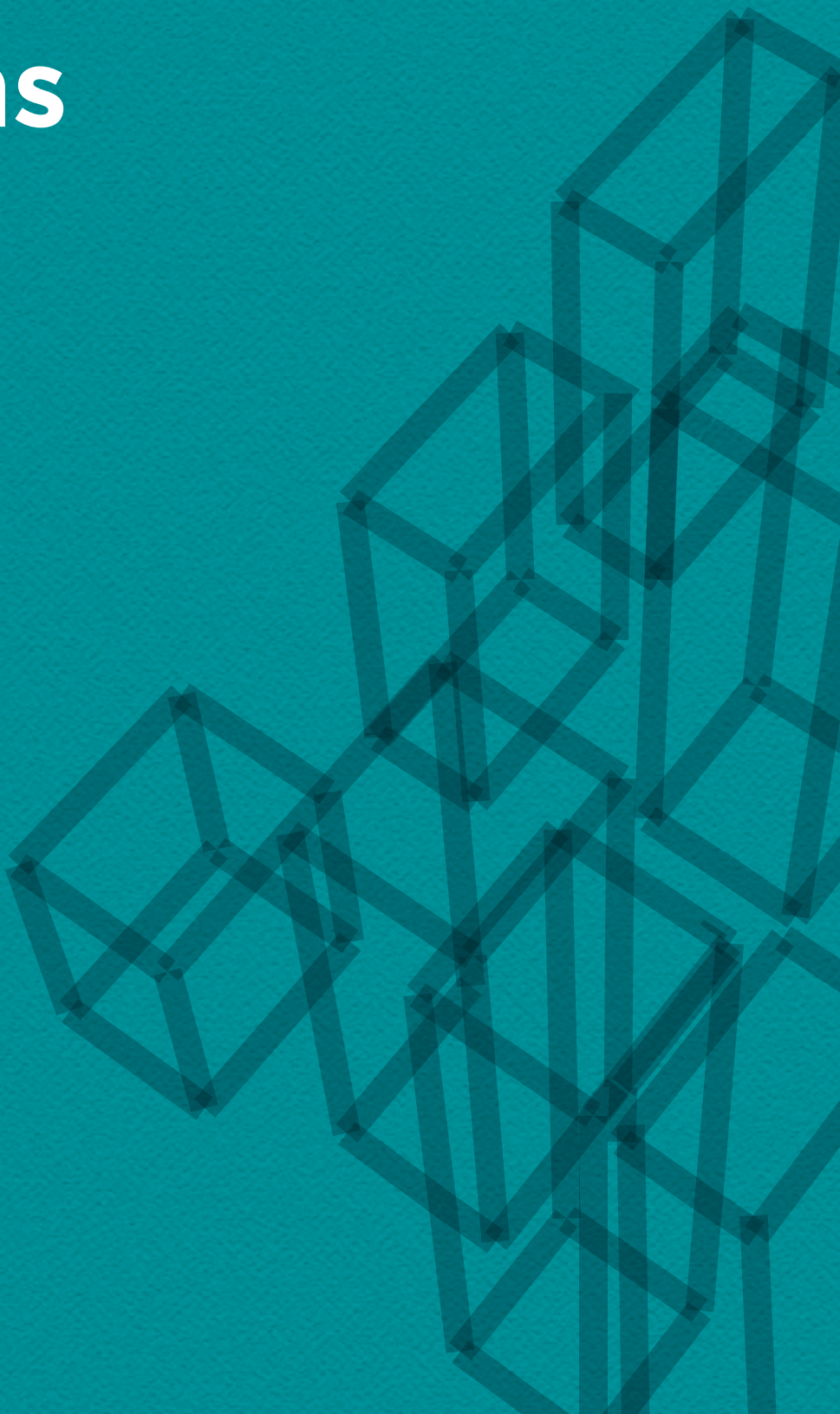
GOOD PRACTICE GUIDE

Sustainable Solid Waste Systems



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C40 Cities Climate Leadership Group

The C40 Cities Climate Leadership Group, now in its 10th year, connects more than 80 of the world's greatest cities, representing 600+ million people and one quarter of the global economy. Created and led by cities, C40 is focused on tackling climate change and driving urban action that reduces greenhouse gas emissions and climate risks, while increasing the health, well-being and economic opportunities of urban citizens. www.c40.org

The C40 Cities Climate Leadership Group has developed a series of Good Practice Guides in areas critical for reducing greenhouse gas emissions and climate risk. The Guides provide an overview of the key benefits of a particular climate action and outline successful approaches and strategies cities can employ to implement or effectively scale up these actions. These Guides are based on the experience and lessons learned from C40 cities and on the findings and recommendations of leading organisations and research institutions engaged in these areas. The good practice approaches are relevant for cities engaged in C40 Networks as well as for other cities around the world.

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EXECUTIVE SUMMARY

Solid waste management must be planned, developed and operated within the framework of local resource availability, economics and environmental concerns. Municipal solid waste management strategies can both provide effective mitigation of GHG emissions through landfill gas recovery and improved landfill practices, and can avoid significant GHG generation through controlled composting, integrated waste to energy facilities, and/or expanded collection services.

There is a significant opportunity for cities to reduce emissions through sound waste management actions, as cities have the powers to enact change and there is the opportunity for still more action in this area. By understanding the benefits and disadvantages of various management technologies, local decision-makers can best allocate resources, select processes and vendors, and develop policies and procedures to meet the community's needs.

This Good Practice Guide focuses on the key elements critical to deliver a successful solid waste management system, with a survey of good practices from around the world leading to better economic, social, and environmental outcomes for cities. These Good Practice approaches include:

- **Expand sanitary waste disposal and landfill management**
- **Develop infrastructure for waste utilization**
- **Integrate waste management and social inclusion**
- **Promote innovation in waste collection services**
- **Support development of market economy for waste recycling**
- **Use digital mapping to manage solid waste**
- **Ensure and implement integrated waste management systems**

The C40 Sustainable Solid Waste Network was established to support cities in moving up the waste hierarchy by improving collection, recycling and disposal (e.g. managing landfills and landfill gas), while developing community projects for composting and recyclables management.

