



USAID
FROM THE AMERICAN PEOPLE

SECTOR ENVIRONMENTAL GUIDELINES

SOLID WASTE

GENERATION, HANDLING, TREATMENT, AND DISPOSAL

2014



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Cover Photo: Children walk and sort through human and animal waste and trash. Disease control is problematic in a population of 125,000 in the most vulnerable slums of the city of Indore. Photo credit: USAID Chris Thomas

About this document and the *Sector Environmental Guidelines*

This document presents one sector of the *Sector Environmental Guidelines* prepared for USAID under the Agency's Global Environmental Management Support Project (GEMS). All sectors are accessible at www.usaidgems.org/bestPractice.htm.

Purpose. The purpose of this document and the *Sector Environmental Guidelines* overall is to support environmentally sound design and management (ESDM) of common USAID sectoral development activities by providing concise, plain-language information regarding:

- the typical, potential adverse impacts of activities in these sectors;
- how to prevent or otherwise mitigate these impacts, both in the form of general activity design guidance and specific design, construction and operating measures;
- how to minimize vulnerability of activities to climate change; and
- more detailed resources for further exploration of these issues.

Environmental Compliance Applications. USAID's mandatory life-of-project environmental procedures require that an environmental analysis be conducted to identify the potential adverse impacts of USAID-funded and managed activities prior to their implementation according to USAID Environmental Procedures 22 CFR 216 or Reg. 216. They also require that the environmental management or mitigation measures ("conditions") identified by this analysis be written into award documents, implemented over life of project, and monitored for compliance and sufficiency.

The procedures are USAID's principal mechanism to assure ESDM of USAID-funded activities—and thus to protect environmental resources, ecosystems, and the health and livelihoods of beneficiaries and other groups. They strengthen development outcomes and help safeguard the good name and reputation of USAID.

The Sector Environmental Guidelines directly support environmental compliance by providing: information essential to assessing the potential impacts of activities, and to the identification and detailed design of appropriate mitigation and monitoring measures. When an activity receives a "Negative Determination with Conditions" these guidelines should be used to help establish which conditions are appropriate to the particular activity.

*However, the Sector Environmental Guidelines are **not** specific to USAID's environmental procedures. They are generally written, and are intended to support ESDM of these activities by all actors, regardless of the specific environmental requirements, regulations, or processes that apply, if any.*

Region-Specific Guidelines Superseded. The *Sector Environmental Guidelines* replace the following region-specific guidance: (1) *Environmental Guidelines for Small Scale Activities in Africa* ; (2) *Environmental Guidelines for Development Activities in Latin America and the Caribbean*; and (3) *Asia/Middle East: Sectoral Environmental Guidelines*. With the exception of some more recent Africa sectors, all were developed over 1999–2004.

Development Process & Limitations. In developing this document, regional-specific content in these predecessor guidelines has been retained. Statistics have been updated, and references verified and some new references added. However, this document is not the result of a comprehensive technical update.

Further, The *Guidelines* are not a substitute for detailed sources of technical information or design manuals. Users are expected to refer to the accompanying list of references for additional information.

Comments and corrections. Each sector of these guidelines is a work in progress. Comments, corrections, and suggested additions are welcome. Email: gems@cadmusgroup.com.

Advisory. *The Guidelines are advisory only. They are not official USAID regulatory guidance or policy. Following the practices and approaches outlined in the Guidelines does not necessarily assure compliance with USAID Environmental Procedures or host country environmental requirements.*

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SOLID WASTE



The adverse impacts of waste management are best addressed by establishing integrated programs where all types of waste and facets of waste management processes are considered together. The long-term goal is an integrated waste management system with the corresponding administrative capacity to manage and sustain it.

The local government and youth in Kaspi, Georgia, took action together to improve their municipality's environment, including volunteering to pick up trash. Photo credit: Urban Institute

BRIEF DESCRIPTION OF THE SECTOR

More than 1.4 billion tons of municipal solid waste is generated globally every year. This number is expected to increase to 2.4 billion tons per year in 2025 as the number of people living in cities increases from 3 billion to 4.3 billion. The global cost of solid waste management, which is currently \$205.4 billion, is projected to increase by 58% in 2025. Solid waste management is a top priority for every country, including low-income countries. Uncollected solid waste or solid waste that is improperly managed has the potential to cause flooding, air pollution, and have impacts on public health. Much of the solid waste generated in Latin America, Africa, and other regions is discharged into water bodies, open dumps, and wetlands, contaminating surface and ground water and posing major health hazards.

In Latin America, an estimated 300 million city dwellers (approximately 80 percent of Latin Americans live in urban areas) generate 225,000 tons of solid waste every day and waste generated per person per day has grown to 0.5-1.0 kilograms. In Africa, thousands of tons of solid waste are generated daily. Generation rates are only available for select African cities and regions, but they range from 0.5 to 0.8 kilograms of solid waste per person per day. These numbers may seem minimal when compared to the 1-2 kg per person per day generated in developed countries. However, the composition of Latin America's household and

For More Information ...

These guidelines are intended to be a starting point for developers and managers of solid waste projects. They are designed to highlight key issues, questions to consider, and technical options. More detailed resources are cited at the end of this document. Solid waste project developers and managers should pay particular attention to The International Source Book on Environmentally Sound Technologies for Municipal Solid Waste Management, produced by the International Environmental Technology Centre of the United Nations Environment Programme.

business waste has shifted from being almost entirely biodegradable to being much less so, including increasing amounts of high-value recyclables, plastics, and hazardous materials. Most waste in Africa is not collected by municipal collection systems because of poor management, fiscal limitations, and inadequate facilities. Between 2011 and 2050, the world population is expected to increase by 2.3 billion, passing from 7.0 billion to 9.3 billion. At the same time, the population living in urban areas is projected to gain 2.6 billion, passing from 3.6 billion in 2011 to 6.3 billion in 2050. Thus, the urban areas of the world are expected to absorb all of the population growth projected to occur over the next four decades while at the same time drawing in some of the rural population. As a result, the world's rural population is projected to start decreasing and there will likely be 0.3 billion fewer rural inhabitants in 2050 than today. Furthermore, most of the population growth expected in urban areas will be concentrated in the cities and towns of the less developed regions. Asia is projected to see its urban population increase by 1.4 billion, Africa by 0.9 billion, and Latin America and the Caribbean by 0.2 billion.¹

Rapid urban expansion, much of it unplanned, generates waste much faster than existing collection and disposal capacities can take on, creating increasingly un-served or underserved populations. While in some cities such as the Bengaluru (Bangalore) in India and Quezon City in the Philippines waste collection coverage rates are over 90 per cent, this is by no means the standard in all urban areas. Generally, waste collection coverage for cities in low- and middle-income countries ranges from a low of 10 percent in peri-urban areas to a high of 90 percent or more in commercial city centers. This means that many households in urban areas receive no services at all, resulting in far too much waste ending up in the environment.²

One of the problems of this unequal distribution is that a significant population growth will occur precisely in those places where the waste collection system is already in a poor shape. For example, throughout most of sub-Saharan Africa, generated solid waste already exceeds collection capacity. While only 35 percent of the sub-Saharan population lives in urban areas, the urban population grew by 150 percent between 1970 and 1990.³ The problem of growing demand is compounded by poor capacity. In West African cities, as many as 70 percent of trucks are out of service at any one time, and in 1999, the City of Harare failed to collect refuse from nearly all of its residents because only 7 of its 90 trucks were operational.

In developing countries, solid waste management services (primarily transfer and disposal) can consume a significant part of municipal budgets and households and neighborhood associations will often pay for primary waste collection services directly. For health reasons, waste in tropical regions should be collected at least two times per week. This makes the challenges and costs of solid waste management in much of Africa, Asia, and Latin America even more burdensome. It is generally the city center and the wealthier neighborhoods that receive service when it is available. In poorer areas, uncollected waste accumulates at roadsides, is burned by residents, or is disposed of in illegal dumps which blight neighborhoods and harm public health. Where present, manual-street sweeping by municipal employees or shopkeepers may help reduce these effects in the most public areas. Nonetheless, roadside accumulation in many cities has reached levels resembling those that spawned epidemics in European cities 500 years ago. Unless more effective urban waste management programs and public water supply systems are put in place, outbreaks of cholera, typhoid and plague may become increasingly common.

¹ World Urbanization Prospects. The 2011 Revision. Economic and Social Affairs.
http://esa.un.org/unpd/wup/pdf/WUP2011_Highlights.pdf

² Scheinberg, A., D.C. Wilson, and L. Rodic-Wiersma. (2010). Solid Waste Management in the World's Cities: Water and Sanitation in the World's Cities. Earthscan for UN Human Settlements Program (UN-HABITAT).
http://waste.nl/sites/default/files/product/files/swm_in_world_cities_2010.pdf

Only a small amount of the waste in many developing countries around the world is disposed of in sanitary landfills; most is deposited in open dumps or semi-controlled unlined landfills with no groundwater protection, or treatment systems. The larger dumps are located on the edges of cities, towns, and villages, sometimes in ecologically sensitive areas, or areas where groundwater supplies are threatened. These may serve as breeding grounds for rats, flies, birds and other organisms that serve as disease vectors. Smoke from burning refuse may be damaging to the health of nearby residents and the smell degrades their quality of life. The great majority of waste (~70 percent) is organic. In theory, this waste could be converted to compost or used to generate biogas, but in situations where rudimentary solid waste management systems barely function, it is difficult to promote innovation, even when it is potentially cost-effective to do so. Separation and treatment of organic waste is very rare in developing countries. Municipal composting programs exist in some South African cities, but the few large-scale composting facilities built elsewhere are no longer operating. In addition, hazardous and infectious materials are often discarded along with general waste, generating dangerous conditions that complicate the problem of waste separation and management.

Though some of the high- and low-value recyclables are recovered and reused, these make up only a small portion of the total waste stream. Generally, recovery and reuse of materials is for personal use, but there are also many professional waste pickers. Recycling and recovery of high-value waste streams, such as paper, are higher in Latin America than in many industrialized countries. These processes are carried out by employees of municipal collection services and other independent collectors, including microenterprises and waste-pickers. Low-value organic waste is not recovered by waste-pickers.

While solid waste collection is generally a municipal function, some countries and municipalities are now experimenting with limited privatization of these services, with some success. For example, in Guatemala all service is contracted privately. Because of the poor levels of collection, many residents—from impoverished to wealthy—pay for private collection of their wastes where these services are legalized. Municipally funded services in Latin America and the Caribbean are provided through an array of institutional arrangements, including contracting, selling concessions, franchising, and the direct provision of services by municipal employees. In many cases, collection and disposal by individuals or small enterprises have proven better at keeping pace with rapid urban growth than government systems.

