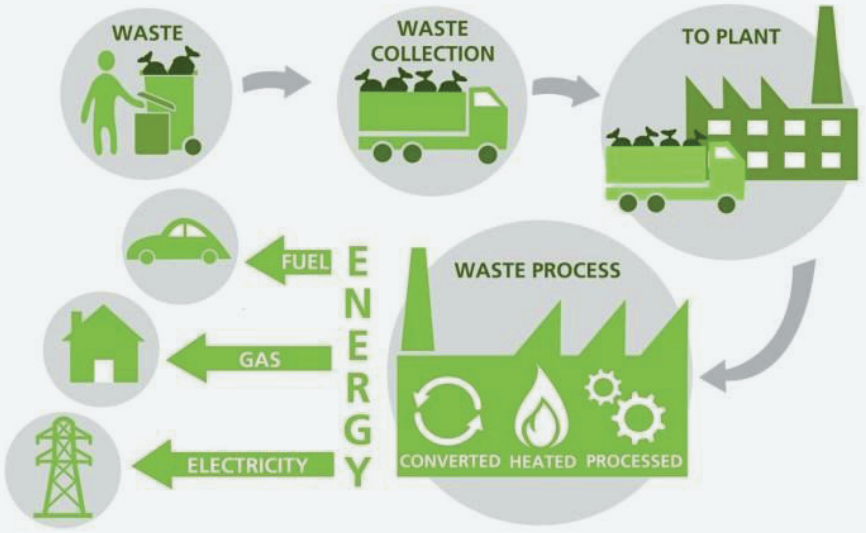
Waste-to-Energy Projects stand out as innovative and crucial components of waste management strategies due to their transformative approach to handling municipal solid waste. These projects play a central role in addressing two significant challenges simultaneously: efficient waste disposal and sustainable energy generation. By utilizing technologies these projects

5 According to the Earth Summit, organized by the UN in 1992, established four program areas related to waste: minimizing waste, maximizing eco-friendly reuse and recycling, promoting ecologically rational disposal and treatment, and expanding waste management services. These areas aimed to drive sustainable and ecologically rational development globally and were reviewed in 2002 at the World Summit on Sustainable Development in Johannesburg. The proposal remains globally relevant, with the additional goal of ensuring access to basic sanitation for all.

convert waste materials into valuable energy resources, reducing the volume of waste sent to landfills. This not only addresses the issue of space constraints in landfills but also contributes to the reduction of greenhouse gas emissions associated with traditional waste disposal methods.

Besides, Waste-to-Energy initiatives provide an alternative source of renewable energy, aiding in the diversification of energy portfolios and reducing dependence on limited fossil fuels. The innovative integration of waste management and energy generation is an example of how west management sector offer both environmental and economic benefits to communities, while significantly contributing to the pursuit of sustainable urban development.

**Figure No. 3: Waste-to-energy projects Diagram**




**Source: EcoMENA. "Renewable Energy from Wastes." EcoMENA, https://www.ecomena.org/renewable-energy-from-wastes ."**

Although waste-to-energy plants require a significant initial investment and have high operating and maintenance costs, their positive impact can be maximized through the implementation of effective air pollution controls at the end of the process and advanced waste disposal techniques. Some countries in the region have been exploring and implementing Waste-to-Energy projects as a sustainable waste management solution.

## Doña Juana landfill. Bogotá Colombia

Bogotá, Colombia's capital, has addressed its waste issues at the Doña Juana landfill. With an annual intake of 2 million tons of waste, this site posed health risks and added to greenhouse gas emissions. In response, Bogotá launched the innovative Doña Juana Landfill Gas to Energy project. This visionary initiative not only reduces emissions but also cleverly transforms captured landfill biogas into electricity, making Bogotá the first city in Colombia to achieve this milestone.

The Doña Juana Landfill Gas to Energy project in Bogotá is about turning landfill biogas into electricity for the national grid. Since 2009, the city has been dealing with methane from landfill waste, but it made history by becoming the first Colombian city to generate electricity from this waste. The landfill's plant, with one of the country's largest biogas systems, runs 24/7 at a capacity of 30 MW. The project aims to cut 900,000 tons of CO2 emissions annually, with plans for two more plants by 2018 to boost biogas production and reduce CO2 emissions. Importantly, the project allocates 24% of carbon reduction credits and 4% of electricity sales to community projects, including kindergartens, community centers, paths, and sanitation infrastructure.

**Figure No. 4: Doña Juana Landfill Gas to Energy project**

**Source: NEFCO. "Gas to Energy in Bogotá." NEFCO**
**https://www.nefco.int/case-stories/gas-to-energy-in-bogota/**

The initiative has achieved significant environmental milestones, as methane capture at the plant alone cut CO2 emissions by over 4.4 million tons from 2009 to 2016, and 5.4 million tons of CO2 between 2014 and 2020 as a result of the electricity generated by the project[6]. Socially, the project offers vocational training to local youth, creating new opportunities, and brings economic benefits of over $2 million into the city through electricity sales. At the same time, the project ensures health benefits by protecting neighboring communities from harmful gasses like ammonia and hydrogen sulfide. This comprehensive initiative reflects Bogotá's commitment to tackling waste challenges in a well-rounded manner, delivering positive impacts on environmental, social, economic, and health fronts.

Bogotá's waste management initiative, led by the Special Administrative Unit of Public Services (UAESP) of the city, approved the implementation of an innovation park that will include a waste-to-energy plant. The Doña Juana Innovation Park project adopts a modular approach with the initial module operational by 2024. By 2027, the facility is poised to process 2400 to 3000 tons of waste daily, generating over 128 megawatts of electricity. This capacity is anticipated to meet the electricity needs of all public lighting in Bogotá or more than 40,000 homes, solidifying its position as a transformative force in waste-to-energy initiatives.[7]

This initiative not only will address waste management challenges but also will position Bogotá as a pioneer in turning waste into a valuable energy resource, emphasizing environmental and social co-benefits. A new element involves the sale of ashes produced from waste combustion as construction materials, ensuring the full utilization of treated material and mitigating environmental impact. Additionally, the Waste-to-Energy Plant, in collaboration with Biogas Colombia, incorporates an advanced emissions cleaning system, projecting a substantial 66% reduction in harmful gas emissions compared to traditional waste burial methods.

Beyond its local impact, this project signifies a paradigm shift in waste treatment, aligning with circular economy principles and actively contributing to the broader fight against climate change. The financial model proposed by UAESP ensures economic viability, incorporating the sale of both energy and ashes without imposing additional cleaning fees on citizens. Also, this project plans to complement efforts by Recycling Organizations, organic waste treatment pilot projects, and a noteworthy reduction of 7000 tons per month of demolition and construction waste, stemming from illegal dumping at critical points.

6 Go Explorer. "Bogotá Waste-to-Energy Project Supplies National Grid." Go Explorer, https://goexplorer.org/bogota-waste-to-energy-project-supplies-national-grid/

7 Ambiente Bogotá. "Bogotá Tendrá la Primera Planta de Termovalorización de Colombia, la Cual Convertirá los Residuos en Energía para la Ciudad." Ambiente Bogotá, https://ambientebogota.gov.co/noticias-de-ambiente1/-/asset_publisher/CWsNLtoGa4f6/content/bogota-tendra-la-primera-planta-de-termovalorizacion-de-colombia-la-cual-convertira-los-residuos-en-energia-para-la-ciudad

**Figure No. 5: Doña Juana Innovation Park projec**

**Source: Bogotá Official Website** https://bogota.gov.co

Medellín, the second-largest city in Colombia, has demonstrated a proactive approach towards waste-to-energy initiatives as part of its comprehensive strategy for sustainable waste management. Every day, around 3,100 tons of waste from Medellin and 23 other municipalities in Antioquia find their way to La Pradera landfill. This 382-hectare dumping ground has been in operation since 2003 and anticipates a faster fill-up than the initially projected 50-year lifespan.

In response to this challenge[8], the UK-based company Exergy proposed an innovative solution for Utilizing solid waste as a source of both thermal and electric energy, reducing a portion of the 90,000 tons of monthly waste, and cutting landfill operation costs by $2.5 billion.

Implementing the Waste2Energy technology, a collaboration between Exergy, the Cidet (Center for Technological Research and Development for the Energy Sector), and the University EIA in Medellin, could potentially save over 49 billion Colombian pesos annually (US$13.6 million). This proposal aligns with global efforts to minimize the environmental impact of waste and fosters a more sustainable approach to energy production in the region.

Exergy, in collaboration with local entities such as ACI Medellín and Ruta N, aims to explore uncharted territory in waste management. In contrast to the 83% of waste ending up in landfills in Colombia, the Waste2Energy project seeks to emulate successful models in countries like Sweden, the Netherlands, and Germany, where up to 90% of solid waste is utilized for energy generation. The “exergetic” methodology employed by Exergy optimizes the use of resources like energy and water, minimizing CO2 emissions and other pollutants.

Exergy, in collaboration with Ruta N, continues to explore alternative solutions within the local ecosystem. Thanks to ACI Medellín’s facilitation and the collaboration with local entities, Exergy remains committed to reducing ecological footprints and promoting planetary sustainability, investing in a mixed-use building in line with Medellín’s urban renewal vision, integrating sustainable features such as bioclimatic design, solar energy, and waste separation education.

8 “Sustainable Energy is the Bet Medellín is Making.” ACI Medellín, https://acimedellin.org/energia-sostenible-es-la-apuesta-que-tiene-medellin/

### Box No. 2: Barueri Waste-to-Energy Plant in São Paulo

In the bustling state of São Paulo, Brazil, Waste-to-Energy (WtE) initiatives are gaining traction, with a particular focus on incineration as a prominent Waste-to-Energy technology. While incineration is a well-established practice globally. São Paulo is in the early stages of implementing commercial-scale WtE projects. A notable project in the municipality of Barueri showcases the region's foray into this transformative approach.

The Barueri project, initially planned in 2010, encountered societal opposition but secured public authority approval for construction commencement. Touted as the "first WTE project" with a "mass burn WtE contract" in Brazil, it was initially slated to be operational by February 2020. The project led by Foxx Haztec, aimed to process 825 tons of Municipal Solid Waste (MSW) daily with a 20 MW installed power capacity. Despite several setbacks, including ownership changes and delays, it remains a proposed endeavor.

The construction of the incineration plant was planned through a concession obtained by the company Fox (now Fox-Haztec), through a public-private partnership. This initiative encompasses a significant investment, ranging from SR 300 to 400 million, for the construction phase, and Fox-Haztec will assume control of the plant for the initial 30 years.

Furthermore, the incineration facility will handle additional waste from Carapicuba and Santana de Parnaíba. employing a Waste-to-Energy (WtE) process to generate electricity for approximately 80,000 residents. Project developers emphasize that the technology utilized in this plant is well-established and draws inspiration from successful implementations in developed countries and includes technology with filters that prevent the release of toxic particles and a transparent monitoring system for tracking emissions.

In 2018, Foxx, having merged with Haztec in 2013, became a subsidiary of China Jianjiang Environment, with a substantial 51% ownership stake. An additional noteworthy aspect of the project is the anticipated financial support, approximately 62 million Reais, from the International Finance Corporation (IFC) of the World Bank Group. emphasizing the global significance of the endeavor.

This WtE initiative showcases São Paulo's commitment to exploring innovative waste management solutions. While facing challenges, these projects aim to contribute to sustainable waste disposal and energy generation, addressing the growing waste concerns in the metropolitan region. Continued efforts and collaborations are essential to realizing the potential benefits of Waste-to-Energy technologies in the Brazilian context.

## Recycling and Organic Waste Management:

Recycling involves a series of activities to collect used, reusable, or discarded items that would otherwise be considered waste. This means organizing and processing recyclable products to convert them into raw materials, which are then used to manufacture new products. An essential component in the global recycling system is the informal sector.