The purpose of this Good Practice Guide is to summarise the key elements of a modern solid waste system for global dissemination, highlighting the success of C40 cities in planning and delivering sustainable solid waste management systems.

1 BACKGROUND

1.1 Purpose

The C40 Cities Climate Leadership Group has developed a series of Good Practice Guides in areas critical for reducing GHG emissions and climate risk. The C40 Good Practice Guides provide an overview of key benefits of a particular climate action and outline successful approaches and strategies cities can employ to effectively scale up these actions. These Guides are based on the experience and lessons learned from C40 cities and on the findings and recommendations of leading organisations and research institutions engaged in these areas. The following Good Practice Guide focuses on the key elements to successfully develop a sustainable solid waste management system for a city, with a survey of best practices leading to better economic, social, and environmental outcomes. These approaches are relevant for cities engaged in C40's Sustainable Solid Waste Systems Network as well as for other cities around the world.

1.2 Introduction

Solid waste is a vital responsibility of the municipal government and one of the greatest challenges facing urban authorities today, with the amount of waste generated exceeding their capacity both technical and financial to collect and dispose of. Solid waste can also have significant negative externalities, with impacts on the environment and health. Uncollected and mismanaged solid waste provides breeding ground for vermin and insects that proliferate and contribute to air and water-borne diseases. Unsanitary disposal often leads to escaping leachate causing further contamination of ground water and soil resources, while open burning leads to release of toxins and particulates such as black carbon.

Emissions from waste management and disposal represent a growing percentage of urban greenhouse gas emissions. Action to reduce these impacts will be critical as waste generation is growing faster than any other environmental pollutant, including CO2, particularly in the developing regions where waste represents a larger share of overall emissions.

Data shows that municipal solid waste and wastewater systems contribute about 3 to 5 per cent to current global anthropogenic greenhouse gas emission, but the sector has great potential to avoid emissions throughout the economy thanks to prevention and waste recovery (as recyclables or energy).[i] Solid waste disposal and management activities generate emissions of methane (CH4), carbon dioxide (CO2), nitrous oxide (N2O) and black carbon. Landfills are the third largest anthropogenic source of methane, accounting for approximately 11% of estimated global methane emissions, or nearly 800 MtCO2e. One forecast suggests that this figure could double by 2020 and quadruple by 2050 without mitigation.[ii]

Municipal solid waste management strategies can both provide for effective GHG reductions by improving disposal and treatment operations through landfill gas recovery and improved landfill practices, as well as avoid significant GHG generation through controlled composting and/or state-of-the-art energy recovery systems.

2 SOLID WASTE MANAGEMENT AND CLIMATE CHANGE

2.1 What is solid waste management?

Solid waste management entails all activities required to manage waste from its inception to final disposal, including collection, transportation, monitoring, treatment, recycling, and final disposal. As such, solid waste management is an important component of urban sanitation and one of the most resource-intensive services managed by municipalities. Most municipal governments are responsible for waste management, either through direct ownership and operation or through policy setting and enforcement.

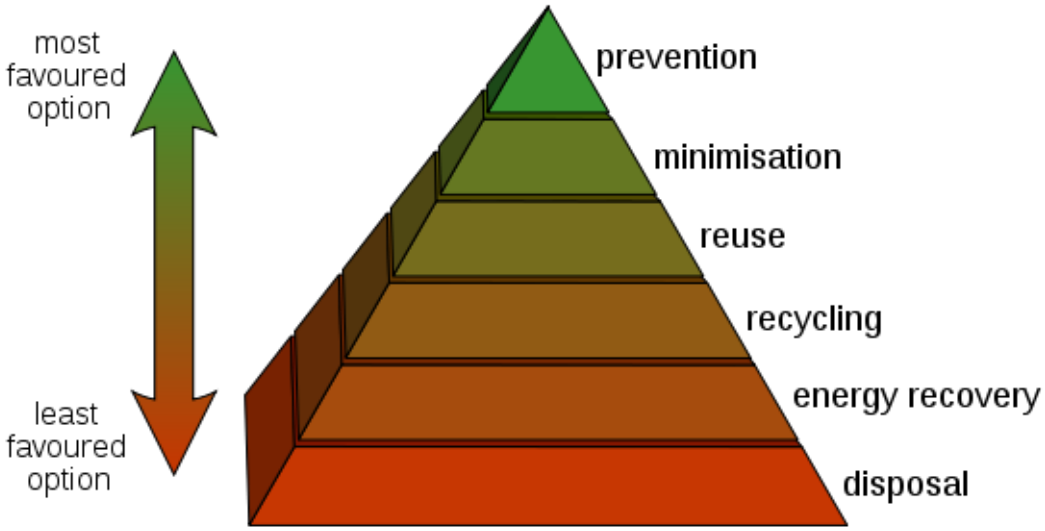
Solid waste management is therefore critical to avoid adverse effects on human health and the environment. C40's research for Climate Action in Megacities 3.0 revealed that C40 cities are taking over 1,279 actions in the waste management sector with two-thirds of them at a transformative scale, meaning that they are being deployed city-wide. 70% of these actions are related to waste separation, recycling and composting, 40% to waste prevention and 10% to waste collection and landfill management. 40% of the total waste actions reported by C40 cities are being delivered through networking and collaboration with other cities.[iii]

As waste management is one of the largest costs to municipal budgets, a successful and sustainable waste management system must consider technological solutions along with environmental, socio-cultural, legal, institutional and economic linkages.

2.2 What constitutes a good waste management system?

Good waste management systems are generally those that prioritise actions as per the 'Waste Hierarchy' (see diagram below).[iv] The Waste Hierarchy is an evaluation of processes that protect the environment alongside resource and energy consumption from most favourable to least favourable actions. This hierarchy establishes preferred program priorities based on sustainability.

The proper application of the waste hierarchy can have several benefits, including GHG emissions reduction, reduction of environmental pollution and energy consumption, resource conservation, jobs creation, and the development of green technologies.



Choosing the right priority order for solid waste management approaches and building a good sustainable waste management system delivers many economic, health and social benefits.