Municipal waste incinerators are too expensive for most communities and impractical since most paper that can be reused from the waste stream is removed, leaving behind an organic waste that is too wet to burn. In Latin American and the Caribbean specifically, incinerators for individual buildings are generally illegal. Some hospitals and municipalities have incinerators for medical waste, but these are often not operated correctly. The HIV/AIDS epidemic has raised concerns about reuse of syringes, and efforts are being made to construct low-cost, high-temperature two-chamber incinerators to destroy syringes along with other medical wastes.

CLIMATE CHANGE

Global climate change is resulting in changes in temperatures, rainfall patterns, sea levels, and extreme weather events that are putting stress on many communities and challenging development efforts. It is becoming more difficult to predict future climate based on historical baseline conditions or trends. This uncertainty is increasing project design risks and community vulnerabilities. In response, project designers should include a focus on climate change adaptation—defined as adjustment to natural or human systems in response to actual or expected climate change effects. Successful solid waste management projects include efforts to moderate climate-related risks and vulnerabilities and to take advantage of potential benefits to improve the likelihood of long-term project success. At the same time, project design should assess the potential contribution of a proposed solid waste project to greenhouse

gas emissions on climate, and reduce contributions by selecting from cost-effective strategies and actions that minimize these emissions. This Guideline provides information on the relationship between climate change and solid waste management project design, construction, operation and maintenance activities. Taken individually, impacts of small solid waste management activities may appear minimal, but collectively, their scale and magnitude can have far reaching effects on human health and life-sustaining natural systems.

When making use of climate change scenarios, those involved in solid waste management projects need to take adequate account of the associated uncertainties around climate change and plan for robustness through adaptive management. Risk management frameworks can be used to understand the implications of uncertainties about climate change impacts when informing planning, investment and operation decisions in the solid waste sector.

POTENTIAL ENVIRONMENTAL IMPACTS FROM SOLID WASTE MANAGEMENT ACTIVITIES

The typical municipal solid waste stream will contain general wastes (organics and recyclables), special wastes (household hazardous, medical, and industrial waste), and construction and demolition debris. Improper waste management activities can:

- **Increase disease transmission or otherwise threaten public health.** Rotting organic materials pose great public health risks, including, as mentioned above, serving as breeding grounds for disease vectors such as rats and flies. Waste handlers and waste pickers are especially vulnerable and may also become vectors, contracting and transmitting diseases when human or animal excreta or medical wastes are in the waste stream. (See the discussion on medical wastes below and the separate report on “Healthcare Waste: Generation, Handling, Treatment, and Disposal” in this series.) Risks of poisoning, cancer, birth defects, and other ailments are also high.
- **Contaminate ground and surface water.** Municipal solid waste streams can bleed toxic materials and pathogenic organisms into the leachate of dumps and landfills. (Leachate is the liquid discharge of dumps and landfills; it is composed of rotted organic waste, liquid wastes, infiltrated rainwater and extracts of soluble material.) If the landfill is unlined, depending on the drainage system and the composition of the underlying soils, this runoff can contaminate ground or surface water. When leachate from sanitary landfills is discharged into surface water it will similarly contaminate these bodies. Many toxic materials, once placed in the general solid waste stream, can only be treated or removed with expensive advanced technologies. Currently, these are generally not feasible in most parts of Africa, Asia, and Latin America and the Caribbean. Even after organic and biological elements are treated, the final product remains harmful.

Flood Risk from Uncollected Waste

Uncollected solid waste blocks drains, and causes flooding and subsequent spread of waterborne diseases. This was the cause of a major flood in Surat, India in 1994, which resulted in an outbreak of disease, affecting 1,000 people.

Annual floods in East and West African and Indian cities are blamed, at least in part, on plastic bags blocking

- **Create greenhouse gas emissions and other air pollutants.** When organic wastes are disposed of in deep dumps or landfills, they undergo anaerobic degradation and become significant sources of methane, a gas with 21 times the effect of carbon dioxide in trapping heat in the atmosphere (see “Climate Change” section below). Garbage is often burned in residential areas and in landfills to reduce volume and uncover metals. Burning creates thick smoke that contains carbon monoxide, soot and nitrogen oxide, all of which are hazardous to human health and degrade urban air quality. In addition, combustion of polyvinyl chlorides (PVCs) generates highly carcinogenic dioxins.
- **Damage ecosystems.** When solid waste is dumped into rivers or streams it can alter aquatic habitats and harm native plants and animals. The high nutrient content in organic wastes can deplete dissolved oxygen in water bodies, denying oxygen to fish and other aquatic life forms. Solids can cause sedimentation and change stream flow and bottom or benthic habitat. Siting dumps or landfills in sensitive ecosystems may destroy or significantly damage these valuable natural resources and the services they provide.
- **Injure people and property.** In locations where shantytowns or slums exist near open dumps or near badly designed or operated landfills, landslides or fires can destroy homes and injure or kill residents. The accumulation of waste along streets may present physical hazards, clog drains and cause localized flooding.



An open refuse dump in downtown Segou, Mali. During the rainy season part of the dump is submerged in water, threatening the health and water supply of the surrounding area.

Preventing Pollution in Puerto Barrios, Guatemala: *Making Cities Work* Partnership Fund

With nearly half of the population of Central America living in urban areas and an annual urban growth rate of 4 percent, the environmental degradation caused by urban pollution is one of the main problems jeopardizing sustainable development in the region. Local governments usually lead and direct efforts to solve air and water pollution, solid waste collection and management, and water and sewage treatment. However, in Central America, most local governments and private sector groups lack the knowledge and infrastructure to properly address environmental problems.

Puerto Barrios is an international commercial seaport on the Caribbean coast of Guatemala. However, uncontrolled waste disposal and the discharge of untreated waste into nearby water bodies (the Atlantic Ocean and the Escondido and Zapatero Rivers) are threatening the port's viability. Open dumps produce a wide range of public health problems, creating breeding grounds for disease vectors such as rats, cockroaches, and flies, contaminating surface and groundwater, and contributing to air pollution through uncontrolled burning of waste. Disposal of untreated hospital waste and gas explosions present further hazards.

USAID's Regional Urban Development Office for Latin America and the Caribbean, in cooperation with the USAID/G-CAP funded Local Environmental Policy and Program Initiative (LEPPI), is working in Puerto Barrios on a pilot project to reduce environmental pollution. This project addresses the management and disposal of solid waste and the reduction of contamination caused by the discharge of wastewater into rivers. The *Making Cities Work* Grant involves the organization of a local Environmental Steering Committee that has coordinated the development of an environmental action plan and a feasibility study on solid waste. As a result, the city is moving toward a more efficient and rational solid waste collection system by:

- Constructing transfer stations and a material recovery facility for handling recyclables and providing training and technical support to the Municipal Board and to the local Environmental Steering Committee to operate the facility.
- Designing a sanitary landfill; planning collection routes.
- Establishing an environmental education program for schools and residents.

In addition, LEPPI supports efforts to organize individuals who are collecting reusables and recyclables from the municipal dump into a recycling and composting microenterprise. The experience of Puerto Barrios demonstrates how a participatory planning approach can effectively identify local resources and address community issues in an integrated manner.

CLIMATE CHANGE

PLANNING FOR A CHANGING CLIMATE

Sea level rise, shifting temperatures and precipitation patterns are climatic changes to baseline conditions that affect solid waste management projects. Climate change will also lead to an increase in the frequency, intensity, and duration of extreme events such as droughts, floods, high winds, and tropical storms. Therefore, solid waste management system design, construction and operation must also take these into account. For solid waste projects designed to last for decades or more, they must be able to withstand exposure to an altered climate and be resilient to deviations from historical conditions. Specifically those aspects of solid waste management design, construction and use

sensitive to weather (e.g., location, vulnerability to flooding or rising water tables, increased precipitation, and extreme rain and wind events) requires greater attention to risk analysis and climate change probabilities than in the past, to help ensure that appropriate designs are selected and the long-term success of solid waste management programs are achieved. Control of leachate into surface and ground water from solid waste disposal sites must be a prime focus for site selection and design.

Of particular concern in the solid waste sector are potential climate impacts on disposal sites as well on management facilities and collection and transportation systems.

ADAPTING TO CLIMATE CHANGE BY MINIMIZING VULNERABILITY THROUGH PROJECT DESIGN

Adapting solid waste management to climate change involves planning for the effects of extreme climate events on collection systems, transfer stations, processing and recycling facilities, and disposal sites. Design and siting for structures near the sea should take into account potential changes in daily sea levels, sea rise, and storm surges. The same principle applies to construction near flood plains, rivers and wetlands. Designers and project managers now must focus on incorporating information on climate from both past baseline trends, as well as mid-term projections (e.g., next 25-50 years, where feasible). In many cases, managing for greater uncertainty and risk associated with potential extreme conditions, rather than past historical trends, emphasizes the **precautionary principle** over “**business as usual**.”

Adapting planning, design, and project execution to climate change involves ensuring that new waste management structures are able to withstand changes and variations in climatic conditions and especially extreme weather events. For example, design and siting for solid waste landfills, transfer stations and recycling facilities should take into account projected sea level rises, and storm surges. The same principle applies to solid waste facilities located in or near flood plains, rivers and wetlands. Constructing landfills or recycling facilities in these areas should be avoided whenever possible. Increases in wind and extreme wind events, flooding and fluctuating water table conditions associated with climate change must also be addressed to minimize potential contamination at disposal sites. Control of leachate from solid waste disposal sites must be a primary concern to prevent contamination of surface and ground water.

Climate change adaptation also includes integrating renewable and/or back up energy systems to maintain solid waste collection and disposal in the event of sudden or intermittent flooding or fuel shortages.

From a **risk management** perspective, it is less costly to design for the potential direct and indirect impacts of climate change on solid waste management projects, than risk major losses or damage to landfills or processing facilities or face loss of service in the future. This type of focus on risk analysis and management is commonly applied by the financial and insurance industries and can also be used in assessing development activities.

In the context of EIA, mitigation is the implementation of measures designed to eliminate, reduce or offset the undesirable effects of a proposed action on the environment.

In the context of climate change, mitigation is an intervention to reduce the sources or enhance the sinks of greenhouse gases in order to limit the magnitude and/or rate of climate change.