The organic waste management focuses on diverting and treating organic waste through techniques such as composting and anaerobic digestion (AD). Compost is an organic material added to the soil to promote plant growth, and AD is a process that produces biogas, a renewable energy source, using organic waste as raw material. Opting for composting or AD to handle food waste, garden residues, and other organic materials prevents these elements from ending up in landfills, taking up space and emitting methane.

Recycling is a good way to manage waste and help the environment. When people collect recyclables, like bottles and cans, it creates jobs and saves money. It's also better for our health and prevents pollution in the soil and water.

In more than 200 cities, they increased recycling a lot— from 40% to 80%! They did this by working with recyclers, and it helped nine million people. They also saved two million trees every year. People who collect recyclables can make more money now, like between USD 180 and USD 260 each month. This way of doing things is good for the environment and helps people have better lives.[9]

## Integrated Waste Management Systems:

Bogotá, Colombia, leads the way with its Integrated Waste Management System, showcasing a comprehensive approach that addresses the entire waste management cycle. Focused on source separation, recycling, and leveraging technology for efficient waste collection, Bogotá's system stands as a holistic model for sustainable urban waste management.

The emphasis on Source Separation is a fundamental aspect of Bogotá's approach, encouraging citizens to sort their waste at the origin. This strategy not only facilitates the recycling process but also minimizes the contamination of recyclable materials, ensuring a more effective and environmentally friendly waste management system. The city's commitment to source separation reflects a proactive stance toward waste reduction and resource conservation.

Recycling plays a pivotal role in Bogotá's Integrated Waste Management System. The city has established robust recycling infrastructure, including community recycling centers and initiatives to incentivize citizens to participate actively in recycling programs. By creating a culture of recycling, Bogotá aims to divert a significant portion of waste away from landfills, contributing to both environmental conservation and the circular economy.

The integration of Technology for Efficient Waste Collection sets Bogotá apart as a forward-thinking city in waste management. Implementing advanced technologies, such as smart bins and data-driven solutions, Bogotá optimizes waste collection routes based on real-time information. This integration not only enhances operational efficiency but also minimizes environmental impact by reducing unnecessary vehicle emissions and fuel consumption.

In summary, Bogotá's Integrated Solid Waste Management System represents a paradigm shift in urban waste management. By focusing on source separation, recycling, and leveraging technology, the city not only addresses immediate waste challenges but also sets a benchmark for other cities aspiring to create sustainable, efficient, and technology-driven waste management systems.

9 UN-Hábitat México. "Recolectar y Eliminar Residuos de Manera Eficiente." UN-Hábitat, https://onuhabitat.org.mx/index.php/recolectar-y-eliminar-residuos-de-manera-eficiente?fb_comment_id=1832372596846012_34098373690995

## Waste Management Renaissance: São Paulo's Holistic Approach to Sustainability

In Brazil, Sao Paulo is the largest city in the southern hemisphere and the largest Portuguese-speaking city in the world. 22 million people live there and 12.5 million in the city area. It currently generates 20 thousand tons of garbage a day. It had two landfills that were disabled and covered. They now have two mechanical sorting plants for recycling and have one of the largest landfill gas power plants in the world, producing 7% of the city's electricity, saving emissions of approximately 11 million tons of CO2, equivalent to emissions from 2 million gasoline vehicles.

In Brazil, São Paulo is the largest city in the southern hemisphere and the world's largest Portuguese-speaking city. that grapples with a daily generation of 20,000 tons of waste, nearly half of which is organic. The city, home to 22 million people, faced the closure of two landfills, prompting innovative waste management measures. Two mechanical sorting plants for recycling were established, alongside one of the world's largest landfill gas power plants, contributing 7% of the city's electricity and preventing emissions equivalent to those of 2 million gasoline vehicles.

**Figure No. 6: Sao Paulo - Landfill Bandeirantes**

**Source: WOIMA.** https://woimacorporation.com/ahogandonos-en-basura-caso-sao-paulo-brasil/

São Paulo's commitment to sustainable waste management is evident in its Integrated Waste Management System. The city strategically focuses on source separation, robust recycling initiatives, and technology integration for efficient waste collection. Residents are encouraged to separate waste at the source, fostering a culture of waste reduction and responsible disposal.

Recycling plays a crucial role in São Paulo's waste management strategy, featuring community recycling centers and programs incentivizing resident participation. The city embraces modern technology to optimize waste collection routes, employing smart solutions and data-driven approaches for real-time adaptability. São Paulo's Integrated Waste Management System serves as a noteworthy model, showcasing the positive impact of holistic approaches to waste management.

The city's forward-thinking initiatives include a landfill gas power plant, one of the world's largest. Formerly, waste was directed to massive landfills, contributing to substantial emissions. Now, the gas generated from these landfills powers a 30MW plant, producing over 175,000 MWh/a, equivalent to 7% of the city's electricity consumption. This transformative step has prevented approximately 11 million tons of CO2 emissions, equivalent to the emissions of more than 2 million gasoline vehicles. São Paulo's journey reflects a paradigm shift towards sustainable waste solutions.

## Comprehensive Waste Management in Curitiba: A Sustainable Model(10)

Curitiba, the capital of Paraná in Brazil, has succeeded in gaining national and international recognition for its effective solid waste management. On average, 2,560 tons of solid waste are collected daily in Curitiba, with a per capita daily average of 1,383 kilograms. Out of this total, 1,473 tons originate from household collection, and 534 tons are collected through selective collection, with only 16% of this total originating from informal selective collection.

The public cleaning department of Curitiba comprises 120 municipal servers with managerial, administrative, and oversight activities, supported by 2,352 workers executing public cleaning services. Conventional collection occurs in two forms: door-to-door, three times a week using compacting trucks, or indirectly with containers placed in hard-to-reach areas, also with a frequency of three times a week. Selective collection is done in two modalities: door-to-door through the "Lixo que nao e lixo" program, which can be three times a week, or by the Câmbio Verde Program, which occurs every fifteen days in public locations.

Ecocidadão: Empowering Recyclable Material Collectors: coordinated by the Municipal Secretary of the Environment, is one of the standout programs. Initiated to improve the quality of life for recyclable material collectors, it has significantly strengthened the network for collecting and separating reusable materials in the city. With around a thousand beneficiaries, Ecocidadão warehouses are supplied with recyclable material collected by the "Trash that is not Trash" trucks, as well as direct contributions from the population and local businesses. The 40 Ecocidadão associations handle approximately 1,700 tons of recycled waste monthly, responsible for the separation and classification of 100% of recyclables from Curitiba's selective collection. These associations receive compensation per ton delivered, contributing to their financial sustainability. Part of the program's benefits for associations comes from the sale of recycled materials. Additionally, the Municipality of Curitiba covers maintenance expenses for equipment and storage, such as water and electricity, and purchases tapes to organize the material.

**Figure No. 7: Curitiba "Cambio Verde"**


**Source: Curitiba City Government. 2023** https://www.curitiba.pr.gov.br/noticias/programas-da-prefeitura-ajudam-curitiba-a-ficar-proxima-de-alcancar-a-meta-lixo-zero/70829

10 Quiceno Florez, A. E. (2023). [Title of the Document]. Retrieved from https://repository.eafit.edu.co/bitstream/handle/10784/32619/Adrian_Esteban_Quiceno_Florez_2023.pdf?sequence=2&isAllowed=y.

Câmbio Verde program: On the other hand, since 1991 the Câmbio Verde program has been a key initiative for environmental sustainability and food security in Curitiba. This program is an environmental management plan designed to promote sustainability and reduce the city's environmental impact and included various projects and actions: i) Recycling and Waste Management programs for waste separation and selective collection throughout the city; ii) Encourage the creation and maintenance of green areas and parks citywide. Tree planting and conservation of existing green spaces are also promoted. iii) Fostering the use of public transportation and bicycles as alternatives to private cars to reduce greenhouse gas emissions from vehicles. iv) Environmental Education activities and programs to raise awareness among the population about the importance of sustainability and environmental protection.

In general, the Curitiba Câmbio Verde Program seeks to improve the quality of life for its inhabitants through responsible and sustainable environmental management. This program promotes the exchange of recyclable material for fruits and vegetables. In the first six months of a year, 441 tons of organic products were delivered to more than 30,647 people. The "Bolsa Verde," as it is called, operates biweekly at 103 points in the city. For every 4 kilograms of recyclable waste or 4 liters of used cooking oil packaged in PET bottles, the program provides 1 kilogram of seasonal fruits and vegetables. This program not only encourages selective collection but also supports small rural producers in the Metropolitan Region of Curitiba.

A distinctive component of the Câmbio Verde Program is the "Feira do Lixo," which encourages the population to exchange solid waste for fresh and healthy locally produced food. Citizens can submit paper, plastic, and glass at these exchange points in return for bus tickets, food, school supplies, toys, and leisure activity tickets. Thanks to this measure, in 2019, around 511,000 tons of solid waste were collected in Curitiba, of which 70% were destined for recycling and composting through the selective collection system.

Finally, since the 1990s, Curitiba has been a national leader in waste recycling through the "Trash that is not Trash" program. The collection frequency varies by region, performed by trucks contracted by the Municipal Secretary of the Environment. Selective collection is carried out by the "Lixo que não é lixo" program, which can be three times a week, or by the Câmbio Verde program.

The funding for these programs comes from various channels. For the Câmbio Verde Program, the institutional purchase of food comes from the Metropolitan Region through the Federation of Producers of Paraná (FEPAR). Resources for food purchases are provided by the budget of the Municipal Secretary of the Environment of the Municipal Government of Curitiba. In 2017, with 101 points in operation, an average of 6,000 people/month was served, and around 81 tons of food were exchanged monthly for 300 tons of recyclable material and 4,000 liters of used cooking oil. The project has been very successful.

It is important to note that these programs not only promote environmental sustainability but also generate social benefits by involving the community, improving the working conditions of collectors, and supporting local small producers. Curitiba has demonstrated that comprehensive waste management, combined with community participation initiatives, can lead to positive outcomes for both the environment and society.

**Figure No. 8: Curitiba "Cambio Verde"**

**Source: Circle Economy. 2023. Curitiba "Cambio Verde".** https://knowledge-hub.circle-economy.com/rethink/article/9252?n=Curitiba-%E2%80%9CCambio-Verde%E2%80%9D-

## Belo Horizonte: A Sustainable Model of Social Inclusion and Environmental Responsibility

In the 1990s, Belo Horizonte, Brazil's third-largest city, faced a rapid population growth phenomenon. Responding to this challenge, the city implemented a revolutionary approach in waste management, focusing on improving recycling practices, establishing sustainable landfills, and collaborating with an unconventional workforce such as the local waste-pickers cooperatives.

The initiative began in 1993 with the introduction of the Integrated Solid Waste Management (ISWM) model, a selective method for waste collection and treatment. A crucial aspect involved legitimizing the role of catadores cooperatives (waste-pickers) in recycling. Partnering with these workers, already significant contributors to recycling, aimed to enhance their productivity and align with environmental and socio economic goals. Over 100 voluntary drop-off sites were set up for household waste, collected and delivered to cooperative warehouses for sorting. Regular door-to-door recycling services covered a substantial portion of the city's inhabitants.

The first catadores association, ASMARE, emerged in 1990, laying the foundation for a broader program to provide better job opportunities for informal workers. By 2005, the city generated 0.7 kg of waste per capita, landfilling 3,500 tonnes daily. Belo Horizonte's waste collection model became a beacon for effective waste management in Brazil. In 2012, Belo Horizonte's Municipal Urban Cleansing Law reinforced the commitment to enhanced collection services, recycling rates, and social inclusion. By that year, 93% of total waste was responsibly disposed of, benefiting 95% of the population with domestic waste collection services. Approximately 600 people were formally employed in waste management cooperatives, enjoying improved working conditions and a monthly minimum wage of US$321.