2.3 Benefits of sustainable solid waste management systems

Good waste management systems aim to extract the maximum practical benefits from products and to generate the minimum amount of waste. Effective waste management systems can provide significant co-benefits beyond addressing emissions, which might serve as the main drivers for action in waste management. Some of these co-benefits include:

Public health: Unmanaged waste often ends up in the streets or water drains, attracting pests and vermin. Waste disposed in unsanitary landfills or dumps can pollute underground water with toxic leachate. Improving waste collection and disposal practices can have a direct impact on public health, access to clean water and a cleaner city environment.

Air quality: The open burning of waste is a persistent practice in many regions of the world and a major source of black carbon. Lack of planning of waste collection routes or the use of old vehicles for waste collection also increases vehicle emissions, negatively affecting air quality.

Poverty reduction: In many cities, waste is an important source of income for a significant part of the population and of raw materials for many sectors of the economy. Waste collectors in many cities operate on the streets and dumps, collecting, sorting, cleaning, recycling and selling materials thrown away by others. Cities' actions can have a profound impact on the economic conditions and quality of life of those sectors of society involved in waste management. For

example, by utilizing proper sanitary landfill disposal techniques, cities can avoid the health hazards of open dump scavenging.

Social justice: Solid waste management is highly visible and affects people's perception of government and of society itself. Planning effective and sustainable investments in municipal solid waste management systems requires an understanding of the needs and preferences of a wide range of stakeholders in service delivery, costs and corresponding environmental and social impacts.

2.4 Challenges to delivering sustainable waste management systems

Solid waste management is a challenge for city authorities, primarily due to the increasing generation of waste, the burden it places on municipal budgets, the lack of understanding of a diversity of factors that affect waste management and of the necessary linkages to enable effective function of the entire handling system. The basic challenges that must be overcome for implementation of a successful solid waste management system include:

Complexity of waste management: Solid waste management is a multi-dimensional issue that engages multiple stakeholders. Municipalities in general seek equipment to find solutions to the diversity of problems they face. But a successful waste management system must consider technological solutions along with environmental, socio-cultural, legal, institutional and economic linkages. It also needs to address syndromes like NIMBY (not-in-my-backyard)[v] that can be prevalent amongst the public.

Involvement of multiple stakeholders: Waste management involves many stakeholders with different and sometimes conflicting interests. A detailed understanding of whom the stakeholders are and the responsibilities they have in the waste management structure is required to establish an efficient and effective system. Effective communication amongst the different stakeholders is important for establishing a well-functioning waste management system, particularly in developing country cities.

Institutional challenges: Many municipalities, particularly the solid waste departments, are understaffed and lack the relevant skills to manage waste. This limited capacity to handle solid waste often leads to unconventional methods of disposal, which include open dumping and burning. There is a significant need for municipalities to invest in capacity building, both in terms of number and quality of staff resources and skills.

Difficulty in recovering costs: Solid waste services have an associated cost that is difficult for municipal governments to recover. Financial resources are required to obtain the skilled personnel, infrastructure, and equipment needed to implement waste management plans.

Implications beyond municipal boundaries: It is critical to produce reliable data to create proper information channels within and between municipalities about waste management.

Decision-makers must be well informed about the situation of the cities in order to make positive changes, developing integrated waste management strategies adapted to the needs of the citizens.

Fortunately, experience from C40 cities has shown that these challenges can often be overcome by inventive solutions, cooperation, coordination, and better planning and management, as highlighted in the best practices illustrated in Section 3 below.

3 GOOD PRACTICES FOR A SUCCESSFUL WASTE MANAGEMENT SYSTEM

3.1 Categories of best practice

In order to address the challenges mentioned above and reap the multiple benefits of a sound waste management system, a number of key good practice approaches have been identified within the C40 Sustainable Solid Waste Systems Network. These include:

- **Expand sanitary waste disposal and landfill management**
- **Develop infrastructure for waste utilization**
- **Integrate waste management and social inclusion**
- **Promote innovation in waste collection services**
- **Support development of market economy for waste recycling**
- **Use digital mapping to manage solid waste**
- **Ensure and implement integrated waste management systems**

Each of these approaches is discussed in more detail below with case studies from cities in the C40 Sustainable Solid Waste Systems Network demonstrating good practices.

3.2 Expand sanitary waste disposal and landfill management

Open dumpsites, still in use in some cities around the world, cause pollution through open burning, leachate infiltration and spread of toxic chemicals. They also adversely affect health and the quality of life of the people living in the general vicinity, and of waste-pickers dependant on them for livelihood and survival. It is critical to phase out open-burning dumpsites as one of the key pillars of sustainable solid waste management and switch to sanitary controlled-disposal landfills. One key consideration while replacing existing open dumpsites with sanitary landfills is to make the waste-pickers part of the solution from the beginning of the project. The case studies below provide more detail on good practices for creating a sanitary landfill and closing responsibly an existing landfill, respectively. More technical details on the internationally accepted approach towards progressive rehabilitation to upgrade and phase out dumpsites can be found in the UN Habitat Report on *Solid Waste Management in the World's Cities.*[vi]

Case study: *Durban - Buffelsdraai landfill closed loop system*

Summary: The Buffelsdraai landfill management is a large-scale project to improve waste management practices in Durban. The project as a whole supports the city's goal to be the most liveable city in Africa by 2030, as it aims to alleviate poverty in the surrounding disadvantaged neighbourhoods, generates renewable energy, and reduce GHG emissions. The Buffelsdraai landfill is managed as a closed loop system, i.e. anything that comes onto site should not leave in any form.

Results: The modern landfill compacts and covers the waste every day to minimise the chances of odour or fly and vermin breeding. The leachate is collected and treated and the water is used for dust suppression, thus saving valuable drinking water. The landfill gas is extracted and used for flaring, thus destroying methane, a potent GHG. By extracting the gas and reducing methane emissions the city is expected to reduce 10 million tons of CO2 equivalent over the life span of the landfill, which is nearly 50 years. In the future, the gas will be cleaned and used as a fuel for city's vehicles or electricity generation. The methane gas captured will be sufficient to produce the equivalent of 10-12 MWh of electricity.