DIRECT IMPACTS	INDIRECT IMPACTS	POSSIBLE ADAPTATION RESPONSES
ILLUSTRATIVE EXAMPLES	ILLUSTRATIVE EXAMPLES	ILLUSTRATIVE EXAMPLES; ADAPTATION RESPONSES SHOULD BE TAILORED TO LOCAL CIRCUMSTANCES
<ul style="list-style-type: none"> • Inundation of solid waste landfills from sea level rise • Damage solid waste landfills from excessive heat 	<ul style="list-style-type: none"> • Adverse impacts on health due to damages done to the landfills • Higher operating and maintenance costs and/or shorter lifetime of the landfills • Loss of transportation system efficiency 	<ul style="list-style-type: none"> • Design back-up for these extreme situations • Relocate landfills to less exposed locations • Increase financial and technical resources for more frequent maintenance and repairs • Establish natural buffer zones on coasts • Update design standards

MINIMIZING GREENHOUSE GAS EMISSIONS AND MAXIMIZING SEQUESTRATION

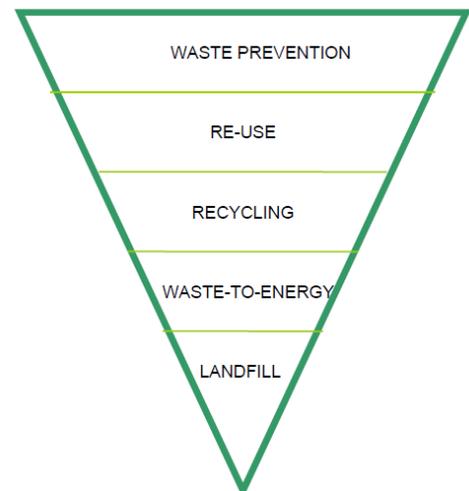
The greenhouse gas emitted from solid waste is primarily methane, but also includes carbon dioxide and nitrous oxide. While the sector is responsible for less than 5 percent of total anthropogenic emissions, the waste sector is in a position to manage and use these gases because they are produced at disposal sites. This could help shift the sector from being a source of emissions to an emissions sink. While all waste management practices generate greenhouse gases directly (i.e. contribute emissions) and indirectly (i.e. through energy consumption), the overall climate impact depends on net greenhouse gases—including downstream reductions.

A holistic approach to waste management has potentially positive consequences for greenhouse gas emissions from the energy, forestry, agriculture, mining, transport, and manufacturing sectors. While minor levels of emissions are released through waste treatment and disposal, the prevention and recovery of paper and organic wastes (e.g., to capture landfill methane and recycle paper products) reduces fossil fuel use and avoids emissions in other sectors of the economy.

One other option that has been used in some countries is waste-to-energy (WTE) plants for electric power generation

In the practice of EIA, mitigation is the implementation of measures designed to eliminate, reduce or offset the potential adverse effects of a proposed action on the environment.

In the practice of climate change, mitigation is an intervention to reduce GHG sources and emissions or to enhance the sequestration of GHG's by natural means (e.g., uptake by trees, vegetative cover, algae) or the use of technology (e.g., underground carbon storage) to limit the magnitude and/or rate of climate change.



and/or heat production. These have a high up-front investment cost and toxic emissions from such units should be controlled. When coupled with effective end-of-pipe air pollution controls and waste disposal techniques, WTE plants can potentially reduce both waste volumes and greenhouse gas emissions.

General global consensus exists that climate benefits from waste avoidance and solid waste source reduction far outweigh the benefits from any waste treatment technology or recycling, even where energy and materials are conserved during the process. However, improved waste management infrastructure, organic waste recovery and recycling in developing countries also mitigate emissions. By prioritizing waste minimization, re-use, recycling, composting, waste-to-energy, and utilizing landfills only as a last option, the solid waste management sector may help mitigate the impacts of climate change. This prioritization scheme is well illustrated by the International Solid Waste Association Waste Hierarchy (above right).⁴

SECTOR DESIGN – SOME SPECIFIC GUIDANCE

Experience and study of solid waste collection programs in various parts of the developing world have identified a set of program elements and common pitfalls as well as a number of operations strategies to meet operational requirements and avoid common problems. Successful programs:

- Apply an integrated holistic approach that takes into account key factors affecting waste generation, storage, and final disposition.
- Secure or establish stable financing and ensure funds are used appropriately.
- Carefully design, develop and implement privatization schemes after weighing the potential costs and benefits.
- Involve the community in waste-management decision making.
- Build capacity of administrative and technical staff in government, NGOs and/or the private sector.

INTEGRATED WASTE MANAGEMENT

The adverse impacts of waste management are best addressed by establishing integrated programs where all types of waste and all facets of the waste management process are considered together. Although financing is always a concern, the long-term goal *should* be to develop an integrated waste management system and build the technical, financial, and administrative capacity to manage and sustain it.

A waste management program should be appropriately tailored to local conditions and that practical environmental, social, economic, and political needs and realities are balanced. Answering the following key questions will help achieve this goal:

⁴ Adapted from UNEP. Waste and Climate Change: Global Trends and Strategy Framework. 2010. <http://www.unep.or.jp/ietc/Publications/spc/Waste&ClimateChange/Waste&ClimateChange.pdf>

- Are adequate financial and human resources available to implement the specific waste management activity whether it relates to introducing a policy, the overall program, or a specific technology?
- Is this the most cost-effective option available?
- What are the environmental benefits and costs? Can the costs be mitigated?
- Is the policy, program, or technology socially acceptable?
- Will specific sectors of society be adversely affected? If so, what can be done to mitigate these impacts?



An illegal dumpsite south of Sumbe, Angola. A well-designed waste management plan can minimize illegal dumping and mitigate severe environmental damage.

For a detailed discussion of key objectives and issues to be addressed in municipal solid waste management strategies, see the UNDP *Conceptual Framework for Municipal Solid Waste Management in Low-Income Countries* listed under references in this document.

FINANCING

SOURCES OF FUNDING

Possible sources of funding for construction and operations are:

- **Communal or municipal funds.**
- **Taxes.** One potential problem of incorporating waste management fees within local tax systems is that inclusion in local taxes will not work if tax collection is deficient, or if the transfer to management committees is not secured. This general taxation method also dissociates waste management costs and revenues.
- **User charges (flat or graded rate).** Block rate pricing could be used in solid waste as well. This method charges a low rate for collection of a basic amount of garbage (the poor usually produce less waste) and higher rates for additional blocks.
- **Metering the amount of electricity used** may be used as a proxy for the amount of solid waste generated by a user. Because electricity consumption is closely correlated with waste generation, fees for waste collection can be tied to electricity use and integrated into household the electrical bills. The utility company may charge an administrative fee for handling such billing.
- **Domestic sales of emission reduction credits** from methane digesters, WTE units, and incinerators with air pollution controls. This could be an attractive option for countries that adopt

cap-and-trade emission trading systems (note that these systems could potentially be for reduction of criteria pollutants harmful to human health as well as GHGs).

- **Vending arrangements**, such as:
 - Shared private connections and sanitary blocks serving clusters of households. In this system, users pay in cash for each use. This system combines well with garbage collection depots.
 - Metered group connections paid for by a user group with its own group committee. This system is comparable to a community or group paying a private operator to collect solid waste in its area. In this case, the group is sold service from the municipal government at a bulk rate and determines its own systems for distribution and fee collection. The municipality can offer additional benefits such as exemption from certain local taxes, or a subsidy to buy equipment.
 - Concession system. A system where local private operators of solid waste collection systems (micro-enterprises) obtain a license or concession from the local government. This may or may not involve community management.
- **Local revolving funds or credit circles.** Voluntary funds, however, often do not generate enough money for effective solid waste management. Other funds that require a communal production base may not be effective in cities.
- **Lotteries and auctions.**
- **Raffles, bazaars, or entertainment (such as movie showings).**
- **Donations from prominent individuals.**
- **Launching community-based organizations.**

FEE COLLECTION

Willingness to pay, combined with ability to manage, is a good measure to assess the feasibility of a community-based project. A service is considered affordable when a community perceives it as valuable. While this strategy will lead to the desired level of service, it is not necessarily the simplest or cheapest approach from an operator's perspective.

Ways to generate more revenue from fee collection include:

- Change type of payment.
- Change tariff system to reflect:
 - Level of service. Different rates could be used for collection from communal, curbside, or house-to-house collection points.
 - Type of user (domestic, institutional, commercial, or industrial).
 - Income level.
 - Property value or characteristics.
 - Amount of waste to dispose (measured by size or weight of bin).

- Educate people on the benefits of their financial obligations. Use community meetings to review the billing rate, fee collection plan, and encourage regular payment.
- Give fee collectors more personal benefits.
- Establish/enforce sanctions for non-payment.
- Fee collection by operators or respected community members rather than by government officials. Small user groups or operators can collect fees via house-to-house collection, via community meetings, via deposits on bank accounts, at government offices, or through payment in cash directly at waste disposal location. For women, payment at central places may be culturally less appropriate than home collection. Payment on a savings account is also an effective strategy because women can make small deposits and poor people can join projects that require larger deposits or tariffs.
- Set fees with the assistance of community organizations. (See section on community based management of solid waste).

ACCOUNTABILITY AND REPORTING

Accountability and reporting are also aspects of financing a solid waste management project. Means of improving accountability and reporting include:

- Provide bookkeeping training, account books, water fee collection cards, etc., and employ teachers or women as treasurers.
- Avoid misuse of funds by requiring two or three committee member signatures, or one signature from someone with of the assisting NGO, to withdraw money from the bank.
- Sign a contract between the management committee and the community detailing rights and responsibilities, including reporting, for both parties. (See section on community- based management of solid waste).
- Communicate financial reports through:
 - Bulletins distributed to households.
 - Oral reports given by the treasurer at community meetings followed by questions and answers.
 - Written reports on large sheets of paper and posted on walls in public places, particularly where people come to pay their bills.
 - Waste committee meetings dealing with financial matters and open to the community.
- Provide training in accountability to:
 - Treasurers, on how to make simple summaries of costs and expenditures, and how to present these to committee and general user assemblies.
 - Committees, on how to account to the users for their performance.
 - Users, on their rights and how they can arrange for accountability (e.g., through statutory annual meetings and an independent audit committee for checking the books.)

PRIVATIZATION

Privatization is the gradual process of disassociating state-owned enterprises or state-provided services from government control and subsidies, and replacing them with market-driven entities. In the context of municipal services, privatization generally implies reducing local government activity within a given sector by:

- Involving participation from the private sector; or
- Reducing government ownership, through divestiture of enterprises to unregulated private ownership, and commercialization of local government agencies.

Private sector participation leaves municipal resources available for urban infrastructure and equipment. Privatization of urban services also can reduce the cost of public services to consumers; relieve the financial and administrative burden on the government; increase productivity and efficiency by promoting competition; stimulate the adoption of innovation and new technology; improve the maintenance of equipment; and create greater responsiveness to cost control measures.

There are five basic modes of privatization:

1. **Concessions:** a contractual arrangement whereby a private operator is selected and awarded a license to provide specified services over a discrete period of time in return for a negotiated fee. The concession agreement sets out the rights and obligations of the service provider, who generally retains ownership of the principle assets. This method is well suited to enterprises which provide services that are economically and socially important and need significant improvement; are large and usually enjoy a monopoly position; are politically and/or practically difficult to sell; and are in need of investment capital, e.g., trucks and bins.
2. **Management contract:** a contract placing a municipal service under private management for a specified period of time, for which the contractor is paid a fee. The fee may be based partly on performance. The private manager has extensive autonomy, as set out in the contract.
3. **Commercialization:** a process in which the city authority forms a wholly owned subsidiary. Shares of the new company are restricted, and consumer representatives, the local government and other stakeholders make up the board of directors. The ownership of assets, regulation of tariffs and quality control remain at all times vested in the municipal authority. This method is suitable for managing water supplies.
4. **Franchise:** a process in which the city authority awards, through competition, a finite-term, zonal monopoly to a private firm for the delivery of service. The private firm pays a license fee to cover the government's costs of monitoring and recovers earned revenue through direct charges to households and the establishments served. The city authority provides control over the tariff charged to the consumer. This method is suitable for solid waste management.
5. **Private enterprise/entrepreneurship:** a mode whereby the city authority freely allows qualified private firms to compete for service delivery. Individual households and establishments make private arrangements with individuals firms who compete for business. Under such arrangements, city councils license, monitor, and (as needed), sanction the private firms. Private firms bill their customers directly.