Stakeholder engagement was pivotal, fostering collaboration between the Superintendence of Urban Cleansing and local cooperatives like ASMARE. Strong financial support from internal stakeholders, including the SLU and local government, demonstrated commitment. Political backing from the Brazilian government highlighted the initiative's potential as a national model, with amendments to local legislation reinforcing its priority.Overcoming initial mistrust, the catadores developed trust in authorities over time, recognizing the need for organized work and partnerships for social inclusion. The objectives, focusing on waste disposal improvement, increased recycling, and sustainable landfills, remained clear and well-maintained. Concerns about program costs were addressed through financial partnerships and assistance from the central government.

Effective project management by the SLU and decentralized operational services contributed to success. The Municipal Waste and Citizenship Forum, introduced in 2003, played a crucial role in training and improving worker productivity. Measurement of worker numbers and average wages, along with measurable increases in recycling rates, demonstrated the initiative's impact. Alignment between SLU and local "catadores" cooperatives, the municipal government's investment in training and equipment, and the participation and external funding from Caixa Bank in 2008 – 2010 for US$150,000 showcased a well-coordinated and supported waste management model. Belo Horizonte's close collaboration with the University of Minas Gerais underlined its commitment to staying abreast of the latest academic insights in solid waste collection optimization.

## Community engagement and education programs

Community engagement and education programs are integral components of sustainable waste management strategies, playing a crucial role in shaping the behaviors and attitudes of residents toward responsible waste practices. These initiatives focus on fostering awareness, instilling a sense of environmental responsibility, and actively involving local communities in waste reduction and recycling efforts. By employing workshops, educational campaigns, and interactive activities, these programs aim to empower individuals with the knowledge and motivation to make informed choices about waste disposal. Across Latin America and the Caribbean, various community engagement and education programs have emerged as powerful catalysts for change, contributing to more sustainable and resilient urban environments.

"Quito a reciclar" is a project in Ecuador that demonstrates the positive changes these programs bring to specific cities, offering valuable lessons for the broader region. Through the "Quito a reciclar" project led by the Municipality, the Comprehensive Solid Waste Management is strengthened by including environmental managers in the waste value chain. This minimizes the environmental impact of solid waste in the Metropolitan District and promotes the economic and social inclusion of the managers and their families. Currently, 174 environmental managers are utilizing recyclable material from different sectors of the Metropolitan District.

Also, this initiative involves the community through workshops and campaigns, aiming to make people more aware of responsible waste disposal and recycling. "Quito a reciclar" project, aims to develop a comprehensive system for recyclable solid waste, involving good environmental practices by citizens, active participation of grassroots recyclers, and technical and operational support from the municipality.

**Figure No. 9: Quito a Reciclar – Ecuador**


**Source: "Quito Informa. (2017). The Municipality of Quito Bets on Recycling. Retrieved from https://www.quitoinforma.gob.ec/2017/10/13/el-municipio-de-quito-le-apuesta-al-reciclaje/.**

With the help of committed citizens, recycling can become a stable economic source for environmental managers, providing them with dignified work while helping the environment. In 2016, an average of 212 tons was recycled per month, and this year, an average of 235 tons is recycled, demonstrating that the collaboration between the Metropolitan Public Cleaning Company of Quito and citizens optimizes recycling efforts.

On the other hand, ReciVeci was launched in 2015, as a citizen-driven effort in Quito to build connections between waste pickers and residents, aiming to enhance the recovery of recyclable waste. Quito faced challenges due to residents' lack of awareness about segregating recyclables, given the absence of a differentiated collection system. With a population of 12,000, including female waste pickers, ReciVeci successfully tripled the amount of recovered recyclable material.

The initiative initially struggled to gain trust from waste pickers, a vulnerable group exposed to street violence and discrimination. Over time, trust was established, and waste pickers actively participated in ReciVeci's activities. The project engaged various stakeholders, including academia, municipal authorities, and waste pickers, contributing to its success. ReciVeci's holistic approach covers social, cultural, environmental, institutional, and financial aspects, promoting gender equity, changing behavior towards waste, preventing landfill pollution, and involving civil society in inclusive recycling policy development in Quito. Despite challenges, the lessons learned highlight the need for patience, continuous dialogue, and financial sustainability for volunteering initiatives like ReciVeci to thrive and leave a lasting impact.

These success programs emphasize the effectiveness of community-oriented educational initiatives in encouraging sustainable waste practices and cultivating a sense of environmental responsibility among residents. The Quito experience demonstrates the transformative impact that targeted community engagement can have on waste management outcomes.

### Box No. 3: Case Study: Project to Combat Sources of Marine Litter in Santos, Brazil

Despite having infrastructure and urban solid waste management programs like the successful Recicla Santos program, the municipality of Santos, Brazil, faced persistent challenges of marine pollution. To specifically address marine litter from land-based sources, a complementary project focused on three main identified sources: stormwater drainage channels, beaches, and stilt communities along the rivers surrounding Santos Island.

The project took a multidisciplinary approach, incorporating technical analyses, diagnostics, and community involvement. Specific strategies were designed for each identified source, applying concepts from behavioral disciplines and experiences from similar projects. These strategies addressed mitigation, prevention, information, and education, standing out as innovative within the Brazilian context.

The positive impacts of the solution are reflected in the proposed technical solutions and communication strategies. Technical solutions mitigated improper waste disposal in drainage channels, stilt communities, and beaches, promoting proper waste disposal. Communication strategies established direct dialogue with the population, using playful and inclusive actions to engage the community in the solution.

This multidisciplinary approach brought about transformations in people's behavior towards the problem. Additionally, the success of government efforts, driven by local political will and supported by the Recicla Santos program, was highlighted. The program experienced a significant increase in the recycling rate, rising from 2% in 2017 to 18% in 2018. This growth of 165% in one year and 221% between 2016 and 2018 illustrates the positive impact of the project on comprehensive waste management in Santos.

Source: Ministry of Regional Development. Best Practices in Urban Solid Waste Management. https://www.gov.br/cidades/pt-br/acesso-a-informacao/acoes-e-programas/saneamento/protegeer-antigo/arquivos/buenaspracticasenla-gestionderesiduossolidosurbanos.pdf"

## Greening São Paulo: A Waste Revolution Model for Sustainable Organic Management

São Paulo, the biggest city in Brazil, faces a huge challenge of dealing with 20,000 tons of waste every day. In response, in 2015 an innovative project was launched to face its organic waste problem establishing a composting strategy at street markets. This effort aimed to build public trust following a previous composting struggle and effectively handle the substantial organic waste output.

The project established a composting plant processing 170 tons of organic waste annually from 26 street markets. Environmental education was facilitated by local cleaning firms, enlightening street market vendors on proper waste separation. Vendors received compostable bags for organic waste, later collected by the cleaning company. These composting plants transformed into educational spaces, informing visitors about the composting process and its advantages, fostering local and international learning.

By 2020, the project triumphantly composted 10,000 tons of waste, totaling 20,000 tons since 2015, resulting in a significant reduction of 14,176 tons of CO2eq. With an 87% reduction in greenhouse gas emissions compared to landfill disposal, the composting technology not only curtailed environmental impact but also provided free organic fertilizer for urban gardening and public green spaces, demonstrating a circular economy in action.

São Paulo's commitment to the UN 2030 Agenda shone through inclusive hiring practices, engaging refugees in composting plants, and robust public awareness initiatives. The project's success hinged on effective stakeholder engagement, education, and inclusive practices, showcasing São Paulo as a replicable model for organic waste management with low costs and scalable technology. The city's experience underscores the potential of decentralized, community-driven waste solutions, offering valuable insights for regions worldwide.

The success of the project was attributed to engaging stakeholders effectively through a combination of education, public debates, visits, and widespread dissemination. By making a modest investment, São Paulo set up decentralized composting plants that leverage efficient waste segregation and collection systems. Using the thermophilic composting method, which costs between US$150,000 and US$250,000, organic waste is transformed into fertilizer in approximately 120 days. The monthly operational costs fall within the range of US$10,000 to US$15,000.

São Paulo's experience underscores the efficacy of decentralized, scalable waste management solutions, emphasizing stakeholder engagement and education. The city's commitment to sustainability and inclusivity positions it as a model for successful organic waste management that can be easily replicated, featuring cost-effectiveness and scalable technology.

## Circular Economy Initiatives

According to Kirchherr et al. (2017), "The circularity approach seeks for an economic system that replaces the 'end-of-life' concept by reducing, alternatively reusing, recycling and recovering materials in production, distribution and consumption processes within the aim to accomplish sustainable development" and "create *environmental quality, economic prosperity and social equity, to the benefit of current and future generations simultaneously".*[(11)]

### Box No. 4: Waste Zero Action Plan and Circular Economy in Mexico City

The Waste Zero Action Plan, towards a Circular Economy, introduced by the Government of Mexico City in May 2019, aims to implement mechanisms focused on reducing the amount of waste reaching landfills. This involves promoting a social culture centered around waste separation and proper disposal at Transfer Stations, with the goal of increasing the amount of waste that, due to its characteristics and correct separation, can be valorized and returned to production chains. Managing approximately 13,149 tons of daily waste, the city strives to achieve this by altering consumption habits, encouraging recycling plant installations, increasing compost production, and dignifying the work of sanitation workers. Various initiatives, including scheduled waste collection, information campaigns, and training sessions, have been executed to foster differentiated waste separation among citizens.

11 Van Acoleyen, K., Laevers, J., Verstuyf, S., et al. "Challenges and opportunities for reflective practice in a digital age: Affordances and constraints of using digital media in early childhood teacher education." Computers & Education, vol. 115, 2017, pp. 21-31. DOI: https://doi.org/10.1016/j.compedu.2017.07.005.

To tackle the daily management of 13,149 tons of waste in Mexico City, strategies have been implemented to alter consumption habits, increase recycling, and dignify the work of sanitation workers. These include scheduled waste collection, information campaigns using 1,500 informative banners accompanying designated collection routes, training sessions for sanitation workers across 16 districts, and collaborative work sessions to establish common strategies. Informative visits to commercial establishments, distribution of promotional materials in public spaces and transportation, further strengthen the emphasis on differentiated waste separation from the source. This approach facilitates the valorization and utilization of waste, ultimately reducing the volume destined for landfills.
Aiming to instigate a sustainable approach to plastic production and consumption, Mexico City has implemented a prohibition on single-use plastic bags and products. This policy seeks to replace short-lived, single-use products with more durable alternatives that can be reused or efficiently repurposed. According to the amendment to Article 25, Section XI Bis of the Solid Waste Law of the Federal District, effective June 25, 2019, the commercialization, distribution, and delivery of plastic bags and single-use plastic products were prohibited from January 1, 2021, onward. This legislative measure aligns with the city's commitment to preventing and reducing pollution generated by quickly discarded, short-lived plastic products.

Source: Secretary of the Environment of Mexico City. https://sedema.cdmx.gob.mx/programas/programa/basura-cero"

## Plant Azcapotzalco in Mexico City[12]

Mexico D.F has a total of 12.2 million people living in the city area and a production of 13.2 thousand tons of solid waste per day, with only 61% of this is usable. Even the capital of México has six landfills, a new waste classification plant and seven compaction plants, the Transfer Station and Selection Plant Azcapotzalco in Mexico City is considered the most advanced in Latin America, marking a significant milestone in waste management in the country. With a daily capacity to receive 1,400 tons of solid waste and the ability to process 1,000 tons daily, this cutting-edge facility handles various materials such as paper, cardboard, PET and HDPE containers, plastic bags, textiles, glass, and other metals from the surrounding 5 municipalities.

12 Ministry of Public Works, Government of Mexico. https://www.obras.cdmx.gob.mx/storage/app/media/00025%20julio%20planta/250721estacion-de-transferencia-y-planta-de-seleccion-azcvf-4.pdf

**Figure No. 10: Transfer Station and Selection Plant Azcapotzalco, México**

**Source: Ministry of Public Works, Government of Mexico https://www.obras.cdmx.gob.mx/storage/app/media/00025%20julio%20planta/250721estacion-de-transferencia-y-planta-de-seleccion-azcvf-4.pdf**

A distinctive feature of this state-of-the-art facility is its dual function as a Transfer Station and Selection Plant. Its strategic location ensures not only local well-being but also contributes to environmental improvement. Representing an investment of 385 million pesos, the station can receive 1,400 tons of solid waste daily, with 1,000 tons processed on-site and the remaining 400 tons, previously separated as organic waste, transferred to the composting plant.