The city also manages the buffer zone as a nature conservancy. There is currently a coastal forest reestablishment project, where the local community is given seeds and cuttings and they grow these to a predetermined size and return them to the landfill area, where they are exchanged for vouchers. The vouchers can be used for various items such as school fees, bicycles, food or any other service. In just five years, 723,000 trees have been planted and some 200 hectares rehabilitated into coastal forests from previous land under sugar cane cultivation. This is expected to save more than an additional 55,000 tons of CO2 emissions per year.

The co-benefits of the project include stronger community engagement and social capital (as the surrounding community is earning a living and improving their economic situation), environmental benefits (through the reintroduction of coastal forests which would otherwise be under threat from farming), and economic development (energy use and sale, local jobs). The project has already been replicated in Durban's other landfills.

Reasons for success: The project's success is based on the strong involvement of the community in directly addressing the project's impacts on local livelihoods and seeing that as an opportunity for development. Multiple co-benefits, such as planned electricity production, also help reduce the long-term costs of the project.

Case study: *Wuhan*[vii] *- Jinkou landfill restoration*

Summary: After the closure of Wuhan's Jinkou landfill in 2005 due to insufficient health and safety standards, environmental issues with landfill gas pollution, leachate infiltration and damages to the landfill site landscape began to surface. The pollution caused by the closed

Jinkou landfill would have taken decades to remove through natural degradation, affecting not only the environment but also residents in nearby areas.

To restore this wasteland more efficiently and cost-effectively, the city began an aerobic ecological restoration project,[viii] which restored more than 52 hectares of land for city landscaping (increased land values and economic development in surrounding areas) and saved $125 million compared to conventional restoration methods.[ix] The landfill site restoration process, which began in 2014, introduced proper planting techniques, diverse plants, and measures to improve the soil. The project also ties in with Wuhan's General Urban Planning scheme (2010-2020), which aims to improve the quality of the city's ecological environment and enhance sustainable urban development.

Results: One of the main climate change objectives of the landfill restoration project was mitigation of GHG emissions, particularly by creating an area for carbon sequestration with local trees and plants (at least 66t CO2 absorbed), and capturing the gases produced from the waste landfill. The project is also restoring 52 hectares of land (recycling more than 1 million m^3 of displaced soil from urban construction projects), improving the environment for 100,000 residents living in close proximity to the landfill, reducing water and air pollution, eliminating risks of methane release and potential explosions, lowering surrounding temperatures through the introduction of green space, serving as water catchment area, shortening the degradation time of waste, and contributing to the local ecosystem by planting local species on the restored land.[x] To cap off its success, this former landfill site hosted the China International Garden Expo in 2015.

Reasons for success: Driven by the urgency of the project and the opportunity for financial savings by opting for an innovative approach, Wuhan successfully took the challenge of restoring one of the most polluted areas and transforming it into an ecological haven in the centre of the city in a remarkably short period of time.

When/why a city might adopt an approach like this: Cities that look into building new landfill sites should adopt this approach, ensuring that any new landfills are sanitary closed-loop landfills. To address impacts on local livelihoods, it is important to involve local communities from the beginning of the project and create new economic opportunities for people who might have previously lived off jobs related to open landfills (e.g. rag pickers). In addition, cities trying to remediate existing landfill sites and improve the health of their citizens in surrounding areas can adopt the landfill restoration approach to combine landscape rehabilitation with other benefits.

3.3 Develop infrastructure for waste utilization

Considering that landfilling is not a long-term option for waste management, in particular in megacities where space for landfills is limited, energy demand is high and landfill-to-city

distance is long, robust waste utilization infrastructure, such as waste-to-energy or composting plants, has to be developed. This approach combines sustainable waste treatment with the generation of local, reliable energy or resources, creating additional value for waste materials.

Case study: *Delhi – Energy recovery*

Summary: Of the total 9,000 tonnes per day (TPD) of municipal solid waste that Delhi generates, more than 2,000 TPD is sent to the Ghazipur dumpsite. This dumpsite is overflowing and poses serious environmental, health and safety hazards to the neighbourhood. The *Integrated Municipal Waste Processing Complex at Ghazipur* project is being implemented to create a sustainable solution to this critical urban issue. The waste-to-energy plant will produce 12 MW of electric power, using 1,300 tonnes of municipal solid waste per day, diverting around 15% of Delhi's municipal solid waste generation and addressing the environmental problems of open dumpsites. To set a benchmark in environmental standards and ensure its adherence to European emissions standard norms, the managing company has used best-in-class technology from Keppel Seigher of Belgium, Siemens, Schneider, SPIG, and BMH Finland amongst others. The project is also providing alternative livelihoods for rag pickers and their families through a mix of direct employment, capacity building and support for micro enterprises.

Results: The waste-to-energy plant uses waste materials from the landfill to produce refuse derived fuel (RDF), which powers a boiler used to generate electricity. The first stage of the project was completed in August 2014 and second phase is scheduled for completion by the end of 2015.

The project generates substantial co-benefits, avoiding a release of methane emissions (saving an estimated 8.2 million tonnes over the 25 years of expected site operation) and dumping of waste in open solid waste disposal site (SWDS). The co-benefits include: lower health and safety risks compared to an open SWDS; land savings (estimated savings in the cost of acquisition of land alone over a period of 25 years equal to USD2.26 million); and environmental benefits through dilution of leachate (saving annual cost of treatment equivalent to 0.4 USD per KWh) and reduction of toxic emissions from the landfill. Moreover, the project has tangible social benefits. Of the total of local 373 rag-picker families, the project will employ over 70 rag pickers directly in the plant. In addition, alternative livelihoods will be provided to about 100 women rag pickers and functional literacy education to 150 rag-picking family members. The project is also providing two crèches where 70 children are being given development and nutritional support. As part of financial inclusion, bank accounts and PAN (Permanent Account Number for income tax purposes) cards have also been provided to over 400 families in the area.