CRITERIA FOR PRIVATIZATION

In deciding whether to privatize a specific aspect or portion of its service, a government needs to weigh the risks—political manipulation, changing environmental regulations, government tariff regulation,

currency devaluation, inflation, and unclear taxation systems—against the economic benefits of private sector efficiency. The following criteria may be helpful in considering private sector involvement in solid waste management services (adapted from Cointreau-Levine, 1994):

- **Ease of defining outputs.** Ensure that defined, measurable outputs of the proposed service are incorporated in written performance specifications to clearly establish public and private sector deliverables. The government must have the resources and capabilities to monitor service levels and enforce penalties for noncompliant behaviors.
- **Efficiency.** Consider reasons for public and private sector inefficiencies, including cost accountability, labor tenure, government wage scales, restrictive labor practices, personnel benefits, inflexible work arrangements, bureaucratic procurement procedures, political limitations, and hiring and firing procedures. Assess options for reducing or removing these barriers. Give preference to plans offering economies of scale.
- **Capability.** Ensure that adequate government capacity exists for planning, design, construction, operation, maintenance and oversight. Evaluate both the public and private sectors for technical and financial resources, including expertise, skills and access to capital. Private companies must possess required facilities and equipment, or have a business plan that covers them. Governments must have both the capability to monitor performance and the political will to enforce contractual or license agreements.
- **Competition.** Ideally, a privatization plan will allow for competition between a number of private firms or between the government and a few private firms. Consider possible barriers to market entry and exit, as well as economies of scale that might limit competition. Determine if financial incentives or technical assistance would result in better performance from private firms. Ensure the government's ability and commitment to conducting a competitive procurement process.
- **Duplication.** Ensure that the government has the political will to cut personnel and assets when services are privatized. Balance the cost savings from reduced staff with new monitoring and enforcement costs.
- **Risk.** In some developing countries, commercial lenders and private companies do not want to risk their money on long-term or large-scale investments that rely on government payments. Regulatory framework must exist to protect the private sector against risks such as environmental damage, currency adjustments, inflation and political changes. Local governments must be able to generate enough revenue to meet contractual agreements with the private sector and protect against economic instabilities. Plans should include provisions for loss due to corruption (kickbacks, bribes and favors).
- **Accountability.** Ensure that private sector participation will not disproportionately benefit wealthy classes. Market openings should be made available to small- and medium-size enterprises, helping to redistribute income. Government must guarantee a fair minimum wage and safe working conditions. Government should also make provisions for displaced workers, including job training and employment networking.
- **Costs.** The costs for public waste collection services must be well understood. Cost factors should be analyzed separately for the different components of solid waste service—collection, cleansing, disposal and transfer. Government must have detailed accounting information to determine whether private sector participation would be more cost-effective. A strategic planning and feasibility study should be conducted to know whether the technology offered by the private sector would result in lower costs.

These criteria help to determine the extent to which a society is open or closed to competitive market forces, whether the procurement process is straightforward or opaque, how interrelated and transparent taxation and subsidies are, and the extent to which corruption skews the system. Moving public services to the private sector will be efficient only where competition, performance monitoring and accountability exist.

Privatization: Beneficial But No Panacea

Solid-waste management (SWM) in Dar es Salaam is the responsibility of the Dar es Salaam City Council (DCC). An estimated total of 1,929 tons of waste is generated daily from households, businesses, institutions and market centers. Before the decision to privatize solid-waste collection and disposal, the City Council was only able to manage 2–4 percent of the waste generated daily.

The main reasons for this inability to manage waste collection were:

- Lack of equipment (trucks and machinery).
- Lack of funds to replace equipment, purchase spare parts, service existing equipment and fuel them. Historically, DCC has allocated less than 8 percent of its total budget for SWM. Out of the 30 trucks and machinery donated by the Japanese government in 1987, only three were operational in 1992. In addition, the operational vehicles functioned at less than 20 percent of capacity.
- Lack of an official disposal site. The only “dump site” in the city was closed following an August 1991 court ruling in favor of residents of the Tabata area who complained of air pollution caused by burning waste dumped at the site.
- Lack of involvement of other stakeholders.

The DCC chose to try privatization to improve waste collection services. Privatization was accomplished in two phases, Phase I from 1992 to 1996, and Phase II from 1996 onwards. For Phase I, a single contractor was assigned to collect waste from 10 city wards and empowered to charge customers directly. For Phase II, four additional firms were given contracts through a process of open tendering, making a total of five contractors servicing 13 wards.

The major achievements realized during the first phase of privatization included:

- Establishment of a solid-waste management partnership advised by a multi-disciplinary stakeholder working group.
- More efficient service and revenue collection. Households responded positively to the need to pay for refuse collection. Initially, collection of solid waste improved to 70 percent of waste generated. However, this rate started to decline six months after the engagement of the private contractor, for reasons outlined below.
- 318 jobs were created for workers employed by the contractor. Also, human resources and stakeholders were used more efficiently; whereas 800 DCC workers collected only 30–60 tons per day, 318 workers under the private contractor collected 100 tons per day.

The problems identified in the first phase of privatization included:

Non-fulfillment of obligations from all parties. Under the contract, the contractor was supposed to pay the DCC the monthly costs of renting trucks, a leased depot, and the refuse disposal charges at the dump. DCC was obliged to pay revenue collection charges for the services provided by the contractor at DCC-owned premises like schools, hospitals, offices, etc. Unfortunately, neither party paid the other, and the DCC withdrew its facilities in September

1995. Also, the DCC was responsible for the public awareness campaigns among residents of the privatized area, and for prosecuting customers who defaulted on refuse collection charges (RCCs). When the defaulters were not prosecuted, the contractor's ability to collect revenue was further limited.

Lack of competition. Using only a single contractor did not result in optimal pricing for the consumer or overall system efficiency.

Poor monitoring. Staffs of both the DCC and the contractor were unfamiliar with privatization of solid-waste collection and disposal, leading to poor monitoring and oversight.

Lack of well-functioning management information system (MIS) to track payment information.

Problems within the contract agreement. Some of the items within the contract were not well elaborated, such as the period when RCCs would be reviewed, how to deal with complaints by the refuse producers, how to monitor the daily operation of the contractors, and methods of arbitration.

During Phase II, the daily solid-waste collection increased in the newly contracted wards. Solid-waste heaps were reduced, especially in open spaces and market places. However, the constraints were similar to phase I, including inadequate payment of RCCs to the contractors. Preparations were insufficient to involve and raise awareness of people on the new strategies to clean the city and the responsibilities of individuals and stakeholders. Inadequate revenue collection prevented contractors from meeting financial targets. Contractors' equipment and facilities were inadequate, and they failed to meet promises to purchase replacements. DCC was unable to provide an enabling environment for the contractors (e.g., information on residents liable to pay RCCs, an effective public awareness campaign). The contractors required close supervision, monitoring, support for planning, technical advice and financial assistance. All households were not treated equally in all wards.

Source: Privatization of Municipal Services In East Africa: Governance Approach to Human Settlements Management, UN Center for Human Settlements

LIMITATIONS OF PRIVITIZATION

To be successful, privatization of solid-waste management must contend with a variety of problems, including insufficient public awareness and little ability to generate the necessary public participation in planning, administering, or monitoring; managerial deficiencies and weaknesses in local authorities that make it hard to carry out policy reform measures; and lack of experienced and competent personnel to administer and manage the privatization process (see privatization story on the previous page). Municipal councils opting to privatize or commercialize their services often find that they need to upgrade all staff in accounting, auditing, information management, policy development and implementation to make these options work.

Although private solid-waste entrepreneurs work all over a city, most activity is concentrated in residential neighborhoods and biased towards middle- and higher-income households who can be relied upon to pay for services. Little or no private sector solid-waste collection activity occurs in low-income areas, due to inability to pay rather than lack of access to these areas. Large firms usually serve wealthy areas, while small firms generally serve a single, middle or lower-middle income neighborhood. Informal private sector waste entrepreneurs or "scavengers" operate in all areas. The impact of the informal sector should not be underestimated. Research for a UN publication indicates that informal recyclers handle 27 percent of the waste generated in Delhi, India, or 1,800 tonnes of waste every day, which the city would otherwise have to pay to collect and dispose of.⁵ In this case

⁵ Scheinberg, A., D.C. Wilson, and L. Rodic-Wiersma. (2010). Solid Waste Management in the World's Cities: Water and Sanitation in the World's Cities. Earthscan for UN Human Settlements Program (UN-HABITAT). http://waste.nl/sites/default/files/product/files/swm_in_world_cities_2010.pdf

primary collection is done by authorized informal sector collectors/ recyclers, who deliver the waste by hand cart to a large private sector operator who provides secondary collection from communal bins.

Although popular belief states that the private sector will field better-maintained refuse collection vehicles, this is not usually the case. Unless contracts provide incentives for the private firms to invest in appropriate equipment, firms lease second-hand dump trucks that frequently break down.

COMMUNITY-BASED MANAGEMENT OF SOLID WASTES (CBM)

Community participation in solid waste management encompasses several forms of local involvement, including:

- Awareness and teaching proper sanitary behavior;
- Contributing cash, goods, labor; and/or;
- Participating in consultation, administration, and/or management functions.

At the most basic level, participation might be providing separated waste at a particular time to the waste collector or granting space to park waste management vehicles. With greater public participation, the community can cooperate with public or private entities to set payment rates for service charges. Community management, the highest level of community participation, gives the community authority and control over operation, management and/or maintenance services benefiting its members. Community management may come about through partnership with governmental agencies and NGOs.



Encouraging recycling can help build capacity among local micro-enterprises and reduce the waste handled by landfills and dumps. (Photo courtesy of United Nations Development Programme)

Community-based waste management CBM projects require institutional support and recognition in order to be successful. An integrated system – including waste separation at the source, resource recovery, and composting of organic waste – requires representation of waste pickers, and integration of the community to work with all land stakeholders, including representatives of waste pickers. Local leaders are often active in management of the service or maintain close contact with the municipality or community management body. Women and teens can play crucial roles, such as initiators, managers, operators, political activists, educators, and watchdogs for the community.