Operational efficiency is a highlighted point, generating annual savings of 88,976,941 pesos. The savings include 48,254,008 pesos from recyclable material sales and 40,722,933 pesos from transportation and final disposal, along with the creation of 404 jobs. The station can accommodate up to 30 garbage trucks: 16 can unload solid waste simultaneously, and the other 14 vehicles can wait their turn within the facilities without causing external traffic.

The Transfer Station and Selection Plant Azcapotzalco perform mechanical separation of waste by type (organic and inorganic) and size (plastics, PET, aluminum, containers, among others). Subsequently, through a manual separation system with conveyor belts for recyclable materials, these are temporarily stored in the lower part of the belt, and once a certain amount of waste is reached in this area, they are compacted. Finally, through a crusher, the waste is homogenized for compaction and packaging. The plant includes automatic sprayers to capture odor particles during operating hours, an intelligent system of nebulization points for applying bactericide and flavoring, and roofing designed to prevent waste dispersion, along with sound insulation to prevent noise spread.

The Transfer Station and Selection Plant Azcapotzalco uses German technology that is adapted to local needs and tailored to the specific requirements, guarantees a mechanical treatment that meets the highest quality and efficiency standards, and is based on the principles of sustainability and the circular economy and make the Transfer Station and Selection Plant Azcapotzalco a symbol of the paradigm shift in waste management.

**Figure No. 11: Transfer Station and Selection Plant Azcapotzalco, México**

**Source: Ministry of Public Works, Government of Mexico.** https://www.obras.cdmx.gob.mx/storage/app/media/00025%20julio%20planta/250721estacion-de-transferencia-y-planta-de-seleccion-azcvf-4.pdf

### Box 5: Argentina: The Economic-Financial Matrix for Solid Waste Management

Argentina, spanning an expansive 3,761,274 km² and divided into 23 provinces and the Autonomous City of Buenos Aires, supports a population of 40,117,096 according to the 2010 National Census. With a significant urban concentration of 90%, the country faces distinct challenges and accomplishments in its waste management landscape.

The waste management infrastructure in Argentina boasts a robust 99.8% coverage for solid waste collection, a 64.7% rate of final disposal in sanitary landfills, and a daily generation rate of 1.15 kg/person of RSU. Despite 54% of the population benefitting from outsourced collection services, the remaining 46% receives direct municipal services, ensuring a high daily collection frequency exceeding 70%. However, geographical disparities in RS final disposal coverage are evident, with the North (50.1%) and Cuyo-Mesopotamia (15.2%) regions demonstrating lower disposal coverage compared to the rest of the country, where coverage reaches 79.4%. In major metropolitan areas, Argentina's waste management infrastructure includes separation plants, fostering an emerging industry for processing recovered waste materials such as plastics, glass, paper, and cardboard. These materials are predominantly collected by waste pickers operating both on the streets and at disposal sites. Despite commendable efforts, Argentina faces ongoing challenges, particularly in addressing geographical disparities in disposal coverage and further advancing sustainable waste management practices across its diverse regions.

Achieving environmentally sound waste management aligned with sustainable models in Argentina necessitates operational and technological improvements in municipalities. This has brought forth challenges in financial sustainability, prompting the Ministry of Environment and Sustainable Development to introduce the "Economic-Financial Matrix for Solid Waste Management (GIRSU)" in 2011. This computer-based tool calculates waste management costs comprehensively, providing efficiency indicators.

The ministry disseminates this innovative tool to municipalities through provincial training workshops. These workshops serve as forums for the exchange of management experiences, emphasizing the estimation of waste costs. The overarching goal is to evaluate the trajectory toward a "comprehensive" approach to waste management. Representatives from diverse municipal departments, including finance, environment, and public services, actively participate in these workshops, fostering collaboration to develop indicators and integrate the concept of "transversality" into comprehensive waste management.

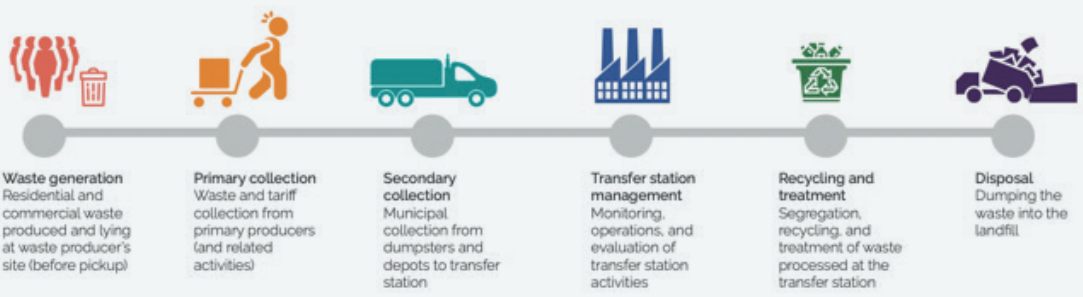
These impactful workshops, conducted across 17 provinces, have engage 184 municipalities, trained 588 officials, and reached approximately 26.5% of the national population. This initiative reflects a collaborative effort to develop waste management practices at the local level, fostering cooperation, sustainability, and a holistic approach to waste management challenges in Argentina.

Source: https://www.argentina.gob.ar/ambiente/control/rsu

# Economics of the Sector

Municipal Solid Waste Management (MSW) is a key public service provision in cities of developing countries with relevant implications for its sustainability given its links to public health, environment adaptation and resilience and preservation of bodies of water. The provision of these services, as a responsibility of local governments is frequently not fully funded via the following three sources: (i) end user tariffs, (ii) transfers from central government (subsidies), and (iii) public debt (i.e., national, state, or local governments). MSW accounts for approximately 20% of municipal budgets in low-income countries, and 10% in middle-income countries and regularly these budgets do not cover the provision of this important environmental service throughout the entire value chain[13].

**Figure No. 12: MSW, Value Chain**




**Source: World Bank, IEG, Solid Waste Management, Transitioning to a Circular Economy, 2022**

Local governments in developing countries, ill-funded to efficiently provide these environmental services, faced competing priorities when allocating resources (i.e., health and education services, security, water provision, etc.) with limited institutional capacities for planning, management, and monitoring, resulting in poor provision of MSW through the value chain. This situation (i.e., lack of funding, limited capacities, and poor service) tends to exacerbate with the rapid urbanization experienced by Cities in Latin America and the Caribbean (i.e., generation of solid waste, and sprawling of the urban footprint).

Making the economics of the MSW sector increasingly more complex, the analysis needs to consider that the provision of these environmental services -- *in cities from developing countries* -- takes place in a context where "willingness" of the end-user to pay for these services in developing countries is relatively weak. These are services that until recently were not usually paid (some parts of the value chain) by the end-user, services that were paid substantially below the full cost of providing the service, and more importantly, services that still today are not quite understood by the end-users (i.e., needs for intensive communication campaigns explaining the

13 What a Waste 2.0, A Global Snapshot of Solid Waste Management to 2050, World Bank, 2019

benefits of recycling, and clean disposal – mitigating negative externalities). Private sector does have an important role to play in the provision of environmental services, and under the adequate funding strategy (end-user fees plus performance-based subsidies), is regularly better placed than the local government to efficiently provide these services (i.e., management, planning and technology capacities). Section No. 4 of this sector note addresses the private sector participation options in the provision of MSW services.

## Externalities

At the pace solid waste is increasing worldwide (i.e., 3.40 billion tons by year 2050), and its direct impact on environmental loss (waste non treated), deterioration of bodies of water (including plastic pollution in oceans), and climate change, the externalities of the provision of safe environmental services are very significant for the increasing urban population in cities. Additionally, unsafe treatment of solid waste has a direct impact on human health (i.e., contamination of potable water and health respiratory diseases due to unsafe waste incineration practices). Unfortunately, these negative externalities are frequently not priced in developing countries (or challenging to price and to be added to the end-user tariffs).

## Economic Regulation

Pricing mechanisms for the provision of these types of environmental services (MSW) are segmented, and frequently the economic regulation framework in cities from developing countries is not fully developed. MSW needs to have funding sources to cover the different stages of its value chain. MSW services from a financing strategy viewpoint needs to have funding sources through the following six phases:

**Waste generation**. Consumers, businesses, and households need to dispose of waste. This phase of the MSW still needs robust education campaigns to strengthen the end-user behavior and responsibility (i.e., separating organics and inorganics, plastic disposal, use of waste bags, recycling, etc.).
**Primary collection**. Frequently this is a phase of the MSW service provision that is contracted out with private companies. Some cities in LAC still provide these services via municipal waste collection corporations.
**Secondary collection**. Waste is taken from local dumpsters and depos to transfer stations. Frequently this is a phase of the MSW service provision that is contracted out with private companies. Some cities in LAC still provide these services via municipal waste collection corporations.
**Transfer station management.** At transfer stations, waste is consolidated and partially sorted (separated) for further transport to specific locations.
**Recycling and treatment.** Waste is sorted for recycling and treated where possible. This is the phase of the MSW service provision that is closely linked with the use of technology (i.e., waste to energy, compost, etc.). It is the phase of MSW where "circular economy" opportunities have a better chance of being "monetized"[14].
**Non-treated Waste.** MSW that cannot be treated or recycled is taken to a landfill for disposal.

14 "Waste-to-Energy goes hand in hand with high-quality recycling. It is an essential and complementary part of a sustainable circular economy and an indispensable part of the solution to waste management." Confederation of European Waste to Energy Plants, 2020.

**Box No. 6: Converting Waste to Energy**

Even when the hierarchy of sustainable waste management is well implemented, some solid waste must be diverted to landfills. This can be greatly reduced through the use of waste-to-energy plants. Once recyclable waste is sorted out of MSW, waste-to-energy facilities burn the remaining waste to produce steam, electricity, or hot water, which can be used to reduce reliance on fossil fuels. After waste is burned, metals and minerals can be recovered from the bottom ash, then recycled or reused as raw material. Overall, waste-to-energy plants can reduce waste volume by about 90% while also providing valuable byproducts. The waste-to-energy sector is highly regulated and monitored to ensure a minimal environmental impact.

In France, a Combined Heat and Power (CHP) waste-to-energy plant operated by SUEZ Group produces energy for 17,700 households and also sends enough steam to nearby greenhouses to produce 6,000 tons of tomatoes over 10 hectares annually. As well as reducing the volume of waste in landfills, the Econotre eco-center avoids the emissions of 6,000 tons of CO2 annually.

Source: IFC, Financing Waste Management, 2022

One of the important challenges in developing countries to develop a just and fair economic regulation framework in the MSW sector is the lack of adequate financial information, and data base to allocate costs and monitor processes and impact of changing technologies. The MSW sector compared to other infrastructure sectors, has limited investments in economic research, which does not facilitate the segmentation of the service provision and its costs.

## Affordability Challenges

MSW provides environmental services to the full spectrum of end-users (i.e., households, and commercial and small-medium size businesses). In developing countries, the distribution of MSW end-users has a high representation of low-income families that find it almost impossible to pay full cost recovery tariffs for the provision of these important environmental services.

Local governments (municipalities) providing MSW services usually have two important costs centers for these services provision: (a) operational expenditures associated with the cost of providing the services (i.e., labor, equipment maintenance, fleet maintenance, etc.), and (b) capital expenditures associated with the required investments to expand, upgrade, and maintain the MSW infrastructure (i.e., equipment, fleet, landfills, sanitary disposal, waste collection and transfer, etc.). As described in the section on “circular economy”, part of these costs can be absorbed or funded via sale of recycled material (i.e., waste to energy, composts, etc.). Unfortunately, in cities in developing countries still the % of MSW recycled is relatively limited and its financial contribution negligible[15].