Reasons for success: Facing the challenge of limited land available for new landfill sites and a high volume of waste, Delhi has successfully upgraded an existing landfill to add a waste-to-energy plant infrastructure, exploiting the double benefit of waste reduction and power production, while generating support of the local community through social mainstreaming and

re-training of the rag-picking families. This successful project is to be replicated in similar plants in Delhi and in other cities in India.

Case study: *Dhaka – Composting project*

Summary: Dhaka is one of the most densely populated cities in Asia (population of around 12 million), with many people living in slums and squatter settlements. Although it recently adopted a Solid Waste Master Plan, most areas of the city lack sufficient waste collection services. Only 40–60% of Dhaka's waste is collected and transported to the city's two landfills.[xi] Out of the approximately 1.65 million metric tons of solid waste that Dhaka generates annually, more than 80% is composed of organic matter.[xii]

Waste Concern, an NGO, has demonstrated that such a venture can be profitable if land is provided and waste collection facilitated by the city, and if the government promotes the sale of organic fertilizer. In 1995, for the first time in Dhaka, Waste Concern initiated a community-based decentralized Composting Project at Section-2, Mirpur. Since then the plant has been running satisfactorily, is contributing to reducing GHG emissions compared to burning the waste, and has been replicated in other communities with land being provided by public agencies and local government bodies.[xiii]

Results: So far, Waste Concern's model of managing waste has reduced more than 18,000 tons of CO2 emissions each year in Bangladesh and generated 414 new jobs for the urban poor. It is helping to reduce the 52% of generated solid waste that remains uncollected in Dhaka. Waste Concern works with municipal governments to use solid waste as a resource by composting waste in 5 community-based composting plants (one 10-12 tons/day capacity; two 3 tons/day capacity; and two 1 ton/day capacity plants) and then selling it to fertilizer companies.

To scale-up its model, Waste Concern as a Social Business Enterprise partnered with a for-profit private Dutch company using CO2 emissions offsets from the Clean Development Mechanism (CDM) of the Kyoto Protocol. As part of the project, they are building 700 tons/day-capacity compost plants strategically located in the periphery of Dhaka city, with a production capacity of 50,000 tons/year, aiming to reduce CO2 emissions by 560,000 tons over the next 6 years. Over the long term, composting all organic waste in Dhaka would create new jobs for about 16,000 people, especially women. Waste Concern also established a Regional Recycling Training Centre located in Dhaka, offering training programs to help local officials to undertake full operational activities. This model has already been replicated in more than 26 cities.[xiv]

Reasons for success: The success of the composting project in Dhaka is based on the favourable composition of solid wastes, with a higher percentage of organic matter, precisely the right moisture content and C/N ratio slightly higher but adjustable,[xv] as well as partnership with an expert organization experienced in running similar projects. The public-private-community partnership also helped to guarantee financial viability of such a project, in particular thanks to

the initial land provision by the municipality, necessary to launch the composting project and exploit its benefits.

When/why a city might adopt an approach like this: Cities grappling with land scarcity and increasing waste generation need to look for options beyond conventional waste disposal facilities as well as to maximising resources through energy recovery. Similar approaches will help cities reduce the footprint of waste treatment facilities as well as lead to solutions for energy recovery from growing waste generation. Similarly, cities with greater organic composition of their waste stream could invest in decentralized composting facilities to harness eco-friendly compost, thereby reducing several tonnes of methane emissions from waste decomposition in landfills.

3.4 Integrate waste management and social inclusion

When designing solutions for waste management issues, it is important to ensure that their effects are sustainable over the long-term. In developing cities, with age-old informal waste handling systems, it is often counter-productive to completely replace these with new highly automatized technologically mature versions. There are multiple benefits of incorporating informal solid waste management infrastructures into new solutions, such as the regularization of informal waste pickers, thus improving their living standard and promoting participatory waste management. Such adaptations not only promote social well-being and financial efficiency, but also contribute to the creation of public ownership for the waste management system and urban area in the broader sense by directly involving citizens.[xvi]

Case study: *Bogota - Zero Waste Program*

Summary: Bogota's Zero Waste Program[xvii] was created to achieve a change of cultural behaviour and waste perception among citizens. The aim was to privilege conscious consumption and a strong recycling policy for the city, while making sure the informal "recyclers" are integrated into the social and economic structure of the city, dignified for their labour and remunerated appropriately. The Zero Waste program, which was integrated in the city's Development Program "Bogota Humana" in 2012, has 6 priority areas: 1) Separation at source; 2) Manufacturers' extended responsibility; 3) Recycling model; 4) Reduction of disposal in city landfill; 5) Zero debris; and 6) Hazardous and special waste management.

Results: The Zero Waste Program created a legal framework for a social inclusion plan and evolution of the established solid waste collection and disposal system into one that privileges the 'reduce-reuse-recycle' model, conscious consumerism, and social inclusion. The goal for 2016 is to divert at least 20% of solid waste from landfill. The social inclusion of recyclers in particular was designed to address the challenges they were facing, such as a lack of transparent organization and often violent competition between recyclers; a lack of technical training; a lack of information about their basic rights; a significant percentage facing homelessness; and cases of child labour or lack of schooling.

The Zero Waste Program not only contributes to the integration of informal workforce, better waste management and waste reduction (about 1 ton/day of usable materials have been recycled), but also has multiple co-benefits, including a reduction in the cost of waste collection service by 15.23%; better health protection for recyclers through the distribution of about 12,000 protection kits in 2015 by the UAESP (City Public Service Special Administrative Unit responsible for waste management); and power generation at the Doña Juana Landfill biogas plant (39.69 MW monthly average production in 2014), which also leads to CO2 emissions reduction of about 700,000 tons/year.

Reasons for success: The project successfully used the existing informal infrastructure to build an integrated waste collection model, while providing livelihoods to local communities. It also recognized the potential and necessity of behaviour change to achieve a mature and cost-effective waste management system.

When/why a city might adopt an approach like this: Cities with an existing informal waste collection economy can adopt this approach to integrate existing infrastructure and workers at lower costs than establishing new systems. All cities should include an education and awareness-raising element to motivate behaviour change among urban citizens and help build a sustainable modern waste management/ resource valuation system.