Community-based management (CBM) may also address the following social and management problems:

Low participation of households: Households may not participate in waste management programs because they may view solid waste management as a low priority. They may be unwilling to participate in collection systems or in keeping public spaces clean, or they may be unwilling to pay for services. Community provisions for awareness raising are often key to overcoming the best counter to these barriers, but traditional approaches to waste management often do not allot sufficient resources for this. Community-based solutions can use preliminary research and input to generate a list of desired services, appropriate incentives for households and servants, and systems for cleaning streets and other public places.

Management problems. Problems with traditional waste management schemes include ineffective, inefficient, or unrepresentative management, as well as lack of community accountability. CBM can introduce performance control techniques, share management with an NGO, adjust or by-pass an existing management committee, or provide incentives for managers, such as training and exchange visits.

Operational problems. When operators are not motivated due to low salaries, low status, and/or bad working conditions, public service can often become unreliable. Finding adequate space for waste facilities and equipment is another potential operational issue. Sound CBM can address motivational problems by involving operators in decision-making, using special group incentives, and, in some cases, by granting exemptions from municipal taxes. Operators can be officially introduced to households and provided with identity cards to improve operator status. Space problems can be resolved by lobbying municipalities and local leaders, as well as conducting media campaigns in the neighborhood.

Financial difficulties. Public and private management plans often face financial difficulties caused by inadequate fee collection and inability to pay for service in low-income neighborhoods. CBM allows for community input into plans for fee collection payments, and incentives and sanctions for non-payment. Community input can also help waste management providers find lead to additional revenue-generating services.

Lack of municipal cooperation. If waste collection between the municipal government and private operators is badly coordinated, the community may lose interest in trying to improve the waste situation. Extending service, mobilizing communities to lobby the municipality for assistance, involving local authorities, and structuring formal and informal opportunities for cooperation all improve municipal performance and community support for waste management plans and programs.

CAPACITY BUILDING

Insufficient capacity is a fundamental impediment to sound solid waste management programs in much of the developing world. Operating an efficient, effective, environmentally sound municipal solid waste management program requires building administrative capacity for government and private sector players and technical capacity for designing, operating, maintaining, and monitoring each part of the process.

Often the people working in solid waste management—private sector companies, NGOs, and government entities—lack the technical and financial knowledge to operate efficiently. Training that builds human resource and institutional capacity at appropriate levels is essential. Peer-to-peer training for everyone from waste-pickers to local government officials has proven effective in extending and sustaining these programs.

Integrating the Informal Sector

In Rufisque, Senegal, an innovative community initiative helped extend solid waste collection services to 3,000 households by employing horse-drawn cart operators, contracted to work two hours a day to collect refuse from households. The operators were free to work the rest of the time as general haulers. The local municipality is involved in all stages of the initiative—it is regularly represented at community meetings, assigns and approves collection routes, and maintains contractual relationships with cart operators.

Source: UNESCO, MOST Clearing House Best Practices Database. June, 2000

ENVIRONMENTAL MITIGATION AND MONITORING GUIDELINES

In design and operation, integrated solid waste management programs aim to:

- Minimize the quantity of waste that must be placed in landfills through elimination, recovery, reuse, recycling, remanufacturing, composting and similar methods.
- Manage non-hazardous wastes and special or hazardous wastes separately.
- Collect and transport all waste effectively and efficiently.
- Design sanitary landfills and ensure appropriate siting, operation, monitoring and closure.
- Establish sound fiscal and administrative management, privatizing operations with open competition whenever feasible.

The recommendations that appear later in this section are summarized in the table below:

POTENTIAL ADVERSE IMPACT	MITIGATION MEASURES
Reusable materials are not collected or properly managed	<ul style="list-style-type: none"> • Build awareness and create systems to reduce, reuse, and recycle. <ul style="list-style-type: none"> ○ Organize collectors and publicize prices for recoverable materials regularly entering the waste stream. ○ Foster secondary markets/demand from local businesses to use recovered material. ○ Offer incentives to maintain a high recovery rate (e.g., glass bottle deposit). • Facilitate separation at the disposal site to ensure highest quality to end-users. • Promote composting and anaerobic digestion of organic material to maximize landfill capacity and lessen leachate and methane pollution. See below for large, small, and/or local composting options.
Unwanted waste does not reach landfills or recycling centers	<ul style="list-style-type: none"> • Select appropriate collection technology for the region, such as regular trucks if specialized compaction trucks are not available or economical. • Integrate already-established informal sectors such as co-operatives and microenterprises into the waste collection process to keep costs low and build capacity. • Introduce transfer points where local waste is collected and separated before being transported to the landfill or recycling facility to promote fuel efficiency and vehicle lifespan. • Promote direct fee-for-service and local financing instead of collecting revenue by taxes. To promote payment, incorporate these fees into electricity bills (if applicable).

POTENTIAL ADVERSE IMPACT	MITIGATION MEASURES
Public health, safety, and environmental risks	<ul style="list-style-type: none"> • Avoid the creation/use of open dumps where possible. If open dumps are currently being used, implement practices to minimize impacts on public health, safety, and the surrounding environment. • See methods below for transforming open dumps into controlled dumps or sanitary landfills. • Use appropriate siting and design measures when constructing a new landfill, such as environmental impact assessments, installing low-permeability linings, and leachate collection and treatment. • Manage leachate and pollutants physically, chemically, and biologically at lined landfills, with groundwater monitoring, gas recovery and reuse, and fences. • Do not construct incinerators for municipal solid waste.
Mismanagement of hazardous and other types of waste	<ul style="list-style-type: none"> • Hazardous wastes pose a wide range of serious risks and should be handled immediately and cautiously. Manage hazardous wastes from cradle to grave through waste reduction, segregation, safe handling, and disposal. See below for examples of hazardous waste facilities in developing countries. • Reuse or retread tires, refine oil, and recycle lead acid batteries. • Return to the supplier, reuse, or recycle all construction materials. Inventory re-usable items, recover resources on-site and during demolition, and use crushing and milling practices for secondary stone and concrete materials.

WASTE MINIMIZATION

Reduce, reuse, recycle. Reducing the quantity of waste that must be transported and disposed of should be a primary goal of all municipal solid waste management programs. Waste should be recovered at the source, during transport or at the disposal site. The earlier the separation, the cleaner the material, and, in the end, the higher its quality and its value to users. Incentives which integrate and foster the involvement of the informal sector—itinerant collectors, microenterprises, cooperatives—can be essential to improved waste minimization. Other tips on reducing waste include:

- **Organize itinerant collectors and publicize prices.** In cities throughout Africa, itinerant collectors recover high-value recyclable materials at residences and small industries. Organizing collectors can improve both their standard of living and the stability of the collection services. Publicizing prices can help stimulate the market and mitigate possible exploitation by intermediaries.
- **Foster secondary markets.** The extent to which a material is recovered is dependent on the existence of local industries that can use the recovered material. Secondary markets to serve these industries do not always develop independently. Consider developing a program to identify and develop such markets where there is untapped demand.

Tradeoffs Between Curbside Recycling and Centralized Collection Centers

While curbside recycling may be more convenient for many individuals, collection centers may be more cost effective. For example, Brazil and Mexico have experimented with curbside collection of recyclables, but its economic viability has not proven favorable. However, centralized collection centers set up outside of supermarkets have been used with some success in Argentina, Brazil, Columbia, and Mexico.

Planning should incorporate local experience and be informed by social norms on what will

- **Offer incentives.** A deposit system on glass bottles has maintained a high recovery rate throughout the continent. South African beverage manufacturers also issue deposits for tin and aluminum cans, which have generated high levels of reuse. Modest incentives have had promising results in Latin America as well: in Curitiba, Brazil, people receive bus tickets and vegetables in exchange for recyclables.

Facilitate separation at disposal site. When waste pickers are allowed access to disposal sites, significant amounts of material can be recovered. However, because they interfere with efficient operation of dumps and landfills, waste pickers are usually excluded from these sites, lowering recovery rates and causing them severe economic hardship. Some sites provide a measure of structured access to waste pickers. At the Bisasar Road landfill in Durban, for instance, registered pickers from an adjacent squatter settlement are allowed into the site after hours, earning US\$77 per month from this activity. At all other times, armed guards restrict access to the site. Similarly, the South African Boipatong landfill limits access to 100 registered waste pickers. In Rio de Janeiro, waste-pickers were organized into a cooperative to recover recyclables from loads originating in high-income neighborhoods—and by 1997 they earned nearly four times Brazil's minimum wage.

Composting and anaerobic digestion. Organics make up 30–80 percent (~70 percent on average) of the waste stream in Africa and 40-50 percent of the waste stream in Latin America and the Caribbean. The specific amount varies with the incomes of the neighborhood, region or country. If this part of the waste stream could be used for compost or methane production, many adverse impacts of open dumps and landfills would be reduced. Landfills would require less space, last longer, and produce less leachate and methane. At this time, little organic recovery and processing are occurring.

- Evaluate the possibility of composting.
 - **Large centralized composting efforts**, designed to separate the organic component from mixed waste, have almost always failed in Africa and Latin America and the Caribbean for reasons which include poor (or absent) feasibility studies and subsequent failure to meet cost recovery expectations. The city of Accra in Ghana has a successful creative variation on this theme: a **co-composting plant** that converts human waste sludge and solid waste to compost which is then sold to recover the plant's operating costs.
 - **Small composting enterprises** have fared somewhat better. Even the higher-quality compost produced from source-separated waste cannot command prices high enough to support operations, causing these businesses to struggle. Higher urban demand or subsidies may be necessary if composting is to become a part of integrated waste management. For example, a city could pay small composting operations for each ton of material that is diverted from landfills and base that payment on the disposal costs the city can avoid.
 - **Backyard composting** is a third option, but may be difficult to coordinate the level of effort needed for a city-level impact. In Uganda, community-based groups are experimenting with backyard composting, using the compost in a variety of ways, from conventional agriculture to producing fishpond algae as fish feed.
- **Promote vermiculture treatment of vegetable food waste.** Small earthworm composting farms, operated by 5–6 people, have proven more successful than traditional composting facilities in developing countries, though they are not yet in widespread use. Vermiculture benefits from better quality control and the cultural perception that the final product, consisting

of “worm castings,” is derived from “clean” vegetable waste, whereas compost is derived from unclean “garbage.” The final product is also more nutrient-rich than compost.

- **Investigate anaerobic digestion.** Anaerobic digestion is a low-temperature biological process that can generate a methane-and-carbon-dioxide-rich biogas that can be used for cooking or heating fuel, or in combustion engines for producing electricity. This process also produces a concentrated nitrogen byproduct which can be used as fertilizer. China and India have installed millions of small-scale household digesters, and several thousand large-scale operations take place in some developing countries including China, South Korea, Brazil, Nepal, and Thailand. Large-scale industrial digesters require greater initial investment, but have lower costs per unit of biogas production. This option has the potential to be cost-effective and is highly competitive with many fossil fuel alternatives.