15 “Around the world, almost 40 percent of waste is disposed of in landfills (figure 2.12). About 19 percent undergoes materialsrecovery through recycling and composting, and 11 percent is treated through modern incineration. Although globally 33 percent of waste is still openly dumped, governments are increasingly recognizing the risks and costs of dumpsites and pursuing sustainable waste disposal methods. As nations prosper economically, waste is managed using more sustainable methods. Construction and use of landfills is commonly the first step toward sustainable waste management. Whereas only 3 percent of waste is deposited in landfills in low-income countries, about 54 percent of waste is sent to landfills in upper-middle-income countries. Furthermore, wealthier countries tend to put greater focus on materials recovery through recycling and composting. In high-income countries, 29 percent of waste is recycled, and 6 percent composted. Incineration is also more common. In high- income countries, 22 percent of waste is incinerated, largely within high- capacity and land-constrained countries and territories such as Japan and the British Virgin Islands, World Bank, What a Waste, 2.0, 2018”.

The lower-income households tend to generate more food and green waste, and the high-income households tend to generate more solid (i.e., plastic and derivatives), and more complex waste for recycling purposes. Generation of waste is closely linked with income levels. The higher your income, the more you buy, the more you generate waste. Average cost structure (as a proxy to end-user tariffs) is higher in upper middle-income countries and is close to US$ 100 per ton and higher. In low-income countries, and lower-income countries these costs tend to be in average US$ 35 per ton and higher.

**Figure No. 13: MSW Cost Structure by Country Income Level**

**Table 5.2 Typical Waste Management Costs by Disposal Type**

*US$/tonne*

| | Low-income countries | Lower-middle-income countries | Upper-middle-income countries | High-income countries |
|---|---|---|---|---|
| Collection and transfer | 20–50 | 30–75 | 50–100 | 90–200 |
| Controlled landfill to sanitary landfill | 10–20 | 15–40 | 20–65 | 40–100 |
| Open dumping | 2–8 | 3–10 | — | — |
| Recycling | 0–25 | 5–30 | 5–50 | 30–80 |
| Composting | 5–30 | 10–40 | 20–75 | 35–90 |

*Source:* World Bank Solid Waste Community of Practice and Climate and Clean Air Coalition.
*Note:* — = not available.

**Source: World Bank, What a Waste, 2.0, 2018"**

As a proxy to end-user tariffs, full cost recovery of US$ 35 per ton and higher for countries where income per capita is less than US$ 1,036 per year (low-income countries), could represent a very important proportion of its disposable income. This affordability challenge generates perverse incentives to good practices of solid waste management by lower income households (i.e., contamination of bodies of water, poor disposal practices, waste incineration, etc.)[16]

16 Worldwide, waste generated per person per day averages 0.74 kilogram but ranges widely, from 0.11 to 4.54 kilograms. Though they only account for 16 percent of the world's population, high-income countries generate about 34 percent, or 683 million tones, of the world's waste. In low-income countries average solid waste generation per year is between 75 to 400 kilos per person per year. World Bank, 2018.

## Circular Economy

There is an urgent need to migrate from the traditional linear economic model (take-make-dispose) to more widely accepted sustainable alternatives such as the waste hierarchy and circular economy approaches. A waste hierarchy approach prioritizes waste prevention, reuse, recycling, and recovery before disposal. A circular economy closes the loop between extraction, manufacturing, and disposal by advocating for designing products to reduce waste, using products and materials for as long as possible, and recycling materials from end-of-life products back into the economy. The challenge is that such "transition" requires greater financing to improve the capacities and systems for solid waste management and concerted action among local, regional, national, and international actors[17].

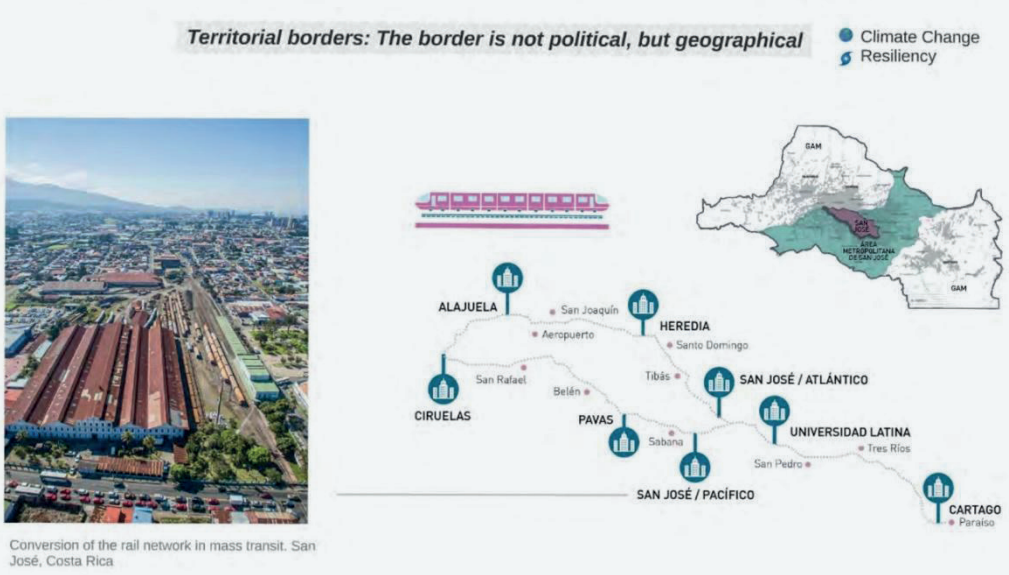
Still, for developing countries -- which already experienced under-funding of the investments in the whole project cycle of the provision of environmental services – migration to waste hierarchy and circular economy represents a huge challenge. As recycling technology evolves and becomes profit making, there will be better opportunities for Cities in developing countries to transition to a circular economy in MSW.

## High Upfront Costs and location specific challenges (Metropolization of Service Provision)

As in the case, of urban mobility (i.e., sector note for the LAC Cities Tour), the provision of MSW services can benefit from economies of scale if they can group the required capital investments (i.e., fleet, solid waste disposal, separation, and recycling centers, landfills, waste-to-energy, etc.) for larger metropolitan areas (i.e., urbanization of different neighboring municipalities). San Jose, the capital of Costa Rica urbanization patterns is creating a de-facto metropolitan area with other 6 municipalities. San Jose is exploring with the other 6 municipalities the creation of a MSW Authority with the responsibilities for full provision of the services.

17 Financing from multilateral development institutions and the private sector for MSWM is low compared to other urban services. The International Solid Waste Association found that, between 2003 and 2012, the share of solid waste management in all official development finance was only 0.32%. World Bank, IEG, Solid Waste Management, Transitioning to a Circular Economy, 2022

**Figure No. 14: San Jose de Costa Rica "Metropolization"**




Conversion of the rail network in mass transit. San José, Costa Rica

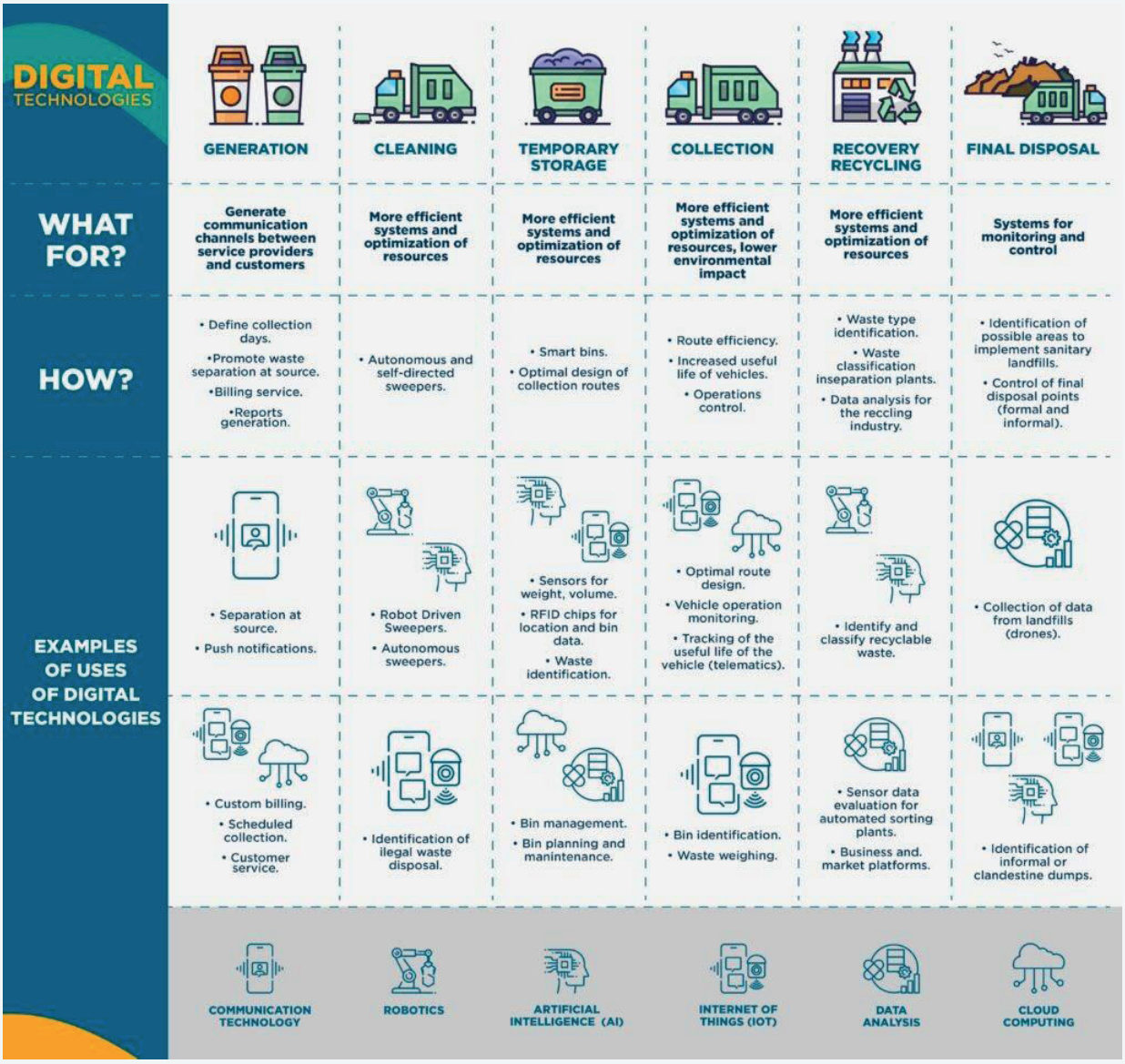
# Technology

MSW has been benefiting from the use of new ICT technology to improve waste collection, separation, recovery, and recycling via smart waste management. This refers to systems that use technology to make the waste management process more efficient, more environmentally friendly, and more sustainable. Many of these new emerging waste management technologies utilize the internet of things (IOT) to help streamline waste collection and improve sustainability.

Smart technology has positively impacted solid waste management systems through the development of tools that tackle the main challenges of waste management, such as cleaning, collecting, transporting, recovery/recycling and final disposal. Digital technologies with greater exposure in the solid waste sector are known as **Smart Waste Technologies (SWT)** and they contain elements of robotics, artificial intelligence, internet of things, cloud computing, data analysis and communication technology[18].

18 "Technological innovation in solid waste management: The digital revolution is transforming the way we see and handle our waste", February 27, 2023, IDB, Paula Guerra.

**Figure No. 15: Use of Digital Technologies in the MSW Value Chain**




**Source:** Technological innovation in solid waste management: The digital revolution is transforming the way we see and handle our waste", February 27, 2023, IDB, Paula Guerra.