3.5 Promote innovation in waste collection services

Innovative strategies for improving collection efficiency can help cities reduce significant municipal costs and free finance for other projects. In today's competitive waste management market, customers want a wide variety of collection options at competitive rates. The solid waste management collection services in many cities have evolved to meet those expectations. Cities can achieve greater success through system improvements such as new technologies, better collection vehicles, new methods of routing, and innovation in contracting mechanisms. The U.S. EPA recommends a set of strategies that can be employed for more efficient waste collection. These include: reducing collection frequency; automating collection services; decreasing fleet size with dual collection provisions; increasing employee productivity; and improving contracting and competition[xviii]. The case study below elaborates on one city's innovative crosscutting policy approach.

Case study: *Lagos – Private sector participation*

Summary: The city of Lagos, due to its position as Nigeria's commercial nerve centre, has continued to experience rapid population growth (projected at 6-8% per annum), reaching over 21 million people in 2014.[xix] This results in increasing waste generation, currently estimated at about 10,000 metric tonnes/day.

Over the last decade, the existing Private Sector Participant (PSP) programme for waste collection in Lagos was established under a franchising arrangement where PSPs/SMEs were duly licensed for collection activities based on ward distributions across the State. However, the combined effects of poor cost recovery on operational overheads, low investment opportunities as well as return on investment, lack of public compliance with waste bill payments, among other market dynamics, resulted in operational deficiencies and the attendant backlogs across the city.

While it was necessary to revamp waste collection services through public education to create the right attitude and receptiveness towards individual responsibility, a more drastic intervention was required to overhaul existing practices for improved service efficiency.

Results: The Lagos State Government, through the Lagos Waste Management Authority (LAWMA) guided by a 10-year (2005-2015) market development strategy, facilitated finance and funding mechanism support for PSPs in collaboration with local banks, providing creditworthiness instruments for access to capital markets. Privatisation models and cost recovery plans for different socio-economic groups/areas within the city were also defined to assist PSPs to recoup capital investment and support debt repayment schemes for collection vehicles procured through government intervention. Further assistance was provided to develop public awareness and engagement activities to foster compliance from local communities. Government subsidy and debt buy-back were also provided for PSPs operating in low-income areas.

The result was an increase in vehicle availability of over 800 trucks (100% increase) which has led to a recorded increase of over 60% in collection service efficiency, and about 55% in cost recovery, since 2005, with projections for further increase based on market potentials. Employment opportunities are being enhanced through the expanded participation of the private sector/SME in waste collection. Hence, the Lagos (waste collection) model is being adopted as a benchmark to improve collection efficiency in Nigerian/West African cities.

Reasons for success: Building on the existing legislation as well as policy and regulatory instruments available at both national and state government levels, LAWMA adopted the 'PSP Handbook' that sets out specific criteria/preconditions, and operating guidelines while also serving as a basis for performance evaluation for private sector (SME) participation in the collection and transport of MSW within the city of Lagos.

Technical assistance for local and overseas training for the PSP/SME representatives were facilitated to bridge knowledge gaps and enhance competency development in the sector. Institutional support was also rendered through LAWMA as a government agency to foster transparency and fairness in dispute resolution between PSPs and client entities.

When/why a city might adopt an approach like this: Cities with vast population aiming to optimise waste collection and cleanliness across different socio-economic regions/areas while ensuring availability of required vehicle/infrastructure may adopt the Lagos approach, which also affords opportunity for economic growth through increased SME/private sector involvement, and attendant job creation.

3.6 Support development of a market economy for waste recycling

Establishing local systems where waste materials can be recycled or reused to fully harness existing outlets -- in addition to identifying and developing new, reliable and stable markets for recycled/ recovered materials in cities -- is key to creating a sustainable waste management system with high valuation for materials. Achieving greater local recycling and reprocessing capacity in cities will also lead to several other benefits, such as job creation; reduced waste transportation (with its associated costs and environmental impacts); greater self-sufficiency and resilience of the waste management system; and greater public confidence and participation. A successful domestic recycling market will provide visible evidence of a successful recycling system, thereby strengthening public confidence in the environmental benefits of recycling and drive forward participation.

Case study: *Mexico City – Barter market for recyclables*

Summary: In March 2012, Mexico City's administration initiated a barter market project to trade clean and separated household solid waste recyclables for locally produced agricultural products. The overall objective of the barter market is to build an educational program promoting a culture of recycling and local consumption among the population of Mexico City. With about 12,500 tons of municipal solid waste generated per day ending up in landfills, the city created the barter market to explore sustainable alternatives to landfilling, as well as develop and maintain a culture of waste minimization and recycling. An additional aim of the project is to provide support to local producers and traditional forms of agriculture in the rural areas of Mexico City.

Results: The barter market takes place once a month on a Sunday morning in public places such as parks or plazas. The market is itinerant in order to gradually cover the different boroughs of Mexico City. Each citizen can trade up to 10 kilograms of waste per market day in one or more categories of valuable recyclables, which currently include paper, cardboard, PET, glass, tetra-pack, aluminium, tin cans, and electronic waste. The agricultural products that are traded for waste are grown by local producers in rural areas of Mexico City and range from fruits and vegetables to plants and homemade jams. The barter market has developed strategic partnerships with 80 local producers and several recycling companies that are responsible for collecting the waste gathered during the event and transporting it to recycling facilities at their own cost. In exchange for the recyclables the private companies provide in-kind donations to the city government in form of environmental education materials.[xx]

The project contributes to the citywide recycling target of 5,000 tonnes/day (twice as much as the current recycling rate) and it has yielded significant results on a small scale. In 2013, 12 editions of the barter market were conducted, with nearly 20,000 citizens trading their recyclable solid waste, adding up to approximately 151,000 tonnes of material in total.

The main environmental goal of this project is to divert valuable recyclable waste from final disposal in landfills, but it is also expected to bring significant co-benefits, such as contributing to the fight against malnutrition, a recurrent health issue in Mexico, by providing healthy, good quality food traded at barter markets. The market not only benefits local agricultural producers (80 were involved in 2014 through a strategic partnership) who receive subsidies from the city in the trading process, but also benefits the private waste industry by generating jobs in collecting and reusing valuable recyclables. The barter market is very popular among citizens, with more than 2,000 citizens participating in the trade every month.