COLLECTION AND TRANSFER

As noted earlier, most city dwellers in developing countries lack regular waste collection or access to disposal services, except in the better-off neighborhoods or communities. Careful consideration of the city, climate, and culture is essential to achieving universal collection at recommended frequencies. The following general insights from international experience may be valuable:

- **Use appropriate technology—regular trucks and alternative vehicles.** Specialized compaction trucks are very expensive, difficult to repair and often out of service. Moreover, compacting garbage provides little advantage, considering the density of the waste currently produced in most of the region. Regular trucks require less capital investment and are easier to maintain. They may also be better adapted to poor road conditions and can be used for other purposes if the municipality or company decides to transfer collection responsibility to others. For waste collection in hard-to-reach areas—very narrow streets, alleys, deteriorated roads—alternative collection vehicles should be considered, including semi-motorized carts, front-loaded tricycles, donkey carts, or handcarts.
- **Integrate the informal sector.** Co-operatives and microenterprises are the primary users of smaller collection vehicles and can effectively collect waste from hard-to-reach areas at a low cost. Community members are generally more willing to pay for such flexible and inexpensive services. For example, municipalities in some countries—for example, in Bolivia, Columbia, Costa Rica, Guatemala, and Peru—integrate recyclable and solid waste collection with microenterprise and cooperative associations through concessions, contracts, or informal arrangements.
- **Build on the existing system.** Radical changes are often difficult to achieve, especially with limited political support, administrative and technical capacity, or financial resources. Develop new structures and processes as part of a strategy of incremental improvement.
- **Introduce transfer activities.** Transfer activities often increase efficiency, for both small- and large-scale systems. In small-scale transfer, microenterprises or cooperatives bring waste to a centralized area for pickup by private or municipal trucks. In large-scale transfer, waste is transferred from a compactor or small truck to larger trailer trucks. Both types of transfer activities save fuel, reduce wear and tear on trucks, and shorten the amount of time spent traveling to and from the landfill. The farther the landfill is from the city, the greater the benefits of large-scale transfer.
- **Shift to direct fee-for-service and local financing.** Most solid waste collection is paid out of tax revenues collected by national or local governments and redistributed to the municipality. Mismanagement of funds, lack of competition, and the resulting inefficiencies often result in

non-payment or unwillingness to pay for services. This jeopardizes a systems' economic viability. Market-oriented systems in which residents' fees support collection and disposal services are less likely to suffer from these crippling flaws. Nevertheless, unwillingness to pay can still be a problem under such systems. One strategy for overcoming this problem, used in a number of developing countries, has been to link billing for solid waste collection to utility bills. Electricity consumption is closely correlated with waste generation, so fees for waste collection can be tied to electricity use and integrated into the electrical bill. After charging a small administrative fee, the utility passes the payments to the municipal solid waste department.

LANDFILLS

Even using the best waste minimization practices at all stages, some non-recoverable waste will remain, making landfills necessary. The ultimate goal for land disposal should be:

- Separate disposal of hazardous and non-hazardous materials; and
- Construction of clean and properly sited landfills with diligent management, including leachate and methane controls, during operation and after closure.

When these conditions are met, the landfill becomes a *sanitary landfill*. It is recommended that the transition from open or controlled dumps to sanitary landfills be made incrementally. The following steps are suggested:

Open dumps. If open dumps are currently being used, initial upgrades can be made with little capital investment and minimal ongoing costs. Take the following initial steps:

1. Construct perimeter drains to catch runoff and leachate.
2. Minimize leaching through soil by periodically (every two months is often sufficient) compacting and grading. This causes rainwater runoff into perimeter drains instead of soaking in. Manual labor or heavy equipment may be used (renting heavy equipment is often the least expensive option).
3. Protect the health of waste pickers and landfill staff by providing hygiene training, soap, and water. Handlers and pickers also face risks from physical injury in the dumps from broken glass and metal, and should be provided with protective clothing, footwear, and equipment. Certain minimum qualifications for pickers (i.e. an age minimum to prevent children from entering dumps) should also be imposed.
4. Regularly test groundwater for contaminants, including bacteria, heavy metals, and toxic organic chemicals.

Siting Guidelines for Landfills

Do not site landfills:

- In wetlands or areas with a high water table
- In floodplains
- Near drinking water supplies
- Along geological faults or seismically active regions
- Within two kilometers of an airport

Do site landfills:

- Above clay soils or igneous rock
- With active public involvement
- In areas with sufficient capacity
- Where they will be easily accessible for waste delivery

Source: IETC/UNDP 1996.

5. Conduct a formal environmental assessment of the current site before making further upgrades. If it is environmentally sound and has adequate additional capacity, it can be converted directly to a controlled dump. Otherwise, an appropriate alternative site for a controlled dump or sanitary landfill must be located.
6. Engage the public in decision-making. Public involvement in upgrades, siting decisions, and subsequent planning is essential. Otherwise, strong opposition that delays or halts the project may develop.

Controlled dumps. To transform an open dump into a controlled dump:

1. Fence in the active face of the landfill and hire staff to monitor and control dumping.
2. Track how much waste is delivered.
3. Compact waste before or after dumping.
4. Schedule monitoring of methane gas production, landfill composition, and surface water and groundwater conditions.
5. Develop closure and post-closure plans.
6. Seal and cover the dump in stages as its capacity to receive waste is exhausted.
7. Maintain scheduled monitoring until sampling indicates it is no longer necessary—possibly 30 years or more.

Sanitary landfills. Sanitary landfills are the only land disposal option that enables control and effective mitigation of

- potential surface and groundwater contamination;
- health and physical threats to waste pickers and sanitation workers; and
- methane emissions.

Sanitary landfills require much greater initial investment and have higher operating costs than controlled dumps. Full community involvement throughout the life cycle of the project is essential. Proper design, operation and closure also require a much higher level of technical capacity.

Siting. Siting is possibly the most difficult stage in landfill development.

1. Carry out an environmental impact assessment that addresses all siting criteria (see box at right).
2. Organize full community involvement. This is especially important given the greater expense and often greater size of sanitary landfills.

Design. To mitigate environmental impacts, sanitary landfill designs should include:

1. An impermeable or low-permeability lining (compacted clay and polyethylene are most common in developing countries; geopolymers and asphalt are prevalent in the developed world).
2. Leachate collection, monitoring, and treatment.

3. Gas monitoring, extraction, and treatment.
4. Fencing to control access.
5. Provisions for closure and post-closure monitoring and maintenance.

Leachate management. Leachate impacts can be controlled only with lined landfills.

1. Install collection systems to retrieve leachate from the bottom of the landfill.
2. Treat leachate physically, chemically, or biologically through:
 - a) An off-site sewage treatment plant (adequate sewage treatment facilities are readily available only in parts of some countries), or in a dedicated on-site treatment plant.
 - b) Recirculation that sprays leachate from the bottom of the landfill onto its surface. This is a popular landfill management practice across the globe. It reduces leachate volume by increasing evaporation, stores remaining leachate in the body of the landfill, and may accelerate degradation and extend the life of the site. However, recirculation is a new technique whose long-term effects are not yet known. In Bogota, Columbia, it is believed to have contributed to the massive collapse and slide of a landfill.
 - c) Evaporation of leachate through a series of open ponds. This method requires pumping and some means for disposing of possibly toxic residues. Ponds should be designed with enough capacity to accommodate increased volume during the rainy season.
3. Monitor groundwater and surface water regularly, both down-gradient and up-gradient from the landfill. At a minimum, monitoring should include indicators of core contaminants, chemical oxygen demand, biological oxygen demand, and total nitrogen and chloride levels.
4. Landfill gas should be recovered and used as fuel. If it is uneconomical to recover and use landfill gas as fuel, it should be vented and flared. Currently, recovery and processing systems are both expensive and difficult to operate. These systems are economical only when the landfill generates large quantities of gas, where local or regional demand exists, or where the price for natural gas or other substitutes is high. At a minimum, buried perforated pipes that can safely vent gas should be installed, and a flaring system should be added to reduce global methane release to the atmosphere.
5. Fence in landfills to prevent waste pickers from accessing the site. This enables landfill personnel to work efficiently and protects waste pickers from exposure to harmful substances. However, it also deprives them of their livelihood. They should thus be integrated into formal collection or disposal operations by, for instance, helping them organize a cooperative and offering them structured access at the landfill gates (e.g., as is done Rio de Janeiro). Also, they should be made a part of the earlier stages of the collection process, perhaps as cooperative that collects recyclables from industry. For example, in Porto Alegre, Brazil, waste-pickers were integrated into the curbside recycling program that serves 80 percent of the city. In Columbia, waste-pickers who were excluded from a landfill were organized into a cooperative that collects recyclables from industry.
6. When the landfill is full, implement the activities specified in closure and post-closure plans that were developed during design. These should include sealing the landfill and applying a final cover (including vegetation) to it, land use restrictions on both the old landfill and surrounding areas, and long-term gas, leachate, surface water and groundwater monitoring.

INCINERATORS

DO NOT CONSTRUCT INCINERATORS

Incineration of municipal solid waste is rarely economically feasible for developing countries. It is virtually non-existent in Latin America and the Caribbean. The burning of wet waste often requires adding supplemental fuel. Furthermore, the composition of the waste often varies a great deal between neighborhoods, which makes consistent and optimal operation difficult to achieve. Without proper controls, incinerators can be highly polluting, generating dioxins and depositing toxic heavy metals into water bodies. The proprietary technologies involved require very large capital investments and have high maintenance costs.

WASTES REQUIRING SPECIAL ATTENTION

Certain wastes merit special handling and disposal because of their dangers or volume. The best option is to minimize or eliminate the generation of these wastes by encouraging users to apply cleaner production approaches and substitute materials or change processes (see “Environmental Guidelines for Activities with Micro- and Small Enterprises” in this volume). Those that are generated should be collected and disposed of separately from one another and away from the rest of the solid waste stream. (For information on medical waste, please refer to the *Medical Waste* section of these *Guidelines*)

HAZARDOUS WASTE

Wastes pose a wide range of risks. They may be chronically and acutely toxic, cause cancer, trigger birth defects, explode, corrode many materials, and cut, puncture, crush, burn and infect people and animals. Hazardous wastes endanger many different classes of people, placing waste producers, collectors, landfill workers, waste pickers, and nearby residents at risk. The leachate from a landfill may be dangerous as well; its level of toxicity is directly related to the quantity and toxicity of hazardous materials mixed in with other solid waste.

Management of hazardous wastes needs urgent attention. The variety and classes of materials and sources—from households to industrial and medical facilities—makes this particularly challenging. Action is constrained by limited financial resources to deal with these problems and ignorance or unwillingness to acknowledge the risks.