However, the largest contribution by technological innovation in the MSW sector is the conversion of waste into a usable by-product that reduces the volume of generated waste**.** Waste-To-Energy plants use special incinerators to convert the trash into energy that can be used to power residential areas and businesses. This not only helps to reduce the amount of waste going into landfills but also provides a clean source of energy. These waste derived fuels include a wide spectrum of sources, including municipal solid waste and industrial byproducts. Through advanced technologies, these materials are transformed into electricity, heat, or fuel, offering an efficient solution to both waste management and energy demands.

As technology continues to evolve, the opportunities to optimize waste-to-energy processes are considerable. Innovations in waste sorting, gasification, and improved emissions control promise enhanced efficiency and reduced environmental impacts. Energy from Waste can take its place as an integral part of circular economy systems, ensuring a greener and more sustainable world. However, we still need to technologically continue to improve the "waste-to- energy" efficiency ratios and operational costs to significantly reduce the generation of solid waste towards the future (particularly in plastic, electronics, and other "more complex to recycle" waste).

**Box No. 7: Project Termo - Mexico City Waste-to-Energy PPP**

The Project involves the establishment and operation of a greenfield waste-to-energy (WTE) plant in the federal zone of the Ex Texcoco-Lake, near Mexico City, and supporting Mexico City's Zero Waste Program, the Project contributes to the city's sustainability goals by promoting responsible waste management and energy generation from urban solid waste.

The plant is considered a key component of Mexico City's waste management strategy, and the total cost is estimated to be around US$ 750 million. Financing is expected to include loans from the Inter-American Investment Corporation (IDB Invest) and other financial instruments. The Borrower has secured a 33-year Public-Private Partnership (PPS) contract with the Mexico City government through the Urban Services Management Unit (AGU). The Equipment, Procurement, and Construction (EPC) contractor is a global leader in energy from waste. Proactiva Medio Ambiente Mexico, a subsidiary of Veolia Environnement S.A., will serve as the Operator and Maintenance Provider (O&M).

The Project aims to add 150 MW to the Mexican electricity system by processing residual urban solid waste after sorting for recycling or composting. The WTE plant will generate at least 965 GWh of electricity for the Mexico City Public Transport System. With the capacity to process approximately 1,678,000 tons of non-organic urban waste annually, equivalent to 35% of Mexico City's annual urban waste generation, the Project aligns with Mexico City's Zero Waste (Basura Cero) Program.

The Project is at the design and development stage, with the construction and operation phases to follow. The anticipated completion will enhance Mexico City's waste management infrastructure and align with its commitment to a sustainable, circular economy.

Source: https://idbinvest.org/en/projects/project-termo-mexico-city-waste-energy-ppp

# Political Economy

The MSW is a complex ecosystem with different stakeholders and high impact on a city's economic and social development. For a rapidly urbanizing world, well-planned and well-functioning MSW can provide important positive externalities to cities' future growth (i.e., preservation of bodies of water and aquifers, improvements in health-related indexes, clean energy production, etc.). However, the affordability of these environmental services throughout the entire MSW value chain presents challenges, where smart economic regulation (i.e., subsidies, cross subsidies, and the presence of private sector providers) play an important role, for cities in developing countries with limited fiscal space to support these services.

# Financing the Provision of Services

The key constraint for the adequate financing of MSW services is affordability. In a world where end users' tariffs and fees could be set at full-cost-recovery levels and where consumers had the disposable income to pay for them, financing infrastructure would be easier, and the gap would be substantially lower. This is not the case worldwide today, much less in EMDE countries and even less so in LDEs[19]. Private capital would only flow into projects if the revenue source for debt and equity is secured. Revenue sources to develop and operate infrastructure assets come from essentially two sources: (a) end-user tariffs and fees and (b) taxes and public budget spending (including subsidies, grants, revenue expenditure and so on). In most sectors, full-cost-recovery tariffs will not be possible, except for some specific sectors such as telecommunications or sectors with commercial clients (such as ports and airports). In this context, no matter how innovative and efficient a financing structure is, a project must have adequate cost recovery mechanisms and/or public support with credible sources of revenue to service and repay capital structure of such a project (i.e., both debt and the equity).

Among the challenges for infrastructure development, access to adequate financing stands out as one of the most relevant issues to solve. The poorer the country, the more difficult it is to access adequate financing for development of sustainable infrastructure. This section will describe the available funding mechanisms to finance infrastructure development, including urban transport infrastructure, and how challenges accessing adequate financing hamper efforts to narrow the current infrastructure gap. The section will also introduce the use of public-private partnership (PPPs) mechanisms as a tool to increase financing support for infrastructure development, and the relevance of maximizing private capital mobilization to effectively reduce the infrastructure gap.

19 EMDE=Emerging Markets and Development Economies, LDCs = Less Developed Countries

# Financing Infrastructure[20]

Governments can fund infrastructure at the national, regional, or local level through public procurement or private procurement (public-private partnerships and private provision of public services). In each case, financial flows to support infrastructure investments will be originated through two different mechanisms: (a) end-user fees and (b) public support, including all available options (such as subsidies, government transfers, tax incentives, and support from development finance institutions). In emerging market and developing economy countries, infrastructure is primarily funded through a blend of these two sources. For a project to be bankable, the revenues resulting from the sum of the two sources must be able to cover the operating expenses of providing the public service, including its maintenance and rehabilitation, as well as the remuneration to long-term financing (both debt and equity). More recently, these revenues should also cover negative externalities such as the impacts of climate change, or congestion in the case of urban mobility.

## End-user fees

Charging end users, a levy for the public services they receive is a mechanism for financing infrastructure projects that share the characteristics of a private good. For example, users can easily be identified and asked to pay a price proportional to the benefits they receive. Several public services meet these characteristics, including urban transport, electricity, water supply, and solid waste management. User charges accomplish several positive outcomes that make levies attractive beyond simply representing an important source of revenue. Fees set on an efficient pricing basis affect the demand for services, which minimizes the inefficiency risk of overconsumption. For instance, underpricing water supply leads to overuse, as price signals lead to the rationalization of water consumption. Charges also help internalize the spillovers generated by the provision of the service, such as the impacts of public urban transportation in greenhouse gas emissions and its contribution to climate change. Despite the importance of efficient pricing for user charges, in practice levies on infrastructure services in emerging economies are rarely sufficient to cover capital, operating, and maintenance costs, let alone any negative externalities.

However, distorted pricing schemes work against this—and often result in a “vicious circle”. Prices are set below cost-recovery levels, a situation that leads to cuts in operations and maintenance. This ultimately deteriorates services and deters the propensity of end users to pay, progressively increasing the gap to achieve full recovery costs and the dependence on subsidies, making private sector participation in service provision unattractive and impairing public finances. Governments facing this situation have two options: (i) to increase tariffs to cost-recovery levels or (ii) to establish transparent and efficient subsidy mechanisms. Except for the telecommunications sector (mostly in private hands in emerging economies), ports and airports (given that their users are mostly high-middle-income consumers or corporations), and some areas of the energy sector (commercial electricity distribution and transmission), the rest of the sectors have their average tariffs and fees usually set below cost-recovery levels in emerging economies. For the Latin American and the Caribbean region alone, the pricing gap estimates (tariffs as a percentage of full cost recovery) has been estimated around 50 percent for public transportation, water and sanitation, and solid waste.

20 This subsection refers exclusively to economic infrastructure (transport, energy, water and sanitation, solid waste management, etc.). It is based on a recent World Bank Publication, Global Review of Public Infrastructure Funds, Optimizing the Use of Public Support for Infrastructure, June 2020.

# Public support

Intergovernmental transfers can help governments increase infrastructure investments, especially in jurisdictions or sectors with budgetary constraints. However, depending on how transfer programs are structured, they can lead to different levels of infrastructure spending. Better-designed programs reduce the volatility of public sector budgets and provide credible risk guarantees that attract private capital into infrastructure finance. Nevertheless, with few exceptions, existing intergovernmental transfer programs in emerging economies do not meet these criteria. Included in the subsidy mechanism (government transfers) are different payments that governments commit to provide to private sector sponsors for the provision of public services. These are earmarked government transfers (current, future, and contingent) to support private investments in the provision of public infrastructure services. From availability payments to complement end-user tariffs set below cost-recovery levels, to contingency payments in the event regulatory changes limit project cash flows (partial risk guarantees), these are earmarked government transfers to make infrastructure provision by private providers financially possible. Government transfers come directly from budgetary sources and are based on current tax revenues and other government sources.

Fiscal management of these earmarked government transfers is key to the fiscal sustainability of an infrastructure development program. Managing the contingent liabilities that arise from these types of government support (future transfers and guarantees) is critical to successful government-led infrastructure development strategies. When infrastructure is financed via subsidies (government transfers), it is done against public sector resources of that budget year (or years). In this case, taxpayers' current resources are being used to fund infrastructure today. Alternatively, governments can issue public debt. In that case, taxpayers' future resources are being used, with a set of implications for the future fiscal sustainability of the country. Public debt is generally less expensive than corporate or project financing debt.

# Public Sector Debt

When infrastructure is financed via subsidies (government transfers), it is done against public sector resources of that budget year (or years). In this case, taxpayers' current resources are being used to fund infrastructure today. Alternatively, governments can issue public debt. In this case, taxpayers' future resources are being used, with a set of implications for the future fiscal sustainability of the country. Public debt is generally less expensive than corporate or project financing debt, except for selected transactions where the project credit rating could pierce the sovereign credit rating ceiling in the country.[21] The debt raised via public issuance will be reflected in government accounts. Hence, the fiscal managers will be able to better forecast, monitor, and manage it. However, the developed world and the emerging economies have widely differing experiences with raising debt due to the underlying credit rating of their economies.[22]

21 Even in such a case, the financial structuring costs, to develop a project finance structure that pierces the sovereign ceiling, need to be added to the overall financing cost. It is likely that the overall financing costs would be higher than the sovereign.

22 Private debt flows are not considered to be part of the infrastructure financial flows, given that they respond to the financing strategies of each private provider, and this debt is supported by one of the three infrastructure financial flows. In the event that the private debt is guaranteed by the government, it is considered public debt.

# Private Procurement: Mobilizing Private Capital

When considering the execution of infrastructure development projects in urban mobility, local governments have two different procurement options: public provision, or private provision. Local governments in emerging economies can also encourage private sector investments (through debt or/or equity) for the provision of infrastructure services by fostering an environment that enhances investors' perception of the risk-to-return ratio. Over the last two decades, Latin America and the Caribbean and Asia have attracted more private capital for infrastructure development than any other developing regions, illustrating the potential of private sector involvement in the provision of infrastructure services.

Private sector participation is prevalent in the telecommunications and electricity sectors, representing 70 percent of total private investment in developing countries. Both sectors usually enjoy less stringent regulations than others, allowing for cost-recovery tariff structures, thus making them appealing to private investors. Meanwhile, urban-related projects including public transportation, water, and sewerage amount to only 15 percent of total private investment in developing countries.[23] These services are generally provided under natural monopolies, making them susceptible to greater government oversight and intervention, which investors tend to associate with high political and fiscal risks. Box No. 7 below provides a case study of a design of a public private partnership (PPP) for a secondary city in Guatemala.

**Box No. 8: Quetzaltenango, Guatemala – Solid Waste Management Program, A design for a PPP structure (2015)**

Quetzaltenango is facing significant challenges in managing solid waste, with a daily average waste collection of 225 tons with deficiencies in the current service's efficiency and coverage. The urban layout, historic center, watercourses, roads, and population density contribute to the complexities of waste management, especially with narrow streets hindering door-to-door collection in the city center. The urban population distribution, with 80% living in urban areas and 20% spread over 60% of the territory, intensifies challenges, particularly during the rainy season. Also, the six markets in the city center present a mix of registered and informal businesses that intensify waste generation.