Reasons for success: The barter market is a remarkable social laboratory in which citizens actively get involved to promote a sustainable recycling economy. It is an opportunity for citizens not only to learn to separate, collect and value recyclable household solid waste in order to reduce final disposal in landfills, but also to consume local agricultural products (healthy produce with fewer GHG emissions from transport as they are grown close to the consumer). The barter market is growing in popularity because it provides families with fresh seasonal agricultural products in exchange for household waste.

When/why a city might adopt an approach like this: Cities can adopt this approach to foster awareness of the value of recyclables among urban citizens, while supporting local agricultural production or other local products and services that can be offered in exchange for recyclable waste. The project particularly benefits the low-income population, generating important social and economic co-benefits.

3.7 Use digital mapping to manage solid waste

Whilst waste management systems have evolved over decades, the uptake of new software technologies for improved and efficient waste collection and transportation services is a relatively new phenomenon. Without proper data collection and management systems, it is challenging to have a sound, transparent waste strategy. Cities have begun to acknowledge this and are leapfrogging with the adoption of software technologies to manage solid waste and create a database of knowledge to generate further positive changes.[xxi]

Case study: *Bengaluru – Digital mapping in waste collection*

Summary: Bengaluru embraced digital mapping to inform waste collection and transportation systems in order to reach the city's goal of 100% solid waste collection. Facing a challenging situation with several closed landfills, an ineffective solid waste management system (with only 50% of waste collected), and unreliable or missing data to accurately plan effective collection

and transportation, Bengaluru adopted a new approach to solid waste management in 2013, when it started collaborating with the Centre for Public Problem Solving. The city launched a process to create a geographic information system (GIS)-based model for its solid waste management, and is now ready to roll it out in almost half of the city. The GIS system enables the city to store, analyse, and share a diverse range of mapped geographic information, such as decentralized infrastructure and existing vehicle routes, which are crucial when planning waste collection and transportation. The data-driven model enables a cost-efficient waste management system by using optimal route algorithms and automated rules for data collection.

Results: A better-planned, efficient, and monitored collection and transportation system is expected to decrease the length of overall waste collection travels by 80% and expand the door-to-door collection to cover the whole city by 2016. This is expected to bring about CO2 reduction from the waste sector of 109 metric tonnes/year, as well as multiple co-benefits. The new norms of waste handling will ensure cleaner and healthier living conditions in vulnerable communities; 19,000 new jobs are to be created when the GIS model covers the entire city by 2016; and with door-to-door collection for the entire city, open burning and dumping of waste will be minimized, reducing air and soil pollution.

Reasons for success: The key to success of Bengaluru's waste management data approach has been the use of the GIS model as a decision support tool for resourceful management of transporting the community solid waste, as well as an extensive parallel citizen engagement program.

When/why a city might adopt an approach like this: This approach is particularly suited to cities aiming to achieve effective and efficient management of waste collection fleet services. The various algorithms available via GIS software help define alternative routes in heavy traffic situations leading to costs and fuel savings for municipalities. In addition, a data repository of past fleet movements would further support the development and improvement of citizens' engagement strategies for waste collection services, for instance through development of user friendly mobile apps to disseminate and update pick-up times.

3.8 Ensure and implement integrated waste management systems

A sustainable integrated waste management policy brings together waste prevention and reduction, re-use of goods, recycling, and waste recovery (composting, waste-to-energy). A strong integrated solid waste management combines different technologies to offer targeted waste processing options for all diverse waste categories. The integration of the different processes and combination of pre-processing, mechanical and manual sorting, recycling and power-generating technologies offers important synergies and economies of scale that would be unreachable if employed individually.[xxii]

Case study: *Buenos Aires - Municipal Solid Waste Reduction Project*

Summary: The Municipal Solid Waste Reduction Project[xxiii] in Buenos Aires, initiated in January 2014 aims to reduce the amount of waste sent to landfills through source separation, resource recovery, recycling and resource valorisation, while bringing responsibility back to the citizens. Buenos Aires for instance launched 'Green Centres' for recyclable materials and green waste, and installed a Mechanical Biological Treatment plant, using new innovative technologies.[xxiv] This should enable the city to reduce an estimated 45,000 tCO2 annually.[xxv] The city is also implementing intensive awareness campaigns to educate citizens on how to sort, separate and dispose of waste in a sustainable manner.

Results: Progress has been made in the deployment of street containers and lateral collection vehicles in order to avoid garbage bags on the streets, reduce odours and improve the street's image. Local waste transfer stations have been installed, which reduced CO2 emissions from waste transportation. During the initial stage, it was possible to achieve a 44% waste disposal reduction, avoiding the emission of 25,297 tCO2e in 2013. In 2014, after a 78% waste reduction during a second stage, the GHG emission reductions reached 45,787 tCO2e. The project has also been designed to generate new job opportunities and foster greater social participation and transparency in the waste and recycling chain. Thus far, 4,500 'urban recoverer' jobs have been created, with 2,000 more expected, in a sustained effort to create long-term formal employment growth.[xxvi]

Reasons for success: Buenos Aires is achieving fast results by focusing on the residential sector and enacting policies to increase the responsibility of waste management for private businesses, significantly reducing the waste stream managed by the municipality. Coupled with the fast deployment of innovative street containers that minimise negative impacts, participation is increasing rapidly.

When/why a city might adopt an approach like this: Cities in need of implementing fast transitions in their waste systems, especially if the city is simultaneously aiming to achieve long-term and ambitious waste reduction targets, can adopt the integrated waste management planning approach to benefit from related synergies and co-benefits.