Sound management of hazardous materials includes four elements: waste reduction, segregation, safe handling, and disposal. The best solution is to not generate this waste in the first place. When this is not possible, every effort should be made to minimize generation, and generated wastes should be handled cautiously to reduce risks. Producers of hazardous waste should segregate different types of materials to make recycling easier and prevent chemical reactions or explosions. Suggested best practices for accomplishing these goals in the developing world include:

- **Providing technical assistance and training** to educate decision-makers, system operators, and the public. These efforts should strengthen stakeholders’ capacity to identify cost-effective waste reduction measures, and to help design and to put in place practical hazardous waste management plans. (See the Cleaner Production approach described in the *Small and Micro Enterprises* section of these guidelines.)
- **Establish incentives, disincentives, or regulations** to promote waste reduction where it is not otherwise cost-effective.
- **Establish dedicated hazardous waste recycling and disposal facilities.** Few countries in Africa operate hazardous waste treatment and disposal facilities. Thus, much of the hazardous

waste generated continues to be disposed of in dumps and landfills without any provisions for segregation, containment or treatment.

- **Develop systems to ensure that waste is not illegally dumped.** One model that provides checks on illegal dumping is the hazardous waste manifest system in the United States, where a “paper trail” (a sequence of required documents) is generated to prove that the material reached its intended final destination.
- **Explore options for contracting private sector firms** that specialize in the handling and disposal of hazardous wastes.

EXAMPLES OF HAZARDOUS WASTE FACILITIES IN DEVELOPING COUNTRIES

COUNTRY	FACILITIES
Argentina	Several hazardous waste treatment and disposal facilities exist. A complete list can be obtained from the Dirección Nacional de Ordenamiento Ambiental-Unidad Registro. Online: www.medioambiente.gov.ar
Brazil	There are several licensed landfills for urban and common wastes, as well as for hazardous and industrial wastes. There are also licensed incineration facilities. A detailed list of these facilities can be obtained from the Directorate of Environmental Control of the Brazilian Institute of Environmental and Renewable Natural Resources (IBAMA). Online: www.ibama.gov.br
Chile	The Hazardous Waste Treatment and Disposal Facility is located at: Hidronor S.A. Vizcaia #260, Santiago, Tel: (56-2) 640-9364
Colombia	The Executive Unit for Public Utilities in Bogotá maintains a security cell for hospital wastes at the Dona Juana Landfill. The government is in the process of bidding the design and construction of hazardous wastes cells in Bogotá. Under the auspices of the Ministry of the Environment, there are a number of initiatives for recycling, regeneration, and reuse of hazardous wastes.
Ecuador	The Guayaquil Municipality operates a landfill (Relleno Sanitario Las Iguanas) that has segregated areas for depositing hazardous waste. In addition, the Ecuadorian telephone and water company collects and stores used oils.
El Salvador	The San Salvador Metropolitan Area Landfill has facilities for autoclaving infectious biological wastes, and several private sector entities also recover, reuse, and recycle hazardous waste. These include Baterías de El Salvador (for recycling of lead acid batteries and use of spent oil as fuel) and Cementos Cessa (for use of spent oil for fuel).
Mexico	Mexico has two large licensed hazardous waste treatment and disposal facilities and is in the process of constructing a third facility.
Panama	The Cerro Patacon Sanitary Landfill also handles hazardous waste. The following companies have recovery, recycling, or reuse facilities: The Panama Refiner, Eco-Klean (for processing spent oil), Derivados de Petróleo S.A., and Proceso y Análisis Metálicos.
Peru	The following landfills in Peru have segregated areas for disposal of hazardous waste:

COUNTRY	FACILITIES
	Portillo Grande, Lurin, Relima; Zapalla, Puente Piedra, Relima; and Huaycoloro, Huarochiri, Petramas. In addition, these private sector entities have facilities for recycling, reuse, and recovery of hazardous waste: Corporación Aceros Arequipa and Tecnofil.

TIRES, OIL, AND BATTERIES

These three common automotive wastes cause difficulties throughout the developing world:

- Stockpiled tires can spontaneously combust, producing prolonged, polluting fires. Reuse or retreading are the best alternatives available for reducing tire waste in developing and industrializing countries.
- Used motor oil from auto shops is often burned as fuel, contributing to air pollution. Re-refining this oil is the best alternative, but this is neither readily available nor commercially feasible in most developing countries.
- Lead acid batteries should not be placed in landfills—the lead is toxic, and the acid is corrosive and contaminated. Lead acid batteries are often recycled in small-scale foundries that are highly polluting and located in residential areas. Recycling in large facilities that have emission and environmental controls is preferable, if this option is available.

CONSTRUCTION AND DEMOLITION DEBRIS

Prevent disposal of construction and demolition debris in dumps or landfills, as this will greatly reduce the life of the facility. Residual lead paint, mercury switches, asbestos and PCBs can also make this debris toxic. Arrange for the return of unused construction materials, recovery of all reusable or recyclable materials, and on-site separation of different waste materials to simplify reuse. The UN Environment Programme's *International Sourcebook on Environmentally Sound Technology for Municipal Solid Waste Management* recommends the following best practices for construction and demolition debris:

- **Inventory control and allowance for return of construction material.** This ensures that unused materials will not be disposed of unnecessarily.
- **Selective demolition.** This involves dismantling, often for recovery, selected parts of buildings to be demolished before the wrecking process is initiated.
- **On-site separation systems.** Use multiple smaller containers instead of a single roll-off or compactor.
- **Crushing, milling, and reusing secondary stone and concrete materials.** There can be a tie-in to approved road construction material specifications.

Recommendation for the Latin America and Caribbean Region

To improve solid waste management disposal practices, the following recommendations may be adopted:

- 1. Technical and institutional guidance.** At the national level, Latin American and Caribbean countries need guidance on siting of landfills with regard to conventional and unconventional environmental protection measures. In particular, the climatic and hydro-geological aspects of leachate management need to be incorporated into landfill policies.
- 2. Development of the “full concept” of leachate management.** First, countries need to improve the criteria for liners and leachate collection systems to assure appropriate technology investments. The use of the entombment concept, questioned in the scientific community as unsustainable, should be carefully considered and reassessed. In addition, the region must advance the concept of recirculation, including the benefits and risks, the principles of simple treatment methods and their functions and education of the principle of attenuation and dispersion. The benefits from evaporation should also be further developed in some countries.
- 3. Re-assessment of passive gas-ventilation systems.** Passive ventilation must be compared with the option of flaring landfill gas in order to reduce methane emissions. The possibilities for recovery of landfill gas for electric power production or utilization of the gas for industrial purposes should be followed up.
- 4. Re-evaluation of daily cover use.** Most landfills in the region use clay materials that may prevent proper recirculation of leachate. Moreover, soil is often used in excessive quantities, constituting up to half of the operating budget for landfills in some countries.
- 5. General knowledge of environmental monitoring.** Many countries have introduced monitoring of leachate and groundwater but selected parameters are too many yet indicators are inadequate. Simple approaches with a few important indicator parameters may yield better results. For instance, monitoring chemical oxygen demand, biological oxygen demand, total nitrogen, and chloride levels may increase understanding of the pollution potential in the landfills and provide an early warning for groundwater contamination.
- 6. Assessing the real costs of tipping fees.** The actual costs associated with landfilling waste in the region are unknown. To assess a comprehensive fee table for depositing waste, costs should include investment, depreciation, operational, and long-term aftercare costs.

Source: Johannessen and Boyer 1999.

RESOURCES AND REFERENCES

GENERAL

- Bernstein, J. (2004). Toolkit for Social Assessment and Public Participation in Municipal Solid Waste Management. Urban Environment Thematic Group, The World Bank, Washington, D.C. <http://www.worldbank.org/urban/uswm/socialassesstoolkit.pdf>
- Beede, David N., and D. E. Bloom (1995). The Economics of Municipal Solid Waste. The World Bank Research Observer 10(2): 113-50. Available for purchase from <http://wbro.oxfordjournals.org/content/10/2/113.abstract>
- CPIS. Enterprises for the recycling and composting of municipal solid waste, conceptual work, vol. 1. Jakarta, Indonesia: Centre for Policy and Implementation Studies (CPIS) and Harvard Institute for International Development (HIID); 1993.
- Coad, A. (1998). Solid Waste Management Directory of English-Language Publications and Organisations for Low- and Middle-Income Countries. SKAT. Switzerland. Available for purchase from <http://www.skat.ch/publications/prarticle.2005-09-29.7288084326/skatpublication.2005-11-10.3524725150>
- Cointreau-Levine, S., and A. Coad (2000). Private Sector Participation in Municipal Solid Waste Management: Guidance Pack (5 volumes). SKAT, St. Gallen, Switzerland. http://www.worldbank.org/urban/solid_wm/erm/CWG%20folder/Guidance%20Pack%20TOC.pdf
- Cointreau-Levine, Sandra (1994). Private Sector Participation in Municipal Solid Waste Services in Developing Countries: Volume 1. The Formal Sector. UNDP/UNCHS/World Bank Urban Management Programme. http://www-wds.worldbank.org/servlet/WDS_IBank_Servlet?pcont=details&eid=000009265_3970128111924

This paper discusses the reduction of government activity through the participation of the private sector in service delivery. The paper poses the questions of whether and how to involve the formal private sector in the provision of municipal solid waste services. The paper also presents decision-making criteria and recommends steps for a phased involvement of the private sector, where justified.

- Decision Maker's Guide to Solid Waste Management Vol. II (sic. Second Edition) (1995). U.S. Environmental Protection Agency, Washington, D.C. <http://www.epa.gov/osw/nonhaz/municipal/dmg2/>
Developed particularly for solid waste management practitioners in the U.S., such as local government officials, facility owners and operators, consultants, and regulatory agency specialists, the guide contains technical and economic information to help practitioners meet the daily challenges of planning, managing, and operating municipal solid waste (MSW) programs and facilities. The guide's primary goals are to encourage reduction of waste at the source and to foster implementation of integrated solid waste management systems that are cost-effective and protect human health and the environment. It covers key technical, legal, economic, political, and social issues that must be addressed to develop effective waste management programs. Detailed guidance is provided on collection and transfer, source reduction, recycling, composting, combustion, and land disposal of solid waste.
- Environmental Resources Management (ERM) (2000). Strategic Planning Guide for Municipal Solid Waste Management. CD-ROM prepared for the World Bank, SCD and DFID, Waste-Aware, London.

http://www.worldbank.org/urban/solid_wm/erm/start_up.pdf; To request a CD-ROM copy send an e-mail to Urban Help: urbanhelp@worldbank.org.

The Guide's purpose is to provide comprehensive information, supporting methodologies and tools to assist development of Strategic MSWM Plans at the local and regional level. It contains a new set of tools for strategic solid waste planning field tested in Peru, the Philippines and Vietnam.