Two entities, Xelajú Limpia and the municipal group, provide services with varying frequencies in different zones, facing a 16.45% deficit and an 87.7% collection efficiency. Despite the increasing population, the number of billed service users has remained stagnant for the past five years, underscoring the need for revenue growth to align with population increases and enhance service quality.

As part of the execution of the Sustainable and Emerging Cities Initiative (ESCI), supported by the Inter-American Development Plan (IDB), in the city of Quetzaltenango a three-stage action plan was developed to address these issues (i.e., immediate operational challenges and a sustainable financial plan). Geosyntec Consulting (USA based firm) was retained by the Inter-American Development Bank (IDB) in 2015 to design improvements in the integrated SWM services in the city at the stages of collection, separation, treatment and recycling, and disposal. The project will be structured such that some or all SWM services are provided under a Public-Private Partnership (PPP) or similar concession.

23 World Bank, PPIAF, PPI database, 2016.

First Stage: Improvement of current service, the primary focus is on enhancing service efficiency and expanding its reach. The proposed actions include a 30% increase in the fleet size to achieve a 90% coverage rate while retaining the existing subcontracting arrangement. Market reorganization involves the installation of compacting containers in the six municipal markets, specifically designed to handle organic waste. Emphasis is also placed on incorporating control measures and technology, such as GPS in service units and electronic scales, to bolster route control and ensure operational efficiency. Information campaigns geared towards public awareness regarding the importance of proper waste management and its associated benefits are integral to this stage.

The financial strategy for this phase involves covering the annual expenditure through adjusted income, applying an average rate of Q24.5. This includes establishing differentiated rates for residential and commercial services, adjusting schedules and frequencies. Moreover, it addresses the elimination of burning and dumping by installing strategic containers attended by specialized services to prevent waste proliferation. The plan also necessitates an increase in personnel for the Xelajú Limpia program, contributing to improved service delivery.

Second Stage: to develop a Comprehensive Service the primary focus is on constructing a regional sanitary landfill. This involves ensuring no environmental contamination through a project subject to environmental impact authorizations. A key aspect of this stage is the concession granted to a specialized company for 20 years, empowering them to handle investments and operation of the new sanitary landfill. Cost recovery is achieved through the application of an average fee of Q15.

Third Stage: The development of a sustainable financial plan that would include private sector participation options in selected SWM services. In terms of financial considerations, the population and the municipality will contribute a relatively important amount of the full cost recovery services (i.e., estimated at 80% of the costs), reflecting favorable socio-economic conditions in the Municipality. Revenues generated from the concession to the specialized company will be utilized for handling investments and operations, recovering costs through the treatment fee. Fiscal sustainability is emphasized, with municipality expenses covering the current deficit and potentially increasing the budget allocation, thereby allowing a reduction in the fee. Unfortunately, the third stage of the Quetzaltenango MSW is still under consideration and no further progress has been made in this area as of late 2023.

Sustainability in Quetzaltenango hinges on a profound transformation in waste management, addressing waste generation and disposal from households to their final use in businesses, hospitals, and markets. A clean city not only enhances aesthetics but also signifies economic opportunities through effective waste management. The efficient handling of waste reduces service costs for users, showcasing the financial benefits of a well-administered waste management system. Additionally, a clean city ensures unobstructed natural and artificial waterways, minimizing flood risks during heavy rainfall.

Source: https://webimages.iadb.org/PDF/Plan+de+Acci%C3%B3n+ICES+Quetzaltenango.pdf

Public-private partnerships (PPPs) are useful mechanisms to mobilize private capital, but they can be cumbersome and have relatively high implementation challenges, particularly in less developed economies. The PPP methodology offers a novel approach to infrastructure provision that brings private sector competencies, efficiencies, and capital to improve public sector asset efficiency and the delivery of infrastructure services. The private sector agrees to take on risk and management responsibility in exchange for profits linked to performance.[24] Certain risks are better managed by the private sector in infrastructure development (such as design and construction risk, and operational risk) and those specific risks should be allocated to the private sector for efficient management.

In the MSW sector of developing countries, the development of successful PPPs is not very common, and the process tends to be cumbersome and complex. In the 1990s, as pro-market reform policies were increasingly introduced, municipalities started introducing private sector participation modalities for municipal waste management, by contracting- out to private companies in the larger towns and cities. Experiences of obligatory tendering were not always successful. Most of the MSW services were performed by municipal corporations that had an important impact in the job generation at cities level. Besides the affordability issues described in the previous section (i.e., economics of the sector) led to a financial design of the PPP transaction for MSW that was highly dependent on public money support (i.e., municipal public finances and/or federal transfers). With the exemption of some large cities (i.e., national capitals)l, most of the secondary cities in the Latin American and Caribbean (LAC) Region have weak public finances and relatively poor credit quality credit ratings.

Despite the sector complexities, the development of pro-market reforms in MSW in the 1990's and 2000's attracted European multinational companies to the region, in particular French and Spanish companies (i.e., Suez, Veolia, Acciona, FCC, etc.) to the LAC Region. Argentina was one of the key markets in LAC where these European companies initiated their PPP efforts. Suez bought a 50% stake in CLIBA, a company with waste collection contracts in the cities of Cordoba and Buenos Aires. Veolia set up Proactive, a joint venture with a Spanish multinational FCC, which also gained contracts in Buenos Aires and elsewhere. After the economic crisis of 2001, many multinational companies left Argentina although by 2017, Veolia has returned and has several municipal waste contracts[25].

One of the PPP models that seems to have better results in less developed economies is the use of management and service performance-based contracts. Under this modality, MSW sector assets remain under the ownership of the municipality, and the provision of the service becomes the sole responsibility of the private sector company. Some of these contracts also include the responsibility for the maintenance and upgrade of the related infrastructure (i.e., garbage collection truck fleet, disposal and separation centers, landfills, and recycling centers, etc.).

The figure below illustrates different types of service contracts for the provision of MSW services in the Pacific Islands of Papau New Guinea, Fiji, Solomon Islands, and Samoa. The study supported by the Asian Development Bank, and the Governments of New Zealand and Australia, analyzed the different types of contracts and the services it included as well as the payment mechanism utilized in this case.

24 World Bank Group and PPIAF 2016.

25 Municipal Solid Waste Management Services in LAC, Public Services International, Research Unit, Jane Lethbridge, 2017.

**Figure 16: Solid Waste Management Contracts in Pacific Island Countries, 2015**

**Solid Waste Management Contracts in Pacific Island Countries, 2015**

| Country | Project | Form of Public–Private Partnership | Contract Period | Services Provided | Payment Mechanism |
|---|---|---|---|---|---|
| Papua New Guinea | Port Moresby waste collection | Service contract | 3 years | Three contracts for waste collection (domestic, commercial, and medical) | Monthly fee; key performance indicators are collection rates and equipment standards (deductions if collections not completed). |
| | Baruni landfill operation and maintenance (O&M) | Management contract | 3 years | O&M of landfill; same contractor also doing civil works upgrade | Flat management fee, plus payment against volume of waste managed |
| | New Britain palm oil biomass | Independent power production; build-operate-own | | Conversion of biomass waste to energy; 3-megawatt plant selling power to PNG Power at negotiated price | Power purchase agreement |
| Fiji | Nadi recycling | Service contract | | | Fee for service, plus recycling revenue |
| | Naboro landfill O&M (Greater Suva area) | Management contract | 5-year contract until 2010; then 2-year contracts | O&M of the Naboro landfill | Lump sum for first contract; now weight-based |
| | Suva green waste collection | Service contracts | 3 years | 10 contracts; each for collection from a specific zone | Lump sum component, plus fee per load of waste transported to the Naboro landfill |
| | Tropik Wood Industries and Fiji Sugar Corporation | Independent power production; build-operate-own | | Conversion of biomass waste (wood waste and sugarcane waste) to energy; sale to Fiji Electricity Authority at negotiated price; Tropik Wood capacity is 9.2 megawatts | Power purchase agreements for excess power generated |
| Solomon Islands | Honiara garbage collection | Service contract | 1 year | Household garbage collection in 4 out of 10 zones; three private contractors | |
| Samoa | Apia urban and rural solid waste (rubbish) collection services | Service contracts | 3 years | Household garbage collection in 15 zones | Lump sum, monthly payments |
| | Apia waste management landfill maintenance | Service contract | 3 years | Landfill O&M | Lump sum, monthly payments |

Source: Pacific Private Sector Development Initiative research based on Pacific Region Infrastructure Facility Urban Working Group responses to questionnaire.

# African Development Bank

The African Development Bank (AfDB) provides important financial and technical assistance to African Cities through different funding sources (i.e., own and third party funded sources), deployed via different financial and technical assistance products. Except for South Africa's metropolitan cities, African cities have not been able to borrow on their own balance sheets. This is because in many countries, the legislation and regulatory framework in place is either limited in its allowance of cities to borrow without Sovereign Guarantee or does not allow independent access to debt by municipalities. Furthermore, many cities have not received a positive credit rating, or are not deemed creditworthy. To improve this situation, the Bank Board of Directors approved the first and possibly only existing among MDBs, "the Guidelines for Subnational Finance," which allow the Bank to lend directly to Subnational entities such as cities, and other local governments. For further information on the AfDB financial support to African Cities please refer to Annex No. 1 of this note.

# Annex No. 1

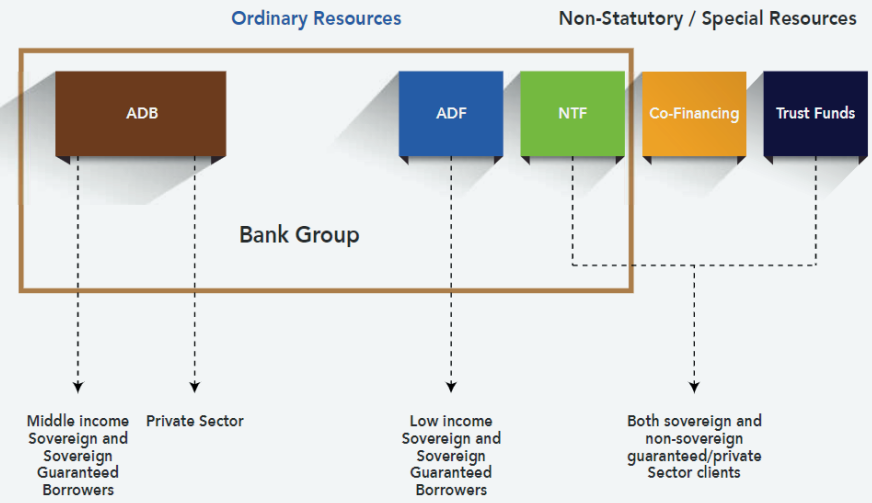
# Overview of African Development Bank Group (AfDB) Resources and Financial Products

# Funding Sources.

The AfDB Group is made up of three legally separate financing windows namely, the African Development Bank (ADB), the African Development Fund (ADF), and the Nigerian Trust Fund (NTF) which were set up to address the diverse financing needs of the continent. The ADF and NTF are concessional financing windows accessible to low-income countries while the ADB is the non-concessional financing window accessible to middle income countries, the private sector and some ADF eligible countries. Through these windows, the Bank provides a wide range of financing products: (i) Lending instruments: (ii) Risk management products; (iii) Guarantees; (iv) Equity; (v) Trade finance; (vi) Technical assistance funds – trust funds in form of grants, concessional loans, equity in select cases and reimbursable grants; and (vii) Partnerships – syndication and co-financing e.g., with the Africa Guarantee Fund, Africa Export-Import Bank.

Eligibility to specific financing windows and instruments is determined by the country's classification. Countries and their subnational governments classified under Category A are considered ADF only countries and are eligible for ADF and NTF concessional windows only. Lending terms for these countries will depend on the GNI per capita relative to the average GNI per capita of ADF only countries and level of debt distress. ADF loans would be guaranteed by the State. Countries and their subnational governments classified under Category B are eligible for both ADF concessional and ADB non-concessional windows. This has significantly increased the amount of loan resources available to borrow for such countries from both ADF and ADB windows.