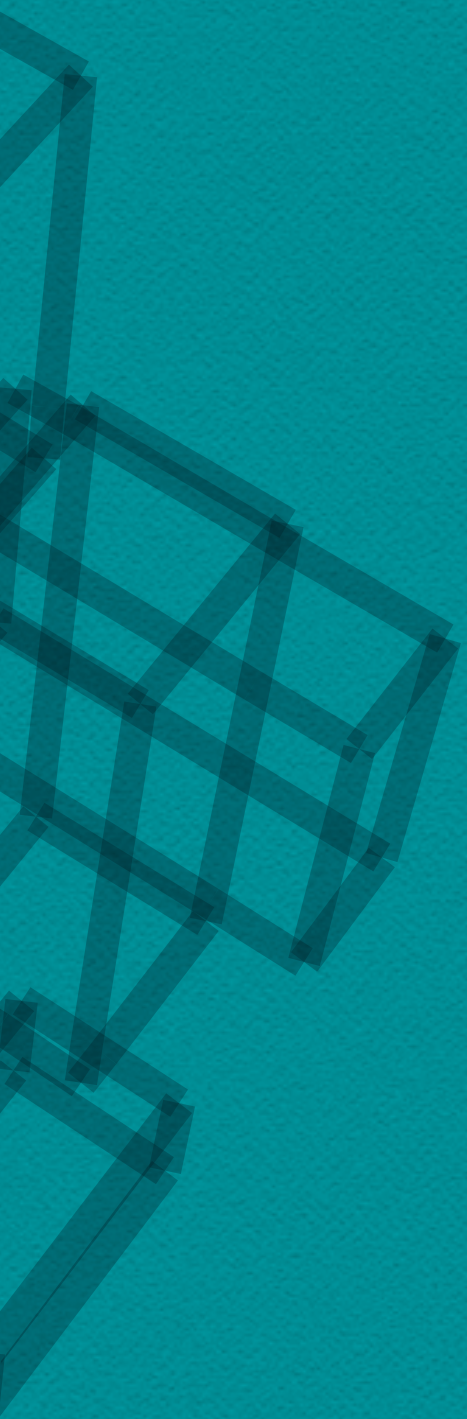
4 FURTHER READING

A number of external organisations, including C40 partners, have published best practice guidance for developing waste management projects including:

- UNEP / IETC - Developing Integrated Solid Waste Management Plan – Training Manuals, Jun 2009
  http://www.unep.org/ietc/InformationResources/Publications/tabid/56265/Default.aspx#iswm1

- UNEP / IETC - The Japanese industrial waste experience: Lessons for rapidly industrializing countries, March 2014
  http://www.unep.org/ietc/Portals/136/Publications/Waste%20Management/UNEP%20DTIE_Japanese%20waste_english_web.pdf
- World Bank - Results-Based Financing for Municipal Solid Waste Projects
  http://documents.worldbank.org/curated/en/2014/07/20328140/results-based-financing-municipal-solid-waste-vol-2-2-main-report
- The World Bank - What a Waste: A Global Review of Solid Waste Management
  http://go.worldbank.org/BCQEP0TMO0
- National Institute of Urban Affairs - Compendium of Global Good Practices - Urban Solid Waste Management, 2015
  http://www.citiesalliance.org/sites/citiesalliance.org/files/GP-GL3%20SWM.pdf

[i] http://www.unep.or.jp/ietc/Publications/spc/Waste&ClimateChange/Waste&ClimateChange.pdf
[ii] http://www.unep.org/ccac/tabid/1060441/Default.aspx
[iii] http://cam3.c40.org/images/C40ClimateActionInMegacities3.pdf
[iv] http://www.fccenvironment.co.uk/assets/files/pdf/content/wrap-applying-wastehierarchy.pdf
[v] http://www.oxforddictionaries.com/definition/english/nimby
[vi] http://www.waste.nl/sites/waste.nl/files/product/files/swm_in_world_cities_2010.pdf
[vii] http://www.c40.org/awards/3/profiles/62
[viii] http://www.kinghome.com.cn/Home/Products/1/2014-08-21/337.html
[ix] http://issuu.com/sustainia/docs/cities100/35?e=4517615/31305566
[x] http://cjweek.cjn.cn/images/2015-11/20/19/2015112019_pdf.pdf
[xi] http://waste.ccac-knowledge.net/sites/default/files/files/city_fact_sheet/Dhaka_MSW_FactSheet_0.pdf
[xii] http://waste.ccac-knowledge.net/sites/default/files/files/city_fact_sheet/Dhaka_MSW_FactSheet_0.pdf
[xiii] http://ro.uow.edu.au/cgi/viewcontent.cgi?article=1716&context=scipapers
[xiv] http://www.c40.org/case_studies/organic-waste-is-composted-and-sold-as-bio-rich-fertilizer-reducing-emissions-generating-jobs-and-cleaning-up-the-city
[xv]http://www.sswm.info/sites/default/files/reference_attachments/ENAYETULLAH%20et%20al%20ny%20Community%20based%20Decentralized%20Composting.pdf
[xvi] http://www.citiesalliance.org/sites/citiesalliance.org/files/GP-GL3%20SWM.pdf
[xvii] http://uaesp.gov.co/uaesp_jo/index.php?option=com_wrapper&view=wrapper&Itemid=16
[xviii] http://www3.epa.gov/epawaste/nonhaz/municipal/landfill/coll-eff/k99007.pdf
[xix] http://worldpopulationreview.com/world-cities/lagos-population/
[xx] Text adapted from: http://www.c40.org/profiles/2014-mexicocity-solidwaste
[xxi] http://www.waste.nl/sites/waste.nl/files/product/files/swm_in_world_cities_2010.pdf
[xxii] http://www3.epa.gov/climatechange/wycd/waste/downloads/overview.pdf
[xxiii] https://www.c40exchange.org/download/attachments/47644728/Buenos Aires - Case Study October 2014.pdf%3Fversion=1%26modificationDate=1415989545805%26api=v2
[xxiv] http://futurenviro.es/en/planta-de-tratamiento-mecanico-biologico-norte-iii-ceamse-provincia-de-buenos-aires-argentina/
[xxv]https://www.c40exchange.org/login.action;jsessionid=084D130440470B3083C36703ECA02979?os_destination=%2Fdownload%2Fattachments%2F47644728%2FBuenos+Aires+-+Case+Study+October+2014.pdf%3Fversion%3D1
[xxvi] Adapted from: http://www.c40.org/profiles/2014-buenosaires



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