- Gopalan, P. and C. Bartone (1997). Assessment of Investments in Solid Waste Management: Strategies for Urban Environmental Improvement. Transport, Waster and Urban Development Department Discussion Paper, World Bank, Washington, D.C.
- Haan, H.C., A. Coad and I. Lardinois (1998). Municipal Solid Waste Management: Involving Micro- and Small Enterprises - Guidelines for Municipal Managers. International Training Centre of the ILO, SKAT, WASTE, Turin, Italy. Available for purchase from <http://www.skat.ch/publications/prarticle.2005-09-29.7288084326/skatpublication.2005-12-02.3152081139>
- Hoornweg, D. and P. Bhada-Tata (2012). What a Waste: A Global Review of Solid Waste Management. World Bank. Urban Development Series Knowledge Papers. <http://documents.worldbank.org/curated/en/2012/03/16537275/waste-global-review-solid-waste-management>

This report provides consolidated data on MSW generation, collection, composition, and disposal by country and by region.

- IETC/UNEP (1996). International Source Book on Environmentally Sound Technologies for Municipal solid Waste Management. International Environmental Technology Centre/United Nations Environmental Program. <http://www.unep.or.jp/ietc/ESTdir/pub/MSW>

Directed toward MSW management (MSWM) decision-makers of developing countries and countries in transition, NGOs and community-based organizations involved in waste management, the source book is designed to serve as a general reference guide to researchers, scientists, science and technology institutions and private industries on global state-of-the-art environmentally sound technologies for MSWM. The publication provides a list of information sources, overviews of practices around the world in environmentally sound management of MSW (waste reduction, collection and transfer, composting, incineration, landfills, special wastes, waste characterization, management and planning, training, public education and financing).

- Iyer, Anjana (2001). Community Participation in Waste Management: Experiences of a Pilot Project in Bangalore, India. Urban Waste Expertise program, the Netherlands. September.
- JICA (1999). Country Profile on Environment: Senegal. Japan International Cooperation Agency. <http://www.jica.go.jp/english/global/env/profiles/e99sen.pdf>
- Johannessen, Lars Mikkil and G. Boyer (1999a). Observations of Solid Waste Landfills in Developing countries: Africa, Asia, and Latin America. World Bank, Washington, D.C. http://www.worldbank.org/urban/solid_wm/erm/CWG%20folder/uwp3.pdf

A survey of landfills in Asia, Africa and Latin America. The authors report the following three cross-regional findings: (1) the extensive use of daily soil cover on newly deposited or compacted waste; (2) little management of landfill gas, and; (3) problematic and often inadequate leachate management

measures. The report review long-term environmental impacts and offers recommendations for improving World Bank projects that have solid waste components.

- Johannessen, L. M. (1999b). Guidance Note on Recuperation of Landfill Gas from Municipal Solid Waste Landfills. Urban and Local Government Working Paper Series No. 4, The World Bank, Washington, D.C. <http://info.worldbank.org/etools/docs/library/128809/Johannessen%201999.pdf>
- Johannessen, L. M. (1999c). Guidance note on Leachate Management for Municipal Solid Waste Landfills. Urban and Local Government working Paper Series No. 5, The World Bank, Washington, D.C. http://www.worldbank.org/urban/solid_wm/erm/CWG%20folder/uwp5.pdf
- Johannessen, L. M. (in press). Guidance note on Landfill Siting. Urban and Local Government Working Paper Series, The World Bank, Washington, D.C.
- Johannessen, L. M., M. Dijkman, C. Bartone, D. Hanrahan, G. Boyer and C. Chandra (2000). Health Care Waste Management Guidance Note. HNP Discussion Paper, Human Development Network, World Bank, Washington, D. C. <http://siteresources.worldbank.org/HEALTHNUTRITIONANDPOPULATION/Resources/281627-1095698140167/Johannssen-HealthCare-whole.pdf>
- [Kantha, Sivan and Larson, Eric D. UN Development Programme, Bureau for Development Policy \(2000\). Bioenergy Primer: Modernised Biomass Energy for Sustainable Development. New York, NY. Available at: http://www.undp.org/content/undp/en/home/librarypage/environment-energy/sustainable_energy/bioenergy_primermodernisedbiomassenergyforsustainabledevelopment/](http://www.undp.org/content/undp/en/home/librarypage/environment-energy/sustainable_energy/bioenergy_primermodernisedbiomassenergyforsustainabledevelopment/)
- Lardinois, Inge (1996). Solid Waste Micro and Small Enterprises and Cooperatives in Latin America. The Global Development Research Center. <http://www.gdrc.org/uem/waste/swm-waste.html>

This research paper describes the nature, type, origins, economics and institutional relationships of micro and small enterprises and cooperatives providing solid waste collection services in Bolivia, Brazil, Colombia, Costa Rica, El Salvador, Guatemala and Peru, based on research carried out between January and May 1996.

- Medina, Martin (1997). Informal Recycling and Collection of Solid Wastes in Developing Countries: Issues and Opportunities. United Nations University, Institute of Advanced Studies. <http://www.gdrc.org/uem/waste/swm-ias.pdf>
- MOST Clearing House Best Practices Database. Community Participation in the Management of the Urban Environment, Senegal. <http://www.unesco.org/most/africa6.htm>
- Privatization of Municipal Services in East Africa: A Governance Approach to Human Settlements Management. Published by United Nations Centre for Human Settlements (Habitat), with support from the Ford Foundation, Office for Eastern Africa. Nairobi, Kenya. <http://www.chs.ubc.ca/archives/?q=node/933>
- Rushbrook, P.E., and M.P. Pugh (1999). Solid Waste Landfills in Middle and Lower-income Countries: A Technical Guide to Planning, Design and Operation. World Bank/SDC/WHO/SKAT. <http://documents.worldbank.org/curated/en/1999/01/2063254/solid-waste-landfills-middle-lower-income-countries-technical-guide-planning-design-operation>

This guide is targeted at senior waste management staff in local authorities. It provides waste management with practical guidance on how to make gradual improvements. The emphasis is on upgrading disposal of wastes at modest cost, while still providing acceptable levels of environmental protection in widely different climatic, cultural and political regimes. Guidance is also provided on siting, developing, and operating full sanitary landfills, along with comprehensive policies and programs to reduce waste generation and increase recycling.

- Scheinberg, Anne (2001). *Micro and Small Enterprises in Integrated Sustainable Waste Management: Tools for Decision-Makers: Experiences from the Urban Waste Expertise Programme (1995-2001)*. WASTE, Netherlands. ISBN number of the series: 90-76639-02-7
- Scheinberg, A., D.C. Wilson, and L. Rodic-Wiersma. (2010). *Solid Waste Management in the World's Cities: Water and Sanitation in the World's Cities*. Earthscan for UN Human Settlements Program (UN-HABITAT). <http://www.unhabitat.org/pmss/listItemDetails.aspx?publicationID=2918>

UN-Habitat's Third Global Report on Water and Sanitation in the World's Cities focuses on the state of solid waste management by providing detailed case studies and analyses of waste management in 20 cities.

- Schübeler, Peter, in collaboration with Karl Wehrle and Jürg Christen of SKAT (1996). *Conceptual Framework for MSWM in Low-Income Countries*. UNDP/UNCHS (Habitat)/World Bank/SDC Collaborative Programme on MSWM. http://www.worldbank.org/urban/solid_wm/erm/CWG%20folder/conceptualframework.pdf
- Thurgood, M., ed. (1999). *Decision-maker's Guide to Solid Waste Landfills: Summary*. Transport, Water and Urban Development Department, The World Bank, Washington, D.C. http://www.worldbank.org/urban/solid_wm/erm/CWG%20folder/landfill-dmg.pdf
- UN Department of Economic and Social Affairs, Population Division (2012). *World Urbanization Prospects: The 2011 Revision, Highlights*. New York. http://esa.un.org/unpd/wup/pdf/WUP2011_Highlights.pdf
- UNEP (2010). *Waste and Climate Change Global Trends and Strategy Framework*. United Nations Environmental Program. <http://www.unep.org/ietc/Portals/136/Publications/Waste%20Management/Waste&ClimateChange.pdf>

The present paper presents examples of the potential benefits of different waste management activities for climate change abatement, discusses the relationships between waste and climate change, and identifies specific impacts of waste management on climate change. The objective of the paper is to identify the potential impacts and benefits of different waste management systems in terms of climate impact, derived from information presented in the literature.

- UNEP-GEO-Team (1999). *Global Environmental Outlook-2000*. United Nations Environmental Program. <http://www.unep.org/geo/geo2000.asp>. The fifth Global Environment Outlook (GEO-5) is available at: <http://www.unep.org/geo/geo5.asp>
- Van de Klundert, A., and J. Anschütz. (2001). *Integrated Sustainable Waste Management - the Concept Tools for Decision-makers Experiences from the Urban Waste Expertise Programme (1995-2001)*. WASTE, Netherlands. http://www.wastekeysheets.net/pdf/tools_iswm_concept_eng_ebook.pdf

The report introduces the concept of Integrated Sustainable Waste Management (ISWM) and provides an analytic framework for the assessment of waste management services, which takes into account aspects of the system that are often neglected in traditional municipal waste management. It looks at institutional, social, environmental, political, technical and financial aspects, while emphasizing the critical role that different stakeholders - including waste pickers, women, micro- and small enterprises - play in waste management operations such as collection, treatment, recovery, reuse, recycling and prevention.

- World Bank. (2012). Waste and Wealth: Lessons Learned from World Bank Solid Waste Management Projects. Learning Day Conference Proceedings. <http://go.worldbank.org/MCAGB56N70>

The presentations cover the World Bank's program in municipal solid waste (MSW), global trends, priorities, regional review, waste estimates, new MSW initiatives in cities' search for sustainable development. The state of the World Bank's current and future solid waste portfolio was discussed, and innovations and best practices were examined for lessons for developing countries. Key research needs and learning events for the coming year were highlighted.

OTHER USEFUL INTERNET RESOURCES

- Waste Advisors on Urban Environment and Development. <http://www.waste.nl/>

WASTE is a non-profit organization for development projects in countries in Africa, Asia, Latin America and Eastern Europe. WASTE works for organizations engaged in sustainable improvement of the living conditions of urban low-income populations, and of the urban environment in general. Their website contains a variety of papers and project reports relevant to all sectors of waste management and practical approaches to small-scale waste management activities.

DOCUMENTS DISPONIBLES EN FRANÇAIS

- Manuel en environnement. Ressources complémentaires. Gestion des déchets solides Outils pour l'identification des effets environnementaux de secteurs d'activités spécifiques, des mesures d'atténuation appropriées et lignes directrices. <http://www.acdi-cida.gc.ca/acdi-cida/acdi-cida.nsf/fra/REN-218123431-NMU>
- Lignes directrices environnementales 318-7 Mesure et gestion des déchets solides. Service correctionnel Canada. http://www.csc-scc.gc.ca/text/plcy/doc/318-7-gl_e.pdf
- Diagnostic de la Gestion des Dechets au Benin. Republique de Benin Pnud Mai 2011. <http://www.bj.undp.org/docs/publications/PAGIDF%20diagnostic%20valid%E9.pdf>