**Figure No. 1: AFDB Financing Mechanisms for Sustainable Infrastructure**





**Source: UMDF/AfDB, October 2023**

The AfDB also works as the implementing agency for a number of climate funds, such as the Global Environmental Facility (GEF) and the Green Climate Fund (GCF). Grants or loans from climate funds are used as co-financing for a Bank financed project e.g., a transport, water, and sanitation infrastructure project. More recently, the GEF has co-financed the Kampala City Road Rehabilitation Project in Uganda, the Dodoma City Outer Ring Road Project in Tanzania among others. A separate project document is prepared for each of the climate financed projects that requires approval by the Climate Fund and the Bank Board of Directors. Implementation of Climate Funds uses the same implementing procedures as the rest of Bank financing. While GEF financing is typically granted to countries, the GCF is in the form of low concessional loans.

## Financial products provided for urban infrastructure projects.

In the case of urban infrastructure projects, the Bank group has previously only considered Sovereign and Sovereign Guaranteed Borrowers. With the exception of South Africa's metropolitan cities, African cities have not been able to borrow on their own balance sheets. This is because in many countries, the legislation and regulatory framework in place is either limited in its allowance of cities to borrow without Sovereign Guarantee or does not allow independent access to debt by municipalities. Furthermore, many cities have not received a positive credit rating, or are not deemed creditworthy. In an attempt to improve this situation, the Bank Board of Directors approved the first and possibly only existing among MDBs, "the Guidelines for Subnational Finance," which allow the Bank to lend directly to Subnational entities such as cities, and other local governments. But this is only possible under certain conditions, among them, the creditworthiness of those Subnational entities. The Bank is supporting the development of a number of initiatives under the umbrella of "Municipal Finance" aimed at improving municipal finances and the creditworthiness of cities.

Recently in 2019, the Bank launched the ***Urban and Municipal Development Fund,*** a Multi-donor trust fund dedicated to sustainable development of cities. For the next 4 years, the Trust Fund will support four key areas, (i) the Africa Cities Program; (ii) the Project Preparation Work; (iii) Municipal Finance; and (iv) other Technical and Capacity Building Assistance. The Cities Program is aimed at improving sustainability at the city level to better adapt to the urban development demands of the next few decades while providing technical assistance to bridge the gap between governance, urban planning, and infrastructure and social services investments. The Cities Program aims to make cities an integral part of the solution in fighting climate change.

# References


- Ana Carolina MJ, R Palacios-Bereche, S Nebra (2021), Comparative Assessment of municipal Solid Waste Management plans in European and Brazilian Cities. J Waste Manag Disposal 4:104
- Ambiente Bogotá. "Bogotá Tendrá la Primera Planta de Termovalorización de Colombia, la Cual Convertirá los Residuos en Energía para la Ciudad." 2022 https://ambientebogota.gov.co/noticias-de-ambiente1/-/asset_publisher/CWsNLtoGa4f6/content/bogota-tendra-la-primera-planta-de-termovalorizacion-de-colombia-la-cual-convertira-los-residuos-en-energia-para-la-ciudad
- Argentinian Government. "Manejo de Residuos Sólidos Urbanos." [Online] Available at: https://www.argentina.gob.ar/sites/default/files/residuos.pdf.
- Bogotá. "Bogotá Official Website." Bogotá, https://bogota.gov.co." "Medellín. "Sustainable Energy is the Bet Medellín is Making." ACI Medellín, https://acimedellin.org/energia-sostenible-es-la-apuesta-que-tiene-medellin/
- Circle Economy. (Year). Curitiba "Cambio Verde". 2021 Available at: https://knowledge-hub.circle-economy.com/rethink/article/9252?n=Curitiba-%E2%80%9CCambio-Verde%E2%80%9D-
- Contreras S, Maira J (2008). Evaluación de experiencias locales urbanas desde el concepto de sostenibilidad: el caso de los desechos sólidos del municipio de Los Patios (Norte de Santander, Colombia). Trabajo Social(10), 109-134.
- C40: "Cities100 - Bogotá Waste-to-Energy Project Supplies National Grid" (2016) https://www.c40.org/case-studies/cities100-bogota-waste-to-energy-project-supplies-national-grid/
- Climate and Clean Air Coalition. "Sao Paulo Waste Actions" https://www.ccacoalition.org/projects/sao-paulo-waste-actions.
- Deutschland.de. "Reciveci Ecuador." 2017 Available at: https://www.deutschland.de/en/reciveci-ecuador
- Dias Sonia M. "Recycling in Belo Horizonte, Brazil – An Overview of Inclusive Programming" WIEGO Policy Brief (Urban Policies) No 3 (2011) WIEGO (Women in Informal Employment: Globalizing and Organizing)
- EcoMENA. "Renewable Energy from Wastes." EcoMENA, https://www.ecomena.org/renewable-energy-from-wastes/
- El Financiero. (2023). "Planta de Carbonización en CDMX será la Primera del Mundo en Convertir Basura Orgánica en Energía." [Online] Available at: https://www.elfinanciero.com.mx/cdmx/2023/07/27/planta-de-carbonizacion-en-cdmx-sera-la-primera-del-mundo-en-convertir-basura-organica-en-energia/
- Governo do Brasil: "Buenas Prácticas en la Gestión de Residuos Sólidos Urbanos" https://www.gov.br/cidades/pt-br/acesso-a-informacao/acoes-e-programas/saneamento/protegeer-antigo/arquivos/buenaspracticasenlagestionderesiduossolidosurbanos.pdf
- Go Explorer. "Bogotá Waste-to-Energy Project Supplies National Grid." 2018 https://goexplorer.org/bogota-waste-to-energy-project-supplies-national-grid/
- Green Policy Platform: "Green Growth in Practice" 2014 https://www.greenpolicyplatform.org/sites/default/files/downloads/resource/Green-Growth-in-Practice-GGBP_0.pdf
- Green Growth Knowledge Platform. "Green Growth in Practice." Available at: https://www.greenpolicyplatform.org/sites/default/files/downloads/resource/Green-Growth-in-Practice-GGBP_0.pdf
- Global Recycling. 2021 "Waste-to-Energy Technology in Brazil: On a Massive Transition into the Future." Available at: https://global-recycling.info/archives/5956.
- Institute of Physics (IOP). "Solid Waste Management and Green Economy: A Case Study on Waste-to-Energy in Latin America." IOP Conference Series: Materials Science and Engineering, Volume 1196, Issue 1, 2021, Article ID 012004. Available at: https://iopscience.iop.org/article/10.1088/1757-899X/1196/1/012004/meta
- Kirchherr Julian, Reike Denise , Hekkert Marko, ScienceDirect: "The production of biofuels and biochemicals from organic solid waste of urban areas: A review" 2017) https://www.sciencedirect.com/science/article/pii/S0921344917302835?via%3Dihub
- Mexico Business News. (2022). "Bordo Poniente Plant in CDMX Nearing Completion." Available at: https://mexicobusiness.news/energy/news/bordo-poniente-plant-cdmx-near-completion
- Mexico Business News. (2023). "Mexico City Inaugurated LatAm's Largest Waste Selection Plant." Available at: https://mexicobusiness.news/infrastructure/news/mexico-city-inaugurated-latams-largest-waste-selection-plant

- Obras CDMX: “Estación de Transferencia y Planta de Selección” https://www.obras.cdmx.gob.mx/storage/app/media/00025%20julio%20planta/250721estacion-de-transferencia-y-planta-de-seleccion-azcvf-4.pdf
- ONU Medio Ambiente (2018) Perspectiva de la Gestión de Residuos en América Latina y el Caribe https://www.magconsultorias.com/wp-content/uploads/2018/10/UN_Manejo-de-residuos-PREVIEW19-ilovepdf-compressed.pdf
- Paper Brazilian waste management: Belo Horizonte’s case study of sustainable management Evaldo de Melo Ferreiraa,*, Raphael Tobias de Vasconcelos Barrosb , Jakub Soviarc
- Prefeitura de Curitiba: “Programas da Prefeitura Ajudam Curitiba a Ficar Próxima de Alcançar a Meta Lixo Zero” (2023) https://www.curitiba.pr.gov.br/noticias/programas-da-prefeitura-ajudam-curitiba-a-ficar-proxima-de-alcancar-a-meta-lixo-zero/70829
- Quiceno Florez, Adrian Esteban (2023), Review of the state of the art of some integrated solid waste management systems in Colombia and the world, to generate recommendations for the implementation of best practices in the municipality of Sopetrán, Department of Antioquia.
- Quito Informa. (2017, October 13). The Municipality of Quito Bets on Recycling. Available at: https://www.quitoinforma.gob.ec/2017/10/13/el-municipio-de-quito-le-apuesta-al-reciclaje/
- Quito Ambiente. 2022. “Quito a Reciclar.” http://www.quitoambiente.gob.ec/ambiente/index.php/politicas-y-planeacion-ambiental/proyectos/quito-a-reciclar
- Recycling Inside: “The Largest Sorting Plant in Latin America Begins Operation in Mexico City” (2021) https://recyclinginside.com/recycling-technology/separation-and-sorting-technology/the-largest-sorting-plant-in-latin-america-begins-operation-in-mexico-city/
- Redalyc: “Efecto de la aplicación de la Norma ISO 14001 en la producción de residuos en empresas del sector construcción en Cuba” 2014 Available at: https://www.redalyc.org/pdf/737/73737091009.pdf
- SEDENA CDMX: “Programa Basura Cero” 2019 https://sedema.cdmx.gob.mx/programas/programa/basura-cero
- United Nations News. (2018). “El municipio colombiano que es ejemplo mundial en gestión de residuos.” [Online] Available at: https://news.un.org/es/story/2018/10/1443562
- U.S. Environmental Protection Agency. (2023). “Waste Management and Climate Change” https://www.epa.gov/system/files/documents/2023-09/swm_climate-spanish.pdf
- Urban Agenda Platform. “Advancing Organic Waste Composting in Sao Paulo, Brazil.” Available at: https://www.urbanagendaplatform.org/best-practice/advancing-organic-waste-composting-sao-paulo-brazil.
- United Nations Human Settlements Programme (UN-Habitat). “Efficient Collection and Disposal of Waste: Challenges and Strategies.” Available at: https://onuhabitat.org.mx/index.php/recolectar-y-eliminar-residuos-de-manera-eficiente?fb_comment_id=1832372596846012_3409837369099519
- U.S. Environmental Protection Agency (EPA). “Solid Waste Management and Climate Change.” EPA 2023 https://www.epa.gov/system/files/documents/2023-09/swm_climate-spanish.pdf.
- UN-Habitat: “Solid Waste Management in the World’s Cities - Water and Sanitation in the World’s Cities 2010” https://unhabitat.org/sites/default/files/2021/02/solid_waste_management_in_the_worlds_cities_water_and_sanitation_in_the_worlds_cities_2010.pdf
- VOLTA Chile. (2020). “Panorama de países latinoamericanos con sus residuos.” Available at: https://www.voltachile.cl/panorama-paises-latinoamericanos-con-sus-residuos/
- Van Acoleyen, K., Laevers, J., Verstuyf, S., et al. “Challenges and opportunities for reflective practice in a digital age: Affordances and constraints of using digital media in early childhood teacher education.” Computers & Education, vol. 115, 2017, pp. 21-31. DOI: https://doi.org/10.1016/j.compedu.2017.07.005.
- Waste Management in the LATAM Region: Ecuador (2021) Report 20210208 report Waste Management Study LATAM of Holland Circular Hotspot.
- WOIMA Corporation: “Ahogándonos en basura - Caso Sao Paulo, Brasil” 2023
- https://woimacorporation.com/ahogandonos-en-basura-caso-sao-paulo-brasil/
- World Bank. “World Bank Open Data: Solid Waste Management.” World Bank Data Catalog, https://datacatalog.worldbank.org/search/dataset/0039597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